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HOME RANGE, HOMING BEHAVIOR, AND MIGRATION IN TURTLES

BY
FRED R. CAGLE

ANN ARBOR
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FREDERICK M. GAIGE
Director of the Museum of Zoology

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INTRODUCTION

THE biologist has learned much about home range, homing ability, territorial behavior, and migration in fishes, birds, and mammals, but little information has been accumulated on these aspects of the ecology of reptiles.

Studies dealing with lizard behavior have demonstrated that a few species are territorial and that some have a limited homing ability (Noble and Bradley, 1933; Evans, 1938, for more complete bibliography; Fitch, 1940).

Blanchard and Finster (1933) reported the only intensive research on movements in snakes. On the basis of studies of marked individuals they concluded that the wanderings of snakes may or may not be extensive and are not predictable.

Pearse (1923), who studied the movements of the painted turtle (*Chrysemys picta bellii*), stated: "Of the 166 instances of turtles that were recaptured, 50 (30 per cent) had traveled and 116 (70 per cent) had not. The average time that elapsed between release and recapture was 5 months and 19 days, and the average distance traveled by the 166 recaptured turtles was 112 meters."

Breder (1927) devised a method of studying land turtles (*Terrapene carolina*) by attaching a spool of thread to the carapace so that the movements could be followed by a trail of thread. She concluded that each individual occupies an area of rather circumscribed dimensions, a home range, to which it will attempt to return when removed a short distance.

Bogert (1937) released twenty desert tortoises (*Gopherus agassizii*) marked with aluminum tags and recovered two, one within 150 feet of the release point after 680 days and another within 300 yards of the release point after four years. Woodbury and Hardy, who have in progress research on the movements of the desert tortoise, have in a preliminary report (1940) pointed out that individuals are closely restricted to a small territory (indicated as 10–40 acres).

Nichols (1939), who studied the range and homing behavior of box turtles over a period of twenty years, found that most grown turtles (89.5 per cent) had some homing instinct, but that only three of seven young turtles, when moved, showed any tendency to return to home territory.

Schmidt (1916), who marked green turtles (*Chelonia mydas*) in the West Indies, found all but one of nine recoveries near the point of release. Romanes (1883) intimated that turtles are able to find their way over enormous distances in the season of migration, but offered no basis for this inference.

These reports indicate that an individual lives within a restricted area to which it will attempt to return when removed, but the very meagerness of data stresses the need for information on home range, homing ability, and related problems. Data should be accumulated for each species on the problems designated in the following paragraphs.

The first series of problems deals with the question of home area, home range, and territoriality. Does the turtle inhabit a home area? If so, what is its extent, and what factors determine its limits? How strong is the tendency of the individual to remain within the home area? What influences are most powerful in forcing movement away from the home area? What degree of homing ability is present? Does the individual move at random within its home area or are specific feeding and basking stations repeatedly used? Is there territoriality?

A second series of significant questions deals with the reported migrations of turtles and the overland movements of aquatic forms. Does the turtle make seasonal migrations? If so, what are the primary factors determining the time, direction, and extent of such migrations? Does the turtle migrate when its habitat becomes unsuitable? How responsive is it to habitat changes? If there is a forced migration, what factors direct the movement of the individual? Does it return to its original home area when the habitat is restored?

Information on these problems is essential before one can arrive at a satisfactory comprehension of chelonian population dynamics. Recent years have seen a substantial increase in the study of movements of vertebrate animals through the observation of marked individuals. It is hoped that this report will serve to stimulate further work of this type with turtles, which are almost ideal animals for this kind of research. They are easily collected, easily marked, and individuals of some species may be recovered repeatedly for a period of fifty years.

A long-term program to study movements and growth problems has been underway in southern Illinois and northern Michigan for four years. The data that have accumulated on turtle movements are presented here.

ACKNOWLEDGMENTS

The researches in which these data were gathered would not have been possible without the enthusiastic and aggressive aid given by Mr. Lendell Cockrum, Mr. Philip Smith, Mr. Mearl Stanton, and numerous other students. I am grateful to Mr. Clifford Fore, superintendent of the Carbondale Water Plant, and Mr. Albert Twisdale, city water commissioner of Carbondale, Illinois, for their complete co-operation and encouragement of that aspect of the research utilizing the Carbondale city lake.

This work has been guided by Dr. Norman Hartweg, Museum of Zoology, University of Michigan, to whom I wish to express sincere gratitude for

constant and stimulating criticism. Dr. William H. Burt, Museum of Zoology, has made manuscript suggestions for which I am grateful.

METHODS

Information on the movements of turtles was collected by four means: (*a*) tracing the movements of marked individuals, (*b*) field observations of behavior, (*c*) study of migrating turtles, (*d*) population analysis.

The most significant data were gained from the recovery of individuals that had been marked and released. The marking and collecting methods were similar to those previously described (Cagle, 1939), except that a small electric grinder mounted in a drill stand was substituted for the file and scissors used earlier. The grinder, an excellent labor and time saving device (Pl. I, Fig. 1), had a further advantage in that it made a clean-cut mark with no danger of fracture and subsequent erosion of the marginal plates. In the three years that this program has been underway 2401 turtles have been released and 649 recovered: 1885 specimens of *Pseudemys scripta elegans* were released and 589 recovered; 491 specimens of *Chrysemys picta* ssp. were released and 58 recovered; and 25 specimens of *Terrapene carolina* were released and 2 recovered. Unfortunately, it was not possible to record data on the specific points of collection, release, and recovery for all *Pseudemys* studied.

The second source of data, field study of behavior, has provided information that will serve as a basis for determining the time and the nature of overland movements and the probability of territorial behavior. Observations were made from shore, boat, and two observation towers especially erected in shallow water. These towers, one with a platform twenty feet above the water, provided positions from which an observer, with the aid of field glasses, could note the activities of turtles at a depth of several feet within a considerable radius. Particular attention was given to evidence of aggressiveness, courtship, and feeding behavior.

The third approach, study of migrating populations, has furnished data on the response of turtles to habitat changes. Many turtle populations in southern Illinois seek new quarters periodically, when many of the shallow ponds and lakes become completely dry during late summer.

The fourth approach involves the analysis of population samples. Such a study in this area has been reported elsewhere (Cagle, 1942), and some of the data will be used in the discussion here.

AREAS STUDIED

These studies were made primarily in three regions: the Carbondale city lake with its associated ponds, in southern Illinois; a part of a drainage ditch system of the Mississippi flood plain; and Nigger Creek and Douglas Lake, Michigan.

The Carbondale city lake is about three-fourths of a mile long and one-half mile wide, with a maximum depth of twenty-five feet, and an average depth of approximately five feet (Fig. 1). As a result of activities of city officials, there is little aquatic vegetation and much of the shore line has been stripped of plant growth. These procedures have also eliminated much of the invertebrate life. The game fish are few, and the lake is dominated by large, rough fish. Few basking sites and few favorable feeding areas are available for turtles.

Trapping was first done in the fall of 1938, when twenty box traps were dispersed throughout the lake. These traps were set so that the samples

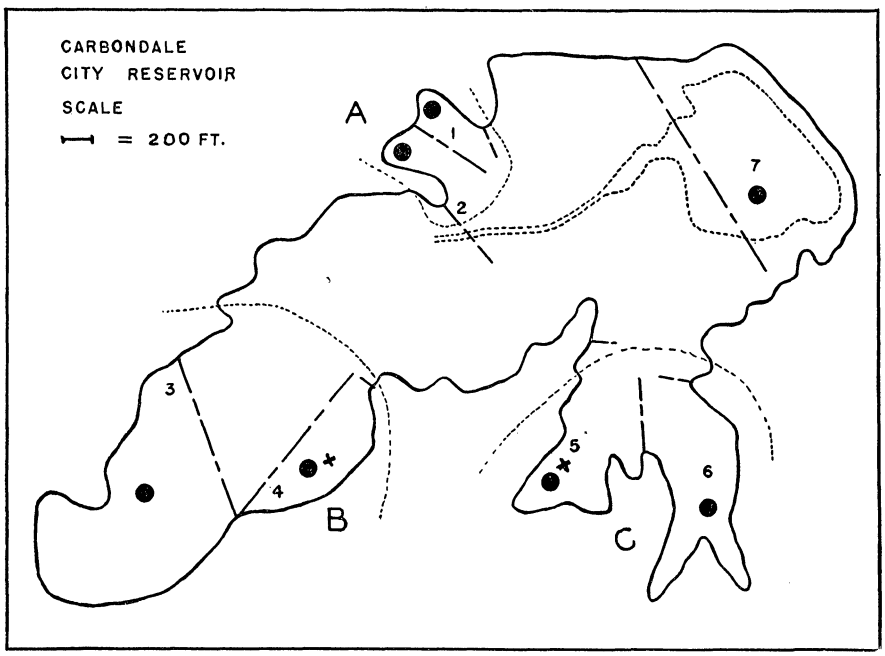
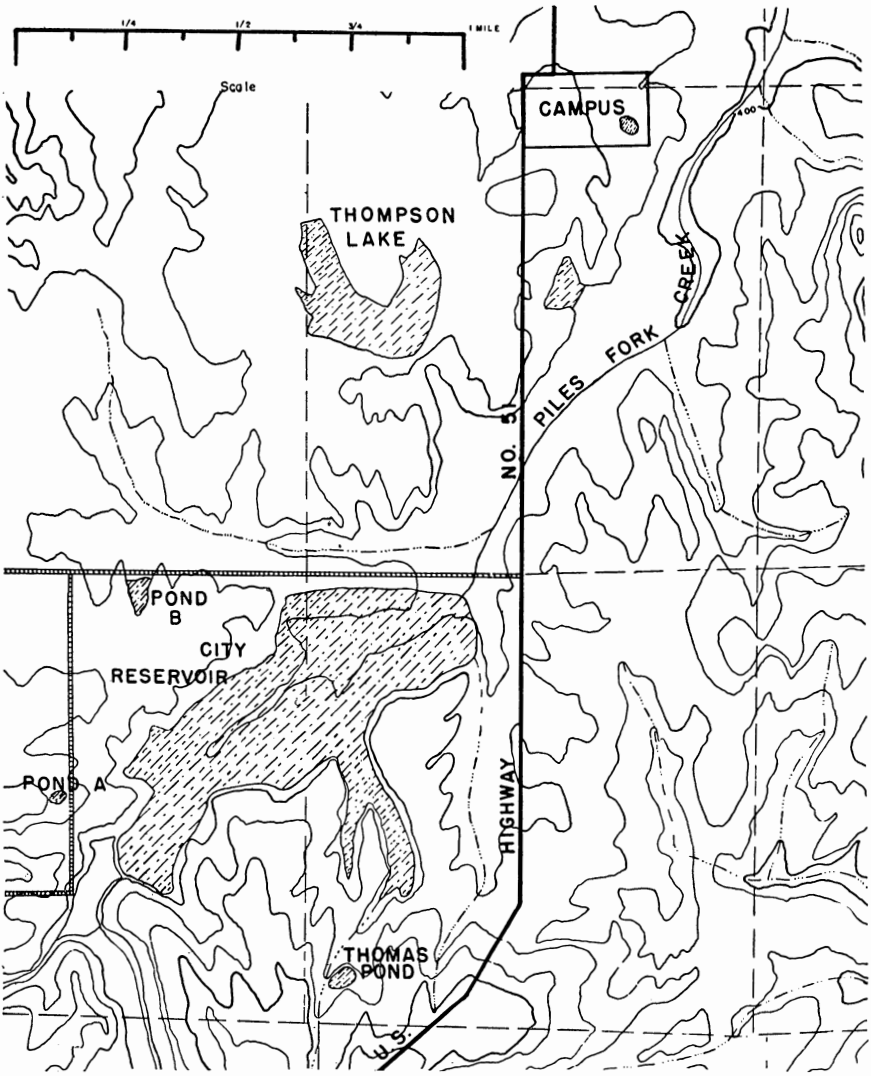


FIG. 1. The city lake. The numbers indicate collecting areas and the dot-dash lines the parts included for hand collecting; the dotted lines and the letters A, B, C, the three major sections. The position of the traps in each area is indicated by a black circle; the position of observation towers by a cross.

obtained would yield information on the distribution of turtles within the lake. This trapping plan was continued through the early spring of 1939, but was then abandoned in favor of trapping in three sections of the lake, the only places where traps were productive. These sections are indicated in Figure 3 as A, B, C. Traps outside these areas yielded only a few large individuals of *Pseudemys* and *Chelydra.*

The three sections include most of the shallow water in the lake and all the areas where there is any abundance of aquatic vegetation. The shoreline outside these areas is mainly barren, wave-washed clay and gravel.

The trapping records of 1938–39 indicate a secondary distribution of turtles within the lake. Quiet shallow water a few inches to three feet deep



MAP 1. The city reservoir system adapted from a United States topographic map. Note the position of the campus pond, the state pond just south of it, and the distribution of ponds A, B, and Thomas pond about the city lake. Piles Fork Creek offers an excellent highway for turtles moving between the state pond or the campus pond and the water bodies of the city lake.

(mainly in the tips of inlets in areas 1, 2, 5, 6, and through most of area 3), where there is much vegetation, is inhabited by individuals of *Sternotherus,*

of *Chrysemys,* and of small *Pseudemys.* Waters margining these shallows and the parts of the inlets formed by creek channels yielded larger individuals of *Chelydra* and of *Pseudemys,* but rarely large examples of *Sternotherus* and of *Chrysemys.* Deep (more than five feet), open water with no aquatic vegetation was inhabited primarily by the large individuals of *Pseudemys* and *Chelydra.* Specimens of *Sternotherus* and *Chrysemys* rarely ventured into these waters. This dispersal is somewhat modified in that larger turtles will occasionally enter shallow water to forage at night or to select basking sites and small turtles will flee to deeper water when pursued. This distribution is important in any attempt to trace the movements of individuals, for the very large turtles probably move in a direct line across the lake and smaller ones along the shallow waters of the shore.

In order to define more adequately the movements of turtles each of the three sections (Fig. 1, A, B, C) was subdivided into two areas, and another trapping area (7) was established. These areas were numbered, and they are considered as that part of the lake marked off by the dot-dash line (Fig. 1). Traps were set at the approximate points indicated by the black circles, but the position of the traps was necessarily changed with the extensive fluctuation of the water level. Turtles collected by hand along the shore were recorded from the area within which they were collected. If found outside any of the designated areas, they were simply recorded as being collected in the city lake without more specific data.

Immediately adjacent to the city lake there are three small, artificial ponds. These will be designated Thomas pond, pond A, and pond B (Map 1). Thomas pond is a small, clear-water pond, approximately one acre in extent, supporting a rich fauna and flora. Ponds A and B are typical, small stock ponds with clay shores and bottoms.

Within a radius of one mile of the city lake there are three other permanent water bodies (Map 1). The largest of these is Thompson Lake, an artificial lake supporting a luxuriant biota. Lake Ridgeway is a small pond on the Southern Illinois Normal University campus. To the south of Lake Ridgeway is the state pond, on the property of the state farm. Piles Fork Creek, a small stream running near the state pond and thence to the overflow of the city lake, is dry throughout much of the year.

Turtles were collected in these ponds and lakes by either trapping or "muddling," a technique involving feeling about in the water and mud until a turtle is found (Pl. I, Fig. 2).

The second general region, a segment of the drainage ditch system of the Mississippi flood plain, consists of a main ditch approximately seven miles long and two principal tributaries each about four miles long (Pl. I, Fig. 2, and Fig. 3). These ditches, constructed to drain the extensive swamps of the region, are fifteen to thirty feet deep and twenty to fifty feet wide at the

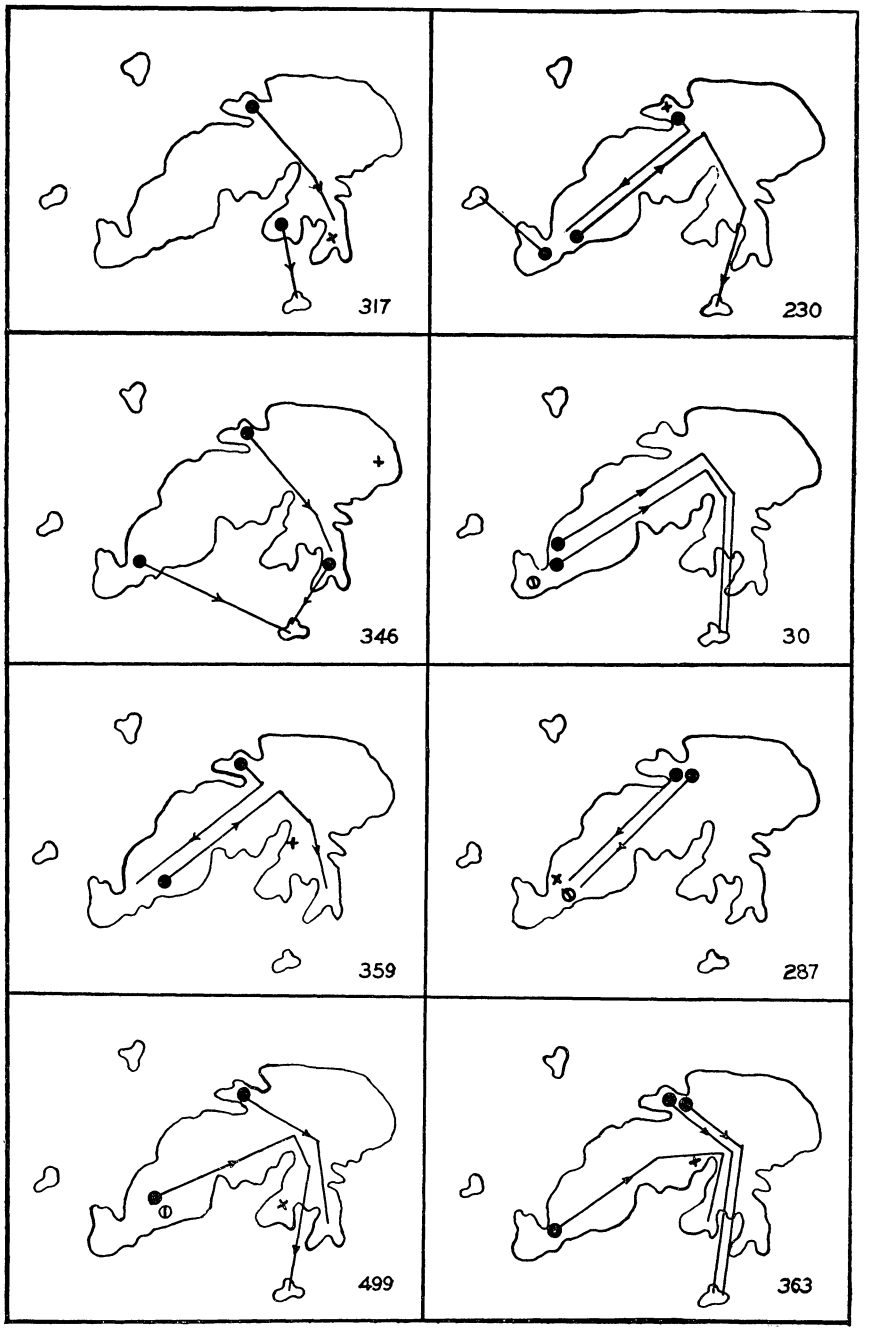


FIG. 2. The movements of turtles in the city lake system. An X indicates the point of original collection, and ● indicates the point of release. The halved circles indicate a release and recovery at the same site. The lines do not represent, except in a general sense, the pattern of the movement, but only the points of release and recovery.

Individuals Nos. 317, 346, 499, 363, 30, 287 returned repeatedly to the area of original collection.

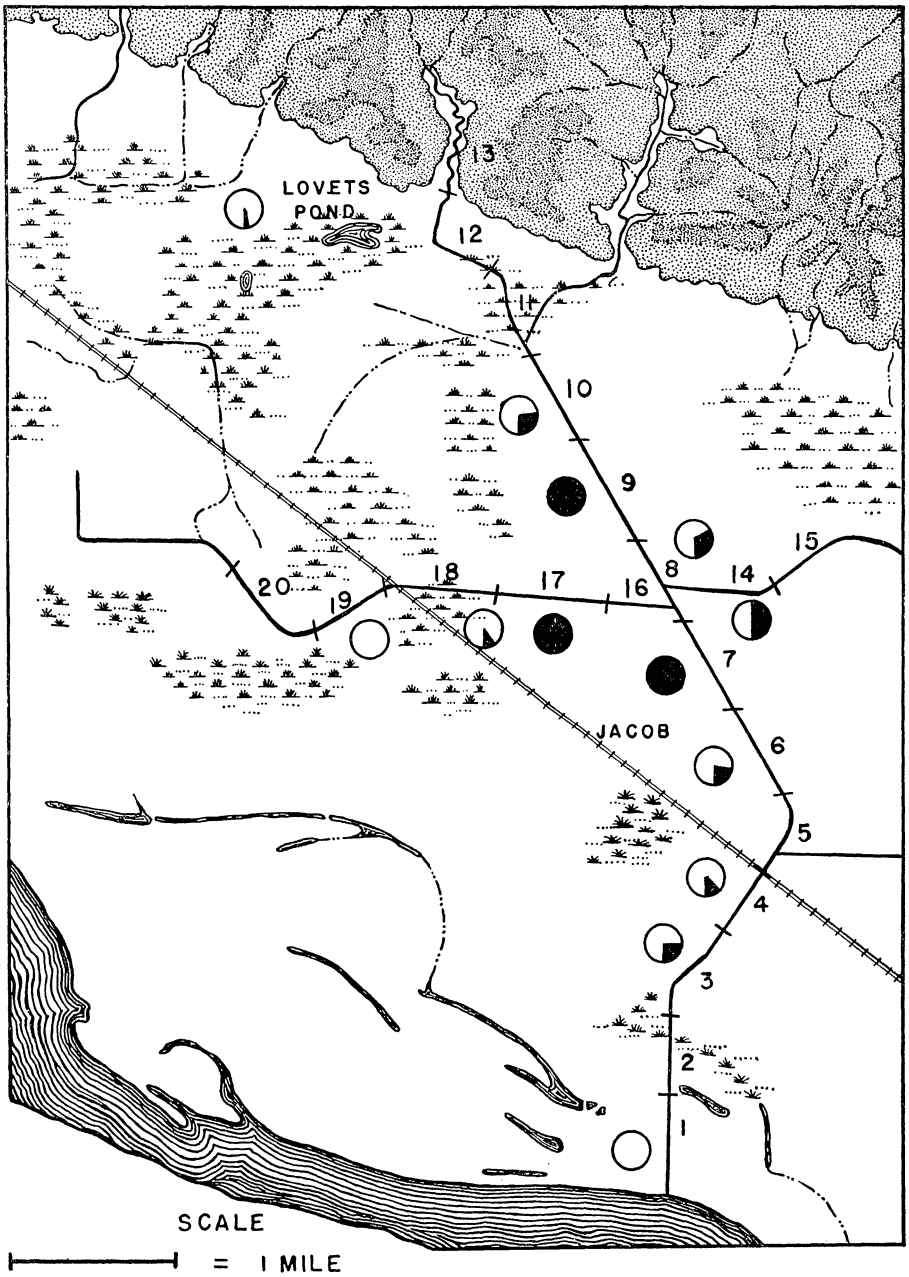


FIG. 3. The section of the drainage ditch system studied. The stippled part represents the bluff area bordering the plain. The flood plain is level, varying from 340 feet above sea level at the river's edge to 363 feet near the bluffs. The ditch is divided into half-mile areas, indicated by a number. The circles represent 100 per cent of all turtles collected at the respective stations; the blackened parts represent the percentage of recoveries.

top. During seasons of normal rainfall the main channel and lower reaches of the tributaries contain several feet of water and support a lush growth of aquatic vegetation with a large population of vertebrates, most of which move into the ditch from the river sloughs. During drought seasons these ditches dry, forcing the aquatic life to aestivate or move long distances down the dry channel to the river.

This part of the ditch system was divided into twenty sections, each approximately one-half mile long (Fig. 3). Collections from ponds and swamps adjacent to the ditch were indicated by the names of the areas in which they were made.

Data derived from study of turtles in these two regions will be supplemented by records of the movements of the painted turtle, *Chrysemys picta marginata,* studied at the University of Michigan Biological Station, Douglas Lake, Michigan.

ACTIVITY

There are three major categories of turtle movements: first, local activity resulting from the foraging for food, seeking of basking sites, or the mating impulse; second, seasonal migrations; third, irregular periods of migration.

LOCAL ACTIVITY

When not stimulated to activity by the need for food, shelter, or basking, the turtle rests at the surface or on the bottom in shallow water. An individual may remain in one position for several hours, moving just enough at irregular intervals to thrust the tip of the nose above water in order to breathe. Several turtles were kept under observation one to three hours during which time they remained on the bottom beneath a thin layer of silt or in beds of floating vegetation. Turtles resting in this fashion are difficult to see, and observers in the towers often studied a patch of bottom for many minutes before the position of a turtle was betrayed by some slight movement. The painted turtle (*Chrysemys*) and the slider turtle (*Pseudemys*) were usually concealed under thin layers of silt formed when the turtles stirred up the bottom before settling quietly in some spot. Although this habit provides concealment it is not so efficient as is the concealing activity of the snapping turtle (*Chelydra serpentina*) and the musk turtle (*Sternotherus odoratus*). These turtles work their way into the mud by digging with the front legs and by pushing violently with the rear legs. After penetrating a few inches, they push the head forward and upward forming a tunnel to the surface. Mud settling about the point of entrance and on the turtle's head held just within the tunnel exit effectively conceals the animal. Individuals of both *Chelydra* and *Sternotherus* were observed going through this procedure on several occasions and were frequently collected from such places of concealment. A collector experienced in sighting the character-

istic "plugged hole" appearance of the tunnel finds shallow water collecting productive.

The need for food or basking forces the turtle to move from its resting position. Although snapping turtles and musk turtles bask primarily by resting on the bottom in very shallow water or by floating at the surface, they were occasionally observed clambering to exposed positions on stumps and logs projecting from the water—the sites usually utilized by large numbers of individuals of *Chrysemys* and *Pseudemys*. Only rarely did the slider turtle attempt to bask in the immediate vicinity of a snapping turtle, and rarely was more than one of the latter observed on a given basking site. Musk turtles were sometimes observed in small groups. Specimens of *Chrysemys* and *Pseudemys* often covered every available inch of space on the favorite basking logs, and newcomers crawled on the backs of early arrivals. In such accumulations there was only rare evidence of any aggressiveness.

Availability of the proper type of basking sites is probably an important factor in attracting turtles to areas 3, 5, and 6. The records of trapping and hand collecting in Carbondale Lake for a three-year period indicate that such areas have the greatest concentration of the turtle population.

Foraging for food requires the greatest activity and probably results in the most extensive of the local movements. It has been frequently suggested that turtles secure their food by remaining in concealment until their prey ventures close enough for capture, but these studies indicate that the majority of the food is secured through active foraging with careful stalking once prey is sighted.

The search for food may lead the turtle overland. Specimens of *Pseudemys* and *Chrysemys* collected and released in the city lake were often recovered from pond A and Thomas pond (Tables III and IV), both of which provide a much greater wealth of food than does the city lake.

It has not been generally accepted that individuals of *Pseudemys* leave the water to secure food on land, but I have repeatedly watched them crawl several feet up on to the shore where they grazed until a large mouthful was accumulated, and then they returned to the water. Several of these turtles were collected, and their stomachs were found to be packed with the terrestrial grasses. Such feeding behavior may contribute to some of the overland movements.

Painted turtles were frequently observed crawling about on the land, but none was ever observed feeding. Cahn (1937) stated: "There is considerable diversity of individual habits exhibited among these turtles [*Chrysemys picta marginata*], some being highly aquatic, others showing a tendency toward a terrestrial habit. During the summer and fall in particular I have frequently found specimens wandering about in fields and

woods nearly half a mile from water, their wanderings having no connection with age, sex, breeding, or hibernation.''

Individuals of *Sternotherus* and *Chelydra* rarely venture on the land except during early spring. Of numerous specimens collected on land none contained terrestrial food items in the stomach. Their land ventures are probably associated with the spring period of wandering rather than food seeking. Both musk turtles and snapping turtles make long journeys overland when forced to do so, but both will remain in the bed of a lake or stream until the mud begins to dry before they leave, whereas individuals of *Pseudemys* and *Chrysemys* usually do not linger when the last water is gone.

Heape (1931) stated that snapping turtles are known to make long journeys overland and that they appear to be merely wandering over territory which includes several feeding areas. Anderson (1942) reported numerous individuals migrating from a Missouri lake and indicated that the nearest water was one and three-fourths miles distant.

Individuals of *Amyda* rarely move about on land. Once trapped in a pool of water they simply bury themselves in the mud and remain there. In the drainage ditch, several specimens of *Amyda* were dug from dried mud where the last remnants of a water pool had evaporated.

Although no substantial evidence is available on *Graptemys,* its absence in the drainage ditches of the Mississippi flood plain as contrasted with its abundance in the river (Cagle, 1942) suggests that it does not readily move overland. Its failure to move into the ditches may be a result of the absence of the molluscan fauna which represents the major part of the food of *Graptemys.*

All the forms studied here may move to the land for basking or egg laying. Apart from these two factors, their overland movements may be charted as follows:

Frequently on land; movements between adjacent water bodies; home range may include parts or all of several water bodies *Chrysemys* *Pseudemys*	Seasonal migration may be overland	Forced migration may be overland
Occasionally on land; no regular overland movements; home range probably confined to one water body *Sternotherus* *Chelydra*		
Very rarely on land; ranges probably confined to one water body *Graptemys* *Amyda*		

The pattern of the local movements of any of these species is principally determined by the ability of the turtle to move overland and the dispersal of suitable basking and feeding sites.

HOME RANGE

The work of the investigators previously cited (p. 5) suggests that some species have a home range to which they tend to return when removed. This is further emphasized by many reports of incidental observation.

Medsger (1919) reported that in the year 1878 initials and date were cut on the plastron of a land tortoise found near Pittsburgh, Pennsylvania. Eighteen years later the tortoise was taken not more than a hundred yards from the point of original release. Again, thirty-five years after the first date, it was found within 150 yards of the original spot.

Schneck (1886) reported a box turtle that was found within one-half mile of where it had been released sixty-two years earlier. Abbey (1882) stated that a mud turtle (species not indicated but probably an aquatic form as he mentions placing it in the water) was found near the point where it had been released seventeen years earlier. Many similar records of marked turtles have been reported. Some of them are probably valid, but many are based on inadequate evidence and are at least of questionable validity.

Grant (1936) stated of the desert tortoise (*Gopherus agassizii*): "Fantastic stories of homing instincts may contain a grain of truth as the tortoises usually return to the same burrow nightly. Accounts of treks or migrations and turtle towns are prevalent. I once saw what appeared to be a migration of *Gopherus berlandieri* in southern Texas and have noted that tortoises are numerous only in restricted localities."

The most extensive movement reported for any inland species is described by Wickham (1922), who marked a large *Macrochelys lacertina* by attaching an inscribed copper plate to the carapace. Liberated in July, 1918, it was recovered September 11, in the same year, about three hundred yards from the point of release; and a second time in July, 1921, at a point seventeen or eighteen miles upstream.

Experiments to determine whether or not *Pseudemys scripta elegans* and *Chrysemys picta* ssp. have home ranges were initiated in October, 1938, when thirty-three adults of *Pseudemys,* marked for observation by painting large numerals on the carapace with white enamel, were released in the state pond. A group of fallen willows in the center of this small pond provided excellent basking sites which could be readily observed from the shore. Observations were made weekly or oftener at this pond during April, May, and June, 1939, and the positions of the basking turtles recorded. All of the enameled turtles retained the white numerals throughout the winter, and basking individuals could be identified at a distance with the aid of binoculars.

A large male occupied the same position at the end of an upturned willow stump in ten of twelve observations. A large female repeatedly occupied the basking station opposite this male, but was seen five times at a site

approximately twenty feet away. In each of eight observations another female occupied a basking position on a small willow that bent beneath her weight so that she was never completely out of the water. Five other individuals, observed at the basking sites three or more times, appeared to exhibit no preference as to basking station.

This situation was abnormal in that: (*a*) these turtles were transferred to the pond from a swamp many miles distant; (*b*) the basking logs were all within a twenty-foot square area, and the individuals had either to select a site in this section or bask on the shore. In spite of these factors the observations suggest that a turtle may select and regularly occupy a particular basking station.

A second group of turtles was marked at the city lake in June, 1941.

TABLE I

A Summarization of the Data on the Movements of Turtles Recovered Only Once in the City Lake Region

The time interval between release and recovery of these individuals varied from three days to three years.

	Collected and Released in Same Area			Collected in One Area and Released in Another				Collected in One Pond or Lake (Within City Lake Region) and Transferred to Another		
Recovered	Same Area	Another Area	Another Water Body	Area of Collection	Area of Release	Another Area	Another Water Body	Same Pond or Lake Collected	Pond or Lake of Release	Another Pond or Lake
♂♂	2	5	6	4	1	6	8	1	2	1
♀♀	3	3	3	3	0	3	1	2	0	0
j	20	9	6	9	3	5	8	1	4	0
Total	25	17	15	16	4	14	17	4	6	1

These turtles were collected and released in area 4 in the immediate vicinity of one of the observation towers (Fig. 1). A wide range of basking sites, partly submerged stumps, logs, driftwood, masses of floating vegetation, and shoreline were available in this area. Of the twelve turtles marked only three were subsequently observed basking more than once. One of these was observed three times in the same position at intervals of several weeks; the other two, observed twice each, were in four different basking sites.

The data from these basking observations are inconclusive, but this technique promises to yield much valuable data in future work.

The records of 119 marked *Pseudemys* provide the best source of data on the question of home range (Table I). Of fifty-seven turtles recovered after

having been collected and released in the same area, twenty-five were recovered in that area, seventeen in others, and fifteen in an adjacent pond. The time elapsing between release and recovery of these turtles varied from three days to three years. In view of the fact that, during the study, samples were taken from six areas of the city lake and two adjacent ponds, these data strongly indicate that each turtle tends to remain within one area. If the movement was purely at random within the lake one would expect, over a period of three years, to recover approximately equal numbers from each collecting station; yet seventeen recoveries were dispersed among five stations and the twenty-five recoveries were made at one station.

It has been stated that the turtles are present primarily in three sections of the lake referred to as sections A, B, and C (Fig. 1). If Thomas pond is associated with area C and pond A with area B and the above data grouped accordingly, it may be seen that there was some movement of turtles from A to B and A to C and from B to C, but there was no movement from B or C to A (Table II).

These data indicate that individual turtles usually remain in one section

TABLE II

THE CORRELATION BETWEEN SECTION OF RELEASE AND SECTION OF RECOVERY OF MARKED TURTLES

Section Recovered	Section of Collection and Release		
	A	B	C
A	15	0	0
B	1	24	3
C	3	7	4

of the lake. This is further demonstrated by the records of turtles recovered more than once (Table III and Fig. 2). Turtle No. 214 was recovered from area 3 twice, once after 348 days and a second time after an additional 330 days. Nos. 285 and 287 were each recovered thrice from area 3, after periods of release varying from 27 to 679 days. Nos. 355 and 632 were recovered twice each from area 1 at intervals of 27 to 649 days. Nos. 341, 369, and 384 were recovered from area 5 twice each during intervals of 22 to 814 days. These turtles appeared to restrict their movements to one area of the lake. Many of the recoveries were made in the same trap set in the same position.

The turtles from areas 3 and 4 frequently moved to pond A and those from areas 5 and 6 to Thomas pond. Twelve turtles, recovered more than once each, made the trip between area 3 and pond A; and thirty-four turtles made the trip between areas 5 and 6 to Thomas pond. Only five turtles collected in area 3 were found later in Thomas pond, and one of these had been originally removed from Thomas pond to area 3 (No. 299, Table III). The

TABLE III

THE MOVEMENTS OF SPECIMENS OF *Pseudemys* RECOVERED MORE THAN ONCE IN THE CITY LAKE REGION

The abbreviations indicate: L.B.S., little black slough; C.L., city lake; S.P., state pond; T.P., Thomas pond; P.A., pond A; H.L., Herrin Lake; D.D., drainage ditch. The numbers indicate stations in the city lake (Fig. 1).

No.	Sex	Date	Coll.	Rel.	Days
9	♂	10/13/38	L.B.S.	S.P.	.....
		6/14/41	3	3	974
		8/ 6/41	C.L.	.....	53
15	♂	10/13/38	L.B.S.	S.P.	.....
		7/27/40	T.P.	3	652
		8/ 5/40	T.P.	.....	9
18	♂	10/13/38	L.B.S.	S.P.	.....
		5/ 1/39	S.P.	S.P.	200
		6/20/40	S.P.	.....	415
22	♂	10/13/38	L.B.S.	S.P.	.....
		6/ 8/40	S.P.	3	603
		7/21/40	T.P.	.....	43
30	♂	10/13/38	L.B.S.	S.P.	.....
		5/ 1/39	S.P.	S.P.	200
		6/20/40	S.P.	3	415
		7/21/40	T.P.	3	31
		9/14/40	3	3	55
		5/22/41	T.P.	.....	38
52	♀	10/16/38	L.B.S.	S.P.	.....
		6/ 8/40	S.P.	3	600
		7/21/40	T.P.	.....	43
73	♀	10/16/38	L.B.S.	S.P.	.....
		4/ 5/40	5	1	356
		5/22/41	T.P.	3	47
		8/ 6/41	C.L.	.....	74
75	♀	10/16/38	L.B.S.	S.P.	.....
		7/30/39	C.L.	C.L.	287
		10/ 7/39	5	5	69
		5/11/40	4	.....	206
78	♀	10/16/38	L.B.S.	S.P.	.....
		7/27/40	T.P.	3	284
		8/ 1/41	C.L.	.....	5
81	♂	10/16/38	L.B.S.	S.P.	.....
		6/ 8/40	S.P.	3	600
		7/27/40	3	3	49
		8/ 6/41	1	.....	375
90	♂	10/16/38	L.B.S.	S.P.	.....
		6/12/40	S.P.	3	604
		8/16/40	T.P.	.....	65
128	j♀	6/ 9/39	H.L.	1	.....
		7/27/39	C.L.	C.L.	48
		5/ 5/41	5	1	647
		6/ 6/42	2	.....	397
129	j	7/27/39	H.L.	1	.....
		7/10/40	C.L.	C.L.	348
		8/ 3/40	3	3	24
		6/ 6/42	2	.....	672
143	j♀	6/18/39	C.L.	1	.....
		6/ 6/42	3	2	1083
		9/ 9/42	2	.....	95

TABLE III—(*Cont.*)

No.	Sex	Date	Coll.	Rel.	Days
149	j	6/18/39	C.L.	1	.....
		7/27/39	C.L.	4	39
		6/ 6/42	2	1	1044
		9/ 9/42	2	.....	.....
155	♀	6/18/39	C.L.	1	.....
		8/ 9/39	C.L.	C.L.	52
		6/30/40	1	3	325
		6/ 5/41	3	.....	340
163	j♀	6/21/39	D.D.	1	.....
		5/28/40	5	1	341
		6/30/40	3	.....	33
164	j♀	6/20/39	D.D.	1	.....
		6/30/40	3	3	355
		8/ 1/41	C.L.	.....	398
169	♀	6/20/39	D.D.	1	.....
		4/25/41	5	5	674
		5/ 5/41	5	5	10
		7/21/41	C.L.	.....	77
200	j♀	7/27/39	C.L.	1	.....
		5/ 5/41	5	5	647
		5/22/41	T.P.	.....	17
214	♂	7/27/39	C.L.	1	.....
		7/10/40	3	3	348
		6/ 5/41	3	3	330
		8/ 6/41	C.L.	.....	62
215	j♀	7/27/39	C.L.	1	.....
		9/17/40	3	3	417
		6/ 6/42	3	.....	627
230	j♀	7/28/39	C.L.	1	.....
		9/18/40	3	3	417
		5/14/41	P.A.	3	238
		6/ 5/41	T.P.	.....	22
232	j♂	7/28/39	1	1	.....
		6/16/41	3	3	657
		8/ 1/41	C.L.	C.L.	46
		9/ 1/42	3	.....	395
233	♂	7/28/39	C.L.	1	.....
		5/ 5/41	5	5	646
		6/ 5/41	3	.....	31
237	j♀	7/28/39	C.L.	1	.....
		6/30/40	3	3	337
		5/ 5/41	5	5	309
		8/ 1/41	C.L.	.....	88
272	j♀	8/ 9/39	C.L.	1	.....
		6/19/40	5	3	314
		5/22/41	T.P.	.....	337
285	♂	8/11/39	C.L.	1	.....
		6/30/40	3	3	323
		9/18/40	3	3	80
		6/ 5/41	3	.....	260
287	♀	8/12/39	C.L.	1	.....
		6/30/40	3	3	322
		7/27/40	3	3	27
		6/ 6/42	3	1	679

TABLE III—(*Cont.*)

No.	Sex	Date	Coll.	Rel.	Days
297	j ♀	8/11/39	C.L.	1	.....
		6/19/40	5	3	312
		4/23/41	5	5	318
299	j ♀	8/11/39	C.L.	1	.....
		8/ 5/40	T.P.	3	359
		9/17/40	3	3	43
		5/22/41	T.P.	.....	308
317	j ♀	8/11/39	C.L.	1	.....
		5/28/40	6	5	290
		7/10/40	T.P.	3	43
320	j ♀	8/11/39	C.L.	1	.....
		6/ 4/40	5	3	297
		8/ 5/40	T.P.	.....	62
341	j ♀	8/19/39	5	1	.....
		5/28/40	5	5	282
		6/19/40	5	.....	22
346	j ♀	8/19/39	7	1	.....
		5/31/40	5	5	285
		8/ 5/40	T.P.	3	66
		5/22/41	T.P.	.....	290
355	j ♀	8/26/39	1	1	.....
		4/13/40	1	1	230
		7/10/40	1	.....	88
356	j ♀	8/26/39	1	1	.....
		6/12/40	3	3	290
		9/18/40	3	.....	98
359	j ♀	8/26/39	4–5	1	.....
		6/30/40	3	3	308
		5/14/41	5–6	.....	318
363	j ♀	8/26/39	4–5	1	.....
		5/19/40	5	1	266
		5/22/40	T.P.	3	3
		8/ 1/41	C.L.	.....	436
369	j ♀	8/26/39	5	1	.....
		5/18/40	5	1	265
		6/19/40	5	.....	32
384	j ♀	8/27/39	5	1	.....
		6/19/40	5	3	296
		9/11/42	5	.....	814
388	♂	8/27/39	5	1	.....
		6/ 4/40	5	3	291
		8/ 3/40	T.P.	3	60
		5/ 1/41	5	5	271
		8/ 7/41	C.L.	.....	98
396	♂	8/27/39	5	1	.....
		6/30/40	3	3	317
		5/14/41	T.P.	3	318
		8/ 6/41	C.L.	.....	84
499	j ♀	5/19/40	5	1	.....
		8/ 5/40	T.P.	3	78
		5/22/41	T.P.	3	290
		8/11/41	C.L.	.....	81

TABLE III—(*Cont.*)

No.	Sex	Date	Coll.	Rel.	Days
544	j♀	5/18/40	2	1	.....
		5/ 5/41	4	3	322
		6/14/41	3	3	40
		8/ 6/41	C.L.	.....	53
569	j♀	5/30/40	5	3	.....
		5/22/41	T.P.	3	357
		6/ 5/41	T.P.	.....	14
571	♂	5/30/40	5	3	.....
		6/ 5/41	T.P.	3	371
		8/ 5/40	T.P.	.....	61
577	j♀	5/30/40	5	1	.....
		8/ 5/40	T.P.	3	67
		5/22/41	T.P.	.....	290
632	j♀	6/30/40	1	3	.....
		7/27/40	1	3	27
		6/ 6/42	1	3	649
664	♂	7/ 2/40	3	1	.....
		8/ 5/40	T.P.	3	34
		5/ 3/41	5	5	271
		6/ 5/41	3	3	33
698	♂	7/19/40	T.P.	3	.....
		5/14/41	T.P.	3	299
		6/ 5/41	3	.....	22
718	♂	7/10/40	3	3	.....
		4/27/41	5	5	291
		5/ 5/41	5	1	8
		6/ 5/41	3	.....	31
811	♂	9/18/40	3	3	.....
		5/ 5/41	5	5	229
		5/14/41	5–6	.....	9

other four turtles had been released at sites other than that in which they were collected. No turtle originally collected in section C was found in pond A.

The extent of the movement between Thomas pond and the lake is further demonstrated by the records of trapping in Thomas pond and the city lake in May, 1941. Of seventy-four turtles collected from Thomas pond, forty-two (56.8 per cent) were recoveries, but only a few (approximately 5 per cent) had been originally collected there.

Individuals of *Chrysemys* were rare in any areas other than 5 and 6, where they were comparatively abundant. Out of fourteen recoveries of turtles from area 5 and released in areas 3 and 1 there was one recovery in area 5, eight in Thomas pond, and five in area 3 (Table IV). As this section furnishes the most satisfactory habitat for *Chrysemys* (an assumption based on its abundance there) this return may have been a result of a random movement toward a proper habitat and should not be construed as unqualified evidence of homing behavior.

Thus, the turtles residing in sections A, B, and C tend to remain in and

to return to them when released elsewhere. Some individuals live in a much smaller part of the lake—numerous turtles were recovered in the same inlet or from the same trap in which they were originally collected. There is an exchange of turtles between areas 5 and 6 and Thomas pond and between areas 3 and 4 and pond A. These two ponds are thus part of the home range of at least some of the individuals in the lake.

The slider turtles studied in the drainage ditch displayed a similar tendency to remain within a small part of it. On March 31, 1941, 1311 turtles were collected at stations 8, 16, and 18 (Fig. 3), and 1006 slider turtles were subsequently marked and released at station 8. At the time of release the water level was low and much of the ditch was dry.

TABLE IV

THE MOVEMENTS OF *Chrysemys* IN THE CITY LAKE AREA
The abbreviations are the same as those used in Table III.

No.	Sex	Date	Coll.	Rel.	Days
395	♂	6/19/39	C.R.	1	.....
		9/14/40	3	3	452
		11/ 2/40	3	3	49
431	♀	5/17/40	C.R.	1	.....
		5/ 3/41	3	3	351
		5/22/41	2	1	19
432	♀	5/17/40	5	1	.....
		6/ 6/40	5	1	20
		7/19/40	T.P.	3	43
		8/10/40	T.P.	3	22
		5/15/41	T.P.	3	278
442	♀	8/ 3/40	T.P.	3	.....
		9/18/40	3	3	46
		5/14/41	T.P.	5	238
439	♀	6/ 4/40	5	3	.....
		7/22/40	T.P.	3	48
440	♀	6/ 4/40	5	3	.....
		11/ 2/40	3	...	151
435	♂	6/ 4/40	5	3	.....
		7/22/40	T.P.	3	48
436	♀	6/ 4/40	5	3	.....
		7/22/40	T.P.	3	48

On May 8, 1941, samples were collected from ten of the stations (Table V). The water level had risen to the extent that all of the ditch bottom was covered. All turtles in a sample of twenty-five taken at station 7, adjacent to the point of release, were recoveries, as were 50 to 100 per cent of all samples taken within three-quarters of a mile from the point of release (Table V and Fig. 3). On May 31, 1941, a sample of seventy-four turtles from station 8 contained twenty-three recoveries (31 per cent). The ditch was again checked on June 28, 1941, but the water was so high that it was impossible to make collections at stations other than 3, 18, and Lovet pond. All of the samples contained some recoveries (Table V and Fig. 3).

The majority of the turtles remained within one-half mile of the point of release, but some individuals moved greater distances. Some recoveries were obtained at all the stations checked, except area 1, which includes the last half mile of the ditch before it empties into the Mississippi. The one specimen recovered from Lovet pond on May 8 must have moved up the ditch approximately two miles and then one-fourth of a mile over low land, during a period of twenty-seven days. At least nine other individuals had made this same journey by June 28. Since this pond and the stretches of ditch between it and station 8 contained only small, shallow pools when the original collection was made, it is possible that its population moved down the ditch with the receding water and that these turtles that returned were individuals formerly inhabiting the pond.

The water was not low enough to permit collecting again until July, 1942, when samples taken at stations 8, 14, 18, and 19 (Table V) all contained some

TABLE V

THE MOVEMENTS OF *Pseudemys* IN THE DRAINAGE DITCH

The upper figure in each line represents those not marked; the lower, the number of recoveries.

Date	1	3	4	6	7	8	9	10	14	17	18	19	L.P.
May 8, 1941	2	.....	17	45	25	17	1	10	2	8	.....	.....	2
	0	.....	3	13	25	13	1	4	1	8	.....	.....	1
May 31, 1941	.....	.....	.....	.....	.....	51	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....
June 28, 1941	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	24	.....	137
	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	9
July, 1942	.....	.....	.....	.....	.....	9	.....	.....	10	.....	15	81	.....
	.....	.....	.....	.....	.....	1	.....	.....	1	.....	3	10	.....

recoveries. Turtles were observed in abundance throughout the ditch, but deep water prevented satisfactory collecting except at station 19, where numbers of *Pseudemys* had aggregated in shallow water about the bases of cattails. Of ninety-one taken from this section, ten were recoveries. The point of collection was one-quarter of a mile above that at which the majority of the turtles were originally collected.

It is probably of significance that all of the nine turtles recovered from Lovet pond on June 28 were large adults. The smallest of these had a plastron length of 18.4 cm. Only twenty-seven of the 137 turtles collected on that date (exclusive of the recoveries) had plastron lengths of 18.4 cm. or greater and only 347 of the turtles released at stations 8 and 16 on April 12, had plastron lengths 18.4 cm. or greater. It thus appears that only the large adults of the marked group made the long overland journey.

That extensive movements do occur during periods of low water is amply demonstrated by the presence of shallow runways connecting adjacent pools.

These runways, formed by the crawling of many turtles from one pool to another, are often worn to a depth of several inches and to the width of the adult *Pseudemys* carapace.

Researches at Douglas Lake, northern Michigan, in the summer of 1938 and 1939 give further evidence of the tendency of turtles to remain in a given area. During the summers of both years painted turtles were trapped from a half-mile section of Nigger Creek. One hundred and thirty of these were released at a station in the midpoint of the section. Of these, thirty-four were subsequently recovered in the section once, eight twice, and four three times after periods of 8 to 368 days (thirty of these after a lapse of 316 to 368 days), a total of forty-six individuals recovered and of sixty-two recoveries. No collecting was done outside this half-mile section.

These records indicate that individuals of *Pseudemys* and *Chrysemys:* (*a*) live within selected areas that may be designated home ranges within which they seek their food, basking sites, and mates; (*b*) have home ranges that may include parts of two or more water bodies; (*c*) make frequent overland movements.

If an animal occupies a definite home range, as is indicated here, it might be expected to exhibit defense of some part of the area, but these turtles offer little evidence of aggressive behavior. Anyone who has observed several layers of turtles on a basking log or a large number of turtles basking close together at the water surface realizes that aquatic turtles are rather indifferent to each other, at least under these conditions. In a pond supporting a large turtle population, as many as twenty-five or fifty heads may be observed in a few square feet of water. Even during the breeding season, when a female may be actively courted by several males, they display little aggressiveness other than pursuance of the female. If there are evidences of territoriality in the species studied here, they have not yet been discovered. However, the frequent literature records of fighting among terrestrial turtles do suggest territoriality.

HOMING BEHAVIOR

Turtles were tested for homing ability by releasing them at some site distant from the point of collection. Of fifty-one individuals of *Pseudemys* so treated and recovered once, sixteen were recovered in the original area, four back in the area of release, fourteen in another area and seventeen in an adjacent water body (Table I). If these data are grouped according to sections A, B, and C, thirty-one of the turtles were recovered from the section from which they were originally collected; eleven from the point of release and nine from the third section.

The records of the *Pseudemys* recovered more than once also demonstrate homing behavior (Table III). Turtles Nos. 363, 369, and 384 (Fig. 2) were originally collected in section C and were recovered there twice each after

being transferred to areas 1 or 3. Turtles collected in areas 5 or 6 and transferred to other areas were often recovered in Thomas pond (see Nos. 363, 346, 317, 388, 396, 499, 569, 571, 577, Table III, and Fig. 2). Turtles from area 3 returned to either area 3 or pond A (see Nos. 214, 215, 230, 287, Table III, and Fig. 2). The interval between collecting dates ranged from 3 to 814 days.

Chrysemys displayed a similar homing ability. No. 432 was removed from section C five times and each time was recovered from the same section after periods of 20, 43, 22, and 278 days. Of five other *Chrysemys* removed from section C to section B, two were recovered from B and three from C after intervals of 46 to 238 days (Table IV).

Many of the turtles removed from their home site were recovered at various points in the city lake, apparently wandering about seeking a satis-

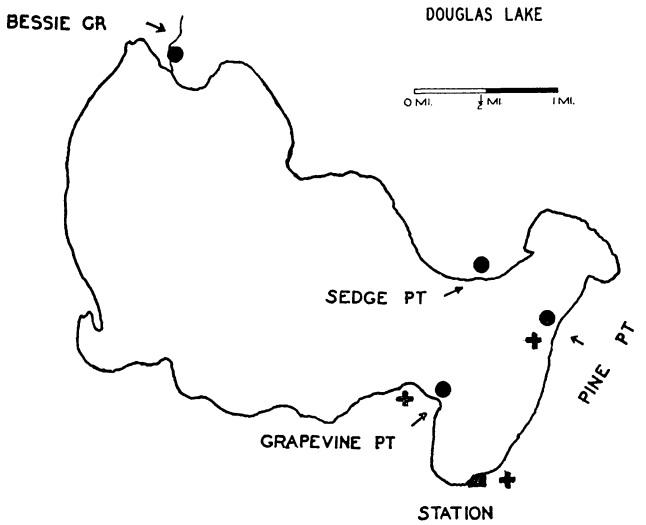


FIG. 4. The distribution of the individuals of *Chrysemys* recovered from Douglas Lake is indicated by the circles. The points of recovery of one turtle collected several times is indicated by the cross marks. All turtles were released on the beach at the Biological Station.

factory home site. Nos. 359, 396, 544, 664, and 811 exhibited such movements (Table III). Turtles transferred from one water body to a distant one displayed similar wandering movements.

In October and November, eighty-nine turtles were moved from a cypress swamp near Vienna, Illinois, to a small, recently constructed pond on the state farm of Southern Illinois Normal University. During the summer and fall of the next year the turtles were frequently observed basking on the logs in the pond, and thirty were actually recovered from the pond (see Nos. 18, 22, 30, 52, 81, 90, Table III). Two of the turtles were recovered from

Thomas pond, and three from the Carbondale city lake in 1940 and 1941. In December, 1940, a careful search for turtles when the pond was drained yielded only one recovery. The other turtles had either died or moved from the pond. It was known that riffles took a toll of some of the turtles, but the carapaces found accounted for very few of the eighty-nine released. Those turtles moving away from the pond probably followed the bed of a shallow ditch that entered a creek leading to the city lake (Map 1).

Turtles introduced to the city lake from distant areas and subsequently recovered are repeated indications of random movement in the lake. Turtle No. 128, collected in Herrin Lake and released in the city lake was recovered in area 5 after 647 days and area 2 after 397 additional days. Another, No. 129, also from Herrin Lake, was recovered in area 3 after 372 days and area 2 after 672 additional days.

Of 164 individuals of *Chrysemys* collected in Nigger Creek and released in Douglas Lake in 1937, seven were recovered one year after their release. These were collected at scattered points, three of them on land many feet from the water (Fig. 4). The dispersal of the recoveries suggests that the transfer of the turtles to a strange habitat stimulated nomadic behavior. The history of turtle No. 23 is of particular interest. It was recovered twice from Nigger Creek and was then transferred to Douglas Lake, where it was subsequently recovered at Pine Point, August 4, 1938, at Grape Vine Point eight days later, and, finally, on the land just south of the camp road six days later. After each recovery the turtle was released on the beach at the Biological Station. That some of these turtles found conditions satisfactory is demonstrated by the fact that four of the seven grew 0.4 to 1.2 cm. in carapace length.

Turtles display some homing behavior. Many of those released at a distance from the original area of collection returned. A few turtles transferred from Thomas pond to the city lake were recovered in Thomas pond, a trip requiring an overland journey. Turtles transferred to a strange water body appear to wander at random.

SEASONAL MIGRATION

Extensive spring and fall overland movements of turtles have been reported by many observers. It has been suggested that the fall movements result when hibernating quarters are sought and that the spring movements result when the hibernation period is terminated. Probably both these factors wield some influence, but they are not the sole contributing ones.

In the spring there is a period of restlessness during which individuals may wander extensively. At such times turtles many yards from the nearest water are apparently moving at random. That this spring movement is not simply a result of the mating stimulus is indicated by the fact that many

juveniles also wander. These movements often occur too late in the spring to have any correlation with emergence from hibernation. Accurate data on this spring movement are difficult to obtain, but the automobile and the modern highway are of some aid. During the late spring of 1940 thirty-five turtles were collected from the roads in the vicinity of Carbondale:

Pseudemys	1 adult and 9 juveniles
Chelydra	2 adults
Sternotherus	5 adults
Chrysemys	8 adults and 10 juveniles

A similar movement occurs during the fall, but is combined with a definite shift of populations to suitable hibernating quarters. This movement is particularly conspicuous in the box turtle (*Terrapene carolina*) in southern Illinois. During early October these turtles are restless and may be observed moving toward the hibernating facilities of low wooded lands.

Netting (1936) reported that Albert W. Davis had observed turtles (*Clemmys guttata*) moving across a highway from an upland situation to a shallow swamp during April. Netting suggested that this was a migration of turtles that had hibernated in the upland situation.

Cahn (1937) stated that individuals of *Chelydra* may undertake overland journeys of considerable length at any time during the summer and that these are not necessarily associated with the nesting instinct or with the drying up of ponds: ". . . . they seem, rather, to be the gratification of a 'wanderlust' which frequently attacks the turtles and drives them afield."

FORCED MIGRATION

In aquatic turtles the most conspicuous cause of forced migration is the drying up of water bodies. Under such conditions the turtle population will often remain until the water is very shallow, hot, and thickened with decaying aquatic life. There is an apparent reluctance to move out of areas that have provided a suitable, if not optimal, habitat. Several such observations have been made.

Cahn (1937) stated that the painted turtle (*Chrysemys picta dorsalis*) usually remains in the dried bed of a water body even when a short migration would lead it to water. He described two instances in which many of these turtles died as a result of failure to migrate from drying areas. In the bed of one dried pond near Reelfoot Lake, Tennessee, he found 116 dead specimens of *dorsalis* with no other species of turtle, although slider turtles were present in adjacent ponds, suggesting that these had more of a tendency to migrate than did individuals of *Chrysemys*. Cahn suggested that the migratory "mechanism" of turtles inhabiting a lake that rarely goes dry might fail to function as it does in turtles living in ponds that regularly go dry.

In October, 1939, a six-hundred-acre lake near Cave-in-Rock, Illinois, was drained within a few days as a result of the opening of a limestone sink into an underground cavern. When the dry lake bed was examined five days after the last small pool had disappeared, the uppermost two or three inches of the bottom had dried and cracked above six to eighteen inches of thick mud. A hasty examination of a part of the lake bed yielded twelve large specimens of *Chelydra* and many others were undoubtedly present. These turtles, located by sounding with a steel rod, were buried at a depth equal to the lengths of their necks, each turtle being as deep as it could be and still reach the surface. The repeated movement of the head to the surface had kept open a tube the diameter of the head that ended in an exit merely large enough to accommodate the end of the nose. Mud adhered so closely to all other parts of the turtle, that when one was removed an excellent negative mold was left of its body.

Individuals of *Chelydra* in great numbers were removed from the bottom by commercial turtle hunters. One of these collectors indicated in conversation that the turtles left in the dry bed of the lake would remain until the mud cracks extended down to their retreat, or until the area was again flooded.

Despite a careful search no other species of turtles were found buried in the mud. That many turtles had left the last pools was indicated by the multitude of turtle tracks crossing the bottom (Pl. II, Fig. 2). The well-defined trend of these tracks toward the lower parts of the shore indicated that the great majority of the turtles had moved up a small ditch toward a spring that provided a trickle of water. Turtles moving up the ditch had worn a channel eight inches wide and two inches deep (Pl. II, Fig. 1). This trail was followed to a large pile of rocks that blocked the stream. The turtles had dispersed from this point.

Two large specimens of *Chelydra* were found buried several hundred yards up this small stream. No other species were noted, although many *Chrysemys* and *Pseudemys* scutes were scattered along the ditch.

Another group of tracks converged on a small pool and the large sink hole that had drained the lake. The pool, about thirty feet in diameter, contained a mixture of thin mud, dead fish, and wriggling maggots. As the depth of this pool was unknown and as it was somewhat repulsive both in odor and appearance it was not examined carefully, but probing with rods about the margins yielded one small male slider turtle.

Several large holes in the vicinity of the pool led to unknown depths in the ground. Many turtles must have been carried into the underground caverns by the last outflow of water, although these probably represented a small proportion of the total population, since turtles seek the bottom when disturbed.

Although tracks tended to converge on the entrance to the small stream and the last pool, many led in all directions from the lake. Two turtles were collected while they were crossing a highway near the lake bed. There was no indication that the turtles moved as a group toward any neighboring body of water. Those following the stream and entering the pool merely followed the lowest part of the lake bed until they found water and then continued to move upstream. Other turtles simply wandered from the lake bed at random. The great abundance of tracks and the reports of observers suggest that the majority of the turtles remained until the last pool of water suitable for existence was gone.

Observations of a similar nature were made in September, 1940, at Lovet pond near Grimsby, Illinois, on the Mississippi flood plain. During spring and early summer aquatic vegetation is abundant in the pond, and large numbers of turtles inhabit the waters, which have an average depth of approximately four feet. This population is occasionally forced to leave the pond during late summer, when its bed may become completely dry. During the past four years this had happened twice.

In September, 1940, the pond was almost dry. In three pools of water covering several hundred square feet there was an abundance of dead and dying fish. The warm water was two to twelve inches deep over a four- to twelve-inch layer of thick mud. Although numerous turtles had already migrated from the lake, as indicated by tracks, many were moving about in the pools or were buried in the soft mud. Twenty-six large individuals of *Pseudemys* and several of *Chrysemys* were collected within a few minutes.

The available evidence suggested that many of the turtles had left the pools during the previous night. In order to observe this apparently nocturnal movement, the pools and shoreline were checked from dusk until 8 : 30 A.M. Three turtles were found fifty to one hundred feet from the pools they had just left, and several others were frightened back by the movements of the collectors.

Although most of the turtles from this pond had undoubtedly moved into and out of the area several times, individuals wandered about the extensive mud flats in a haphazard manner and then moved away from the pond bed in all directions. Turtles moving to the south found a drainage ditch within a quarter of a mile, but turtles moving in any other direction encountered great difficulty, as the nearest water to the north and west was at least one mile, and to the east there were the high bluffs at the edge of the flood plain (Fig. 3). Some turtles had moved toward the lowest part of the pond, a former shallow creek entrance, but others had moved up the comparatively steep sloping banks on the west and toward a concrete highway and the bluffs. Three crushed turtles on the highway had apparently been moving toward the bluffs even though no water was available there.

The situation at the Carbondale city lake in 1941 was somewhat similar. In October the lake reached its lowest level since its construction. From spillway level (450 acres) it dropped steadily with slight fluctuation to an average depth of a few inches covering about ten acres. Previous to this stage few turtles had been observed moving away from the lake, but as the water area continued to be reduced the wide mud flats became criss-crossed with the tracks of turtles moving out, and numerous individuals of *Chelydra* were buried in the mud at the edge of the water. During mid-October the lake was drained, leaving only two small pools. Mr. Clifford Fore stated that one of the pools was approximately ten by twenty feet with a maximum depth of ten inches, and the second pool was approximately ten by fifteen feet, with the water not more than one foot deep. He had treated these pools with a large dose of carbide in an attempt to destroy all the fish. No turtles were observed in or about them.

During the draining of the lake some turtles were collected from the water, but the greater part of the population had apparently moved out or retreated into the deep mud. That many turtles did move away is indicated by: (*a*) the tracks crossing the mud, (*b*) the reports of a large increase in the number of turtles in one of the small ponds adjacent to the lake, (*c*) reports of turtles crawling overland. Turtles were observed crushed on roads bordering three sides of the lake.

Again, the situation is not one of concerted migration in any one direction but that of random movement, this, in spite of the fact that there had been for the past three years a constant movement of turtles between the lake and its adjacent ponds.

A heavy rain, October 27, extended the lake to an area of approximately eight acres and the level increased with some slight fluctuation to spillway level in April, 1942. Trapping records of July, 1942, indicate a high return of marked turtles from the lake. Of twenty-two recoveries, ten were collected in the same area of the lake in which they had been collected and released one to three years previously. These turtles had either moved from the lake or buried themselves in the mud and subsequently reinhabited their home range.

Trapping records in July, 1942, indicated a change in the species composition of the population. During the three years previous to the draining of the lake, specimens of *Chelydra* were comparatively scarce (Cagle, 1942) and represented only 6 per cent of the turtles taken from the lake. The opposite condition was true in 1942. In fact, snapping turtles were so abundant that they occupied the traps set for slider turtles and prevented successful trapping, for these turtles hesitate to enter a trap containing an individual of *Chelydra*. Snapping turtles represented approximately 55 per cent of 120 turtles taken in the summer of 1942, and most of them had a carapace length

of more than eight inches. Trapping methods were identical with those used in previous years. Other data presented in this report indicate that snapping turtles commonly protect themselves by burrowing deep into the mud, whereas slider turtles and painter turtles usually migrate. The apparent explanation for the change in comparative abundance is that the majority of the snapping turtles were buried in the mud during the entire period when the lake bed was devoid of any standing water, whereas many of the slider turtles and painter turtles died during their overland journeys or simply failed to return to the lake.

The migrations of turtles from unsuitable habitats have been reported by several observers.

Cahn (1937) stated of the migration of the common snapper (*Chelydra serpentina*): "During the seasons of excessive drought, they leave their native ponds as they dry up and with apparently unerring instinct travel overland to more congenial and habitable regions." Strecker (1908) reported a migration of forty-five musk turtles (*Kinosternon*) from a drying marsh to a large stock pond more than a half-mile distant. Anderson (1942) reported individuals of *Chelydra* abandoning a Missouri lake. He said that residents reported that the turtles had been migrating and that two to a half dozen could be seen daily on and alongside a road leading away from the lake. He stated: "The weather had been dry and the level of the lake lower than normal, but it is doubtful if this occasioned the migration." Butler (1885) reported winter movement of mud turtles (*Sternotherus*) from dry ponds to a river and finding tracks of a large turtle in the snow that indicated it had moved from the bed of a pond to the river.

SUMMARY AND CONCLUSIONS

A basis is furnished here and in another report (Cagle, 1942) for some suggestions on the dynamics of aquatic turtle populations. A group of turtles may occupy a particular section of a lake or stream, and the individuals removed and released elsewhere usually return to it. Each individual may occupy a home area, which may include parts or all of adjacent water bodies, and within which it usually remains until affected by the breeding stimulus, necessity of movement to areas of hibernation, or aberrant habitat changes. The effects of these forces are varied according to the tendency of the various species to move overland.

The amydid turtles rarely move overland, in fact, will usually not do so even when the water completely disappears from their habitat. Streams or lakes separated by several miles of dry land may support isolated amydid populations; but this may not be true of individuals of *Pseudemys, Chrysemys, Chelydra,* or *Sternotherus,* all of which move long distances overland.

None of the turtles showed aggressive protection of feeding or basking

sites or active competition for mates during the breeding season. Territoriality appears to be nonexistent.

Seasonal movements away from the home range occur during early spring and late fall, when either the need for hibernating quarters or the period of spring wandering leads the turtle to new areas.

Turtles, forced from their home area by aberrant habitat changes, either follow the last remnants of water or move at random in search of a suitable environment. Individuals so forced from their home ranges may return to them when conditions are again suitable.

These data suggest the limited value of literature reports of population based on meager samples taken from small areas. It should be emphasized such samples of turtle populations may be misleading.

These population and movement notes are of some pertinence to those concerned with lake management. That the turtles are often abundant in some sections of a lake and absent in others, with a resultant uneven distribution of predation, that fish shelters, through providing excellent basking and feeding sites, attract concentrations of turtles, that there is difficulty of control by trapping in regions where water bodies are numerous and that there is an influence of turtle populations remaining in or returning to a lake after draining or poisoning are all factors of significance in lake biology.

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PLATE I

FIG. 1. An electric grinder mounted in a drill stand provided an efficient marking tool.

FIG. 2. A section of the drainage ditch when the water level was low. Turtles were usually buried in the soft mud under a few inches of water. The two assistants are using the collecting technique, locally called "muddling," the only satisfactory way of obtaining turtles in abundance from such areas.

PLATE I

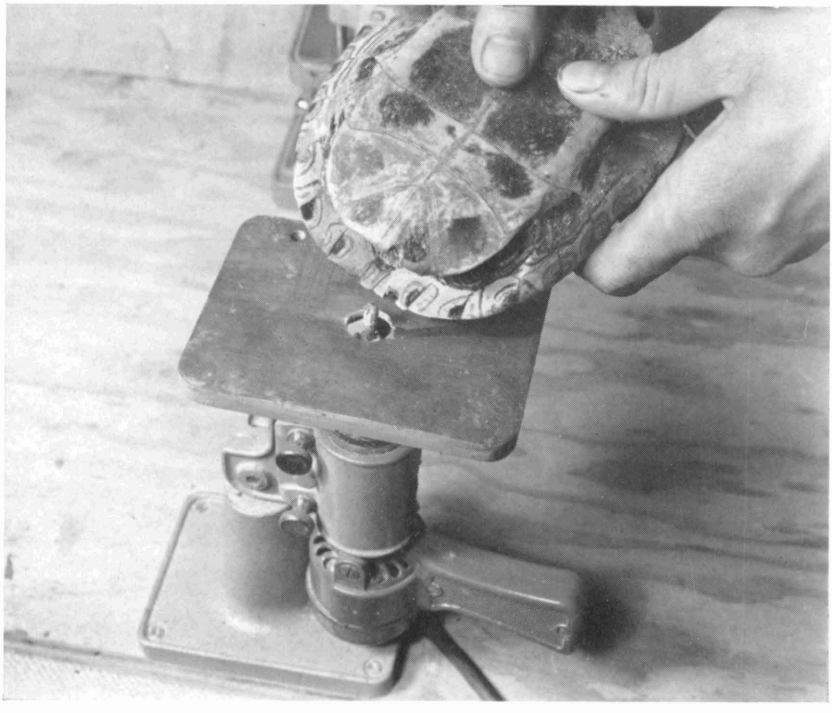

FIG. 1

FIG. 2

PLATE II

FIG. 1. A ditch ten inches wide and three to six inches deep formed by the migration of turtles up a shallow ditch at Running Lake, 1941.

FIG. 2. Turtle tracks across a drying lake bottom. Such tracks give ample evidence of the wandering of turtles migrating from their home area.

PLATE II

FIG. 1

FIG. 2

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