AQUATIC AND TERRESTRIAL MOVEMENTS OF FARM POND

POPULATIONS OF THE EASTERN MUD TURTLE

(Kinosternon subrubrum subrubrum)

IN EAST-CENTRAL ALABAMA

Arthur Floyd Scott

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IN EAST-CENTRAL ALABAMA

Arthur Floyd Scott

A Dissertation

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VITA

Arthur Floyd Scott, son of Herman Augustus and Ruby Ellen (Stuart) Scott, was born in Dickson County, Tennessee on January 10, 1944. He received his early education in the Dickson County public schools and graduated from Dickson High School in May 1961. He entered Austin Peay State College (Clarksville, Tennessee) in September 1961 and received the degree of Bachelor of Science in August 1965. His major was biology. In September 1965, he entered the graduate program at Austin Peay and received the degree of Master of Arts in Education in August 1967. After leaving Austin Peay, he worked as an Instructor in Biology at the University of South Alabama (Mobile, Alabama) until the fall of 1970 when he entered the doctoral program at Auburn University. While working toward the degree of Doctor of Philosophy in Zoology, he served as a graduate teaching assistant in the Department of Zoology-Entomology. With all degree requirements completed, excepting the dissertation, he left Auburn in August 1974 to assume the duties of an Assistant Professor of Biology at Union College (Barbourville, Kentucky). He married Billie Anne Hambaugh, daughter of the late William Poindexter Hambaugh III and Jean (Foster) Hambaugh Hadley on August 5, 1966. They have a son, Stuart Foster, who was born on August 3, 1969, and a daughter, Melissa McShane, who was born on February 13, 1973.

DISSERTATION ABSTRACT

AQUATIC AND TERRESTRIAL MOVEMENTS OF FARM POND POPULATIONS OF THE EASTERN MUD TURTLE (Kinosternon subrubrum subrubrum) IN EAST-CENTRAL ALABAMA

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A study of the aquatic and terrestrial movements of eastern mud turtles, Kinosternon subrubrum subrubrum Lacépède, inhabiting two adjacent east Alabama farm ponds was conducted from 1 April 1972 through 31 March 1974. The capture-mark-release-recapture system of monitoring movement was employed. Individuals were marked according to the system of shell notchings commonly used on turtles. Wire traps were used to study aquatic movements, whereas drift fences and specially designed thread-trailing devices were used to study terrestrial movements.

A total of 1826 captures was recorded for 333 individuals marked on the study area. In both ponds, individuals large enough (carapace length greater than 50 mm) to be sexed by external observation were found to outnumber the smaller ones. Females were found to outnumber

the males among sexable animals. Turtles became active each year in March at about 18 C and ceased being active in December at about 16 C. Movement on land generally began earlier in the year and lasted later than movement in the water. Aquatic movements were almost totally restricted to a narrow zone of shallow water habitat adjacent to each pond's shoreline. Within this zone, the movements of individuals were confined to an area referred to as the aquatic feeding range. Terrestrial movements (studied only at one pond) occurred within an area immediately surrounding the pond and involved mainly those habitats supporting a thick ground cover. Two distinct phases of overland movement were apparent: (1) a phase of continuous outward and inward movement occurring during spring and summer which was associated with egg laying and feeding and (2) a phase of predominantly outward fall movements and predominantly inward late winter movements which was the result of a migration to terrestrial hibernacula. Movement between ponds occurred mainly in one direction, involved only 4.5% of the marked population and was overland via the shortest route. Precipitation was positively correlated with the number of drift fence captures and proved to be the most important environmental variable controlling the amount of terrestrial activity. Temperature appeared to be the most important factor controlling its seasonal duration. Alien turtles introduced into the fenced pond reacted, in most cases, by leaving it within one or two days after their release. Although most of these were never seen again, a few returned and took up residence as members of the local population.

## ACKNOWLEDGEMENTS

To all who contributed of their time and talents in bringing this study to a successful conclusion, I wish to extend my sincere thanks. Without their help, it could never have been completed.

For permission to use a portion of Auburn University's Dairy Research Unit as a study area, special thanks are extended to Dr. W. W. Warren and Mr. Joe A. Little of the Department of Animal and Dairy Sciences.

For providing me with many of the supplies and tools that were used during this study and for printing the photographs that appear in this dissertation, grateful appreciation is offered to Dr. Kirby L. Hays of the Department of Zoology-Entomology at Auburn University.

For assistance in identifying the various species of plants found on the study area, I am grateful to Auburn University professors Dr. John D. Freeman of the Department of Botany and Microbiology and Dr. Wiley C. Johnson, Jr. of the Department of Agronomy and Soils.

For help in mapping, I am indebted to Messrs. John Hurd, Mack Braid, Tommy Creel and Roger Stemp.

For aid in checking traps, I wish to thank Messrs. John Hurd and Jerry Waters.

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And for her continued encouragement and untiring patience demonstrated throughout the course of this project, I wish to thank my wife, Billie.

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# I. INTRODUCTION

Movements of eastern mud turtles, Kinosternon subrubrum subrubrum Lacépède, inhabiting two adjacent farm ponds in east-central Alabama, were studied from April 1972 through March 1974. The aim of this investigation was to record and analyze both the aquatic and terrestrial activities of this species as they occurred throughout the annual cycle in habitats associated with small impoundments. This involved the following specific objectives: (1) to determine the approximate size, density, composition and spatial distribution of the local populations associated with each of the two ponds; (2) to determine the duration of the seasonal activity period for turtles in this area and the temperatures coinciding with the beginning and end of this phase of their annual cycle; (3) to determine the size and shape of the aquatic range of the turtles in each of the two ponds and to test the homing ability of individuals displaced from this part of their habitat; (4) to determine the amount of interchange occurring between members of the local populations in each of the two ponds; (5) to determine the seasonal patterns of terrestrial movement occurring around the larger of the two ponds; (6) to determine the nature and extent of overland wanderings of adults leaving the larger of the two ponds; (7) to attempt to correlate the amount of terrestrial movement occurring around the larger of the two ponds with the environmental variables of temperature, precipitation, relative humidity, fluctuations in water level, evaporation rate, wind speed, solar radiation and photoperiod and (8) to compare the movements exhibited by members of the native population with those of turtles introduced into the area.

## II. LITERATURE REVIEW

Several papers have appeared which deal with movement and related aspects of the life histories of non-marine turtles. Of these, however, only a small portion contains information on members of the family Kinosternidae. In this section, only the contents of these latter papers will be discussed; papers dealing with species in other families will only be cited in connection with the species to which they pertain.

Documented accounts of movement in the Kinosternidae date from the latter part of the last century but, except for the more recent works, are scanty at best. Butler (1885) related an account of several Sternotherus odoratus moving away from dry ponds to a river during winter. Strecker (1908) mentioned observing 45 Kinosternon subrubrum hippocrepis in Texas traveling from a drying marsh to a large stock pond which was more than half a mile away. Noble and Breslau (1938), in studying the senses involved in the migration of hatchling fresh-water turtles, found large areas of illumination to be the guiding force enabling S. odoratus to reach water upon hatching. The marked negative geotaxis of hatchlings accounted for their escape from the nest. Cagle (1944), in a study of home range, homing behavior and migration of turtles in southern Illinois, concluded that S. odoratus may exhibit seasonal or forced migrations overland, but that home range was probably confined to one body of water. Nichols (1947), in commenting on dates of emergence from hibernation in the spring and cessation of activity in the fall for K. subrubrum, stated that the earliest individual found active by him on Long Island was on 11 April and the latest was on 11 November. Williams (1952), in a paper on homing behavior of painted and musk turtles in a lake in Michigan, reported that certain S. odoratus showed definite indications of homing behavior, with some exhibiting it more strikingly than others. Skorepa and Ozment (1968) stated that K. subrubrum in southern Illinois emerge in mid-March and are active for about six weeks. Mahmoud (1969), after conducting a comparative ecological study of the kinosternid turtles (S. odoratus, S. carinatus carinatus, K. s. hippocrepis and K. flavescens flavescens) of Oklahoma, concluded that all four species were maintaining limited movements within their habitat, mostly during crepuscule periods, and that all had definite activity ranges. He found the annual activity periods for each of these forms to be 300 days, 310 days, 265 days and 140 days, respectively, and attributed the comparative shortness of the latter to a late summer period of aestivation which was continuous with winter hibernation. Gibbons (1970), using pitfall traps and drift fences to monitor terrestrial movements of turtles inhabiting a South Carolina bay, found that overland wandering of S. odoratus and K. subrubrum were far more extensive than had been supposed. However, he could not correlate these movements with any single environmental variable. Bennett, Gibbons and Franson (1970), after following turtles tagged with Tantalum-182 pins around the same South Carolina bay, found K. subrubrum to be exhibiting a pattern of short movements followed by burrowing and then longer movements, with some individuals straying more than 300 m away from their aquatic environment. Bennett (1972) followed two tagged K. subrubrum through the winter and found that they hibernated from November to early March in terrestrial burrows 2-11 cm below the surface and emerged when burrow temperatures surpassed 21 C. Zug (1971), in studying locomotion in cryptodiran turtles, found overland movement of kinosternid turtles to be characterized by a very slow walk and movement in water to be of the bottom-walking type (like chelydrids and certain aquatic emydines) as opposed to the swimming type (characteristic of most aquatic emydines and all trionychids). Christiansen and Dunham (1972) reported K. f. flavescens in New Mexico to be active from mid-April to mid-October, but to consume food only until mid-September. Ernst and Barbour (1972) stated that among 23 S. odoratus recaptured in Pennsylvania, the average distance between recaptures was 152 m (166 m for 15 males, 113 m for 6 females and 185 m for 2 juveniles).

Articles abound concerning movement in non-kinosternid freshwater turtles. Data on the subject have been published by Pearse (1923), Cahn (1937), Noble and Breslau (1938), Anderson (1942), Cagle (1944), Fitch (1958), Gibbons and Smith (1968), Gibbons (1970) and Murphy and Sharber (1973) for Chelydra serpentina; by Wickham (1922a) for Macroclemys temmincki; by Netting (1936) and Ernst (1968, 1970a) for Clemmys guttata; by Gibbons (1968b) for Emydoidea blandingi; by Fitch (1958), Legler (1960) and Schwartz (1971) for Terrapene ornata; by Wickham (1922b), Breder (1927), Nichols (1939), Stickel (1950), Gould (1957, 1959), Fitch (1958), Giles (1970), Lemkau (1970) and Dolbeer (1969, 1971) for T. carolina; by Pearse (1923), Noble and Breslau (1938), Cagle (1944), Williams (1952), Fitch (1958), Sexton (1959), Ortleb and Sexton (1964), Gibbons (1968a), Emlen (1969) and Ernst (1970b, 1971) for Chrysemys *picta*; by Cagle (1944, 1950), Webb (1961), Gibbons (1970), Bennett, Gibbons and Franson (1970), Murphy (1970) and Moll and Legler (1971) for *Pseudemys scripta*; by Gibbons and Smith (1968) and Gibbons (1970) for *P. floridana*; by Gibbons and Smith (1968) for *P. nelsoni*; by Gibbons (1969, 1970) and Bennett, Gibbons and Franson (1970) for *Dierochelys reticularia*; by Grant (1936), Bogert (1937) and Woodbury and Hardy (1948) for *Gopherus agassizi*; by Hamilton (1944) for *G. berlanderi*; by Gibbons and Smith (1968) and Gourley (1969, 1972) for *G. polyphemus*; by van Zyl (1966) for *Geochelone pardalis*; by Breckenridge (1955) for *Trionyx ferox*; and by Plummer and Shirer (1975) for *T. muticus*.

# III. DESCRIPTION OF STUDY AREA

## Size and Location

The study area included approximately 160 ha of the southern section of Auburn University's Dairy Research Unit, which is located in Lee County, Alabama, 6.9 km air distance NNW of the town of Auburn (Figure 1). This location is in the SW ¼ of Section 2, T19N, R25E, and has the approximate coordinates of 32°39' N latitude and 85°31' W longitude.

## Physiography and Geology

Physiographically, this area is located on the extreme southern edge of the Piedmont Province of the Appalachian Highlands (Fenneman 1938). In this region, the Piedmont Province comprises the Opelika Plateau and is underlain by rocks of Archean age consisting principally of crystalline schists and gneisses and granite (Adams et al. 1926). The elevation of this area ranges from about 215 to 230 m (U.S. Geol. Surv. 1964).

## Soils

At the time of this writing, published information relating specifically to the soils of the study area was not available. However, a progressive soil survey of Lee County was being conducted concurrently with this study and the area under consideration here had been mapped. The following description is based on the results of that survey.

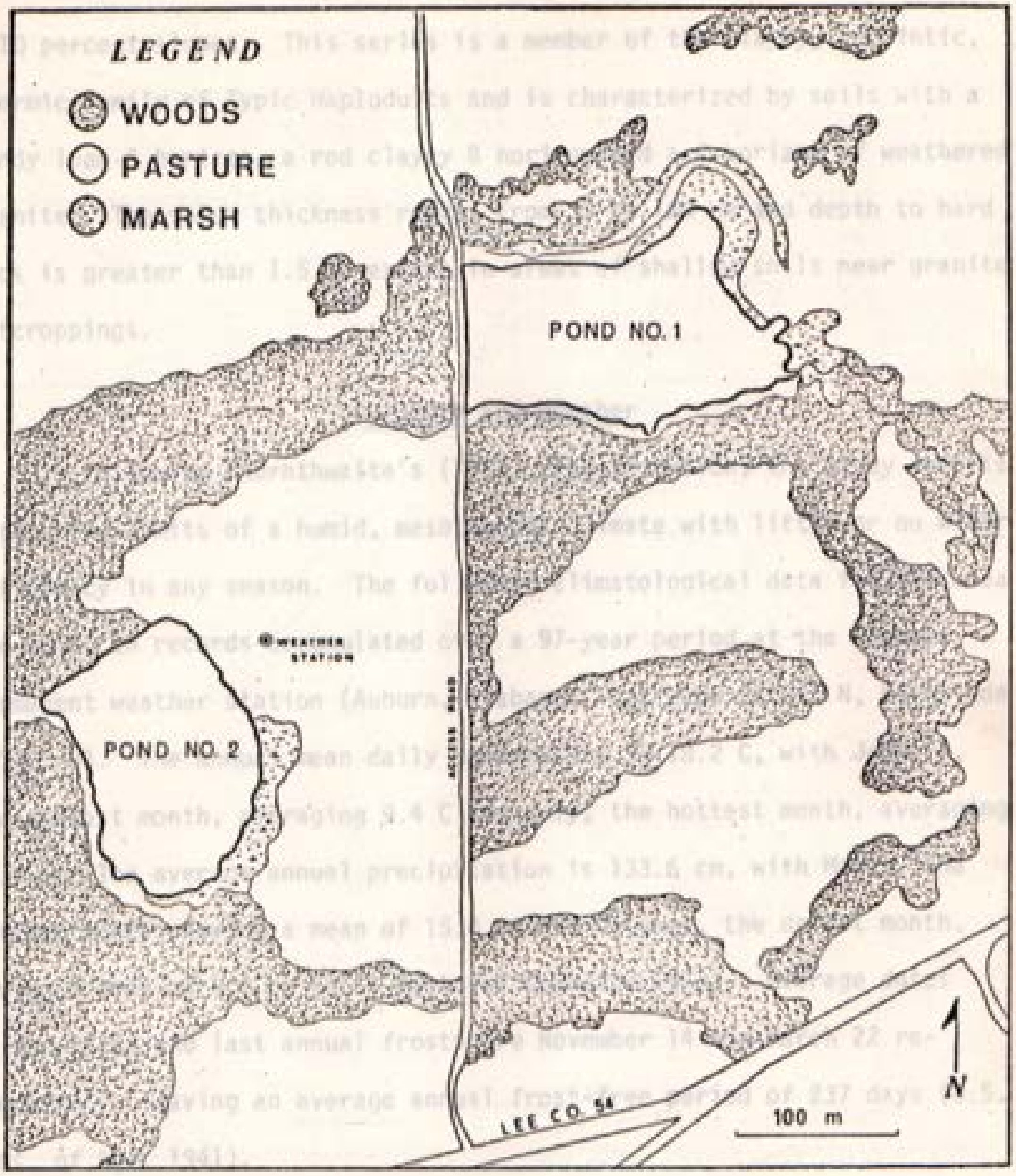



Figure 1. Southern portion of Auburn University's Dairy Research Unit showing location of the study area ponds and surrounding habitat types.

Soils of the study area were mapped in the Pacolet series on 2-10 percent slopes. This series is a member of the clayey, kaolintic, thermic family of Typic Hapludults and is characterized by soils with a sandy loam A horizon, a red clayey B horizon and a C horizon of weathered granite. The solum thickness ranges from 50 to 100 cm and depth to hard rock is greater than 1.5 m, except in areas of shallow soils near granite outcroppings.

## Climate and Weather

Following Thornthwaite's (1948) classification, the study area is within the limits of a humid, mesothermal climate with little or no water deficiency in any season. The following climatological data for the area are based on records accumulated over a 97-year period at the closest permanent weather station (Auburn, Alabama: Latitude 32°34' N, Longitude 85°31' W). The annual mean daily temperature is 18.2 C, with January, the coldest month, averaging 9.4 C and July, the hottest month, averaging 26.3 C. The average annual precipitation is 133.6 cm, with March, the wettest month, having a mean of 15.6 cm and October, the driest month, having a mean of 6.6 cm (U.S. Dept. of Commerce 1973). Average dates of the first and last annual frosts are November 14 and March 22 respectively, leaving an average annual frost-free period of 237 days (U.S. Dept. of Agr. 1941).

Weather of the study area from April 1, 1972 to March 31, 1974 is summarized in Table 1. Compared to the above long-range data, the mean daily temperature for this period was 17.2 C, with February averaging as the coldest month at 7.2 C and July as the hottest month at 25.3 C.

Table 1. Annual and monthly averages for temperature and precipitation occurring on the study area from April 1, 1972 to March 31, 1974.

| Date | Temperature (C) | | | Precipitation |
|---|---|---|---|---|
| | Average Daily Maximum | Average Daily Minimum | Daily Average | Average (cm) |
| January | 15.8 | 4.6 | 10.2 | 20.3 |
| February | 14.1 | -1.0 | 7.2 | 15.1 |
| March | 21.2 | 9.1 | 15.2 | 17.0 |
| April | 22.6 | 10.2 | 16.5 | 11.6 |
| May | 26.2 | 13.5 | 19.9 | 10.8 |
| June | 30.0 | 17.7 | 23.8 | 13.2 |
| July | 31.1 | 19.4 | 25.3 | 15.8 |
| August | 30.9 | 19.1 | 25.0 | 5.2 |
| September | 30.7 | 18.0 | 24.4 | 11.1 |
| October | 24.4 | 10.7 | 17.6 | 4.7 |
| November | 18.1 | 6.0 | 12.0 | 11.5 |
| December | 14.9 | 3.1 | 9.0 | 23.1 |
| Year | 23.3 | 10.9 | 17.7 | 13.3 |

The mean total annual precipitation was 13.3 cm, with December averaging as the wettest month at 23.1 cm and October as the driest at 4.2 cm. November 9 and April 2 averaged as the dates of the first and last annual frosts, leaving a period of 220 frost-free days.

## Impoundments

The study area consisted of two small earthen impoundments and the land surrounding and intervening them (Figure 1).

The impoundment designated as Pond No. 1 (Figure 1) occupied an area of 1.6 ha and was 4.0 m deep at its deepest point. It was constructed in 1941 as a livestock and irrigation pond. Considerable site preparation produced a pond with a clean, mud bottom free of stumps, logs and other debris. Auburn University bought the pond in 1953 and raised the dam by about 1.5 m. Later, the pond was stocked with largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*) and redear sunfish (*L. microlophus*), and has since been used mainly for fishing and for limited irrigation. From 1955 to the present 20-20-5 fish fertilizer has been applied once per month from April through September, with the exception of 1971. Cattle have had only limited access to the pond in recent years and were excluded totally from it during most of this study.

The impoundment designated as Pond No. 2 (Figure 1) occupied an area of 1.4 ha and was 3.6 m deep at its deepest point. It was constructed in 1955 following comparatively little site preparation. This resulted in a fairly shallow pond containing numerous stumps, snags, logs, other debris and a bottom rich in organic matter. It too was stocked with largemouth bass, bluegill and redear sunfish, and has served as a livestock, irrigation and fishing pond. Except for four applications of 20-20-5 fish fertilizer in 1960, the only artificially introduced nutrients to have reached this pond have been those carried in runoff from a pasture on its east bank. Cattle have had rather free access to this pond and used it almost continuously during this study.

## Dominant Plants

Vegetationally, the study area is within the bounds of Alabama's Central Short-leaf Pine Belt (Harper 1943), which constitutes a small portion of the Southeastern Evergreen Forest Formation (Braun 1950). Tree cover about the two ponds consisted mainly of small groves of mixed loblolly pine (*Pinus taeda*) and short-leaf pine (*P. echinata*) surrounded by open pasture (Figure 1). Narrow strips of hardwood trees including sweetgum (*Liquidambar styraciflua*), tulip tree (*Liriodendron tulipifera*), red maple (*Acer rubrum*), black willow (*Salix nigra*) and water oak (*Quercus nigra*) were found along the small streams draining each pond. The floras of each of the ponds were essentially the same and include principally the following species: trees--*Alnus serrulata* and *Acer rubrum*; grasses--*Leersia oryzoides*, *Paspalum urvillei*, *Panicum agrostoides* and *Arthraxon hispidus*; sedges--*Cyperus erythrorhizos*, *Eleocharis obtusa*, *Rhynchospora glomerata* and *Carex lupulina*; rushes--*Juncus acuminatus*; other--*Sagittaria latifolia*, *Polygonum cespitosum*, *P. punctatum*, *P. sagittatum*, *Hypericum mutilum*, *Rhexia mariana*, *R. virginica*, *Ludwigia leptocarpa*, *L. alternifolia*, *Micranthemum umbrosum* and *Mikania scandens*. In addition, Pond No. 2 supported a well developed zone of emergent and floating-leaf plants, consisting of pickerel weed

(Pontederia cordata) and Ludwigia peploides, which were totally absent in Pond No. 1. Both of the species in this zone were accidentally introduced into the pond about five years prior to the beginning of this study.

Dominant Animals

Dominant animals inhabiting the Dairy Unit ponds were also quite similar, the faunas differing only slightly in composition and relative abundance of species. In addition to the fishes mentioned above, green sunfish (Lepomis cyanellus) and mosquito fish (Gambusia affinis) were abundant in both ponds. Also, warmouth (L. gulosus) were present in Pond No. 2 and golden shiners (Notemigonus crysoleucas) occurred in Pond No. 1. The bluegill appeared to be the most numerous species in Pond No. 1, while the warmouth seemed to predominate in Pond No. 2. Five species of frogs were common on the area, all occurring in approximately the same relative abundance around each pond. These included, in order of apparent abundance, green frogs (Rana clamitans), leopard frogs (R. pipiens), bullfrogs (R. catesbeiana), cricket frogs (Acris crepitans) and Fowler's toads (Bufo woodhousei). Six species of turtles occurred on the area, all with representatives at each pond. These included common snapping turtles (Chelydra serpentina), common musk turtles (Sternotherus odoratus), mud turtles (Kinosternon subrubrum), pond sliders (Pseudemys scripta), painted turtles (Chrysemys picta) and box turtles (Terrepene carolina). Box turtles occurred sporadically around both ponds. Pond sliders and painted turtles seemed to be co-dominant in the deeper open waters of the ponds, whereas mud turtles predominated in the shallows. Snakes common on the study area included two species of water snakes (*Natrix sipedon* and *N. erythrogaster*) and three species which dwell mainly on land (*Lampropeltis getulus*, *Thamnophis sirtalis* and *T. sauritus*). All of these occurred in approximately equal abundance around each pond. The cottonmouth (*Agkistrodon piscivorus*) and canebrake rattlesnake (*Crotalus horridus atricaudatus*) were also present on the area, but were rarely seen. Of the numerous species of birds on the area, four appeared most commonly in the immediate vicinity of the two ponds. These included the Little Green Heron (*Butorides virescens*), Belted Kingfisher (*Megaceryle alcyon*), Eastern Kingbird (*Tyrannus tyrannus*) and Red-wing (*Agelaius phoeniceus*). The muskrat (*Ondatra zibethica*) was the only aquatic mammal on the study area, and was restricted to Pond No. 1.

# IV. METHODS AND MATERIALS

## General Information

Trips to the study area were made from 1 April 1972 through 31 March 1974. During the first five months, visits were made about every other day. Sixteen trips were logged in April, 15 in May, 13 in June, 18 in July, and 23 in August. During the remainder of the study, the area was visited at least once a day, and on several occasions twice a day.

The study area was routinely visited during late afternoon, generally within two hours before sunset. The following data were recorded on each visit: (1) general statement of the day's weather, (2) air temperature, (3) water temperature, (4) water level (at Pond No. 1 after 1 September 1972) and (5) the amount of precipitation having occurred since the previous visit.

A temporary weather station including a hygrothermograph and a rain gauge was maintained on the area throughout the study. Its location in relation to the two ponds is illustrated in Figure 1.

Each time a turtle was encountered, its exact place of capture was recorded, along with its identification number (if already marked) and sex (if determinable from external features). Then it was taken to the laboratory and weighed, measured, marked (if previously uncaptured) and examined for the following: epizoic algae, external parasites, number of growth zones on plastral scutes and abnormalities. These data were recorded in a permanent record and the turtle returned to the capture site on the following day.

The marking system employed during the study basically followed the one described by Cagle (1939). It involved creating a system of notches in the marginal scutes which were number coded from 1 to 11 on each side of the animal's body. Individuals with well ossified shells were first marked using a triangular file and later an electric drill motor and grinding stone. Hatchlings and small juveniles were marked using thin-bladed scissors.

## Movement

Three primary methods, all involving the capture-mark-release-recapture (or relocate) system, were employed in obtaining movement data. These included the use of baited wire funnel traps to study aquatic movement and a drift fence and thread trailing device to study terrestrial movements. Collecting by hand in shallow water was occasionally employed during checks of aquatic traps.

### Aquatic Studies

Studies of aquatic movement continued throughout the entire study period at Pond No. 1 and, except for an initial period of reconnaissance work at the beginning of the study, from 1 March 1973 through 31 March 1974 at Pond No. 2.

The technique used to study aquatic movement was as follows. Permanent trapping stations were established at the beginning of the study in each pond (Figures 2 and 3). Those situated along the shoreline of each pond were spaced 10 m apart in water about 25 cm deep;

Figure 2. Locations of aquatic trapping stations plus depth of water at offshore sites in Pond No. 1.

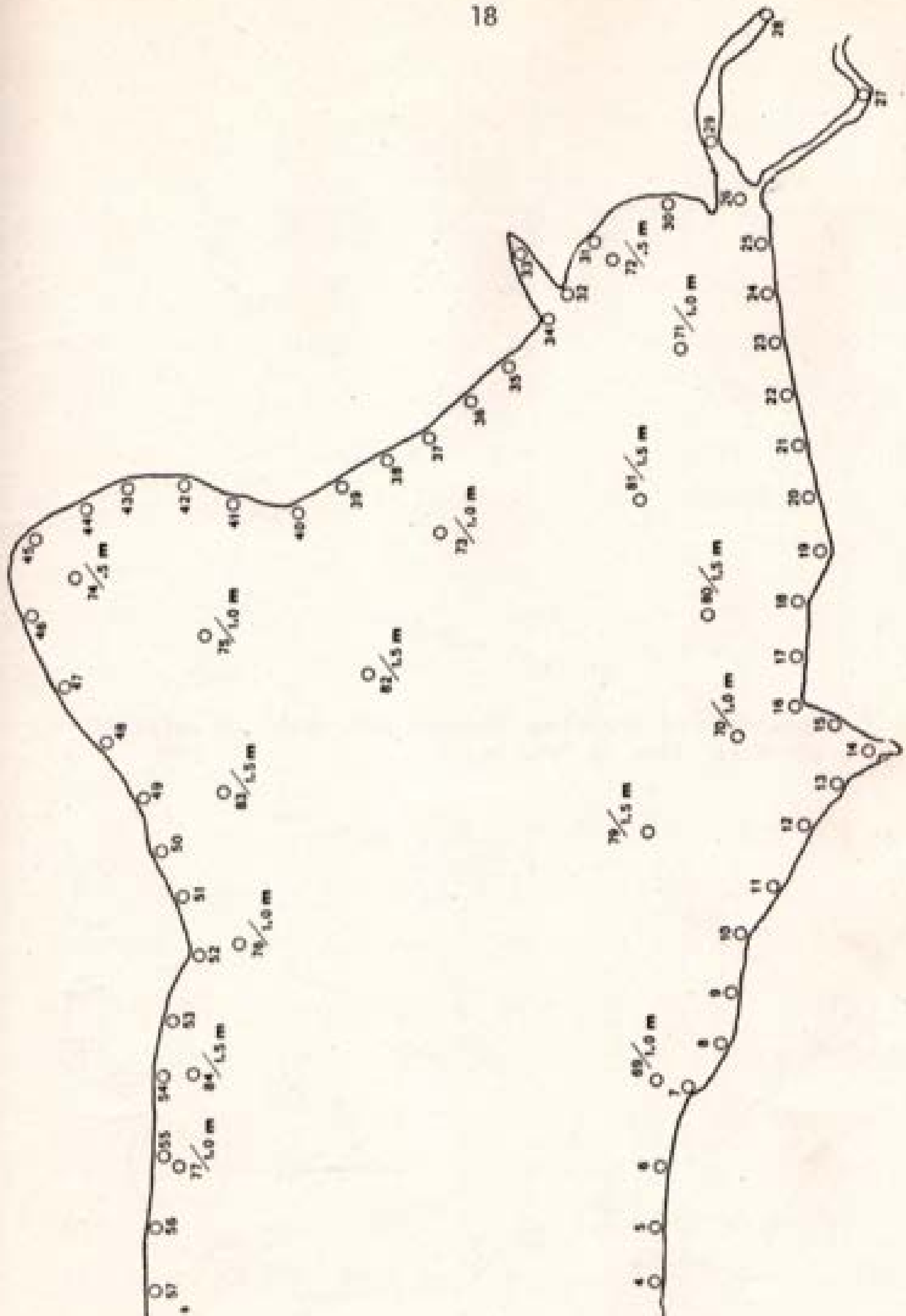
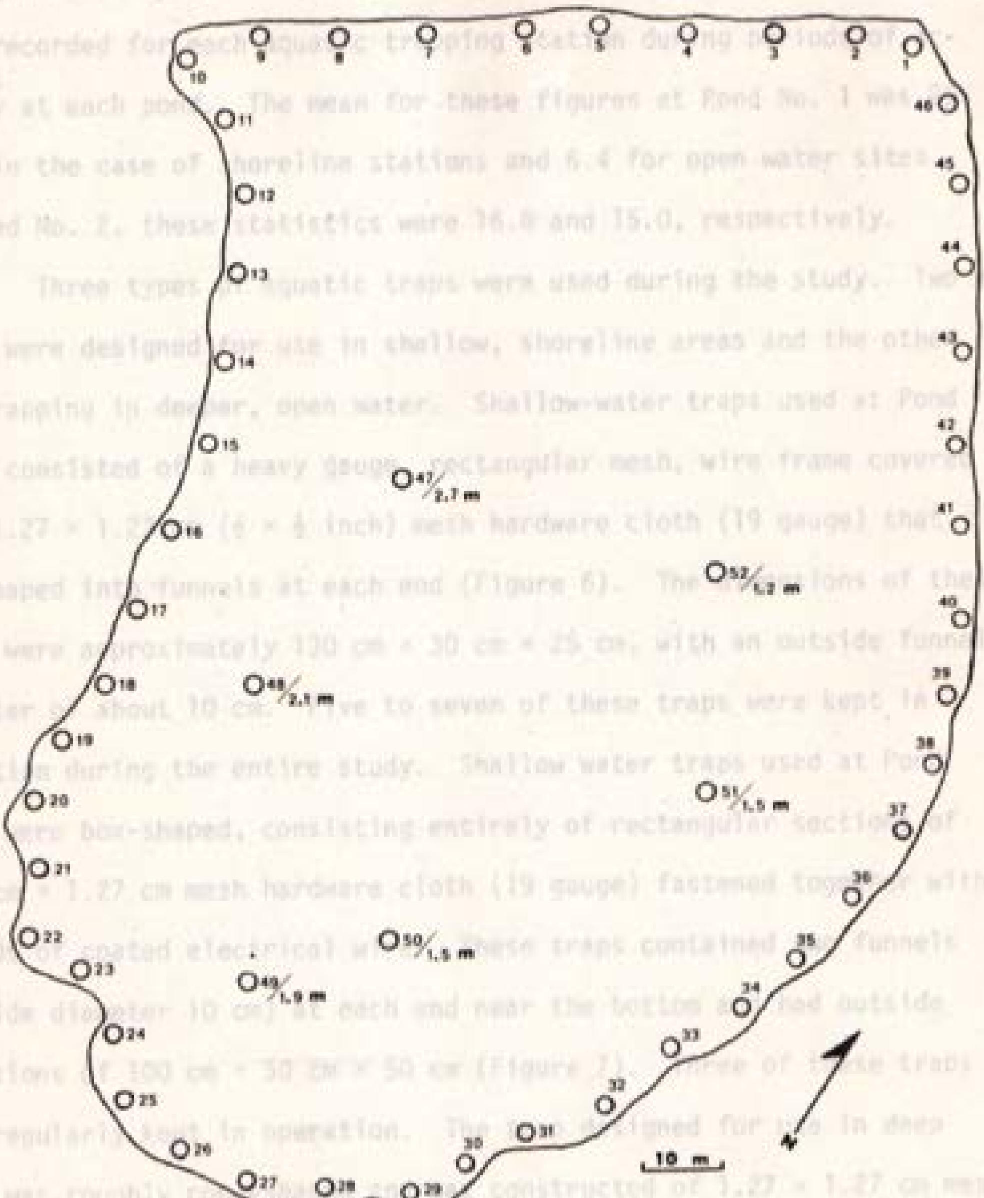


Figure 3. Locations of trapping stations plus depth of water at offshore sites in Pond No. 2.


47/2.7 m
48/2.1 m
49/1.9 m
50/1.5 m
51/1.5 m
10 m

those in open water were irregularly spaced at varying depths. Wire funnel traps were then constructed and utilized at these stations throughout the study. Figures 4 and 5 show the total number of trapping days recorded for each aquatic trapping station during periods of activity at each pond. The mean for these figures at Pond No. 1 was 29 days in the case of shoreline stations and 6.4 for open water sites. At Pond No. 2, these statistics were 16.8 and 15.0, respectively.

Three types of aquatic traps were used during the study. Two of these were designed for use in shallow, shoreline areas and the other for trapping in deeper, open water. Shallow-water traps used at Pond No. 1 consisted of a heavy gauge, rectangular mesh, wire frame covered with 1.27 × 1.27 cm (½ × ½ inch) mesh hardware cloth (19 gauge) that was shaped into funnels at each end (Figure 6). The dimensions of these traps were approximately 130 cm × 30 cm × 25 cm, with an outside funnel diameter of about 10 cm. Five to seven of these traps were kept in operation during the entire study. Shallow water traps used at Pond No. 2 were box-shaped, consisting entirely of rectangular sections of 1.27 cm × 1.27 cm mesh hardware cloth (19 gauge) fastened together with strands of coated electrical wire. These traps contained two funnels (outside diameter 10 cm) at each end near the bottom and had outside dimensions of 100 cm × 50 cm × 50 cm (Figure 7). Three of these traps were regularly kept in operation. The trap designed for use in deep water was roughly cone-shaped and was constructed of 1.27 × 1.27 cm mesh hardware cloth (19 gauge) and heavy plastic screening fastened to a frame of number 8 gauge wire hoops (Figure 8). This trap was about two meters high and had a basal diameter of about three meters, tapering to

Figure 4. Total number of trapping days recorded at each aquatic trapping station in Pond No. 1.

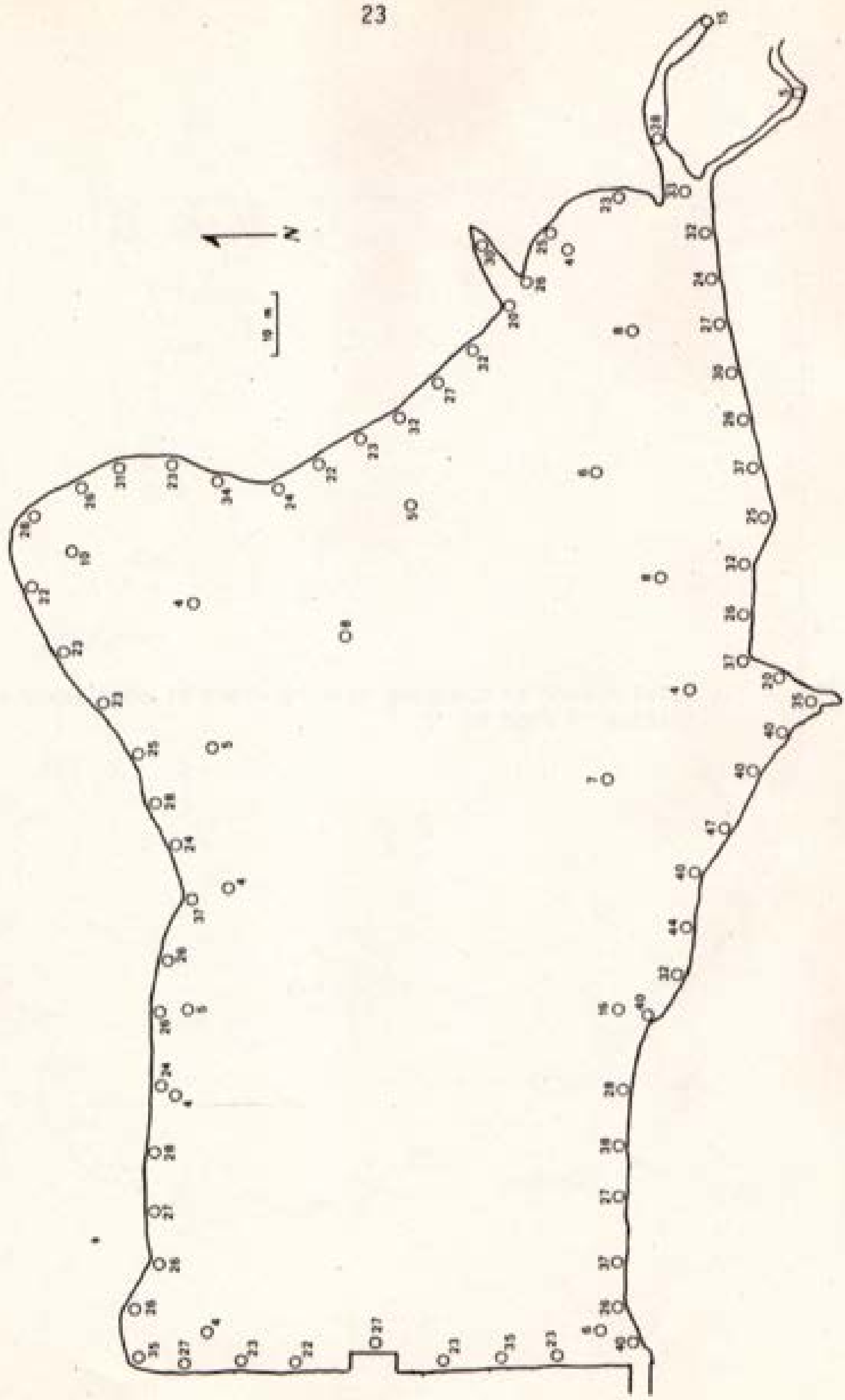


Figure 5. Total number of trapping days recorded at each trapping station in Pond No. 2.

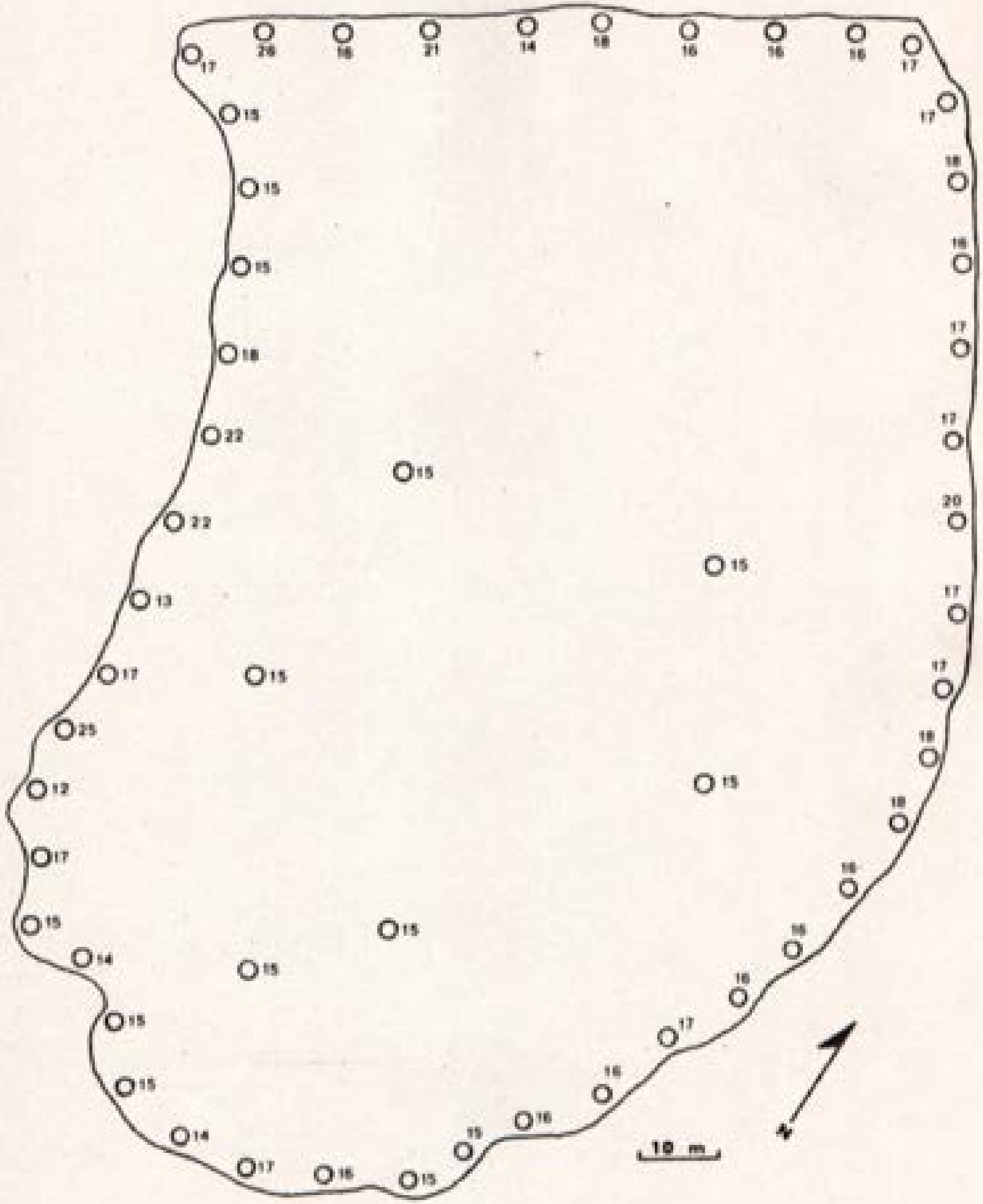

10 m

Figure 6. Wire funnel trap used to capture *K. subrubrum* along the shoreline at Pond No. 1.

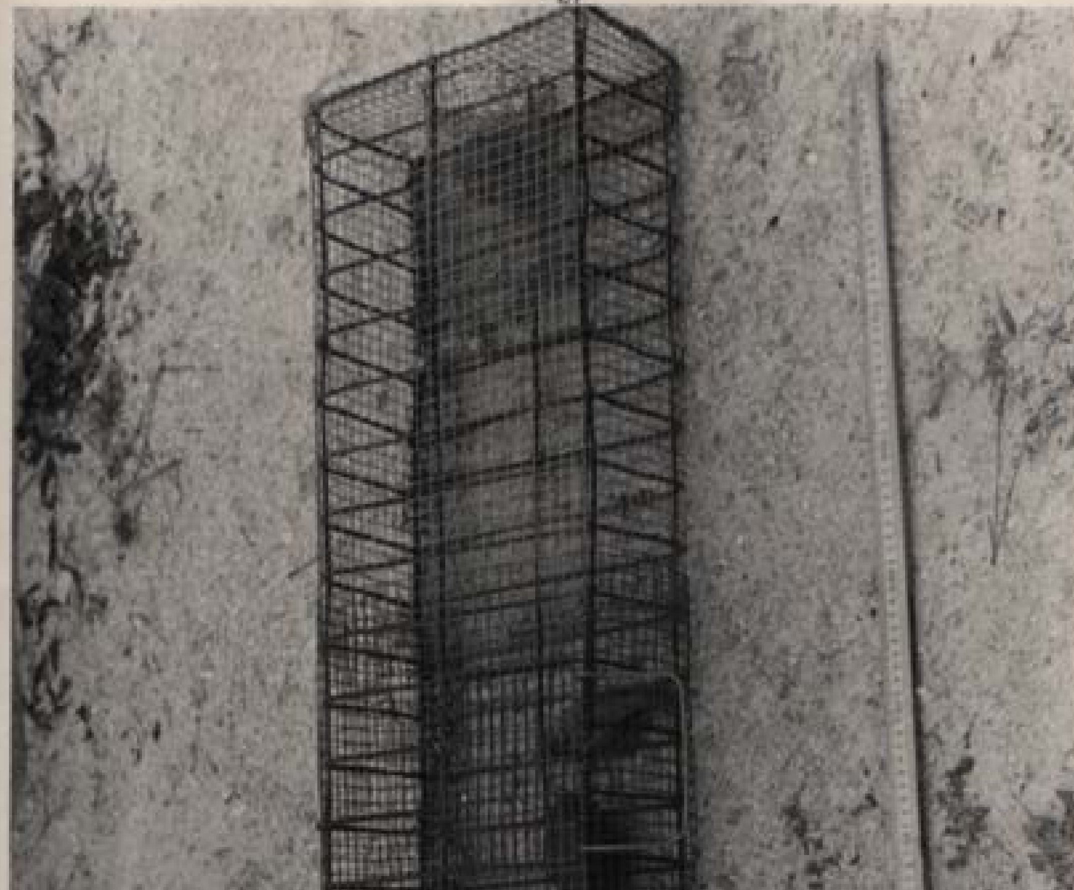


Figure 7. Wire funnel trap used to capture *K. subrubrum* along the shoreline at Pond No. 2.

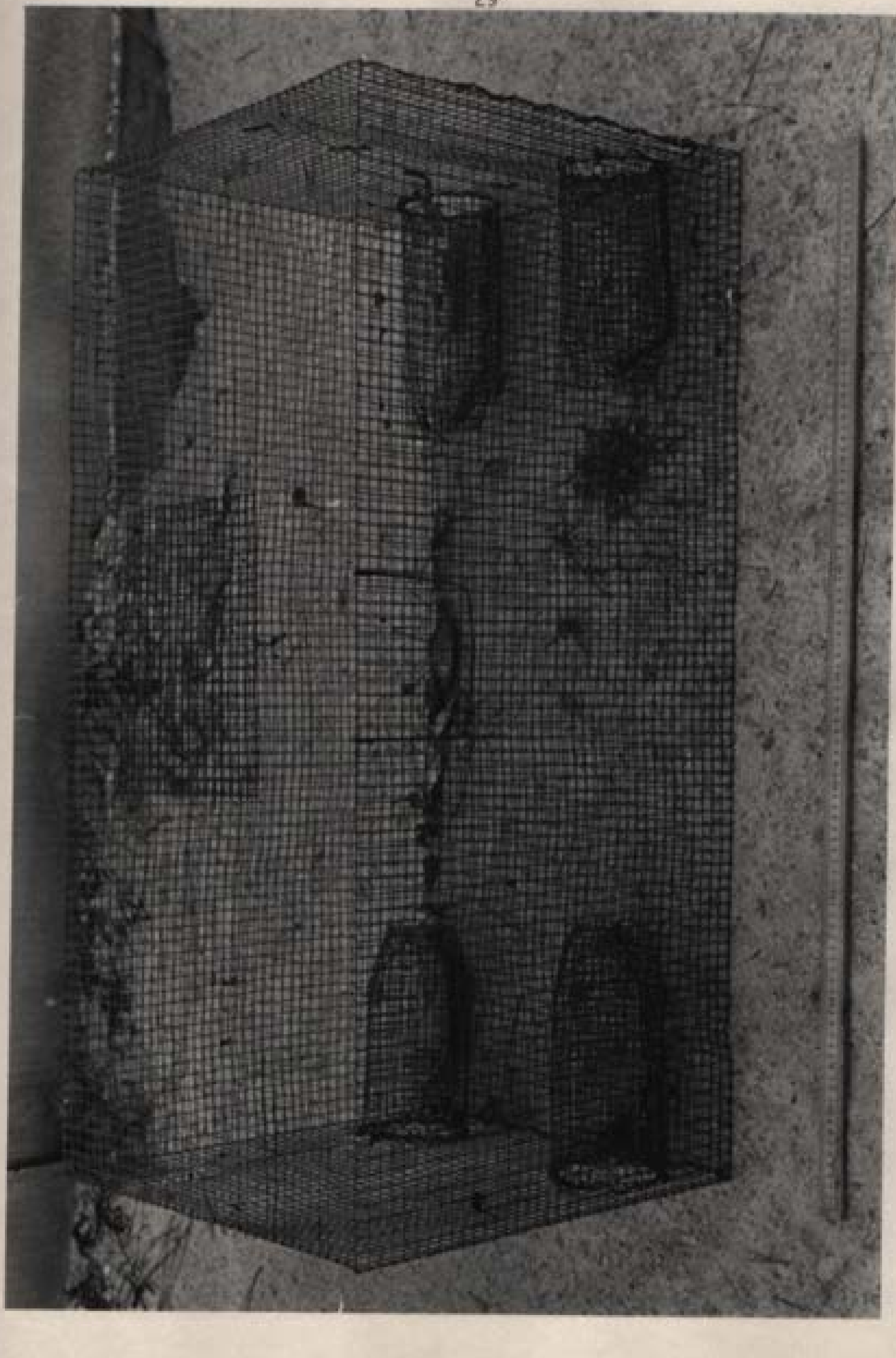
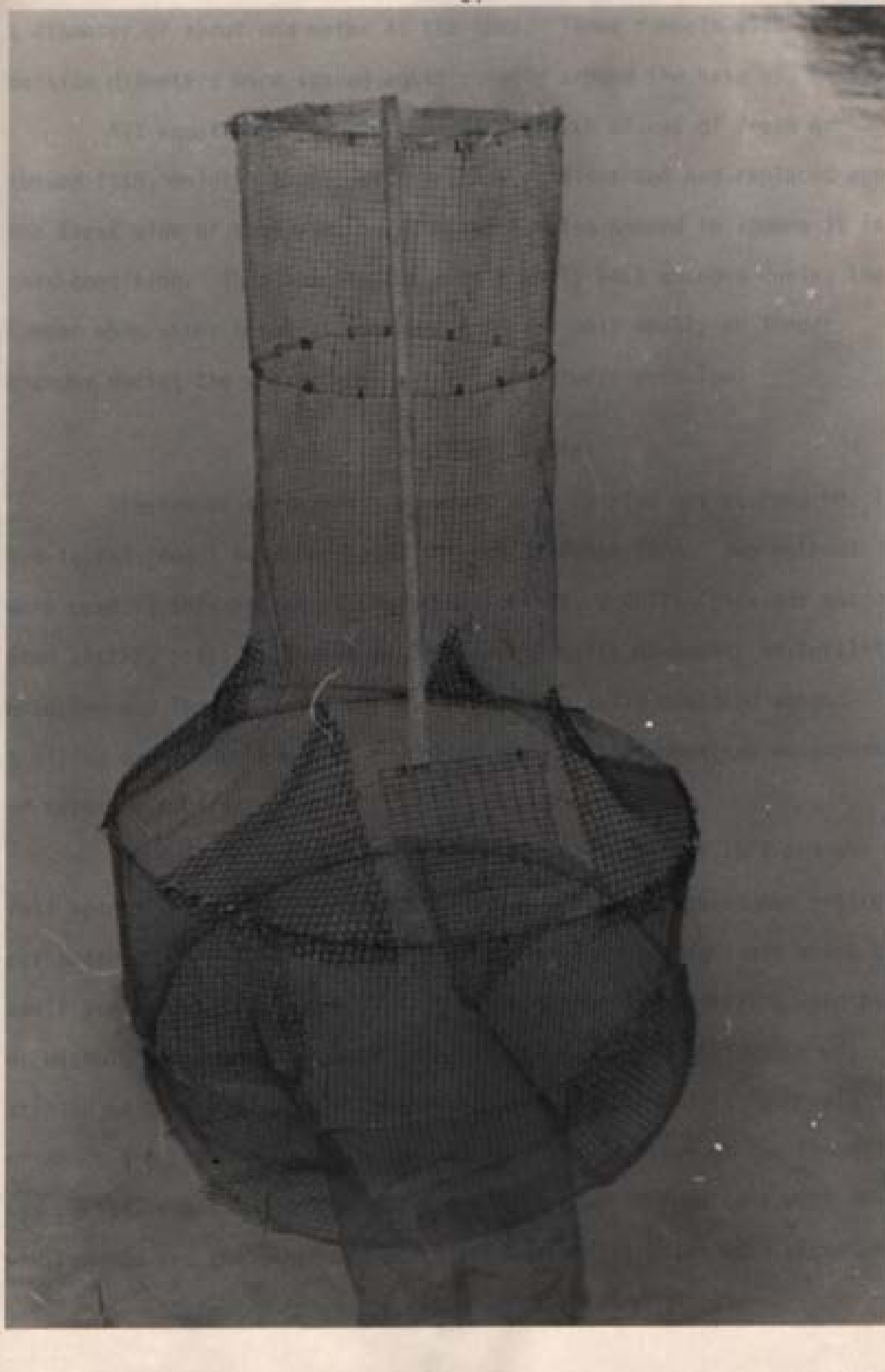


Figure 8. Wire funnel trap used to capture K. subrubrum at deep water sites.



a diameter of about one meter at the apex. Three funnels with 10 cm outside diameters were spaced equidistantly around the base of the trap.

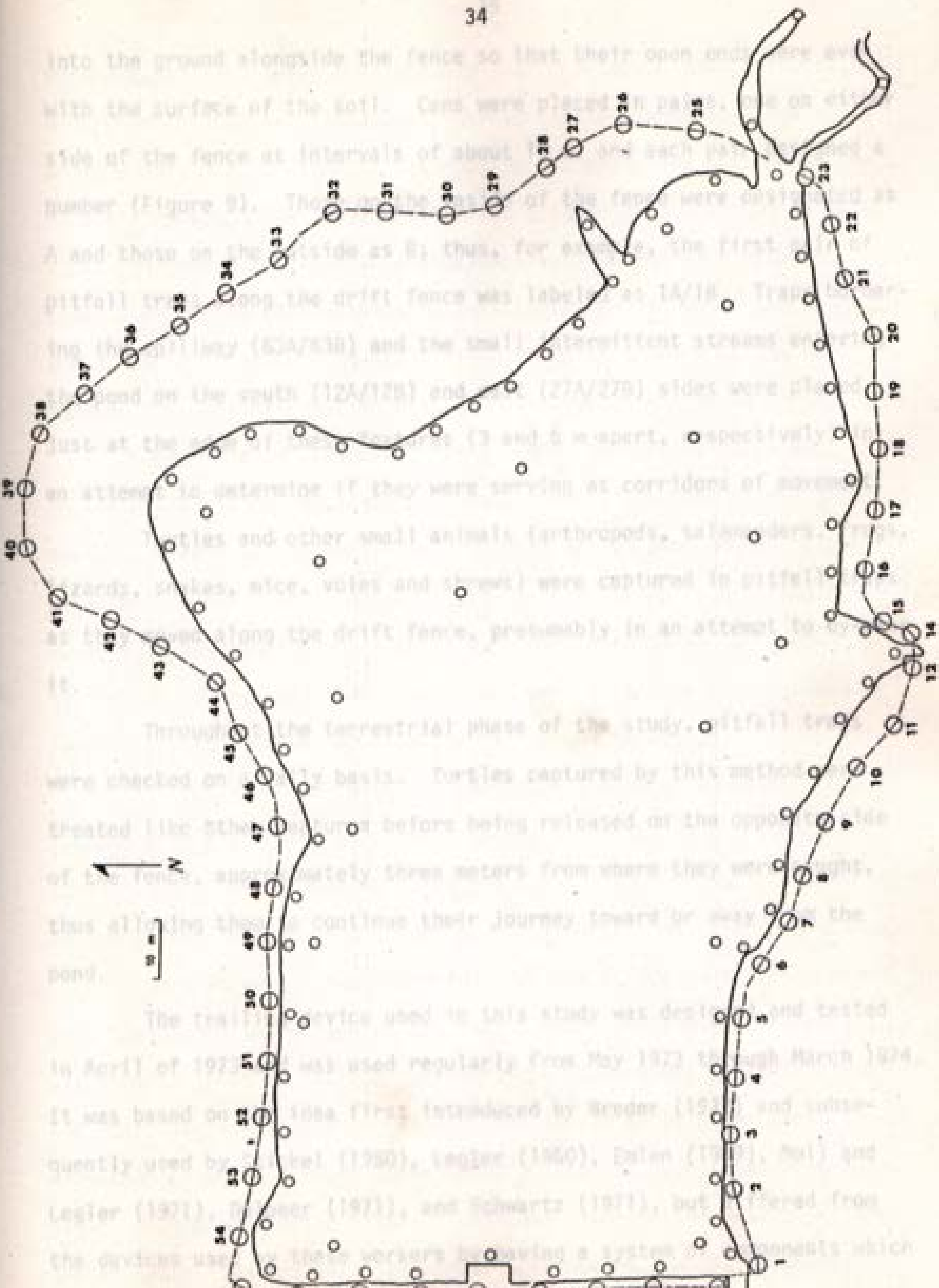
All aquatic traps were kept baited with pieces of fresh or thawed fish, mainly Lepomis sp., which were discarded and replaced upon the first sign of spoilage, because the turtles seemed to ignore it in this condition. This resulted in nearly daily bait changes during the summer when water temperatures were high and only weekly or longer changes during the winter when water temperatures were low.

## Terrestrial Studies

Studies of terrestrial movement were carried out at Pond No. 1 and lasted from 1 September 1973 through 31 March 1974. Two methods were used in this aspect of the study. First, a drift fence and associated pitfall traps were used to monitor the daily movements of turtles entering and leaving the pond. Second, a specially designed thread-trailing device was employed to follow the detailed overland movements of selected adults.

The drift fence was constructed during August of 1972 and was in full operation by 1 September of that year. It encompassed the entire perimeter of Pond No. 1, except for a 5 m span at the east end where a small stream enters (Figure 9). It was constructed of varying lengths of Nichols aluminum Grass Stop material (Stock No. TQ-840) which was stapled to treated wooden stakes driven into the ground at intervals of about 3 m. Throughout its length, the basal portion of the fence was buried from 1 to 2 cm in the ground. Number 10 food cans with one end removed and the other end perforated with nail holes were recessed

Figure 9. Location of drift fence and paired pitfall traps around Pond No. 1. Open circles in the pond represent aquatic trapping stations.



into the ground alongside the fence so that their open ends were even with the surface of the soil. Cans were placed in pairs, one on either side of the fence at intervals of about 10 m, and each pair assigned a number (Figure 9). Those on the inside of the fence were designated as A and those on the outside as B; thus, for example, the first pair of pitfall traps along the drift fence was labeled as 1A/1B. Traps bordering the spillway (63A/63B) and the small intermittent streams entering the pond on the south (12A/12B) and east (27A/27B) sides were placed just at the edge of these features (3 and 5 m apart, respectively) in an attempt to determine if they were serving as corridors of movement.

Turtles and other small animals (arthropods, salamanders, frogs, lizards, snakes, mice, voles and shrews) were captured in pitfall traps as they moved along the drift fence, presumably in an attempt to by-pass it.

Throughout the terrestrial phase of the study, pitfall traps were checked on a daily basis. Turtles captured by this method were treated like other captures before being released on the opposite side of the fence, approximately three meters from where they were caught, thus allowing them to continue their journey toward or away from the pond.

The trailing device used in this study was designed and tested in April of 1973 and was used regularly from May 1973 through March 1974. It was based on the idea first introduced by Breder (1927) and subsequently used by Stickel (1950), Legler (1960), Emlen (1969), Moll and Legler (1971), Dolbeer (1971), and Schwartz (1971), but differed from the devices used by these workers by having a system of components which were thought to produce considerably less friction. Basically, it consisted of a spool of light-weight thread mounted lengthwise inside an empty aluminum film canister fastened to the posterior portion of the turtle's carapace via three small wires (Figure 10). Lacking an axle, this arrangement resulted in a thread-release mechanism similar to those employed in commercial spincast fishing reels, which are noted for their low friction casting quality. A detailed drawing of the device showing the spatial relationships of its components appears in Figure 11.

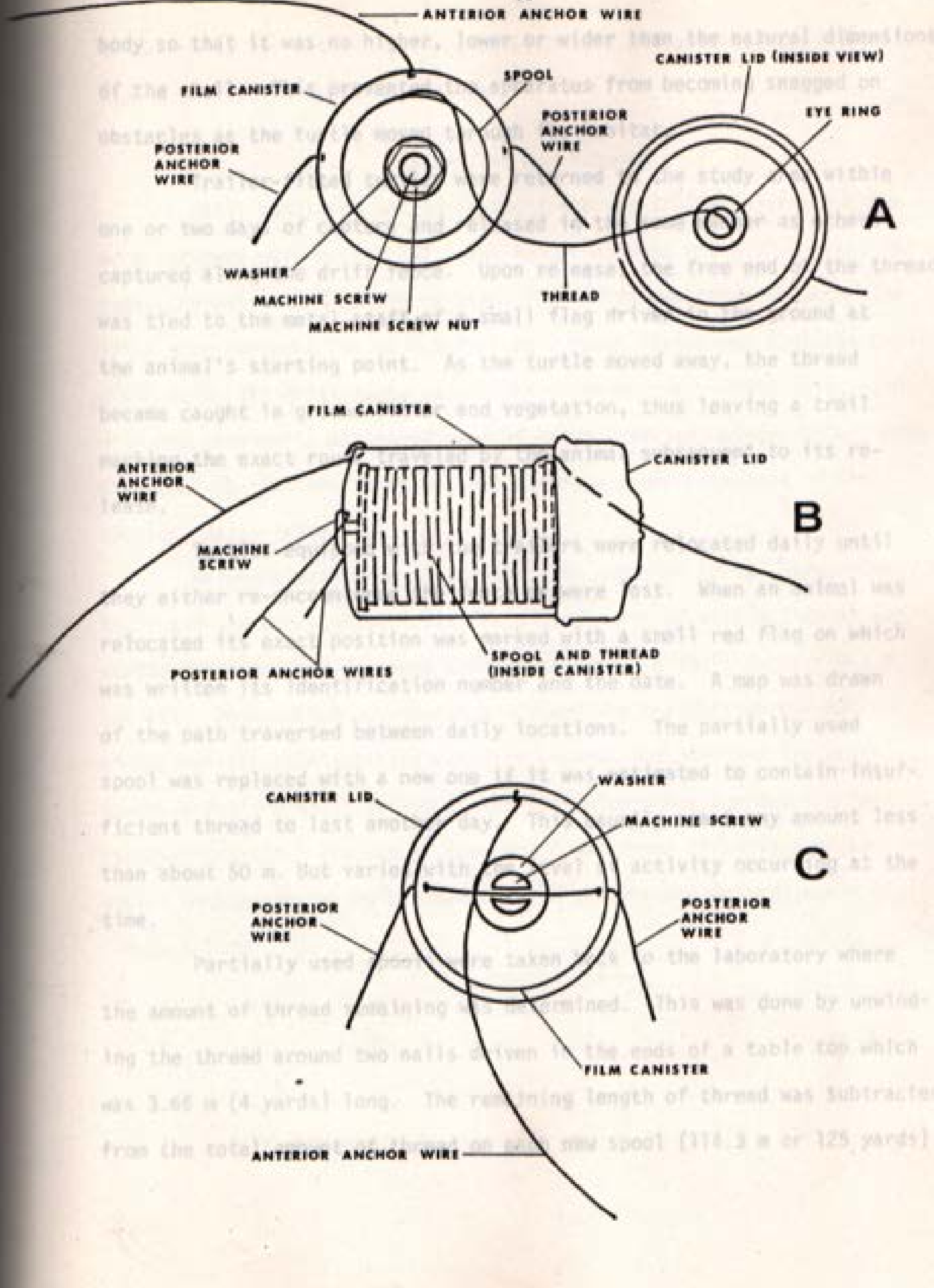
Commercially available, Talon number 50 mercerized thread, wound on 114 m (125 yards) capacity styrofoam spools, was used in the trailing device. Bright orange and white proved to be the most easily distinguishable colors. Round headed steel machine screws (1.5 inches × 8/32), washers and hexagonal machine screw nuts were used to anchor spools to the inside of the canisters. Eye rings were installed in the canister lids to afford a smooth opening for the thread to exit.

Thirty-four trailers were constructed during the study. The average weight of these plus their anchor wires was 20.8 g (range = 19.4-22.3 g), this amounting to an average of 16.8% (range = 9-26%) of the total body weight of the turtles involved in this part of the study.

Turtles were fitted with the trailing device in the laboratory. Once the device was assembled and fitted with anchor wires, holes 1.6 cm (1/16 of an inch) in diameter were drilled thorugh the animal's right and left marginal scutes and through the nuchal scute. The anchor wires were then inserted through these openings and the device fastened into place using needle-nosed pliers. Care was taken to insure a tight fit and to center the device in the cross-sectional plane of the animal's

Figure 10. Thread trailing device attached to an adult male K. subrubrum.

Figure 11. Drawing of the thread trailing device showing the details of its construction. (A) Posterior view looking inside canister and lid which has been removed. (B) Lateral view showing position of spool inside closed canister. Anterior is from right to left on page. (C) Posterior view showing the relationship between the posterior anchor wire and the head of the machine screw.


ANTERIOR ANCHOR WIRE
CANISTER LID (INSIDE VIEW)
SPOOL
FILM CANISTER
POSTERIOR ANCHOR WIRE
EYE RING
POSTERIOR ANCHOR WIRE
A
WASHER
MACHINE SCREW
MACHINE SCREW NUT
THREAD
FILM CANISTER
ANTERIOR ANCHOR WIRE
CANISTER LID
B
MACHINE SCREW
POSTERIOR ANCHOR WIRES
SPOOL AND THREAD (INSIDE CANISTER)
CANISTER LID
WASHER
MACHINE SCREW
C
POSTERIOR ANCHOR WIRE
POSTERIOR ANCHOR WIRE
FILM CANISTER
ANTERIOR ANCHOR WIRE

body so that it was no higher, lower or wider than the natural dimensions of the shell. This prevented the apparatus from becoming snagged on obstacles as the turtle moved through its habitat.

Trailer-fitted turtles were returned to the study area within one or two days of capture and released in the same manner as others captured along the drift fence. Upon release, the free end of the thread was tied to the metal staff of a small flag driven in the ground at the animal's starting point. As the turtle moved away, the thread became caught in ground litter and vegetation, thus leaving a trail marking the exact route traveled by the animal subsequent to its release.

Turtles equipped with the trailers were relocated daily until they either re-encountered the fence or were lost. When an animal was relocated its exact position was marked with a small red flag on which was written its identification number and the date. A map was drawn of the path traversed between daily locations. The partially used spool was replaced with a new one if it was estimated to contain insufficient thread to last another day. This usually meant any amount less than about 50 m but varied with the level of activity occurring at the time.

Partially used spools were taken back to the laboratory where the amount of thread remaining was determined. This was done by unwinding the thread around two nails driven in the ends of a table top which was 3.66 m (4 yards) long. The remaining length of thread was subtracted from the total amount of thread on each new spool (114.3 m or 125 yards) to determine the actual distance covered by a given turtle during the time a particular spool was in use.

### Surveying and Mapping

Daily positions marked in the field for trailer-fitted turtles were surveyed with a type 15T Silva Ranger compass and a 15.3 m (50 ft) tape. Compass bearings and straight line distances between successive sites were recorded for each animal on a rough sketch map that had been drawn using the drift fence as a point of reference. These data, along with the previously mentioned maps of paths traveled between sites, were then used in the laboratory to plot accurate representations of the turtles' daily travels.

Movement data were plotted on maps prepared in two ways. Pond No. 1 and the surrounding drift fence were surveyed with a transit and stadia rod and a map prepared with a scale of 1.5 cm (1 inch) = 9.1 m (30 ft). This method was chosen to insure the correct representation of the spatial relationships existing between the pond and the drift fence, a feature which served as the reference point for mapping terrestrial travels. The map of Pond No. 2 was drawn directly from an aerial photograph, using a pantograph to achieve the desired scale of 1.2 cm = 10 m.

# V. RESULTS AND DISCUSSION

## Trapping and Marking

During the course of this investigation, 333 *K. subrubrum* were encountered in and around the study area ponds. Of this number, 252 (76%) were marked at Pond No. 1 and 81 (24%) were marked at Pond No. 2. At Pond No. 1, 148 (59%) animals were first encountered in the aquatic environment, while the remaining 104 (41%) were first recorded on land (Figure 12). All captures at Pond No. 2 occurred in the water (Figure 13).

The cumulative numbers marked per month at each pond appear in Figure 14. In both cases, diminishing returns of unmarked individuals during the latter part of the study indicate that most turtles on the area were marked by this time. This applies particularly to Pond No. 1 where individuals representing all degrees of maturity and size classes were numerous (see section on population analysis).

Two or more captures were recorded for 263 (79%) of the 333 turtles marked (Table 2). Overall, recaptures totaled 1493 and averaged 5.7 (range 2-24) per individual. At Pond No. 1, the total number of recaptures was 1193 (recorded for 196 individuals) and the mean was 6.1 (range 2-24). At Pond No. 2, the total was 300 (recorded for 67 individuals) and the mean was 4.5 (range 2-12).

Figure 12. Total numbers of _K. subrubrum_ marked at each trapping station around Pond No. 1. No animals were marked at station where numerals do not appear.

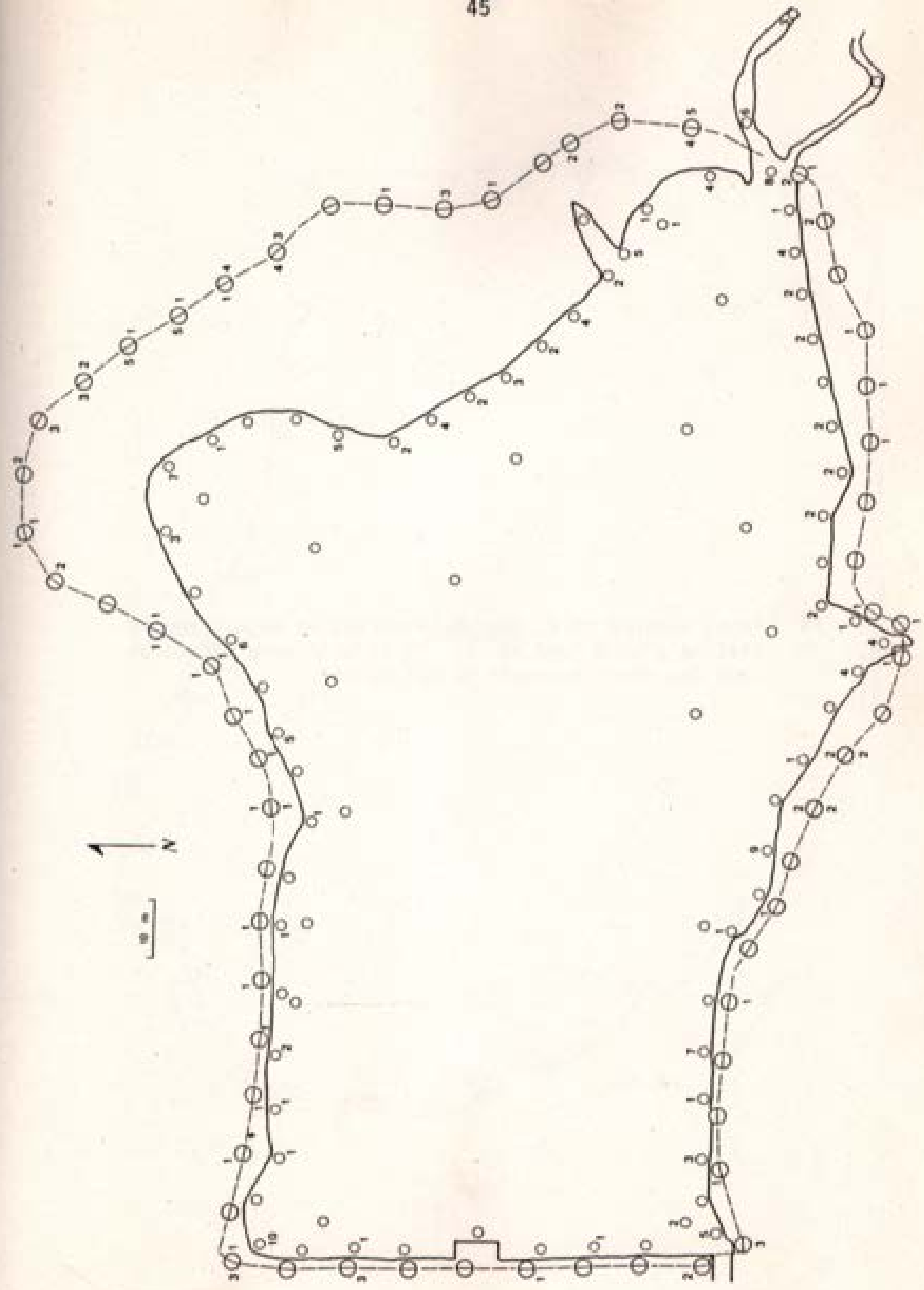


Figure 13. Total numbers of K. subrubrum marked at each trapping station around Pond No. 2. No animals were marked at stations where numerals do not appear.

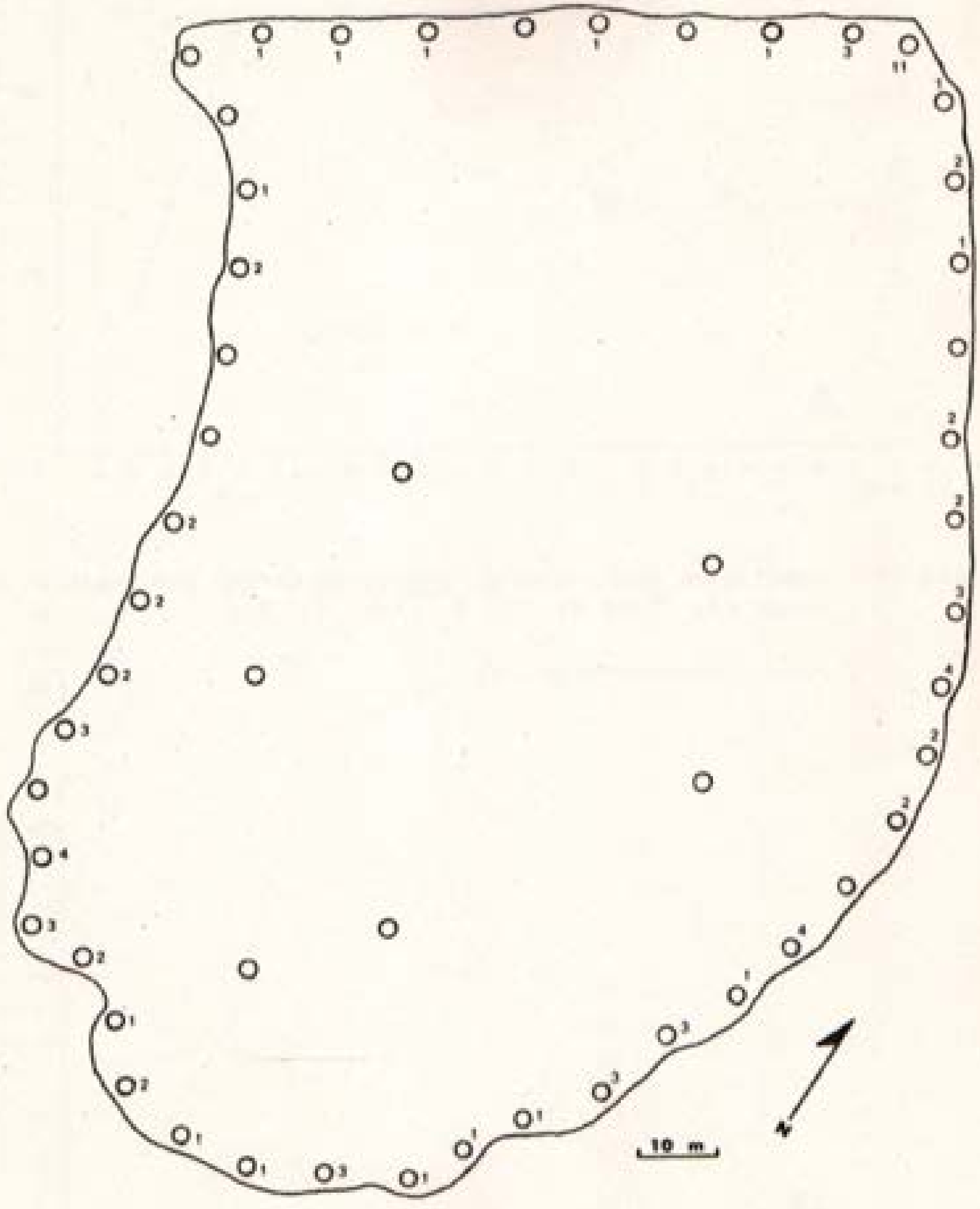

10 m

Figure 14. Cumulative numbers of _K. subrubrum_ marked per month at each pond. A. Pond No. 1. B. Pond No. 2.

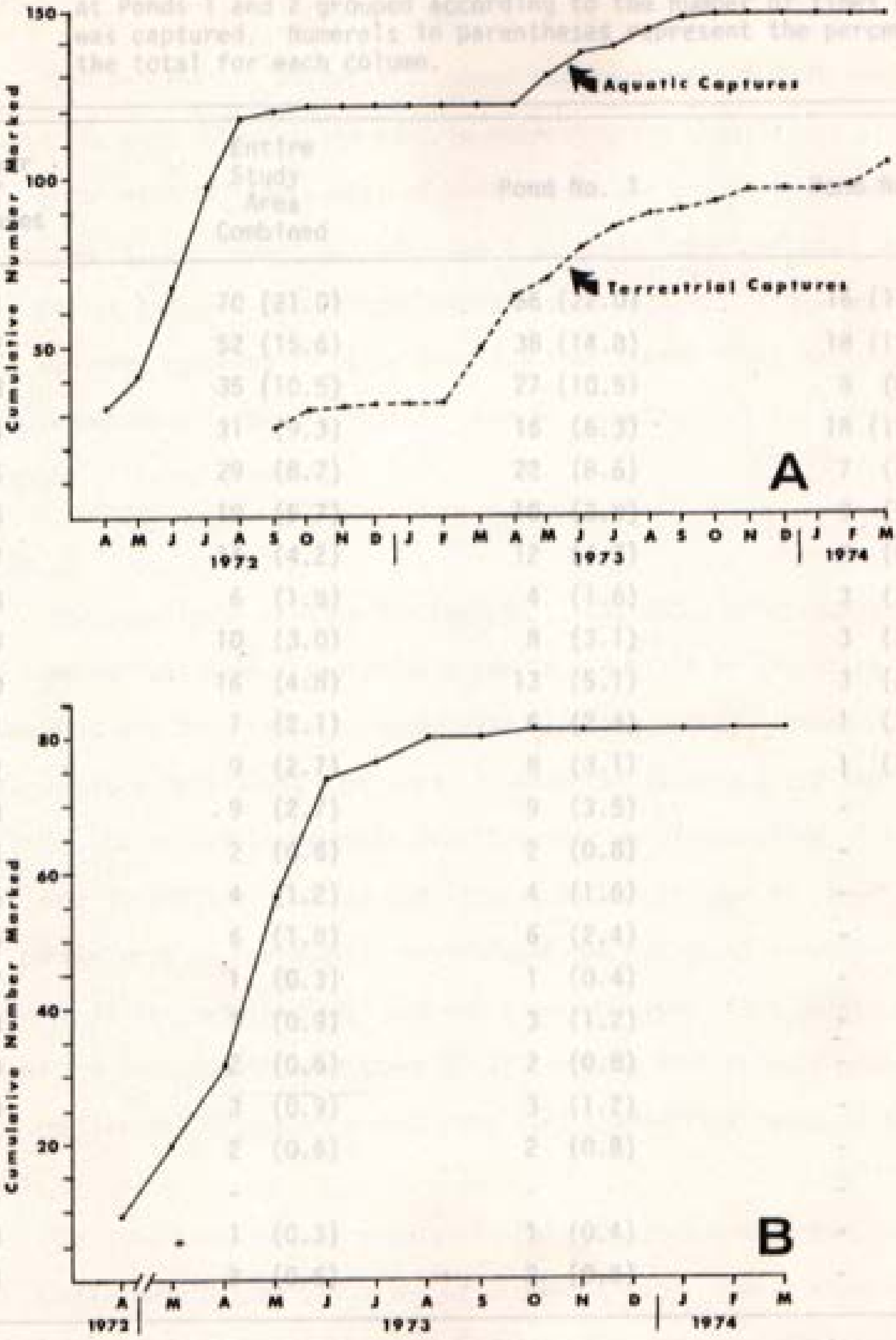

150
100
50
Cumulative Number Marked
Aquatic Captures
Terrestrial Captures
A
A M J J A S O N D J F M A M J J A S O N D J F M
1972
1973
1974
80
60
40
20
Cumulative Number Marked
B
A M A M J J A S O N D J F M
1972
1973
1974

Table 2. Numbers of individuals encountered on the entire study area and at Ponds 1 and 2 grouped according to the number of times each was captured. Numerals in parentheses represent the percent of the total for each column.

| Number of Captures | Entire Study Area Combined | Pond No. 1 | Pond No. 2 |
|---|---|---|---|
| 1 | 70 (21.0) | 56 (22.0) | 16 (17.2) |
| 2 | 52 (15.6) | 38 (14.8) | 18 (19.4) |
| 3 | 35 (10.5) | 27 (10.5) | 8 (8.6) |
| 4 | 31 (9.3) | 16 (6.3) | 18 (19.8) |
| 5 | 29 (8.7) | 22 (8.6) | 7 (7.5) |
| 6 | 19 (5.7) | 10 (3.9) | 9 (9.6) |
| 7 | 14 (4.2) | 12 (4.7) | 6 (6.5) |
| 8 | 6 (1.8) | 4 (1.6) | 3 (3.2) |
| 9 | 10 (3.0) | 8 (3.1) | 3 (3.2) |
| 10 | 16 (4.8) | 13 (5.1) | 3 (3.2) |
| 11 | 7 (2.1) | 6 (2.4) | 1 (1.1) |
| 12 | 9 (2.7) | 8 (3.1) | 1 (1.1) |
| 13 | 9 (2.7) | 9 (3.5) | - |
| 14 | 2 (0.6) | 2 (0.8) | - |
| 15 | 4 (1.2) | 4 (1.6) | - |
| 16 | 6 (1.8) | 6 (2.4) | - |
| 17 | 1 (0.3) | 1 (0.4) | - |
| 18 | 3 (0.9) | 3 (1.2) | - |
| 19 | 2 (0.6) | 2 (0.8) | - |
| 20 | 3 (0.9) | 3 (1.2) | - |
| 21 | 2 (0.6) | 2 (0.8) | - |
| 22 | - | - | - |
| 23 | 1 (0.3) | 1 (0.4) | - |
| 24 | 2 (0.6) | 2 (0.8) | - |
| Totals | 333 | 255 | 93 |

## Population Analysis

### Density

Two expressions of density, based on the number of individuals encountered, were computed and used in comparing the populations of each pond. These were (1) the number of individuals per unit area of pond surface and (2) the number of individuals per unit length of pond shoreline. One of the two, the latter, seemed most meaningful, since no mud turtle was ever recorded in water over 5 m from shore. This was true despite numerous attempts to capture them at trapping stations farther from shore (Figures 4 and 5).

Pond No. 1

The population density for Pond No. 1 was 159.5 individuals per ha of pond surface or 4.1 individuals per 10 m section of shoreline when both aquatic and terrestrial capture data were considered. However, when aquatic capture data alone were used, it amounted to only 112.0 individuals per ha or 2.9 individuals per 10 m section of shoreline. This was because 75 (29%) of the 252 individuals marked at Pond No. 1 were never encountered in the aquatic environment and would not have been discovered if terrestrial traps had not been employed. This points out the need for both aquatic and terrestrial trapping in population studies on mud turtles and indicates a well developed terrestrial habit in this species.

The importance of terrestrial trapping in determining the size of mud turtle populations was noted by Gibbons (1970). While studying a population of turtles inhabiting a Carolina bay, he found that there was a marked increase in the number of captures recorded for K. subrubrum after drift fences had been installed. During 1967, while studies were being conducted using only aquatic traps, this species was considered to be less abundant in the bay than either Sternotherus odoratus or Pseudemys floridana. However, during 1968, after several months of terrestrial trapping, it became apparent that mud turtles were far more abundant than either of the other species.

Pond No. 2

The population density observed at Pond No. 2, where only aquatic trapping was conducted, was 58 individuals per ha of pond surface or 1.3 individuals per 10 m section of shoreline. This is about 1/2 the density observed at Pond No. 1. Thus, it appears that Pond No. 1 was supporting about twice as many turtles per unit of habitat as Pond No. 2. This was somewhat surprising since Pond No. 2, with its abundant aquatic vegetation and heavily cluttered bottom, seemed to be an ideal habitat for K. subrubrum. Yet, this difference in observed densities at the two ponds could have been due to factors unrelated to habitat. Perhaps K. subrubrum was limited at Pond No. 2 by competition with S. odoratus, which was 14 times more abundant there than at Pond No. 1. Maybe regular grazing of cattle around Pond No. 2 limited the number of mud turtles there by causing trampling of individuals and their nests. The greater extent of marshy land around Pond No. 1 may have provided additional habitat for turtles in this area, or possibly a greater amount of colonization had taken place at Pond No. 1, since it was more than 10 years older than Pond No. 2.

Estimates of density in other studies

Previous estimates of density for members of the Kinosternidae have been quite variable, with values for *K. subrubrum* occupying both the lowest and highest ends of the distribution. The lowest recorded estimate was that of Gibbons (1970). He estimated 170 individuals per 10 ha (17 per ha) of aquatic habitat in a South Carolina bay. The highest ever recorded was that of Skorepa and Ozment (1968). They found as many as 10 adults within an estimated 7 m square area (14,285 per ha) of pin oak flatwoods in southern Illinois. Between these extremes are the following estimates presented by Mahmoud (1969) for the four kinosternid species of Oklahoma: *K. subrubrum*, 159.4 to 258.5 per ha (64.5 to 104.6 per acre); *K. flavescens*, 27.9 per ha (11.3 per acre); *Sternotherus odoratus*, 150 per ha (60.7 per acre); and *S. carinatus*, 228.8 per ha (92.6 per acre). The estimates of density presented in this study resemble most clearly those for the Oklahoma populations.

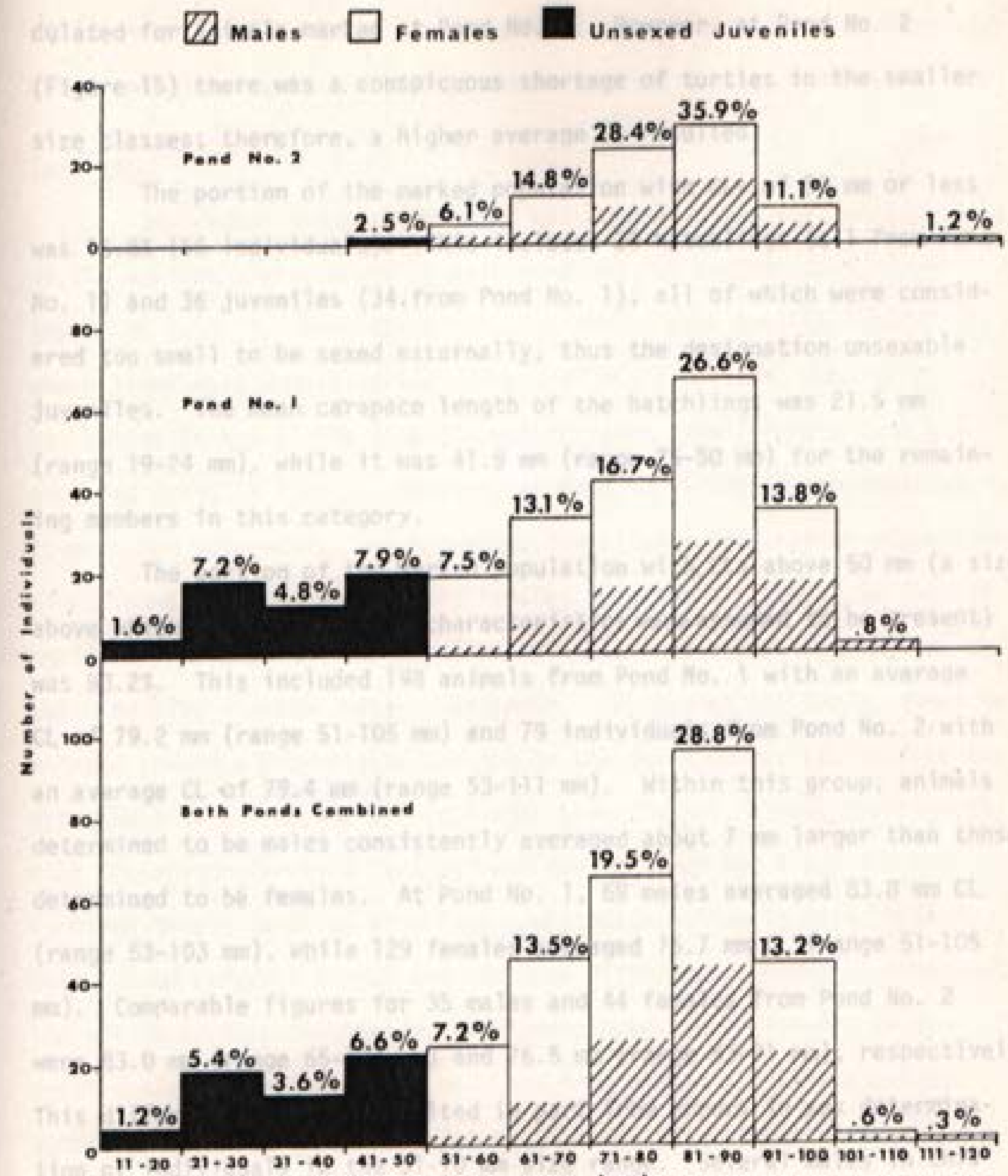
## Composition

The composition of the marked population was analyzed according to size and sex distribution (Figure 15). Age determinations from counts of the growth rings on the plastral lamellae were not included because of wear or crowding in many individuals.

Size

The average carapace length (CL) of the entire marked population, based on measurements taken at the first capture, was 71.5 mm (range 19-111 mm). This was only slightly above the average CL of 69.5 mm (range 19-105 mm) recorded for the individuals marked at Pond No. 1. However,

Figure 15. Distribution by sex and size of the K. subrubrum marked in association with Pond No. 1, Pond No. 2 and both ponds combined.



Males
Females
Unsexed Juveniles
Pond No. 2
2.5%
6.1%
14.8%
28.4%
35.9%
11.1%
1.2%
Pond No. 1
1.6%
7.2%
4.8%
7.9%
7.5%
13.1%
16.7%
26.6%
13.8%
.8%
Both Ponds Combined
1.2%
5.4%
3.6%
6.6%
7.2%
13.5%
19.5%
28.8%
13.2%
.6%
.3%
Number of Individuals
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
91-100
101-110
111-120
Carapace Length (mm)

it was considerably below the average CL of 78.6 (range 47-111 mm) calculated for animals marked at Pond No. 2. However, at Pond No. 2 (Figure 15) there was a conspicuous shortage of turtles in the smaller size classes; therefore, a higher average CL resulted.

The portion of the marked population with CLs of 50 mm or less was 16.8% (56 individuals). This included 20 hatchlings (all from Pond No. 1) and 36 juveniles (34 from Pond No. 1), all of which were considered too small to be sexed externally, thus the designation unsexable juveniles. The mean carapace length of the hatchlings was 21.5 mm (range 19-24 mm), while it was 41.9 mm (range 25-50 mm) for the remaining members in this category.

The portion of the marked population with CLs above 50 mm (a size above which secondary sexual characteristics were assumed to be present) was 83.2%. This included 198 animals from Pond No. 1 with an average CL of 79.2 mm (range 51-105 mm) and 79 individuals from Pond No. 2 with an average CL of 79.4 mm (range 53-111 mm). Within this group, animals determined to be males consistently averaged about 7 mm larger than those determined to be females. At Pond No. 1, 69 males averaged 83.8 mm CL (range 53-103 mm), while 129 females averaged 76.7 mm CL (range 51-105 mm). Comparable figures for 35 males and 44 females from Pond No. 2 were 83.0 mm (range 65-111 mm) and 76.5 mm (range 53-91 mm), respectively. This difference may have resulted in part from errors in sex determination of individuals in the 51-70 mm size range. Several males in this category may have been designated females simply because they had not developed definite male features which are the basis for sex determination in the species. This would have biased the lower end of the size distribution for females, thus lowering the average CL for this group. Also, it would have biased the sex ratios among individuals in this size range contributing to the unexpected sex ratios mentioned below.

Sex ratios

Sex ratios and corresponding chi square values for individuals in the various size classes at each pond and for the combined sample appear in Table 3. From these data, it can be seen that at Pond No. 2, where there were unusually low numbers of small turtles, none of the sex ratios in any of the size classes deviated significantly from the expected ratio of 1 to 1. However, at Pond No. 1 and in the combined figures for both ponds, where smaller individuals were better represented, significant differences favoring females consistently appear in the two smallest size classes. No significant deviations appear anywhere in the table in size classes larger than these. Throughout the table, there is a trend toward a progressive decline in the deviation of ratios from the expected 1 to 1 from smaller to larger size classes. Thus, the significant deviations favoring females recorded for Pond No. 1 and for the combined sample resulted from disproportionate ratios in size classes below 71 mm carapace length and not from differences occurring througout the entire sexable population. This overabundance of females in the smaller size classes may have resulted from biased sex determinations stemming from the fact that males fail to develop secondary sexual characteristics until around 70 mm CL, rather than 50 mm CL as supposed.

Sex ratios favoring females over males have been reported for other members of the Kinosternidae. Comparable results have been

Table 3. Sex ratios (males to females) and chi square values for *K. subrubrum* in various size classes marked at the two ponds.

| C.L. (mm) | Pond No. 1 | | Pond No. 2 | | Both Ponds Combined | |
|---|---|---|---|---|---|---|
| | Sex Ratio | Chi Square | Sex Ratio | Chi Square | Sex Ratio | Chi Square |
| 51-60 | 1:18 | 15.21* | 1:4 | 1.8 | 1:11 | 16.66* |
| 61-70 | 1:3.71 | 10.94* | 1:3 | 3.0 | 1:3.50 | 6.94* |
| 71-80 | 1:1.63 | 2.38 | 1:1.56 | 1.09 | 1:1.60 | 3.46 |
| 81-90 | 1:1.48 | 2.52 | 1.23:1 | .31 | 1:1.23 | 1.04 |
| 91-100 | 1:1.06 | .03 | 1.25:1 | .11 | 1:1 | 0 |
| 101-110 | 1:1 | 0 | - | | 1:1 | 0 |
| 111-120 | - | - | 1:0 | 1 | 1:0 | 1 |
| All Sizes Combined | 1:1.87 | 18.18* | 1:1.26 | 1.03 | 1:1.66 | 46.92* |

*Indicates a significant difference at the 5% level of confidence.

published by Mahmoud (1969) for Kinosternon subrubrum, K. flavescens, Sternotherus odoratus and S. carinatus; by Skorepa and Ozment (1968) for K. subrubrum; by Risley (1933), Cagle (1942) and Tinkle (1961) for S. odoratus, and by Tinkle (1958) for S. minor and S. carinatus. Factors such as chance, differences in seasonal distribution and differential ease of capture were suggested as reasons to account for some of these differences.

## Habitat Utilization

Within the aquatic environment, turtles were found to limit their activities to shallow water along shore. In both ponds, despite extensive trapping efforts at offshore sites, no specimens were collected farther than 5 m from shore or in water deeper than 1 m (Figures 16 and 17). This was not too surprising, considering the feeding behavior of mud turtles. Being omnivorous, they depend on foods such as aquatic insects, mollusks, crustaceans, amphibians and aquatic vegetation (Ernst and Barbour 1972), most of which occur in greatest concentration at or near the shoreline.

Outside the aquatic environment, turtles were observed (at Pond No. 1) using a wide variety of habitats. These included marshy ground, open pasture, upland pine woods, hillsides covered with kudzu, and dense thickets of small shrubs, honeysuckle and blackberry vines. Movement between these terrestrial habitats and the pond was largely through the marshy areas along shore. Nearly half (49%) of the drift fence captures were recorded in pit traps set in marshy ground along only 38% of the fence's total length. The mean number of captures per pair

Figure 16. Total number of captures recorded at each trapping station at Pond No. 1. No captures were recorded at stations where numerals are lacking.

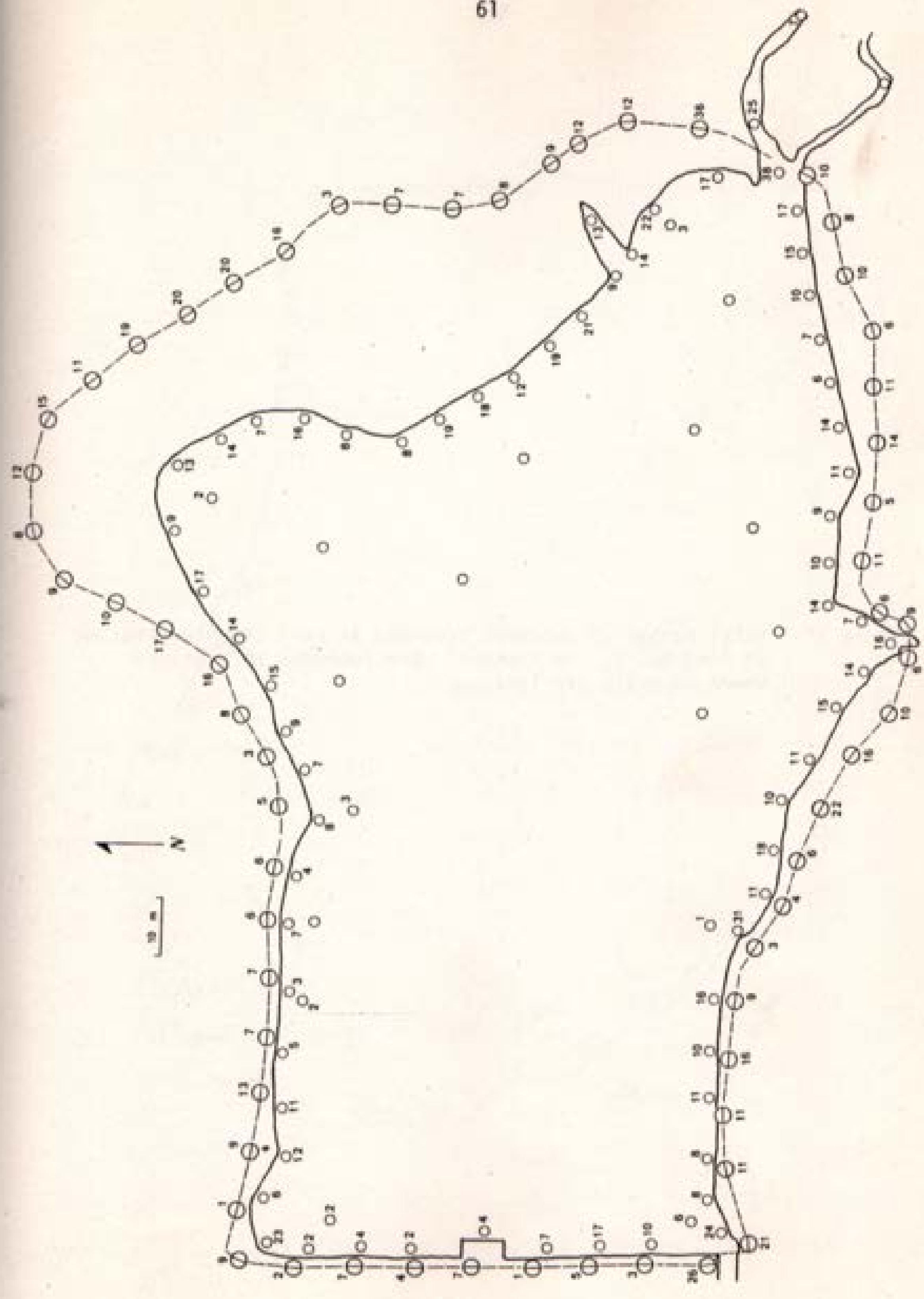
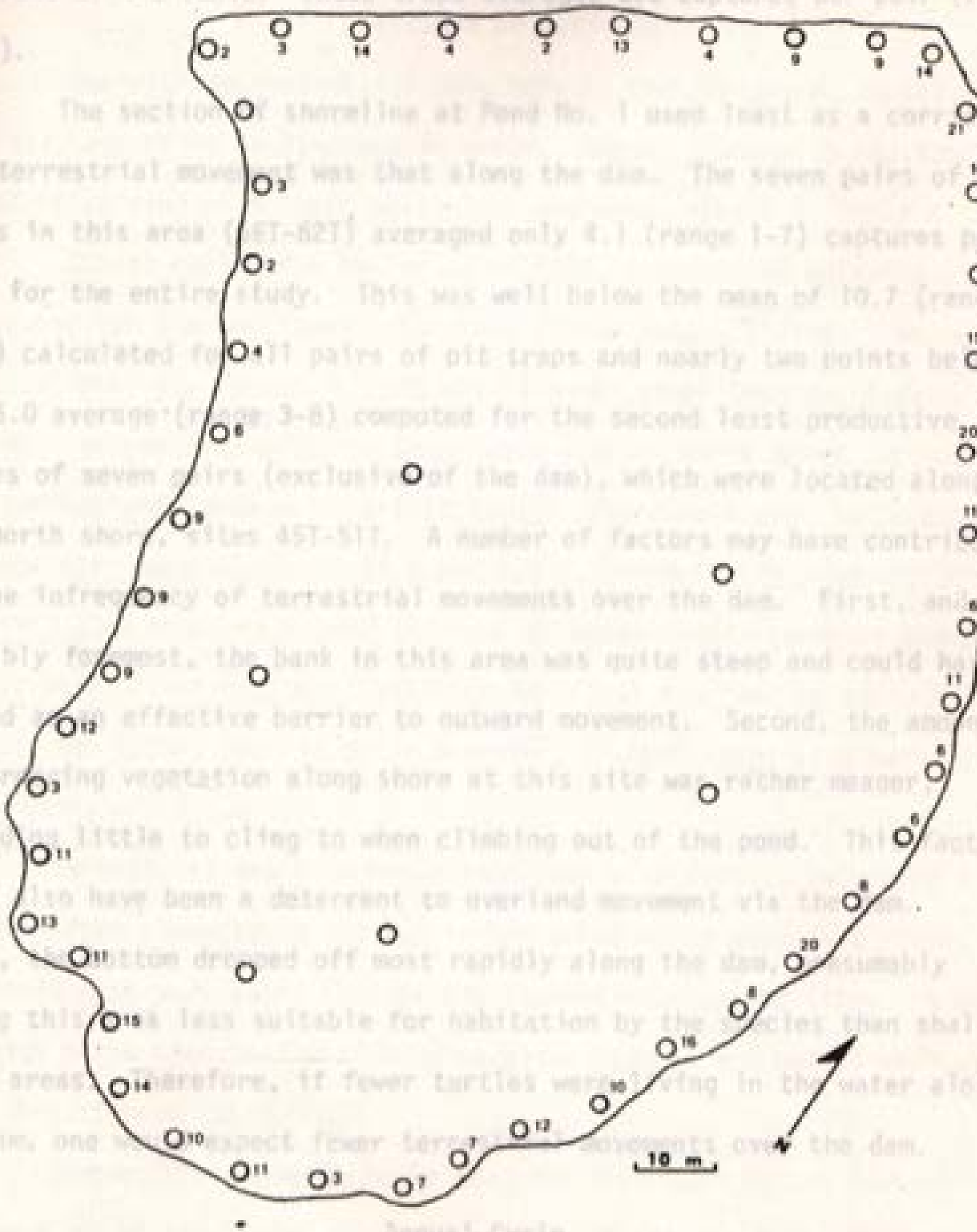


Figure 17. Total number of captures recorded at each trapping station at Pond No. 2. No captures were recorded at stations where numerals are lacking.

for these traps was 14.0 (range 6-36). Drift fence captures representing the remaining 51% were recorded in traps set in dryer situations along the rest of the fence. These traps averaged 8.5 captures per pair (range 0-26).




The section of shoreline at Pond No. 1 used least as a corridor for terrestrial movement was that along the dam. The seven pairs of pit traps in this area (56T-62T) averaged only 4.1 (range 1-7) captures per pair for the entire study. This was well below the mean of 10.7 (range 0-36) calculated for all pairs of pit traps and nearly two points below the 6.0 average (range 3-8) computed for the second least productive series of seven pairs (exclusive of the dam), which were located along the north shore, sites 45T-51T. A number of factors may have contributed to the infrequency of terrestrial movements over the dam. First, and possibly foremost, the bank in this area was quite steep and could have served as an effective barrier to outward movement. Second, the amount of bordering vegetation along shore at this site was rather meager, affording little to cling to when climbing out of the pond. This factor might also have been a deterrent to overland movement via the dam. Third, the bottom dropped off most rapidly along the dam, presumably making this area less suitable for habitation by the species than shallower areas. Therefore, if fewer turtles were living in the water along the dam, one would expect fewer terrestrial movements over the dam.

## Annual Cycle

The annual activity period was set as the time in days between the onset of activity during late winter and the cessation of activity for these traps was 14.0 (range 6-36). Drift fence captures representing the remaining 51% were recorded in traps set in dryer situations along the rest of the fence. These traps averaged 8.5 captures per pair (range 0-26).

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## Annual Cycle

The annual activity period was set as the time in days between the onset of activity during late winter and the cessation of activity during late fall. The hibernation period was considered as the time of inactivity making up the rest of the year.

## Periods of Activity

Separate determinations were made of the periods of annual activity occurring on land and in water. These, along with the temperatures coinciding with their beginnings and ends, appear in Table 4.

Except during the emergence of 1974, terrestrial activity always began earlier and continued later than did aquatic activity. The terrestrial activity period in 1973 was 10 days longer than the aquatic period. Terrestrial activity began each year in early March, at mean air temperatures between 17 and 18 C, and ceased each year in December at mean air temperatures of 14 C and 8.5 C, respectively. Aquatic activity also began each year in March at water temperatures of approximately 18 C. Termination of activity the first year was in early November and the second year in early December, in both cases at a water temperature of 16 C.

Terrestrial activity began each year with turtles returning to the pond from hibernacula located in the surrounding woods and fields. It ceased each year after turtles had located hibernating sites. Aquatic activity began each year when turtles began feeding and ceased each year when they stopped taking food.

Temperature appeared to be the most important factor controlling the duration of the annual activity period. While the dates of cessation of activity in the fall and resumption of activity during late winter were quite variable, the temperatures coinciding with these

Table 4. Dates and temperatures recorded at the beginnings and ends of the aquatic and terrestrial actiyity periods observed for K. subrubrum during this study.

| Year | Emerged from Hibernation | | | | Entered Hibernation | | | | Duration of Main Activity Period (days) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic Environment | | Terrestrial Environment | | Aquatic Environment | | Terrestrial Environment | | | |
| | Date | Water Temp. (C) | Date | Mean Air Temp. (C) | Date | Water Temp. (C) | Date | Mean Air Temp. (C) | Aquatic Environment | Terrestrial Environment |
| 1972 | 28 Mar | 18.0 | - | - | 7 Nov | 16.0 | 21 Dec | 14.0 | 225 | - |
| 1973 | 11 Mar | 18.0 | 3 Mar | 17.0 | 3 Dec | 16.0 | 5 Dec | 8.5 | 268 | 278 |
| 1974 | 3 Mar | 19.0 | 4 Mar | 17.5 | - | - | - | - | - | - |
| Average | 14 Mar | 18.3 | 4 Mar | 17.3 | 18 Nov | 16.0 | 13 Dec | 11.3 | 246.5 | 278 |

changes remained fairly constant. All aquatic activity and most terrestrial activity ceased when temperatures fell to the vicinity of 17-19 C. Mahmoud (1969) reached this same conclusion while studying the Kinosternidae of Oklahoma and cited 16 C as the lower limit of the thermo-activity period for K. subrubrum. In South Carolina, Bennett (1972) recorded K. subrubrum leaving their terrestrial burrows when temperatures exceeded 21 C.

The annual activity period observed for K. subrubrum during this study began earlier and lasted later than any previously reported for the species. Extending from early March until December, it exceeded the mid-April to mid-November period reported by Nichols (1947) for K. subrubrum on Long Island, the early April to late October period reported by Mahmoud (1969) for K. subrubrum in Oklahoma and the early March to November period alluded to by Gibbons (1970) and Bennett (1972) for K. subrubrum in South Carolina.

## Periods of Inactivity

Periods of hibernation continued uninterrupted from beginning to end, both on land and in water, during the winter of 1972-73. Durations of the aquatic and terrestrial inactivity periods were 125 days and 70 days, respectively. During the winter of 1973-74, however, hibernation was briefly disrupted in both habitats by a period of unseasonably warm weather in late January. After 50 days of continuous inactivity (4 December to 22 January) in the aquatic medium, three captures, involving two adult males and one adult female, were recorded on each of the following days: 23 January (male), 27 January (female) and 30

January (male). The mean water temperature over this period was 18.3 C. From 31 January through 2 March, a period of 31 days, no further captures were logged; thus 81 days is taken as the period of inactivity for this particular winter. In the terrestrial environment, 48 days (6 December to 22 January) elapsed without activity. Then, from 23 January to 7 February, 15 individuals (12 males and 3 females) were recorded moving on land. All of the males emerged before any female. The average daily maximum, minimum and mean air temperatures for this period were 20.4 C, 9.9 C and 15.1 C, respectively. From 8 February through 3 March, a period of 24 days, no further movements were observed. Thus, 72 days is taken as the period of terrestrial inactivity during this winter.

No well defined period of aestivation was observed. Aquatic activity continued uninterrupted throughout the activity periods of both years. The same was true for terrestrial activity during the time it was being monitored.

## Diel Activity

Although no intensive effort was made to determine the nature of the diel rhythm over the entire annual cycle, some data were obtained on the subject during the latter part of the activity period. Throughout the month of October 1973, aquatic traps, terrestrial traps and trailer-fitted turtles were checked twice daily to determine if the population tended to be more active during the crepuscular-nocturnal period or during the diurnal perfod. Visits to the study area were made at sunrise and sunset.

The results of this effort revealed a pronounced difference in the behavior of K. subrubrum in the aquatic versus the terrestrial environment. Of 82 total aquatic captures recorded, 42 (12 males, 24 females and 6 unsexable juveniles) occurred during the period from sunrise to sunset and 40 (19 males, 16 females and 5 unsexable juveniles) during the period from sunset to sunrise. Clearly, there was no preference demonstrated for either time period by turtles moving in the water. On land, however, the data were quite different. Of the 21 total terrestrial movements recorded, 20 (13 males, 2 females and 5 unsexable juveniles) took place between sunrise and sunset, while only one occurred between sunset and sunrise. Thus, just as clearly, turtles moving on land demonstrated a marked preference for the diurnal period.

The difference in terrestrial and aquatic diel rhythms reported here may have stemmed from the prevailing temperatures in the two environments. Throughout all but 1 day of the sample period, water temperatures remained at or above 18 C and averaged 24.1 C (range 18-30 C). This should have favored continuous aquatic activity. On land, however, daytime temperatures (except for 2 days) regularly climbed above 18 C reaching an average maximum of 26.2 C (range 18-31 C), while nighttime temperatures (except for 2 nights) consistently dropped below 18 C reaching an average minimum of 10.7 C (range -1 to 17 C). This should have favored diurnal activity and suppressed nocturnal activity.

Whether this pattern of diel movement occurs throughout the entire activity period remains to be determined. Yet, if temperature is an important controlling factor, it probably does not. During summer, when nighttime temperatures often remain above 18 C, nocturnal activity should increase.

My data on the aquatic activity of K. subrubrum reveal little about the precise nature of the diel rhythm. Still, they do suggest that, at least during the latter part of the activity period, these turtles are neither strictly diurnal nor crepuscular-nocturnal since approximately equal numbers were taken during each of these periods. This is consistent with the findings of Mahmoud (1969), who found K. subrubrum to be most active between 4:00-9:00 a.m. and 4:40-10:00 p.m. from June through August in Oklahoma, and Ernst and Barbour (1972), who reported similar morning and evening periods during summer for K. subrubrum in Florida.

## Aquatic Movement

Studies of aquatic movement were restricted to determining (1) the nature of the aquatic feeding range (the area over which individuals normally traveled in search of food) and (2) the homing ability of individuals displaced from within this part of their habitat. Studies of the aquatic feeding range were conducted in both ponds, while homing ability was tested only in Pond No. 1.

### Aquatic Feeding Range

The aquatic feeding range was determined by analyzing the capture data recorded throughout the study for each turtle taken two or more times in the aquatic environment. With representatives from both ponds, this involved 83 males, 122 females and 6 unsexable juveniles.

Turtles of all sizes and both sexes were observed maintaining well defined overlapping aquatic feeding ranges throughout the study. These areas of restricted activity were variously distributed in shallow water around the periphery of each pond. Without exception they appeared as narrow, strap-like zones of marginal habitat extending lengthwise along and adjacent to the shore (Figures 18 and 19). Their shortest dimension or width extended from shore outward to where the water was about 1 m deep. Thus, they were narrowest where the bottom dropped off most rapidly and widest (never exceeding 5 m) where it dropped off least. Their longest dimension or length had no definite boundaries and appeared to vary more with the individual than with any recognizable environmental variable.

For comparative purposes, several statistics relating to the aquatic feeding range were considered. These included: (1) the length of the aquatic feeding range (defined as the shoreline distance between the farthest points of capture); (2) the distance between the first and last capture points; (3) the time between the first and last capture; and (4) the number of captures per individual. Means for these data, as they pertain to various portions of the population, appear in Table 5.

With few exceptions, the results appear quite similar throughout the sample. This is especially true for the first-last capture distances, where only the figures for males and females at Pond No. 2 appear to differ to any great degree. It is also true, but not so obvious, for the size of the aquatic feeding range. Considerable differences between range sizes show up between males and females at both ponds. However, these differences involve greater range sizes for females at one pond (No. 1) and greater range sizes for males at the other pond (No. 2) and are cancelled out in the overall sample mean. The result is a similar aquatic feeding range for males and females. The size of the aquatic

Figure 18. Selected examples of aquatic feeding ranges determined for five individuals in Pond No. 1. Numerals after symbols in legend are identification numbers. Numerals by symbols in pond indicate number of captures when above one.

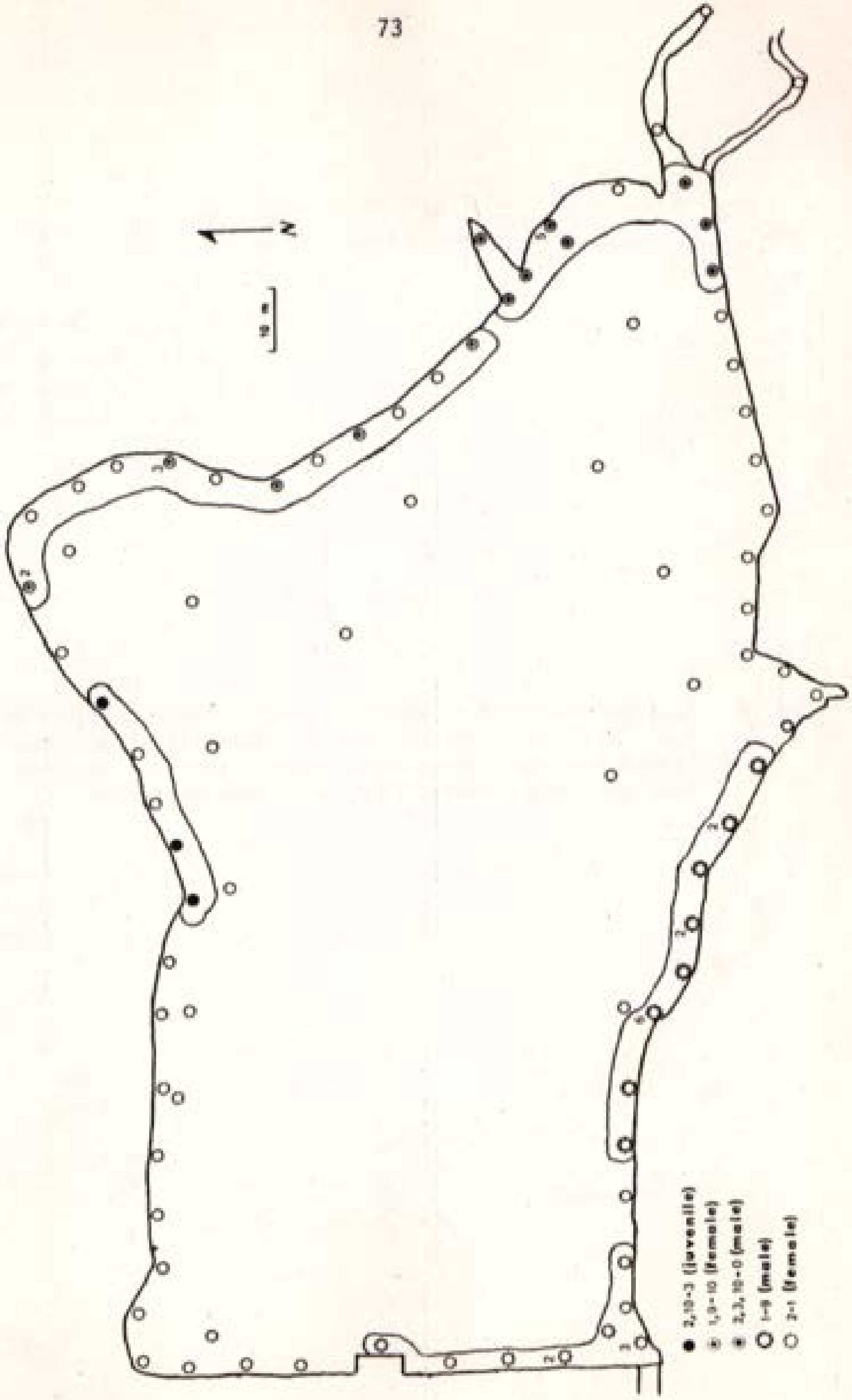


Figure 19. Selected examples of aquatic feeding ranges determined for four individuals in Pond No. 2. Numerals after symbols in legend are identification numbers. Numerals by symbols in pond indicate number of captures when above one.

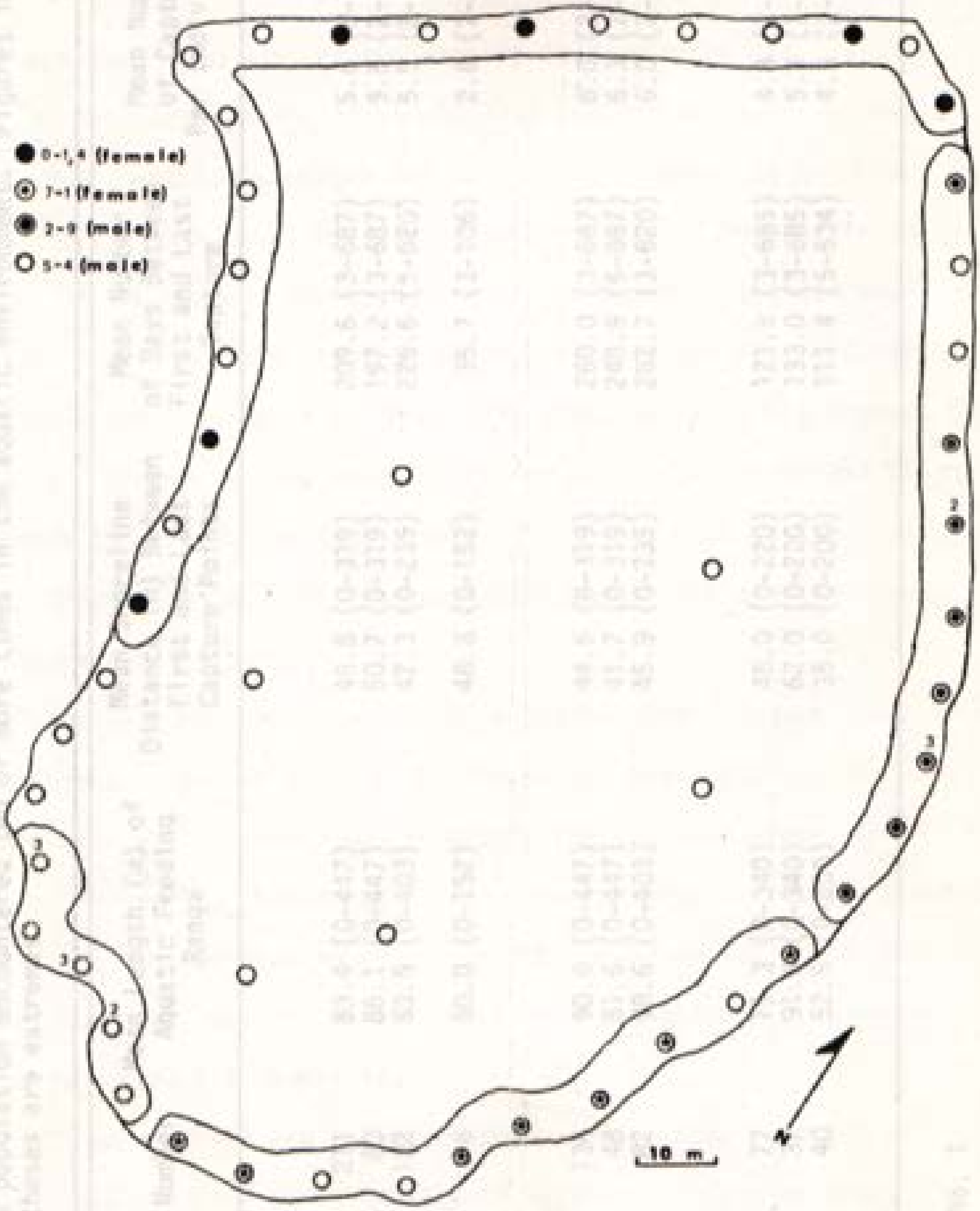

(female)
(female)
(male)
(male)
10 m

Table 5. Mean values for lengths of aquatic feeding ranges, first-last capture distances, first-last capture periods and number of captures per individual recorded for various portions of the population encountered two or more times in the aquatic environment. Figures in parentheses are extremes.

| Portion of Sample | Number | Mean Length (m) of Aquatic Feeding Range | Mean Shoreline Distance (m) Between First and Last Capture Points | Mean Number of Days Between First and Last Capture | Mean Number of Captures Per Individual |
|---|---|---|---|---|---|
| Entire Sample | 211 | 83.4 (0-447) | 45.8 (0-319) | 209.6 (3-687) | 5.6 (2-18) |
| Males | 83 | 86.1 (0-447) | 50.7 (0-319) | 197.2 (3-687) | 5.8 (2-17) |
| Females | 122 | 83.5 (0-403) | 42.3 (0-235) | 226.6 (5-620) | 5.5 (2-18) |
| Unsexable Juveniles* | 6 | 50.0 (0-152) | 48.8 (0-152) | 35.7 (3-106) | 2.8 (2-5) |
| Sample from Pond No. 1 | 134 | 90.6 (0-447) | 44.6 (0-319) | 260.0 (3-687) | 6.0 (2-18) |
| Males | 48 | 81.6 (0-447) | 41.7 (0-319) | 248.9 (6-687) | 6.3 (2-17) |
| Females | 82 | 98.6 (0-403) | 45.9 (0-235) | 282.7 (3-620) | 6.0 (2-18) |
| Sample from Pond No. 2 | 77 | 71.3 (0-340) | 48.0 (0-220) | 121.8 (3-685) | 4.8 (2-12) |
| Males | 37 | 91.6 (0-340) | 62.0 (0-220) | 133.0 (3-685) | 5.3 (2-11) |
| Females | 40 | 52.5 (0-200) | 35.0 (0-200) | 111.4 (5-534) | 4.3 (2-12) |

*All from Pond No. 1

feeding range for unsexable juveniles is considerably below most other segments of the population but so is the sample size for the group.

As a check on the above results, I examined the relationships existing between the size of the aquatic feeding range and (1) the number of days between the first and last capture for each individual and (2) the number of captures per individual (Figures 20 and 21). No apparent relationship was discovered in the first of these pairings. However, in the second, the mean size of the aquatic feeding range generally increased in a stepwise manner up to around six captures per individual, where it began to level off, fluctuating mainly between 100 and 150 m. Therefore, the mean figure for individuals captured six or more times probably approximates more closely the size of the true aquatic feeding range. For the population under consideration here, this figure was 125.5 m.

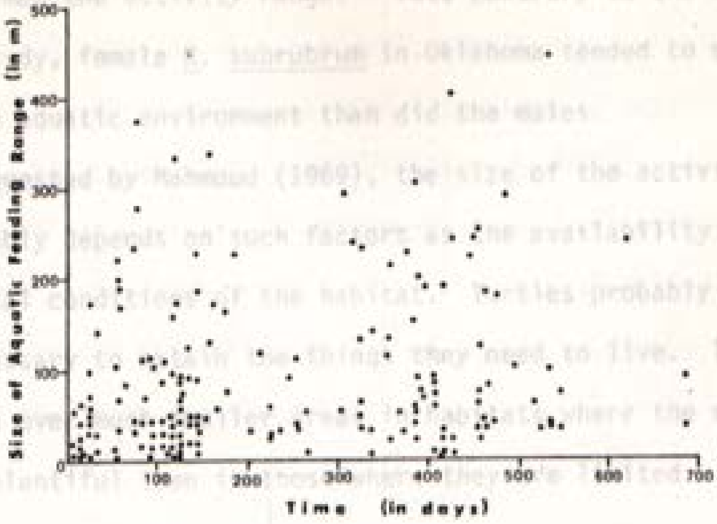
The data on aquatic movement presented above suggests that there is a definite area (the aquatic feeding range) over which mud turtles normally move and to which they regularly return, even after periods of up to two years. This area, at least in the pond situation, appears to be a long, narrow portion of bottom habitat along the shoreline. It is about the same size for males as for females, but may be somewhat smaller for unsexable juveniles.

These findings are basically the same as those reported by Mahmoud (1969) for the Kinosternidae of Oklahoma. There he found *Sternotherus odoratus*, *S. carinatus*, *Kinosternon subrubrum* and *K. flavescens* maintaining limited movements that were concentrated within

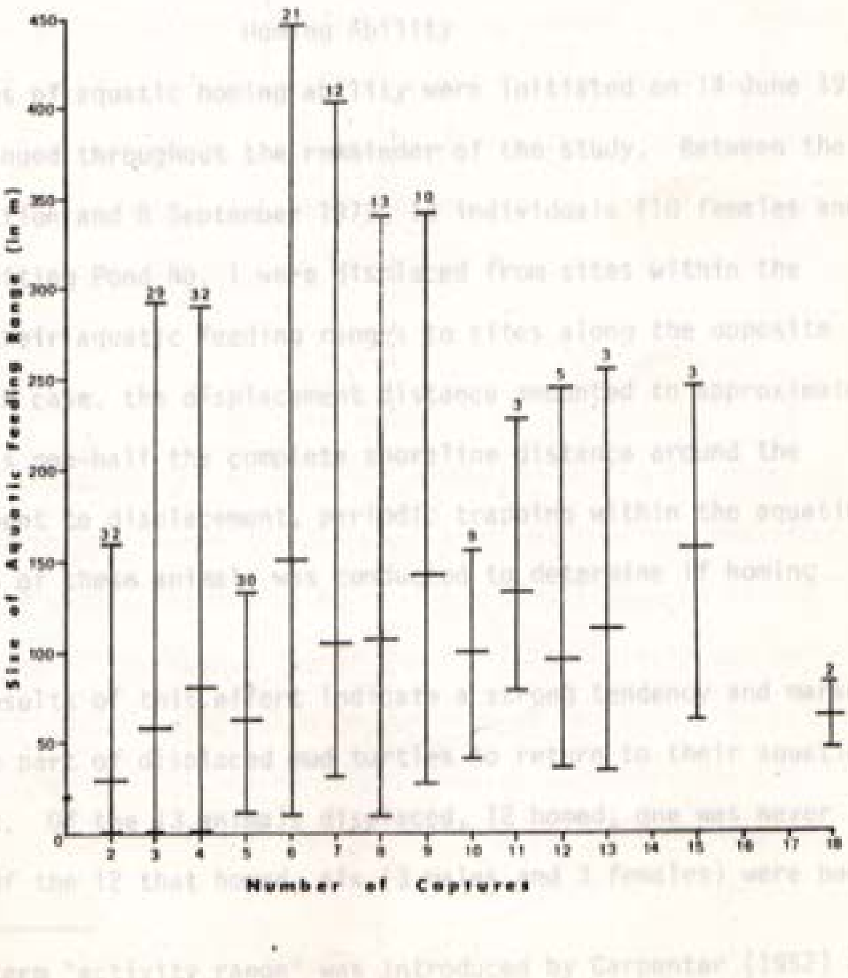
Figure 20. Relationship between the size of the aquatic feeding range and the length of time between the first and last capture for all individuals taken two or more times in the aquatic environment.

Figure 21. Relationship between the size of the aquatic feeding range and the number of captures recorded for all individuals taken two or more times in the aquatic environment. Short horizontal bars at the ends of vertical lines represent extremes; longer horizontal bars in between represent means. Numberals above vertical lines indicate the number of individuals involved.

an area he termed the activity range.[1] Yet, contrary to the results of the present study, female K. subrubrum in Oklahoma tended to move farther in the aquatic environment than did the males.




As suggested by Mahmoud (1969), the size of the activity area in water probably depends on such factors as the availability of food and the physical conditions of the habitat. Turtles probably move only as far as necessary to obtain the things they need to live. Thus, they probably range over much smaller areas in habitats where the requisites for life are plentiful than in those where they are limited.




## Homing Ability

Studies of aquatic homing ability were initiated on 14 June 1973 and were continued throughout the remainder of the study. Between the date of initiation and 8 September 1973, 13 individuals (10 females and 3 males) inhabiting Pond No. 1 were displaced from sites within the main part of their aquatic feeding ranges to sites along the opposite shore. In each case, the displacement distance amounted to approximately 300 m, which is one-half the complete shoreline distance around the pond. Subsequent to displacement, periodic trapping within the aquatic feeding ranges of these animals was conducted to determine if homing took place.

The results of this effort indicate a strong tendency and marked ability on the part of displaced mud turtles to return to their aquatic feeding ranges. Of the 13 animals displaced, 12 homed; one was never seen again. Of the 12 that homed, six (3 males and 3 females) were back

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[1]The term "activity range" was introduced by Carpenter (1952) as "the area covered by an animal in the course of its day-to-day existence."

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in their aquatic feeding range within 1 day, two (1 male and 1 female) within 2 days, one (female) within 5 days, one (female) within 6 days, one (female) within 69 days and one (female) within 88 days.

Whether homing took place directly across the pond or around the shoreline was not determined. However, it seems plausible to suggest the latter route as the surest way back. Since the shoreline is a continuous feature of the habitat, a displaced turtle need only follow it until familiar territory is encountered.

## Terrestrial Movement

Studies of terrestrial movement centered around (1) an attempt to determine if there were any apparent seasonal patterns of overland activity and (2) an effort to trace the exact overland movements of several adults during both the active and inactive phases of the annual cycle. This was accomplished using the drift fence and thread trailing device at Pond No. 1.

### Seasonal Patterns

Seasonal patterns of terrestrial movement for the K. subrubrum living around Pond No. 1 were rather pronounced and involved individuals of all sizes and both sexes moving on land during all seasons of the year. By the end of the study, 203 of the 252 (81%) animals marked in association with this pond had been encountered at least once on land. Of the total number of captures recorded, females accounted for 51%, males for 33% and unsexed juveniles for 12%. In the latter group, 6% were for hatchlings.

A synopsis of the drift fence data appears in Figure 22. When plotting number of captures against time on a monthly basis and when listing the percent of the marked population encountered during each month over its corresponding bar, which has been subdivided into various sex-size groupings, several things become apparent. First, the principal activity period on land during the one complete year considered (1973) was from March through November. Second, there was limited activity during the entire winter of 1973-74 as compared to the winter of 1972-73, during which there was no activity at all in January. Third, peak periods of overland movement during the terrestrial phase of the study occurred during September 1972, March 1973, and June 1973. Fourth, there was a sizable increase in the relative number of captures for females with carapace lengths greater than 80 mm during June of 1973 and a corresponding decrease in the number of captures for males of this size. And fifth, unsexable juveniles were active on land during all of the main activity period of 1973, with peaks in movement occurring in March and April.

Figure 23 gives data on the directional patterns of terrestrial movement observed along the drift fence. Of the 621 total captures, 309 (49.8%) were for inward movements and 312 (51.2%) were for outward movements. Thus there was a net total of only three movements outward over those inward during the entire study. Movements during late summer and throughout fall were predominantly outward, while movements during late winter and early spring were predominantly inward. Movements during late spring and throughout summer were about equally divided among outward and inward movements.

Figure 22. Total number of captures recorded each month in pitfall traps around Pond No. 1. Percentages represent the portions of the marked population moving on land each month.

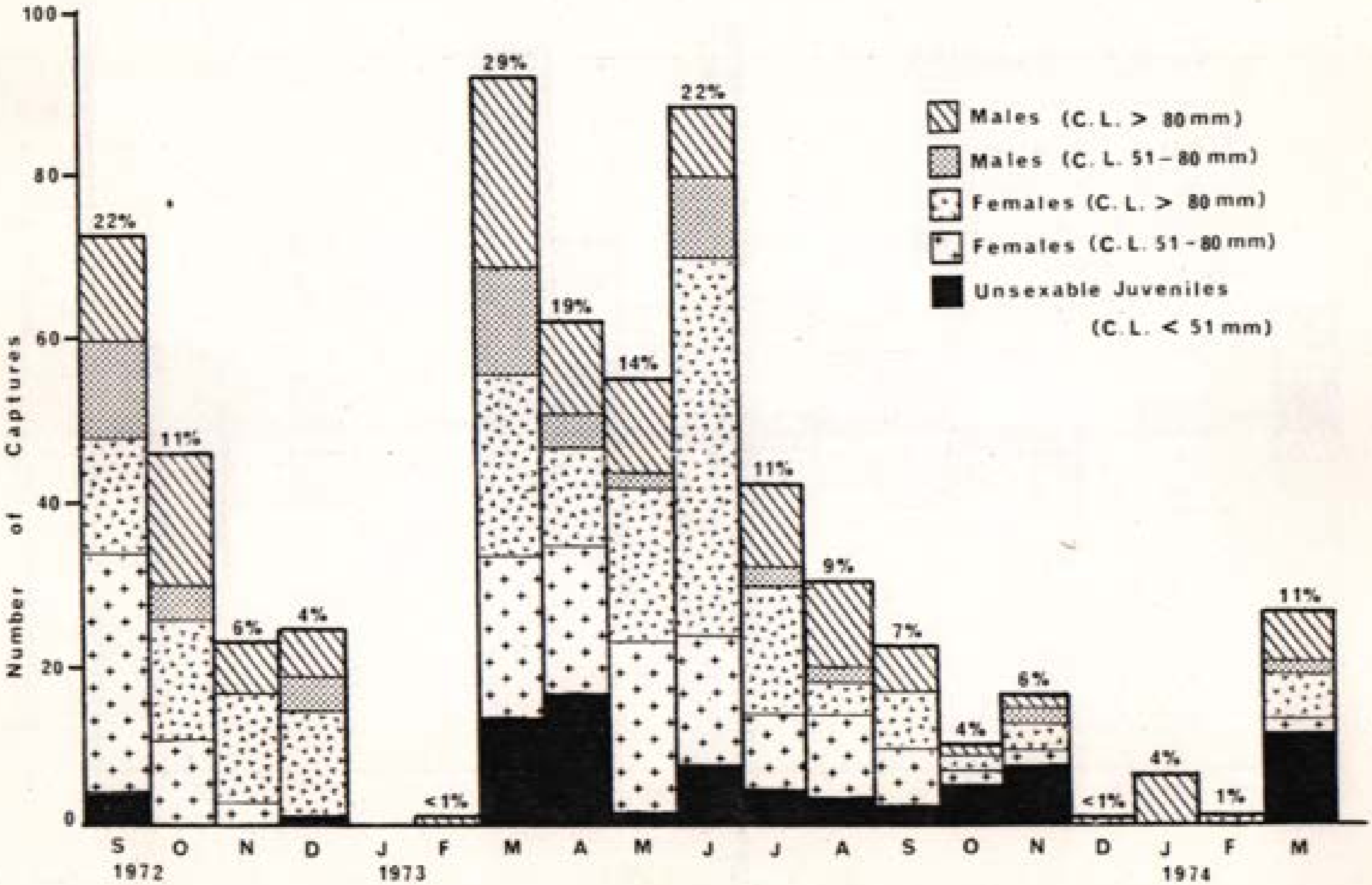
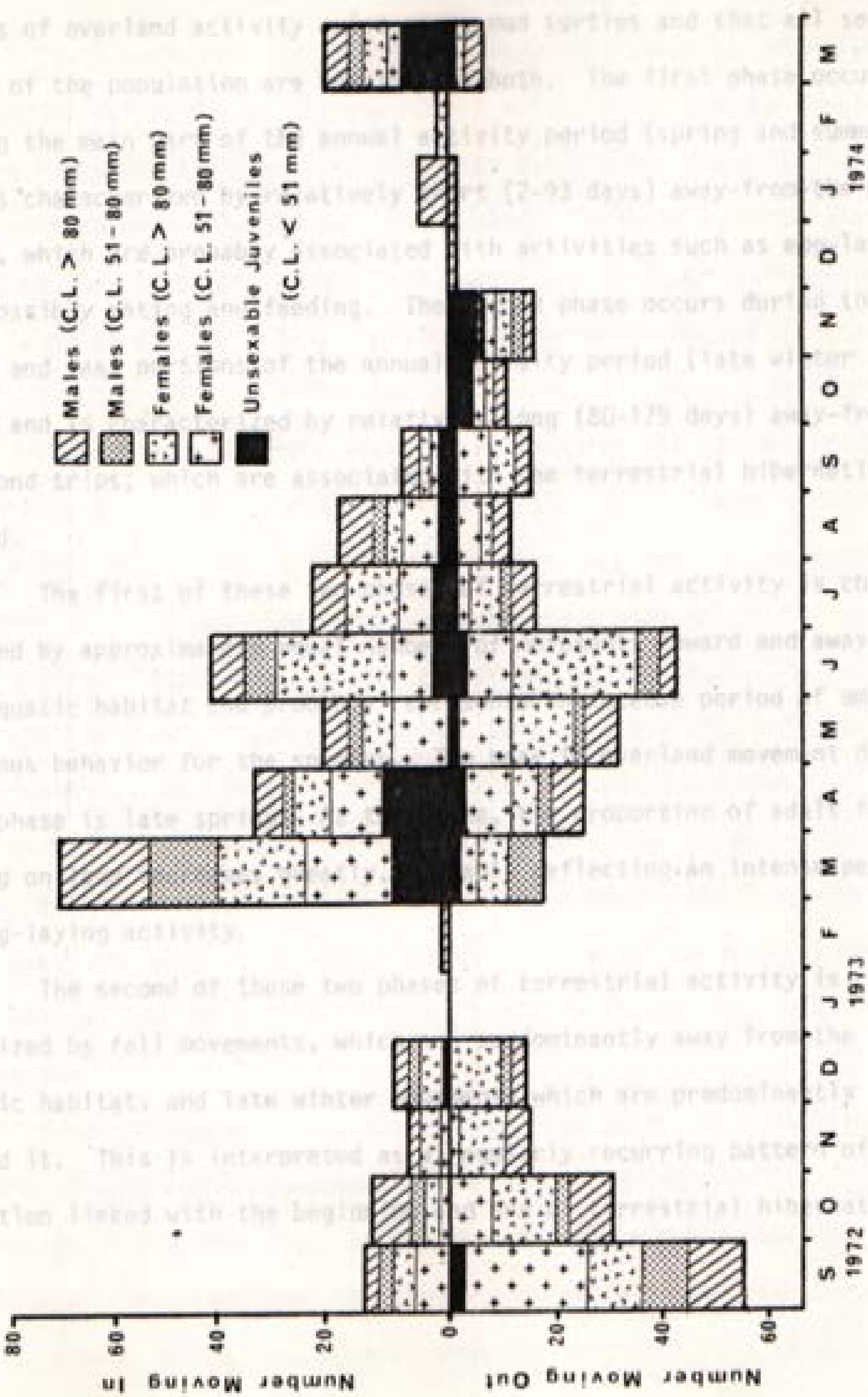

Number of Captures
0
20
40
60
80
100
22%
11%
6%
4%
<1%
29%
19%
14%
22%
11%
9%
7%
4%
6%
<1%
4%
1%
11%
S O N D J F M A M J J A S O N D J F M
1972
1973
1974
Males (C.L. > 80 mm)
Males (C.L. 51–80 mm)
Females (C.L. > 80 mm)
Females (C.L. 51–80 mm)
Unsexable Juveniles
(C.L. < 51 mm)

Figure 23. Total number of outward and inward movements recorded during each month along the drift fence at Pond No. 1.


Males (C.L. > 80 mm)
Males (C.L. 51-80 mm)
Females (C.L. > 80 mm)
Females (C.L. 51-80 mm)
Unsexable Juveniles (C.L. < 51 mm)
S O N D J F M A M J J A S O N D J F M
1972
1973
1974
80
60
40
20
0
20
40
60
Number Moving In
Number Moving Out

The drift fence data cited above indicate that two distinct phases of overland activity exist among mud turtles and that all segments of the population are involved in both. The first phase occurs during the main part of the annual activity period (spring and summer) and is characterized by relatively short (2-93 days) away-from-the-pond trips, which are probably associated with activities such as egg-laying and possibly mating and feeding. The second phase occurs during the first and last portions of the annual activity period (late winter and fall) and is characterized by relatively long (80-175 days) away-from-the-pond trips, which are associated with the terrestrial hibernation period.

The first of these two phases of terrestrial activity is characterized by approximately equal numbers of movements toward and away from the aquatic habitat and probably represents an intense period of amphibious behavior for the species. The peak in overland movement during this phase is late spring. At this time, the proportion of adult females moving on land increases greatly, probably reflecting an intense period of egg-laying activity.

The second of these two phases of terrestrial activity is characterized by fall movements, which are predominantly away from the aquatic habitat, and late winter movements which are predominantly toward it. This is interpreted as a regularly recurring pattern of migration linked with the beginning and end of terrestrial hibernation.

## Relationship Between Terrestrial Movements and the Aquatic Feeding Range

In 92 instances, recapture data were sufficient to permit an analysis of the degree of correspondence existing between the aquatic feeding range and the locations along the drift fence where turtles were observed moving in and out of the pond. To do this, three categories of correspondence were established: (1) Complete correspondence--cases in which all terrestrial movements occurred either adjacent to the aquatic feeding range or within one or two pitfall traps of it (Figure 24); (2) Incomplete correspondence--cases in which all but one or two terrestrial movements occurred adjacent to the aquatic feeding range (Figure 25); and (3) No correspondence--cases in which all terrestrial movements occurred completely removed from areas adjacent to the aquatic feeding range (Figure 26). In 82% (75 of 92) of the cases, the results fell into the first category. Fourteen percent (12 of 92) fell into the second category, and 4% (4 of 92) fell into the third category. Of those in the second category, all but three were females moving on land during the period of egg laying. All of those in the third category were males, the majority of which (3 of 4) exhibited terrestrial movements only during the fall and winter, probably in association with hibernation.

Results similar to the above were obtained in South Carolina by Bennett, Gibbons and Franson (1970) who also found individual _K. subrubrum_ moving to and from their aquatic habitat via a restricted length of drift fence. This indicates the terrestrial activity of these turtles normally occurs in the same general area and that this area is usually

Figure 24. Capture record of male 1-9 as an example of complete correspondence between the aquatic feeding range and terrestrial movements. Darkened circles in pond indicate aquatic capture sites. Darkened half-circles along drift fence indicate captures in only one of a pair of pitfalls. Numerals indicate number of captures when above one.

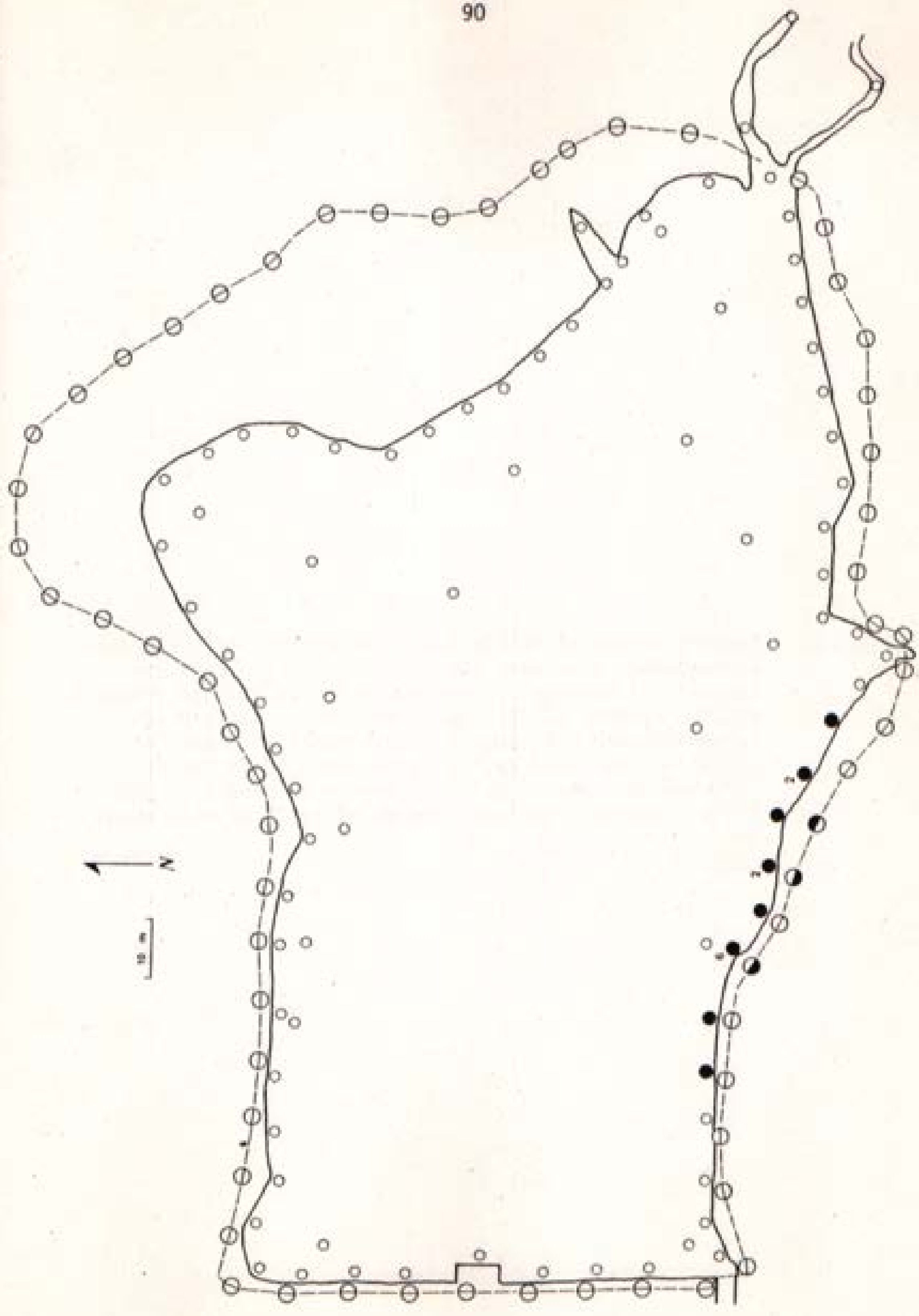


Figure 25. Capture record of female 2-2 as an example of incomplete correspondence between the aquatic feeding range and terrestrial movements. Darkened circles in pond indicate aquatic capture sites. Darkened circles along drift fence indicate captures in both members of a pair of pitfalls. Darkened half-circles along drift fence indicate captures in only one member of a pair of pitfalls. Numerals indicate number of captures when above one.

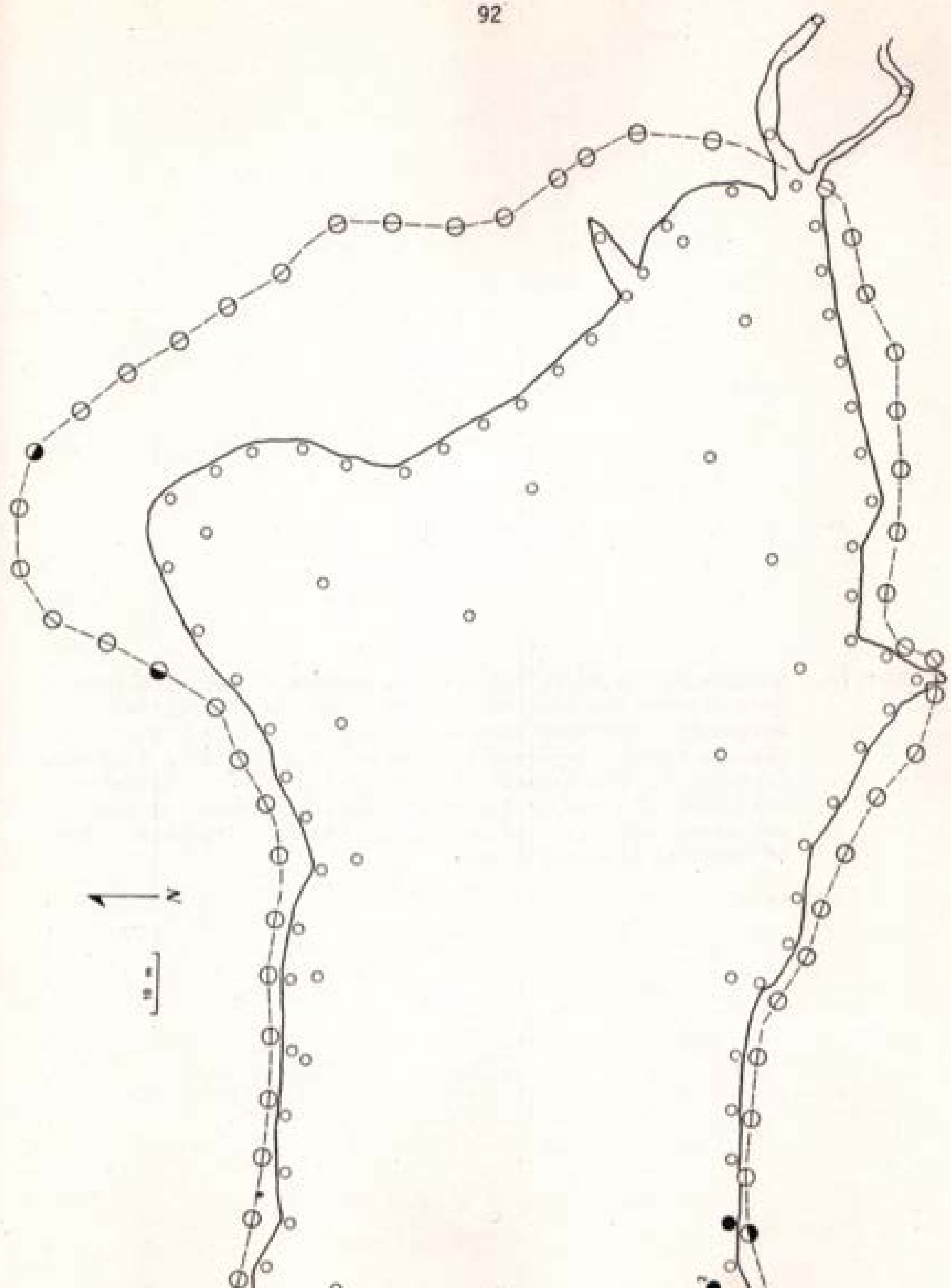
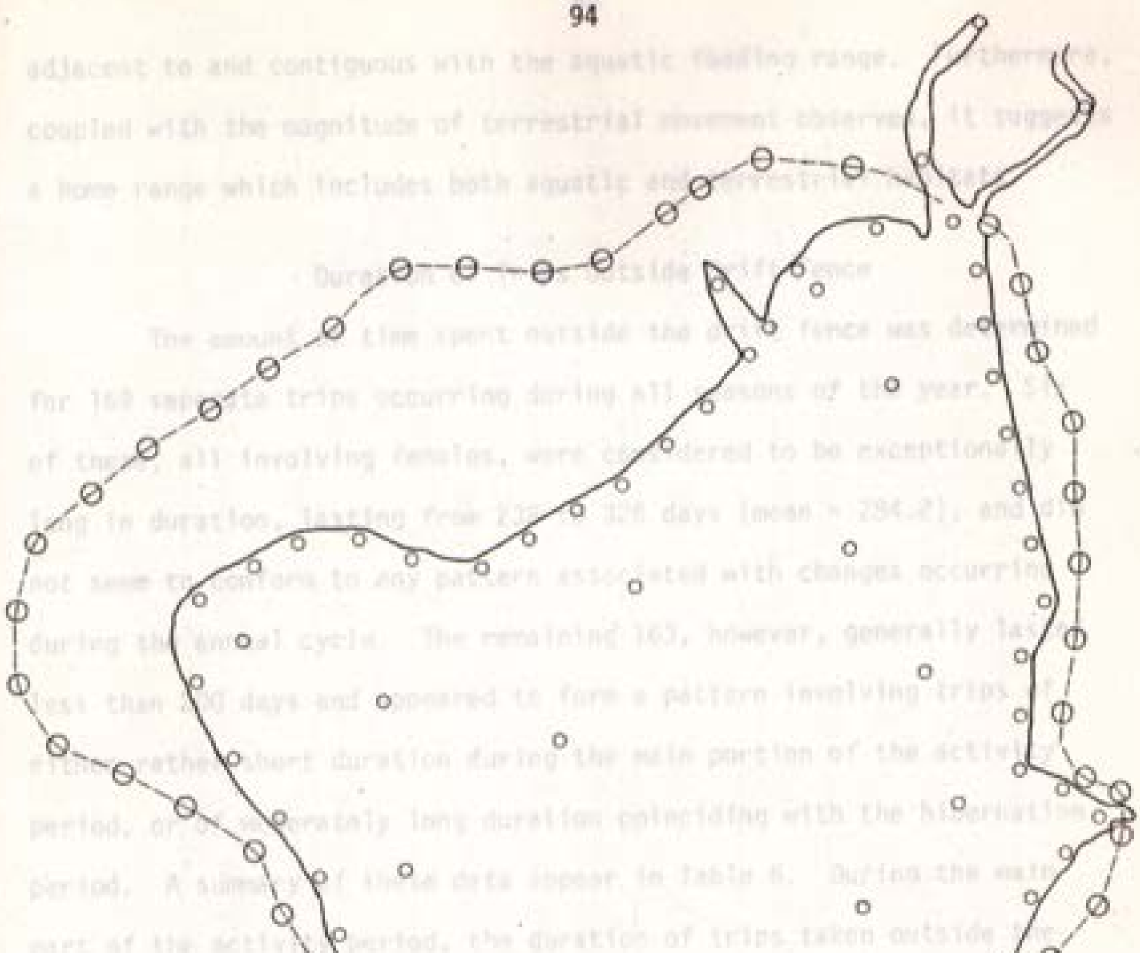


Figure 26. Capture record of male 8-2 as an example of no correspondence between the aquatic feeding range and terrestrial movements. Darkened circles in pond indicate aquatic capture sites. Darkened circles along drift fence indicate captures in both members of a pair of pitfalls. Darkened half-circles along drift fence indicate captures in only one member of a pair of pitfalls. Numerals indicate number of captures when above one.

adjacent to and contiguous with the aquatic feeding range. Furthermore, coupled with the magnitude of terrestrial movement observed, it suggests a home range which includes both aquatic and terrestrial habitats.




Duration of Trips Outside Drift Fence

The amount of time spent outside the drift fence was determined for 169 separate trips occurring during all seasons of the year. Six of these, all involving females, were considered to be exceptionally long in duration, lasting from 235 to 326 days (mean = 294.2), and did not seem to conform to any pattern associated with changes occurring during the annual cycle. The remaining 163, however, generally lasted less than 200 days and appeared to form a pattern involving trips of either rather short duration during the main portion of the activity period, or of considerably long duration coinciding with the hibernation period. A summary of these data appear in Table 6. During the main part of the activity period, the duration of trips taken outside the fence by males and females differed little. Trips embarked upon during late fall, however, differed in duration, both from one year to the next and from one segment of the population to the other. During the winter of 1972-73 (a rather cold winter), the mean period spent outside the fence was approximately 30 days longer than that for the winter of 1973-74 (a rather mild winter). Females consistently remained outside the fence longer than males during both winters. Unsexable juveniles were outside the fence longer than either sex the first winter but averaged only slightly longer out than males the second winter.

adjacent to and contiguous with the aquatic feeding range. Furthermore, coupled with the magnitude of terrestrial movement observed, it suggests a home range which includes both aquatic and terrestrial habitats.

Duration of Trips Outside Drift Fence

The amount of time spent outside the drift fence was determined for 169 separate trips occurring during all seasons of the year. Six of these, all involving females, were considered to be exceptionally long in duration, lasting from 238 to 326 days (mean = 284.2), and did not seem to conform to any pattern associated with changes occurring during the annual cycle. The remaining 163, however, generally lasted less than 200 days and appeared to form a pattern involving trips of either rather short duration during the main portion of the activity period, or of moderately long duration coinciding with the hibernation period. A summary of these data appear in Table 6. During the main part of the activity period, the duration of trips taken outside the fence by males and females differed little. Trips embarked upon during late fall, however, differed in duration, both from one year to the next and from one segment of the population to the other. During the winter of 1972-73 (a rather cold winter), the mean period spent outside the fence was approximately 30 days longer than that for the winter of 1973-74 (a rather mild winter). Females consistently remained outside the fence longer than males during both winters. Unsexable juveniles were outside the fence longer than either sex the first winter, but averaged only slightly longer out than males the second winter.

Table 6. Mean periods of time (in days) spent outside the perimeter of the drift fence during various phases of the annual cycle by _K. subrubrum_ living in association with Pond No. 1. Numerals in parentheses represent extremes.

| Segment of the Population | Main Activity Period | | Hibernation Period 1972-73 | | Hibernation Period 1973-74 | | All Periods Combined | |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | N | Mean | N | Mean | N | Mean |
| Males | 30 | 14.1 (2-93) | 15 | 152.4 (93-209) | 7 | 118.6 (82-160) | 52 | 68.0 (2-209) |
| Females | 61 | 11.3 (2-64) | 34 | 163.8 (85-214) | 7 | 145.6 (122-175) | 102 | 71.3 (2-214) |
| Unsexed Juveniles | - | - | 2 | 175.0 | 7 | 126.0 (80-163) | 9 | 136.9 (80-175) |
| Totals | 91 | 12.2 (2-93) | 51 | 160.9 (85-214) | 21 | 130.1 (80-175) | 163 | 66.3 (2-214) |

The difference in times spent outside the drift fence during the two winters seems to be related to temperature. Cold weather came earlier and lasted longer the first year, apparently resulting in a longer hibernation time. The extensive use made of terrestrial habitats by unsexable juveniles may have occurred year round. Although no data were obtained on times spent beyond the drift fence by individual young during the activity period, the trapping record for this group suggests more movement took place on land than in water. Of the 54 unsexable juveniles encountered at Pond No. 1, 37 (68.5%) were known only from land based traps. Furthermore, at Pond No. 2, where no terrestrial trapping was conducted, unsexable juveniles appeared to be almost non-existent accounting for only 2.5% of the marked population. This compares to 21.5% at Pond No. 1. These data point to a high degree of utilization of terrestrial habitats by young mud turtles throughout the year. From the standpoint of survival, this could be an adaptively significant characteristic. Small mud turtles moving about in shallow water would probably be much more susceptible to predation (by large fish, water snakes, foraging mammals, etc.) than if hidden among vegetation or leaf litter on land. Thus, they would stand a much greater chance of surviving if they made minimal use of the aquatic environment during the first few years of their life.

### Hatchling Movement

Data on terrestrial movement of hatchlings were obtained primarily from captures recorded along the drift fence and secondarily from daily checks of a nest located approximately 27 m south of Pond

No. 1. Direct observation of the nest's contents was possible because heavy rains partially exposed them soon after they were laid.

A total of 32 hatchlings were captured in pitfall traps during the study. One was taken in December, 17 in March, and 14 in April. Twenty of these were marked and released but none were recaptured. Five eggs were deposited in the aforementioned nest on 10 July. From these, four young eventually hatched; the other one died while still in the shell. The first to hatch emerged on 14 November (128 days after ovoposition) and left the nest on the following day. The second to hatch emerged on 16 November and left the nest on 26 November. The third one hatched on 26 November but died in the nest (of unknown causes) on 15 December. The fourth one hatched 12 December (156 days after ovoposition) and left the nest on 20 March. It was found dead beneath leaf litter about 20 cm from the nest on 31 March. The fifth egg never hatched but was found to contain a dead hatchling-size turtle on the last day of the study (31 March 1974).

The information cited here suggests that, in central Alabama, hatchling mud turtles normally spend the winter on land, either in or near the nest, and then emerge from their natal hibernacula in the late winter and early spring to seek water. Furthermore, it suggests that hatching and emergence from the nest may occur at any time from late fall to early spring. Gibbons (1970) obtained similar data in South Carolina where he encountered hatchling mud turtles only during the spring and early summer. However, his conclusion that this was an indication of a wholesale overwintering in the nest may have been in error. The results of my study suggest instead that some may spend the winter in the nest, while others may leave it and spend at least part of the winter burrowed beneath ground litter.

## Paths of Movement

Thirty-four adult mud turtles (80 mm or larger) were fitted with trailers and followed for varying lengths of time during all parts of the annual cycle. Twenty-six (11 males and 15 females) were native to Pond No. 1; two (both males) were native to Pond No. 2 and six (3 males and 3 females) were aliens (imports from areas other than the study area). The results obtained from those native to Pond No. 1 are presented here. Results obtained from the others appear later in the sections on inter-pond movement and movements of imports.

Of the 26 mud turtles trailed around Pond No. 1, 17 (9 males and 8 females) were followed for one or more days, thus providing quantifiable data on overland movements (Table 7). The other nine (2 males and 7 females) were lost (due to thread breaking or running out) on the first day after release and provided no data. Fourteen (7 males and 7 females) of those whose movements were successfully monitored, were trailed during the main part of the activity period (April-September). The remaining three (2 males and 1 female), were trailed during the hibernation period (October-March).

For each turtle trailed at least one complete day, a map of the path traversed was plotted. An attempt was made to secure two expressions of the amount of linear movement being exhibited. First, actual distances traveled were determined from the amount of thread left on spools after replacement. Second, straight-line distances between daily

Table 7. Numbers of individual K. subrubrum trailed for various lengths of time around Pond No. 1 and the time of year the trailing occurred.

| Number of Individuals | Duration of Trailing Period (in days) | Time of Year |
|---|---|---|
| 2 (1 male and 1 female) | 1 | April |
| 2 (1 male and 1 female) | 2 | May |
| 4 (2 males and 2 females) | 3 | April-June |
| 2 (1 male and 1 female) | 4 | April, May, July |
| 1 (female) | 7 | May |
| 1 (male) | 10 | May |
| 1 (female | 16 | June-July |
| 1 (male) | 31 | April-May |
| 1 (female) | 85 | November-March |
| 1 (male) | 146 | October-March |
| 1 (male) | 155 | October-March |

positions were determined by direct measurement. Losing turtles prior to retrieval of spools resulted in an incomplete set of data for the former measurement. However, a complete set of data for the latter was obtained. In cases where both measurements were obtained for turtles moving during a given time interval, the ratio of the former measurement to the latter measurement was determined and used as an index of the straightness of path (Emlen 1969). This meant relatively straight paths resulted in index values approaching one, while paths of a more convoluted nature resulted in values deviating from one.

A summary of the straight-line measurements taken during this phase of the study appears in Table 8. In all cases, females averaged greater distances between daily positions than did males. This was particularly true for the main activity period, during which the average distance between daily positions for females was nearly twice that of males. Winter movements, which were much reduced, were nearly the same for both sexes.

Comparisons between the actual distances traveled and the straight-line distances recorded between daily positions appear in Table 9. Although based on a rather limited sample, certain points concerning these data may be of some significance. First, the actual distances traveled per day (especially by males during the main activity period) were substantially greater than the apparent distances based on straight-line measurements between daily positions. Second, movement associated with hibernation seemed to be considerably more directed, having SPI (straightness of path indices) values of 1.1 to 1.5, than did movement during the main activity period, which carried SPI values of 2.2 to 4.6.

Table 8. Summary of daily straight-line distance measurements (in m) taken during various parts of the annual cycle while trailing native _K. subrubrum_ around Pond No. 1. Numbers in parentheses represent extremes.

| Segment of Population | During Main Activity Period | | | | During Hibernation Period | | | | Both Periods Combined | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Number of Days Trailed | Straight-line Distance Covered | Average Distance Per Day | N | Number of Days Trailed | Straight-line Distance Covered | Average Distance Per Day | N | Number of Days Trailed | Straight-line Distance Covered | Average Distance Per Day |
| Males | 7 | 54 | 312.8 | 5.8 (0-22.9) | 2 | 301 | 448.9 | 1.5 (0-93.3) | 9 | 355 | 761.7 | 2.1 (0-93.3) |
| Females | 7 | 36 | 411.7 | 11.4 (0-43.9) | 1 | 85 | 134.6 | 1.6 (0-37.5) | 8 | 121 | 546.3 | 4.5 (0-43.9) |
| Both Sexes Combined | 14 | 90 | 724.5 | 8.1 (0-43.9) | 3 | 386 | 583.5 | 1.5 (0-93.3) | 17 | 476 | 1308.0 | 2.7 (0-93.3) |

Table 9. Comparison of mean daily actual distances (m) and mean daily straight-line distances, plus straightness of path indices (SPI) computed from data collected while trailing native K. subrubrum around Pond No. 1 during various parts of the annual cycle.

| | Segment of Population | Number of Individuals | Number of Days Trailed | Mean Actual Distance Per Day | Mean Straight-line Distance Per Day | SPI |
|---|---|---|---|---|---|---|
| During Main Activity Period | Males | 2 | 7 | 40.1 | 8.7 | 4.6 |
| | Females | 3 | 19 | 26.5 | 12.1 | 2.2 |
| | Both Sexes Combined | 5 | 26 | 30.1 | 11.2 | 2.7 |
| During Hibernation Period | Males | 2 | 296 | 1.8 | 1.2 | 1.5 |
| | Females | 1 | 4 | 22.9 | 20.0 | 1.1 |
| | Both Sexes Combined | 3 | 300 | 2.1 | 1.5 | 1.5 |
| Both Periods Combined | Males | 4 | 303 | 2.7 | 1.4 | 2.0 |
| | Females | 4 | 24 | 24.8 | 12.9 | 1.9 |
| | Both Sexes Combined | 8 | 327 | 4.3 | 2.2 | 2.0 |

And third, although females appeared to have moved farther than males during the main activity period based on straight-line distance values, they really did not move as far as males when actual distances are considered.

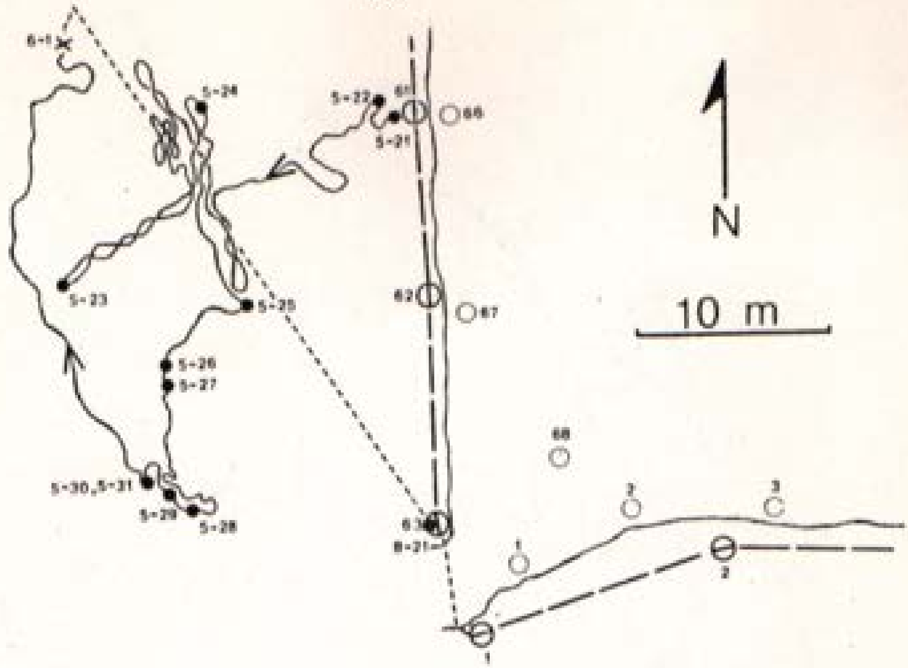
The movements of a male outside the drift fence during the main activity period appear in Figure 27. Released on 21 May, he spent the next 11 days wandering about in the labyrinth of shallow seeps and trickles located in the thickly vegetated area below the dam. Then, on 1 June, the thread tangled and broke and the animal was lost. He was recaptured nearly 3 months later in a pitfall trap just 20 m distant from where he had been released. Plant and insect remains in his feces the day following recapture indicate he had been feeding during his stay beyond the fence.

The movements of a female beyond the fence during the main activity period appear in Figure 28. Released on 25 May, she moved during the first day about 50 m SE to an area of soft soil beneath a stand of mature pines. There she moved for short distances on the second and third days but settled into a temporary burrow beneath ground litter for the next 4 days. On the seventh day she returned to the fence. Although no nest was located, test excavations along her path suggest she was probably moving on land with the purpose of laying eggs.

Examples of movements recorded in association with hibernation for each of the sexes appear in Figures 29 and 30. In both cases, the same general pattern is evident. From the date of release until around mid-November, each turtle gradually moved away from the pond via a series of short to moderate daily treks, which were occasionally interrupted by

Figure 27. Terrestrial movements of male 1,3,8-0 from 21 May 1973 to 1 June 1973. Hyphenated numerals indicate dates. The X marks the last daily position recorded before animal was lost. Dashed line marks the straight-line path between where string broke and where animal re-entered fence.

Figure 28. Terrestrial movements of female 0-1,10 from 25 May 1973 to 1 June 1973. Hyphenated numerals indicate dates.


6-1
5-24
5-22
61
66
5-21
N
5-23
5-25
62
67
10 m
5-26
5-27
68
5-30, 5-31
2
3
5-29
5-28
63
6-21
1
2
1

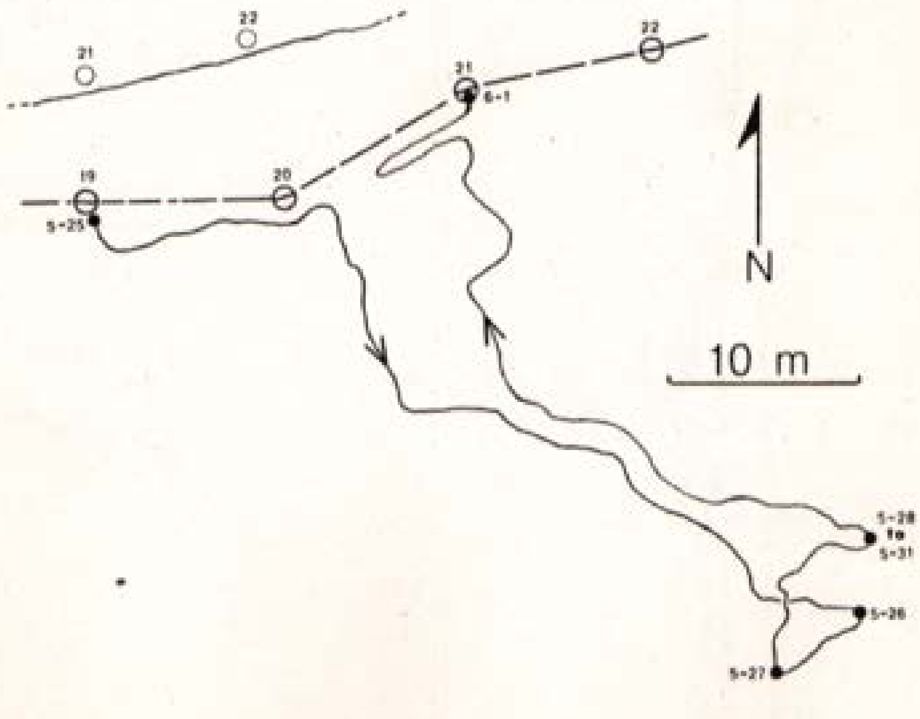

21
22
22
21
6-1
N
19
20
5-25
10 m
5-28
to
5-31
5-26
5-27

Figure 29. Terrestrial movements of female 1,3-0 from 5 November 1973 to 29 January 1974. Hyphenated numerals indicate dates.

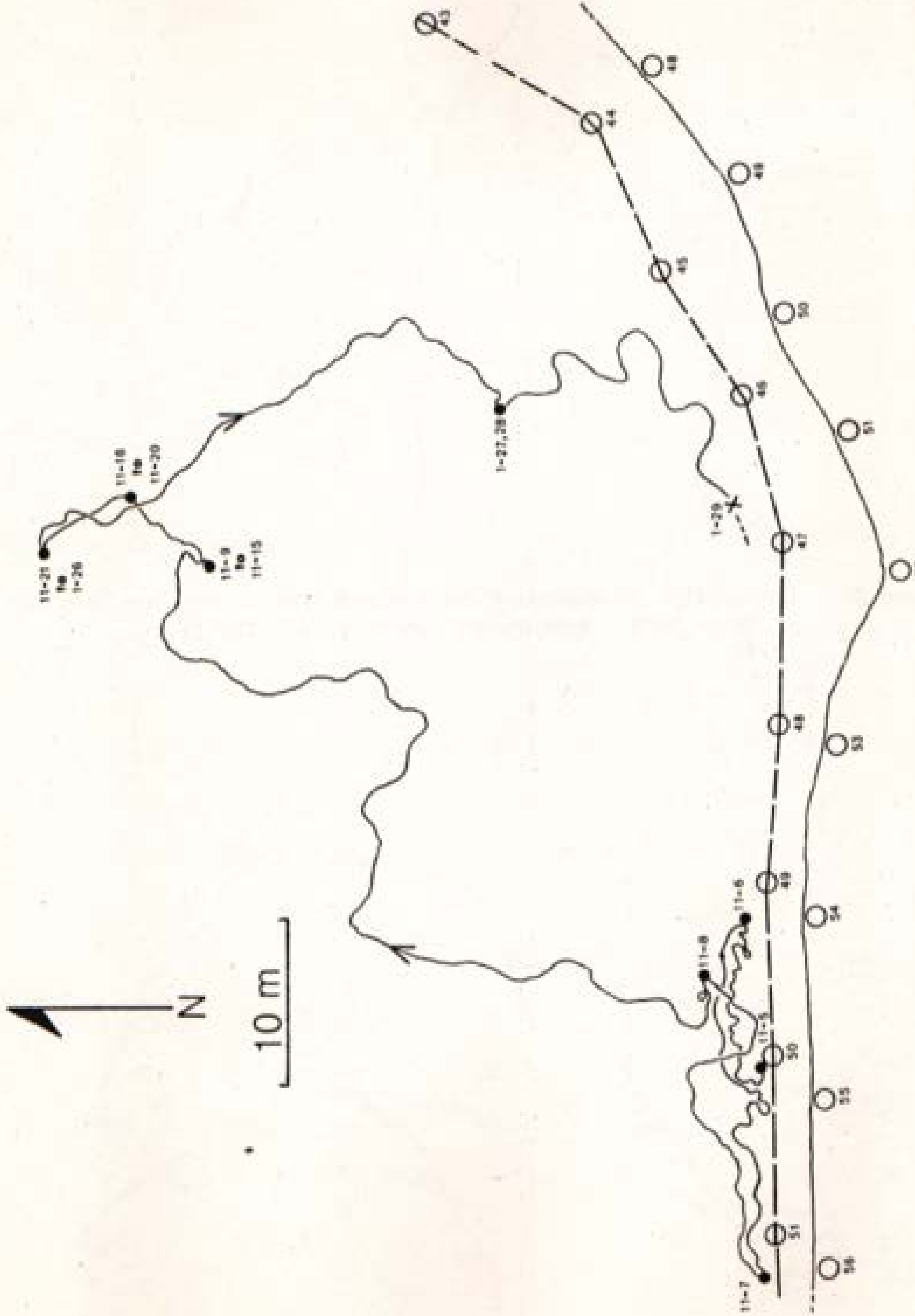
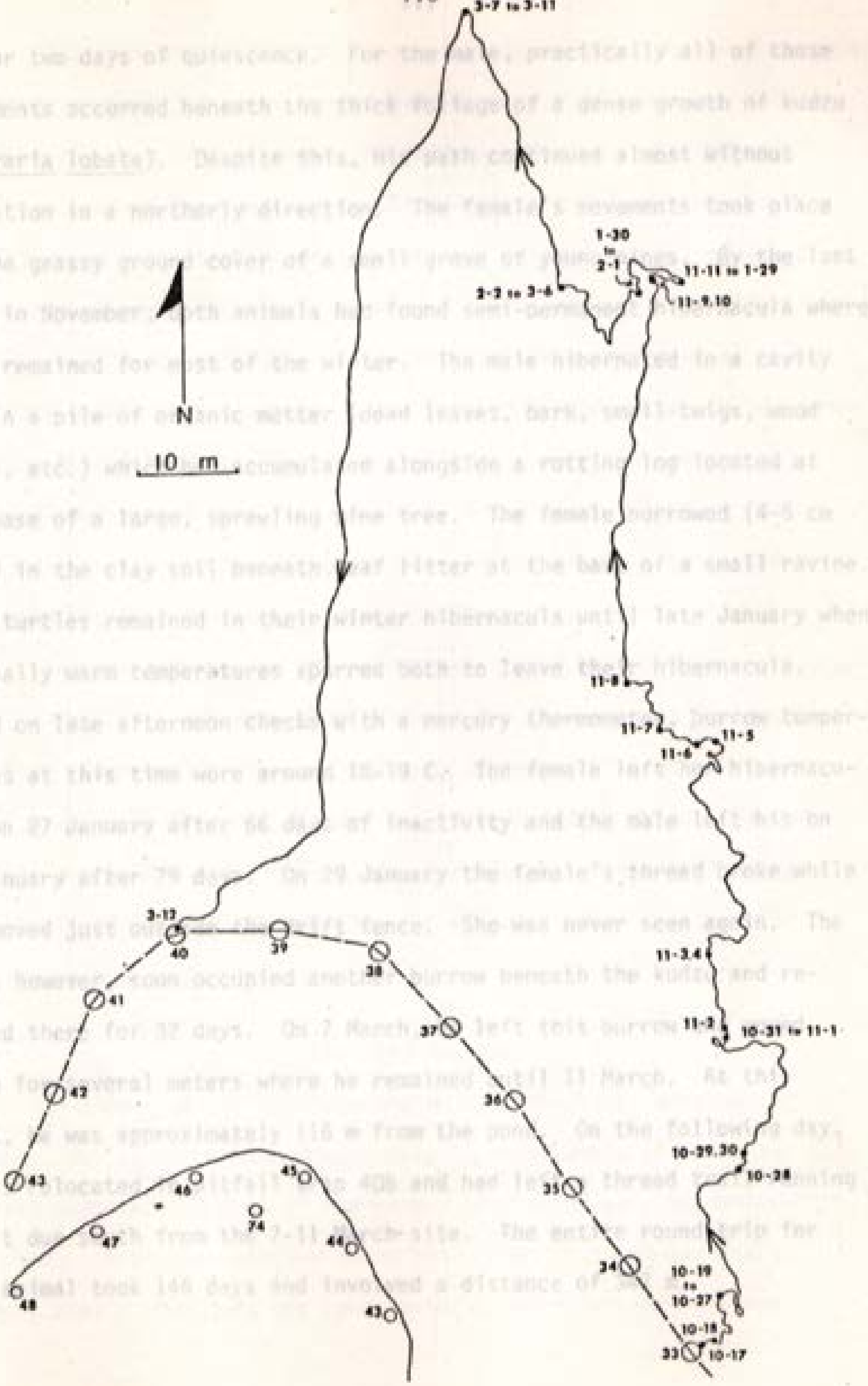

N
10 m

Figure 30. Terrestrial movements of male 3,8-9 from 17 October 1973 to 12 March 1974. Hyphenated numerals indicate dates.


3-7 to 3-11
1-30 to 2-1
11-11 to 1-29
2-2 to 3-6
11-9,10
N
10 m
11-8
11-7
11-5
11-6
3-12
40
39
38
41
11-3,4
37
11-2
10-31 to 11-1
42
36
10-29,30
10-28
43
46
45
35
74
47
44
34
10-19 to 10-27
48
43
10-18
33
10-17

one or two days of quiescence. For the male, practically all of these movements occurred beneath the thick foliage of a dense growth of kudzu (Pueraria lobata). Despite this, his path continued almost without deviation in a northerly direction. The female's movements took place in the grassy ground cover of a small grove of young pines. By the last week in November, both animals had found semi-permanent hibernacula where they remained for most of the winter. The male hibernated in a cavity within a pile of organic matter (dead leaves, bark, small twigs, wood chips, etc.) which had accumulated alongside a rotting log located at the base of a large, sprawling pine tree. The female burrowed (4-5 cm deep) in the clay soil beneath leaf litter at the base of a small ravine. Both turtles remained in their winter hibernacula until late January when unusually warm temperatures spurred both to leave their hibernacula. Based on late afternoon checks with a mercury thermometer, burrow temperatures at this time were around 18-19 C. The female left her hibernaculum on 27 January after 66 days of inactivity and the male left his on 30 January after 79 days. On 29 January the female's thread broke while she moved just outside the drift fence. She was never seen again. The male, however, soon occupied another burrow beneath the kudzu and remained there for 32 days. On 7 March, he left this burrow and moved north for several meters where he remained until 11 March. At this point, he was approximately 116 m from the pond. On the following day, he was relocated in pitfall trap 40B and had left a thread trail running almost due south from the 7-11 March site. The entire round trip for this animal took 146 days and involved a distance of 347 m.

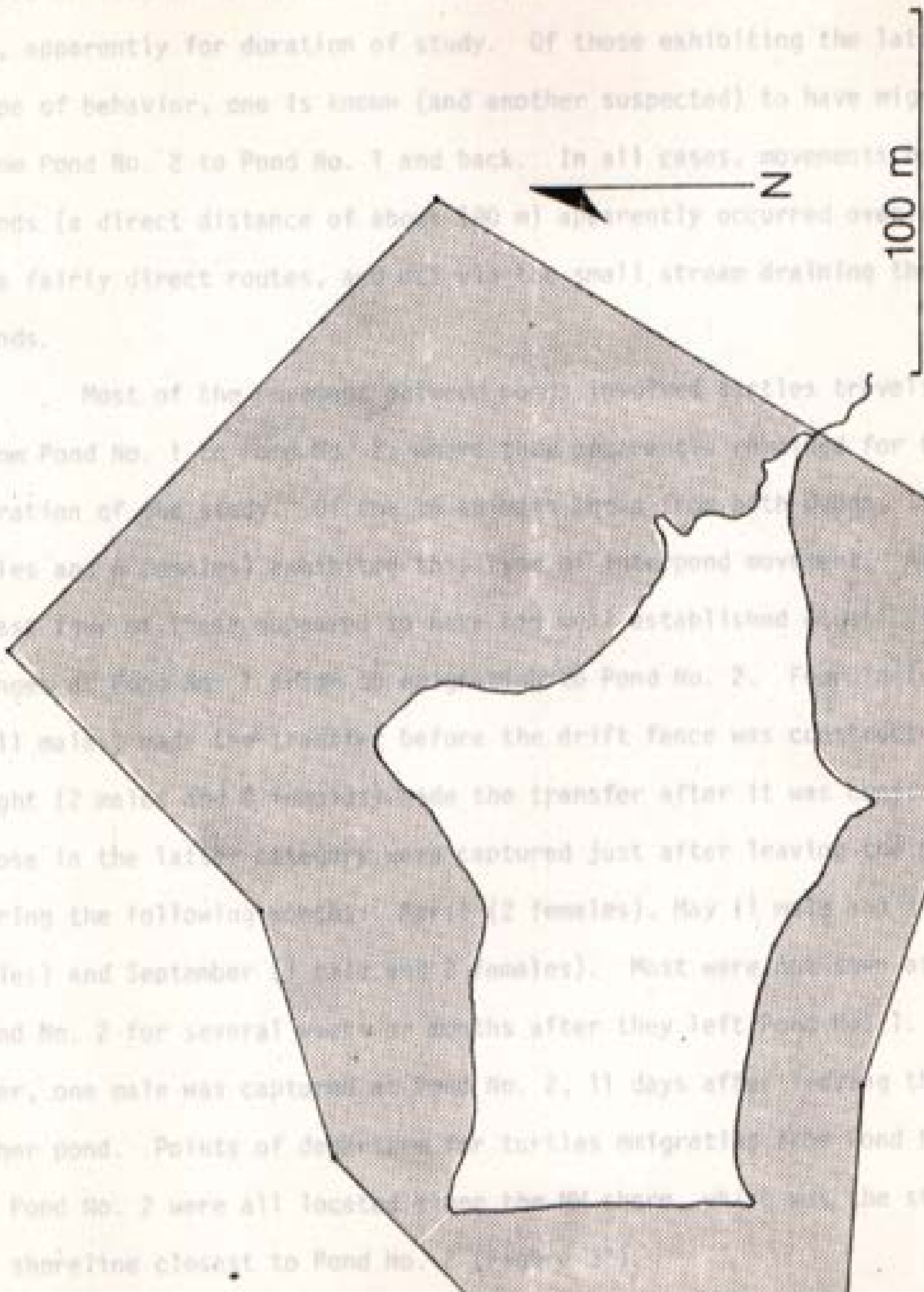
The area around Pond No. 1 in which terrestrial movement occurred amounted to about 3.5 ha of varied habitat described earlier. This is based on the most distant points of landward movement recorded in all directions around the pond. When plotted (Figure 31), it reveals an overall greater utilization of the habitats located N and E of the pond as opposed to those located S and W of it. This might be a reflection of the affinity mud turtles seem to show for areas affording an abundant supply of ground cover, either in the form of ground litter or low vegetation. Around Pond No. 1, the most extensive habitats meeting this apparent requirement were those N and E of the pond. The fact that nearly all the marshy habitat associated with Pond No. 1 was located in this area may also have been a contributing factor.

The characteristics of terrestrial travel observed for K. subrubrum during this study were also observed for this species in South Carolina. Essentially the same patterns of terrestrial behavior were revealed there by Bennett, Gibbons and Franson (1970) during the summer and fall and by Bennett (1972) during the winter. Thus, my findings tend to support and augment the results of previous studies dealing with terrestrial movements of mud turtles.

## Interpond Movement

Movements of turtles from one pond to the other were quite limited. During the entire study, only 15 individuals (7 males and 8 females) representing 4.5% of the marked population were encountered in both ponds. None was observed using both ponds on a regular basis. Instead, they either left one pond, entered the other and remained

Figure 31. Area around Pond No. 1 (drawn by connecting outermost points) where terrestrial movements took place.

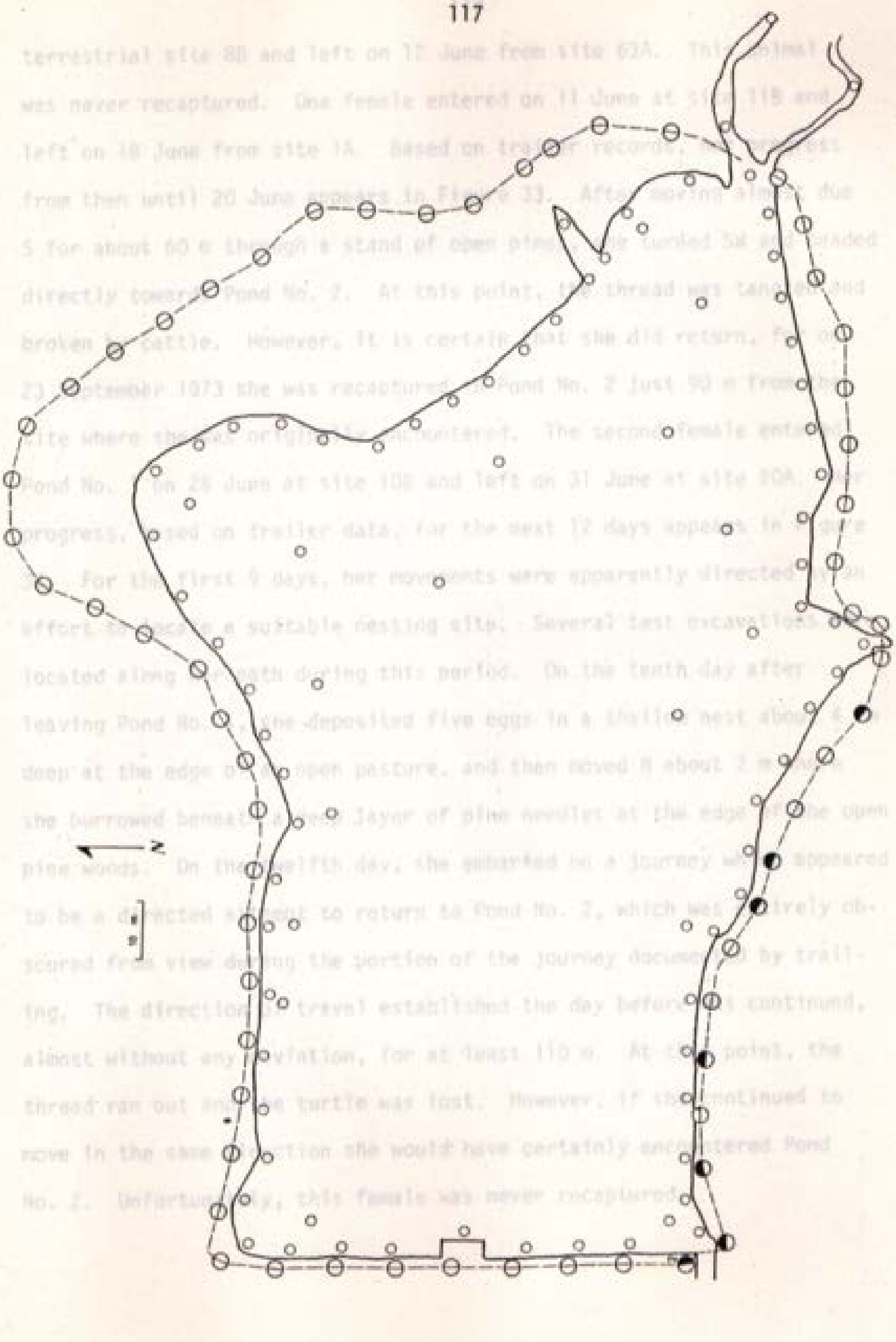

N
100 m

there or left one pond, entered the other for a brief stay and then left it, apparently for duration of study. Of those exhibiting the latter type of behavior, one is known (and another suspected) to have migrated from Pond No. 2 to Pond No. 1 and back. In all cases, movements between ponds (a direct distance of about 190 m) apparently occurred overland via fairly direct routes, and not via the small stream draining the ponds.

Most of the movement between ponds involved turtles traveling from Pond No. 1 to Pond No. 2, where they apparently remained for the duration of the study. Of the 15 animals known from both ponds, 12 (6 males and 6 females) exhibited this type of interpond movement. At least four of these appeared to have had well established aquatic feeding ranges at Pond No. 1 prior to emigrating to Pond No. 2. Four individuals (all males) made the transfer before the drift fence was constructed; eight (2 males and 6 females) made the transfer after it was constructed. Those in the latter category were captured just after leaving the pond during the following months: April (2 females), May (1 male and 2 females) and September (1 male and 2 females). Most were not seen at Pond No. 2 for several weeks or months after they left Pond No. 1. However, one male was captured at Pond No. 2, 11 days after leaving the other pond. Points of departure for turtles emigrating from Pond No. 1 to Pond No. 2 were all located along the NW shore, which was the stretch of shoreline closest to Pond No. 2 (Figure 32).

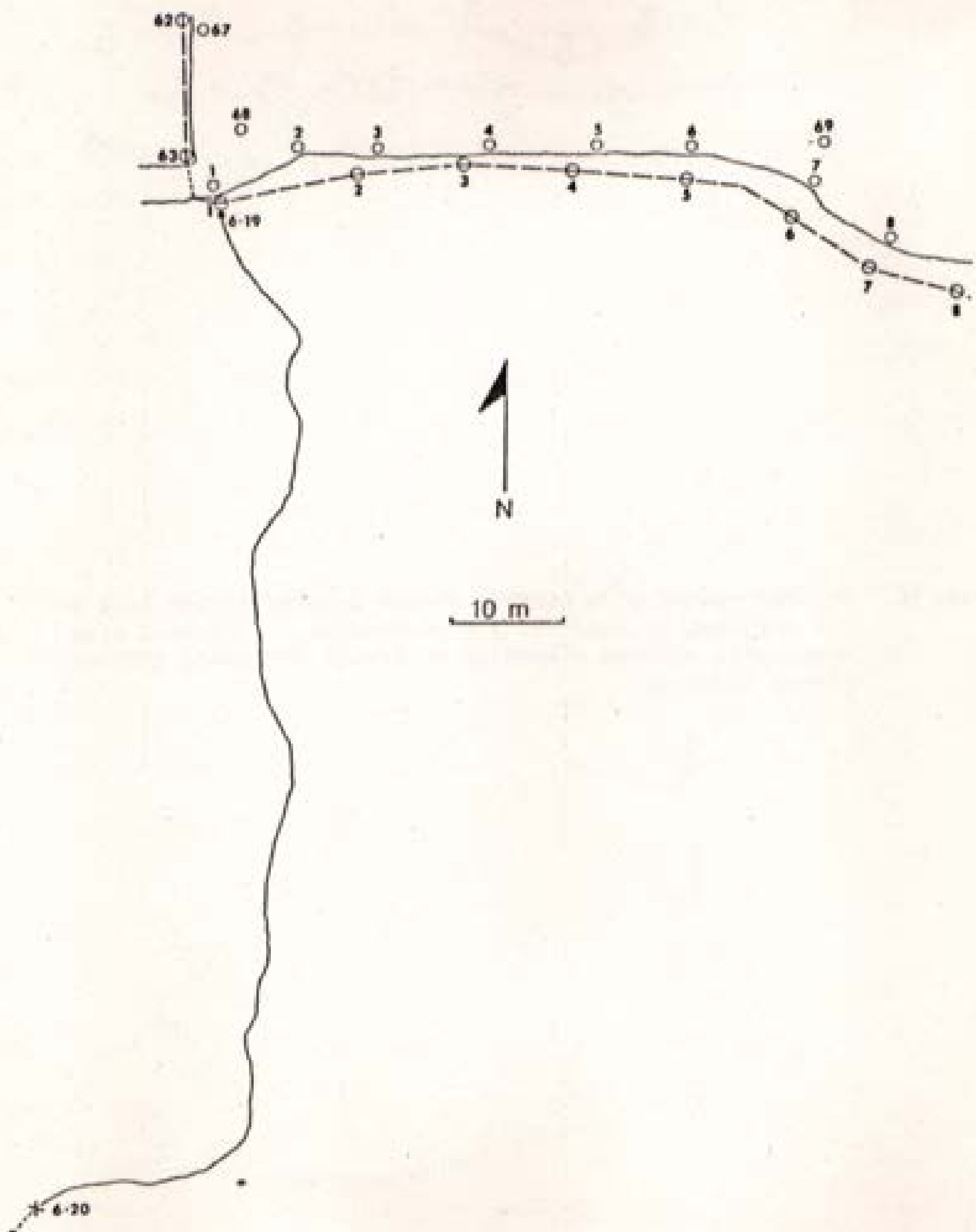
Movement of turtles from Pond No. 2 to Pond No. 1 involved only three individuals (1 male and 2 females). For all, the movement occurred during June of 1973. The male entered Pond No. 1 on 9 June at

Figure 32. Points of departure recorded for eight *K. subrubrum* that emigrated from Pond No. 1 to Pond No. 2.


N

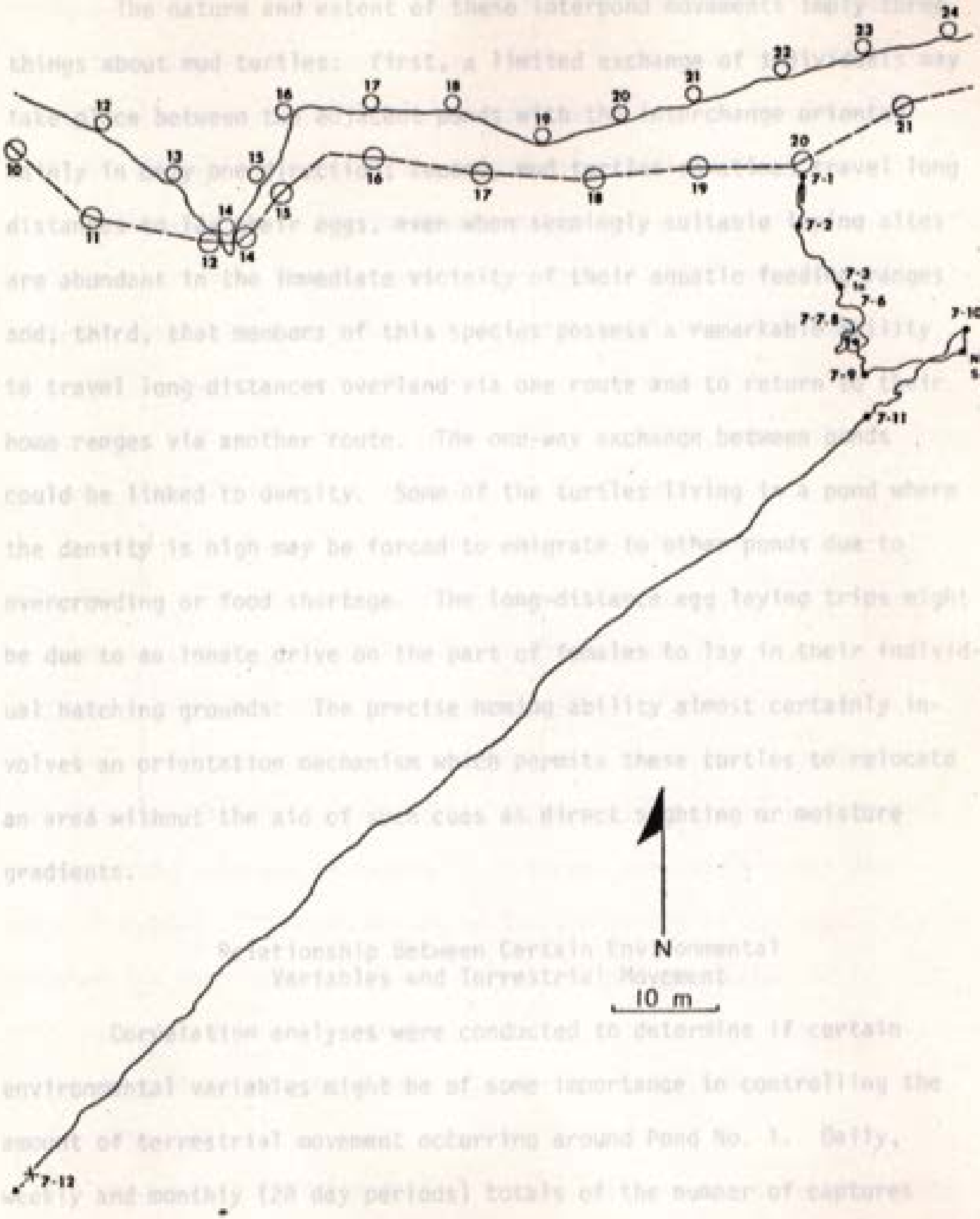
terrestrial site 8B and left on 12 June from site 63A. This animal was never recaptured. One female entered on 11 June at site 11B and left on 18 June from site 1A. Based on trailer records, her progress from then until 20 June appears in Figure 33. After moving almost due S for about 60 m through a stand of open pines, she turned SW and headed directly towards Pond No. 2. At this point, the thread was tangled and broken by cattle. However, it is certain that she did return, for on 23 September 1973 she was recaptured in Pond No. 2 just 90 m from the site where she was originally encountered. The second female entered Pond No. 1 on 28 June at site 10B and left on 31 June at site 20A. Her progress, based on trailer data, for the next 12 days appears in Figure 34. For the first 9 days, her movements were apparently directed by an effort to locate a suitable nesting site. Several test excavations were located along her path during this period. On the tenth day after leaving Pond No. 1, she deposited five eggs in a shallow nest about 4 cm deep at the edge of an open pasture, and then moved N about 2 m where she burrowed beneath a deep layer of pine needles at the edge of the open pine woods. On the twelfth day, she embarked on a journey which appeared to be a directed attempt to return to Pond No. 2, which was entirely obscured from view during the portion of the journey documented by trailing. The direction of travel established the day before was continued, almost without any deviation, for at least 110 m. At this point, the thread ran out and the turtle was lost. However, if she continued to move in the same direction she would have certainly encountered Pond No. 2. Unfortunately, this female was never recaptured.

Fiugre 33. Trailer record of part of return trip of female 5-6 from Pond No. 1 to Pond No. 2. Dashed line represents assumed path after trailer thread was broken.



62
67
68
63
1
2
3
4
5
6
69
7
8
6-19
N
10 m
6-20

Figure 34. Trailer record of a portion of the trip by female 4-11 as she returned to Pond No. 2 from Pond No. 1. Dashed line represents assumed direction of travel following trailer thread breakage.




The nature and extent of these interpond movements imply three things about mud turtles: first, a limited exchange of individuals may take place between the adjacent ponds with the interchange oriented mainly in one direction; second, mud turtles sometimes travel long distances to lay their eggs, even when seemingly suitable laying sites are abundant in the immediate vicinity of their aquatic feeding ranges; and, third, that members of this species possess a remarkable ability to travel long distances overland via one route and to return to their home ranges via another route. The one-way exchange between ponds could be linked to density. Some of the turtles living in a pond where the density is high may be forced to emigrate to other ponds due to overcrowding or food shortage. The long-distance egg laying trips might be due to an innate drive on the part of females to lay in their individual hatching grounds. The precise homing ability almost certainly involves an orientation mechanism which permits these turtles to relocate an area without the aid of such cues as direct sighting or moisture gradients.

### Relationship Between Certain Environmental Variables and Terrestrial Movement

Correlation analyses were conducted to determine if certain environmental variables might be of some importance in controlling the amount of terrestrial movement occurring around Pond No. 1. Daily, weekly and monthly (28 day periods) totals of the number of captures recorded along the drift fence from 1 September 1972 through 31 March 1974 (excluding the months of hibernation, which were December, January and February) were examined in relation to nine different physical

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Comparisons on the daily and weekly basis resulted in no significant correlations. Monthly comparisons in most cases were only slightly stronger (Table 11), but revealed a significantly high correlation (P = .041) between rainfall and drift fence captures (Figure 35). Photoperiod and wind, with r-squares of .14 and .12, respectively, were the only other factors even approaching significance.

The significant correlation between rainfall and terrestrial movement was not surprising, because throughout the activity periods of both years landward activity almost always seemed to increase or decrease in direct proportion to the amount of rainfall (Figure 36). This was true during all months except June and November. During June, terrestrial captures along the drift fence increased sharply without a corresponding increase in rainfall. This was due mainly to an extraordinary number of females moving on land, probably to lay eggs. During November (of both years) rainfall increased, but the number of terrestrial captures dropped or remained about the same. This may be explained by the inhibitory effect of colder temperatures which began to set in during late fall.

The relationships hinted at between terrestrial movement, photoperiod and wind might be explained as follows. First, terrestrial activity generally increased gradually from early spring until June, peaked and then gradually decreased until late fall. This is precisely the

Table 10. Environmental variables examined in relation to terrestrial movement and the ways each was expressed in daily, weekly and monthly comparisons.

| Environmental Variable | How Experssed in Various Comparisons | | |
|---|---|---|---|
| | Daily | Weekly | Monthly |
| Water temperature (C) | afternoon readings | means of afternoon readings | means of afternoon readings |
| Air temperature (C) | | | |
| Maximum | daily readings | means of daily readings | means of daily readings |
| Minimum | daily readings | means of daily readings | means of daily readings |
| Rainfall (cm) | total amount | total amount | total amount |
| Water level (cm above or below capacity) | afternoon readings | means of afternoon readings | means of afternoon readings |
| Solar radiation (radons) | daily totals | means of daily totals | means of daily totals |
| Evaporation (inches) | total amount | total amount | total amount |
| Wind (miles/day) | daily totals | means of daily totals | means of daily totals |
| Relative humidity (%) | means of midnight and noon values | means of daily means | means of daily means |
| Photoperiod (minutes) | total amount | means of daily totals | means of daily totals |

Table 11. R-squares and probabilities resulting from independent pairings on a monthly basis of several environmental variables and total drift fence captures recorded during the main activity period (March-November) at Pond No. 1.

| Environmental Variable | $R^2$ | Probability of Larger F-ratio |
|---|---|---|
| Water temperature (means of afternoon readings in C) | .00 | .884 |
| Air temperature (C) | | |
| Means of daily maximums | .00 | .961 |
| Means of daily minimums | .01 | .734 |
| Rainfall (total amount in cm) | .30 | .041 |
| Water level (means of afternoon readings in cm) | .00 | .905 |
| Solar radiation (means of daily totals in radons) | .08 | .322 |
| Evaporation (total amount in inches) | .03 | .588 |
| Wind (means of daily totals in miles/day) | .12 | .223 |
| Relative humidity (means of daily means in %) | .00 | .814 |
| Photoperiod (means of daily totals in minutes) | .14 | .181 |

Figure 35. Relationship between the number of terrestrial captures and the amount of precipitation recorded on a monthly basis (28 days) during the main activity period at Pond No. 1. Regression equation is $y = 15.66 + 2.32X$. Probability of a greater F-ratio for this pairing is .041, making it significant at the .05 level.

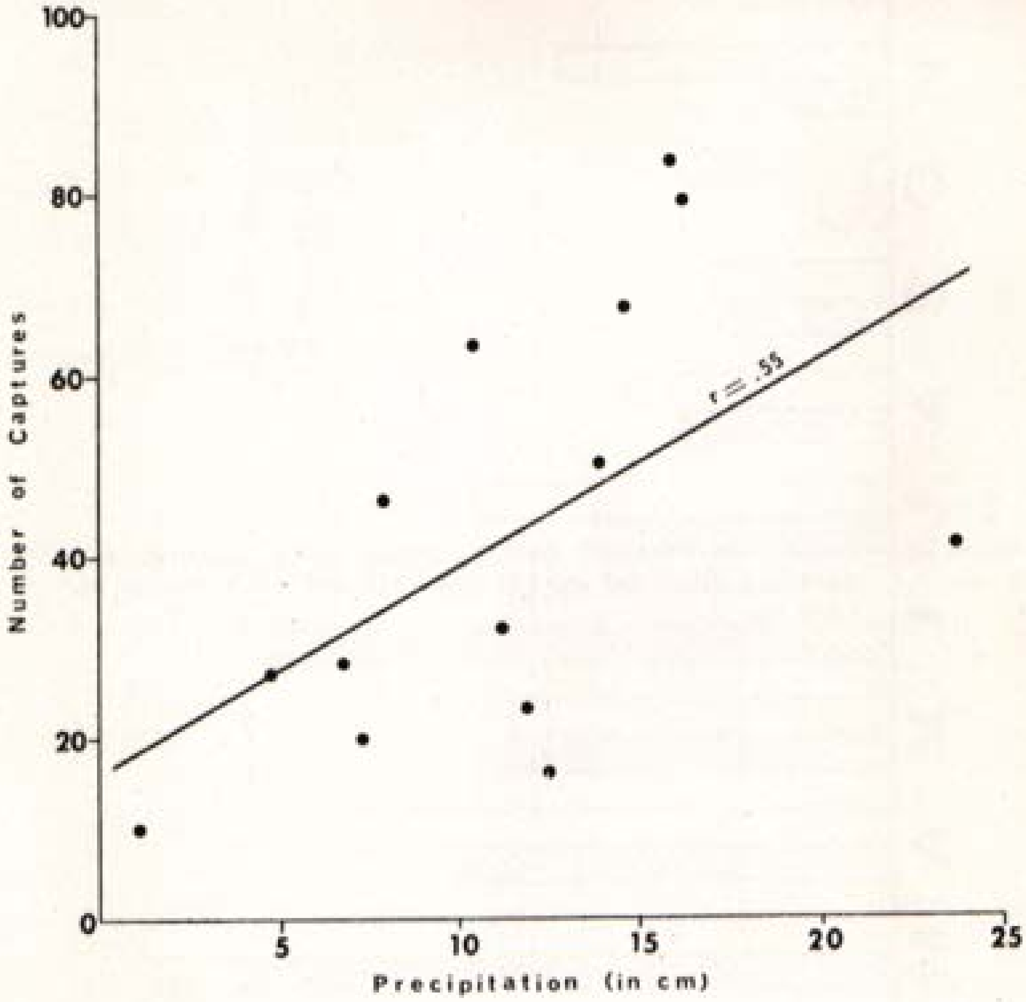
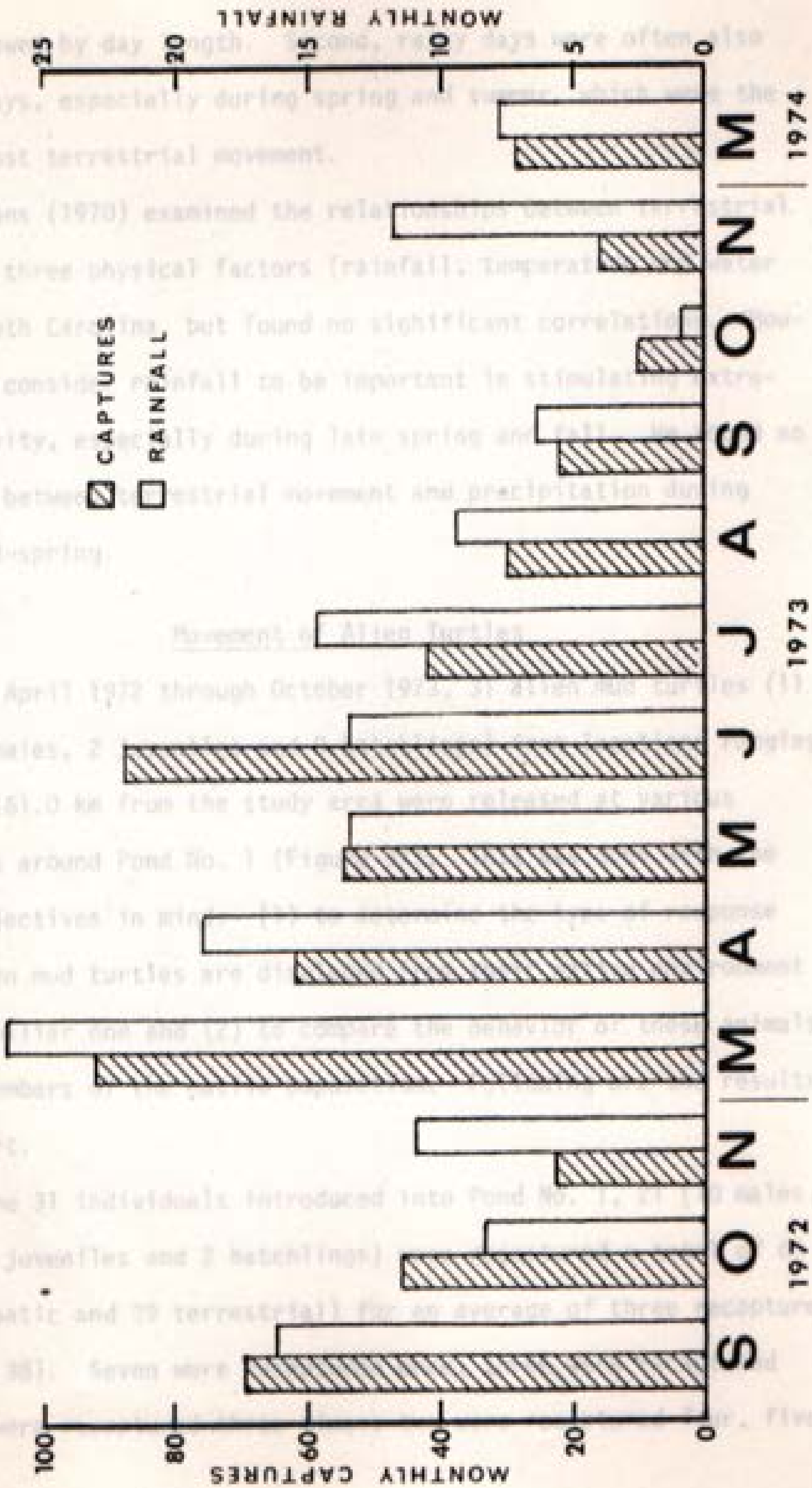

100
80
60
40
20
0
Number of Captures
r = .55
5
10
15
20
25
Precipitation (in cm)

Figure 36. Comparison of total monthly drift fence captures and rainfall recorded during the main activity period at Pond No. 1.


MONTHLY RAINFALL
25
20
15
10
5
0
CAPTURES
RAINFALL
S O N M A M J J A S O N M
1972
1973
1974
100
80
60
40
20
0
MONTHLY CAPTURES

pattern followed by day length. Second, rainy days were often also very windy days, especially during spring and summer, which were the periods of most terrestrial movement.

Gibbons (1970) examined the relationships between terrestrial movement and three physical factors (rainfall, temperature and water level) in South Carolina, but found no significant correlations. However, he did consider rainfall to be important in stimulating extra-aquatic activity, especially during late spring and fall. He found no relationship between terrestrial movement and precipitation during early and mid-spring.

## Movement of Alien Turtles

From April 1972 through October 1973, 31 alien mud turtles (11 males, 10 females, 2 juveniles and 8 hatchlings) from locations ranging from 1.6 to 161.0 km from the study area were released at various aquatic sites around Pond No. 1 (Figure 37). This was done with the following objectives in mind: (1) to determine the type of response resulting when mud turtles are displaced from their native environment into an unfamiliar one and (2) to compare the behavior of these animals to that of members of the native population. Following are the results of this effort.

Of the 31 individuals introduced into Pond No. 1, 21 (10 males, 7 females, 2 juveniles and 2 hatchlings) were recaptured a total of 63 times (24 aquatic and 39 terrestrial) for an average of three recaptures each (Figure 38). Seven were recaptured once; three were recaptured twice; four were recaptured three times; two were recaptured four, five

Figure 37. Locations (solid circles) around Pond No. 1 where 31 alien mud turtles were released. Numerals indicate sites where more than one specimen was released.

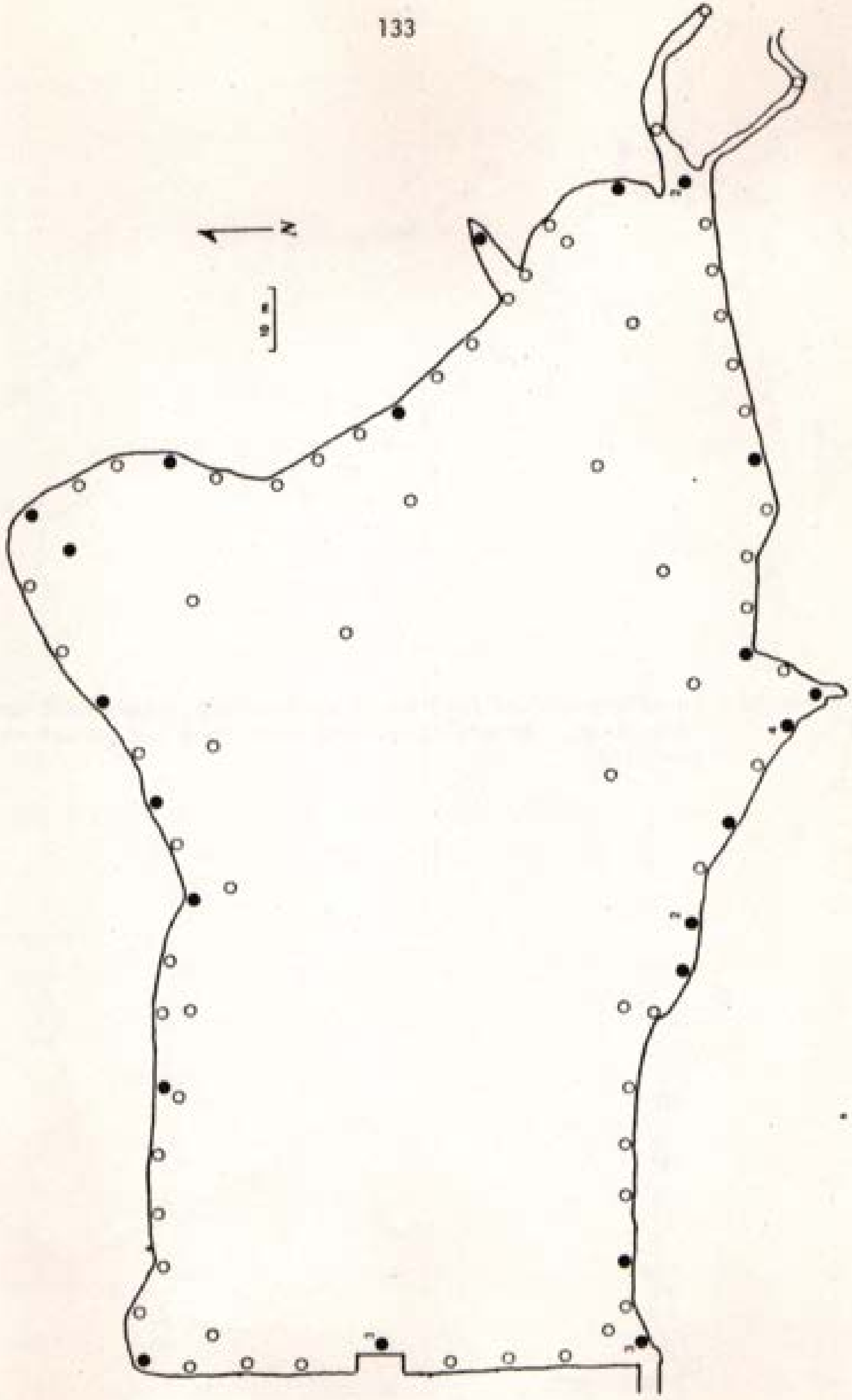
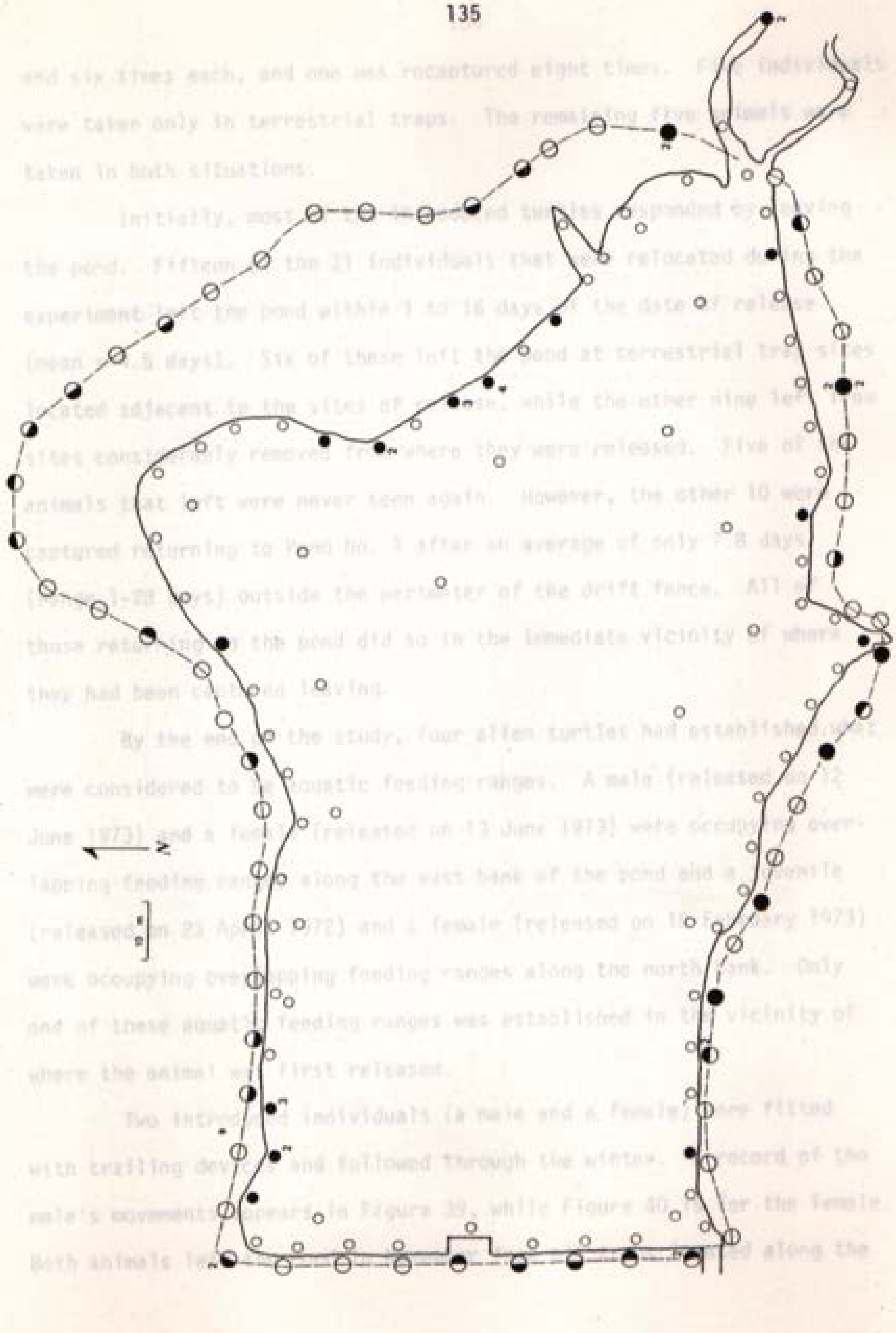


Figure 38. Locations around Pond No. 1 where alien individuals were recaptured. Numerals indicate more than one recapture per site.



and six times each, and one was recaptured eight times. Five individuals were taken only in terrestrial traps. The remaining five animals were taken in both situations.

Initially, most of the introduced turtles responded by leaving the pond. Fifteen of the 21 individuals that were relocated during the experiment left the pond within 1 to 16 days of the date of release (mean = 4.5 days). Six of these left the pond at terrestrial trap sites located adjacent to the sites of release, while the other nine left from sites considerably removed from where they were released. Five of the animals that left were never seen again. However, the other 10 were captured returning to Pond No. 1 after an average of only 7.8 days (range 1-28 days) outside the perimeter of the drift fence. All of those returning to the pond did so in the immediate vicinity of where they had been captured leaving.

By the end of the study, four alien turtles had established what were considered to be aquatic feeding ranges. A male (released on 12 June 1973) and a female (released on 13 June 1973) were occupying overlapping feeding ranges along the east bank of the pond and a juvenile (released on 23 April 1972) and a female (released on 18 February 1973) were occupying overlapping feeding ranges along the north bank. Only one of these aquatic feeding ranges was established in the vicinity of where the animal was first released.

Two introduced individuals (a male and a female) were fitted with trailing devices and followed through the winter. A record of the male's movements appears in Figure 39, while Figure 40 is for the female. Both animals left the pond in November from pit traps located along the

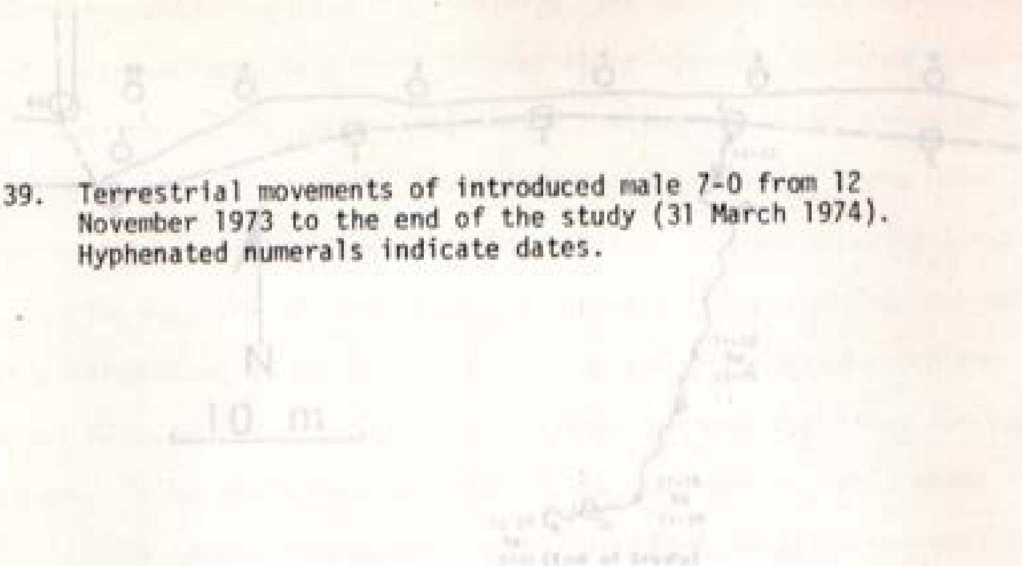



Figure 39. Terrestrial movements of introduced male 7-0 from 12 November 1973 to the end of the study (31 March 1974). Hyphenated numerals indicate dates.

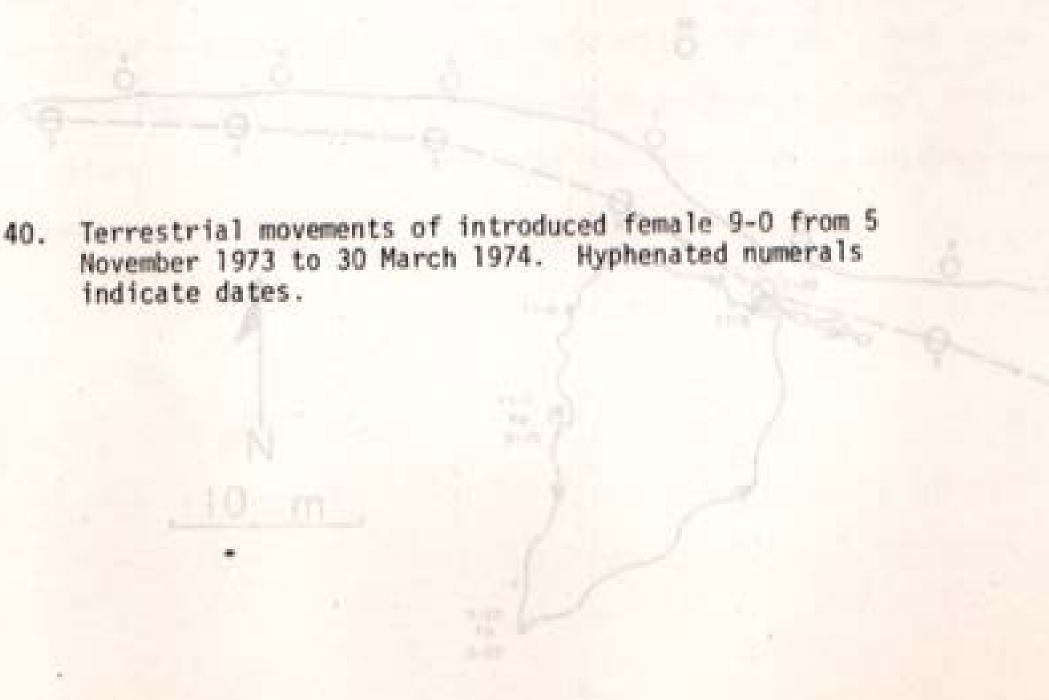
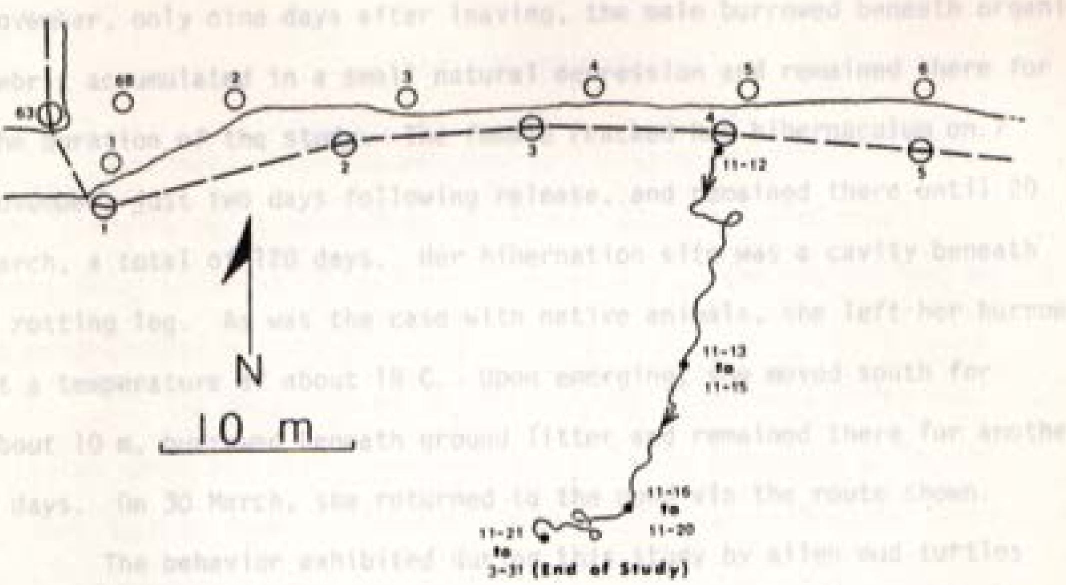
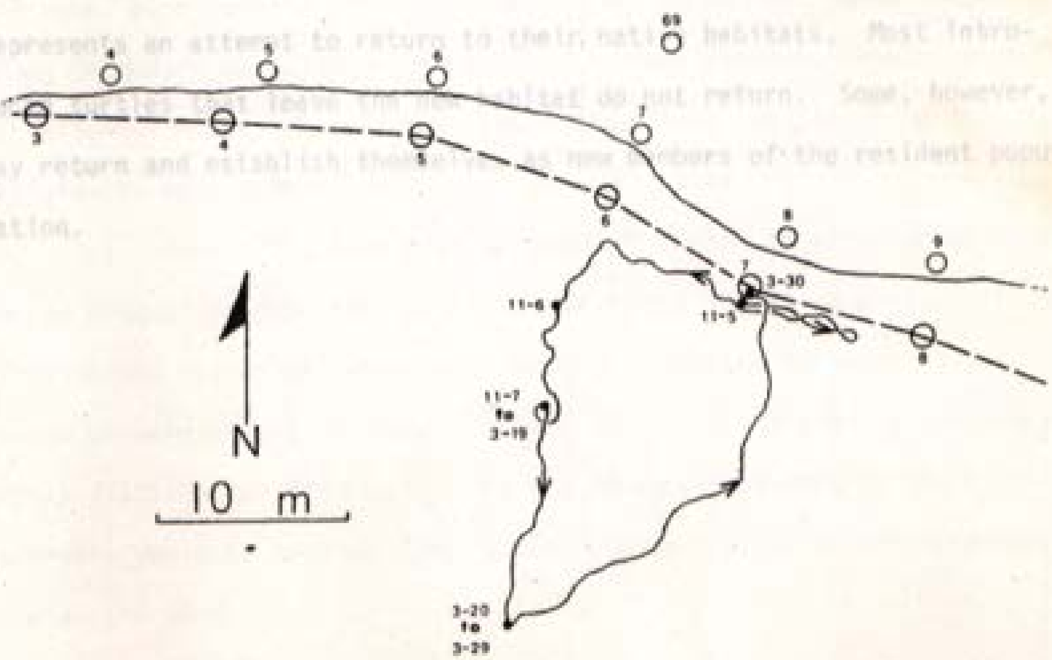



Figure 40. Terrestrial movements of introduced female 9-0 from 5 November 1973 to 30 March 1974. Hyphenated numerals indicate dates.



63
68
1
2
3
4
5
6
11-12
11-13
to
11-15
11-16
to
11-20
11-21
to
3-31 (End of Study)
N
10 m

69
3
4
5
6
7
8
9
3-30
11-5
11-6
11-7
to
3-19
3-20
to
3-29
N
10 m

pond's south shore and moved out into the adjacent pine woods. On 21 November, only nine days after leaving, the male burrowed beneath organic debris accumulated in a small natural depression and remained there for the duration of the study. The female reached her hibernaculum on 7 November, just two days following release, and remained there until 20 March, a total of 120 days. Her hibernation site was a cavity beneath a rotting log. As was the case with native animals, she left her burrow at a temperature of about 19 C. Upon emerging, she moved south for about 10 m, burrowed beneath ground litter and remained there for another 9 days. On 30 March, she returned to the pond via the route shown.

The behavior exhibited during this study by alien mud turtles suggests that there is, at least initially, a considerable amount of reluctance on the part of these animals to remain in their new surroundings. This tendency to leave the area soon after introduction probably represents an attempt to return to their native habitats. Most introduced turtles that leave the new habitat do not return. Some, however, may return and establish themselves as new members of the resident population.

## VI. CONCLUSIONS

The information accumulated during this investigation suggests the following about population structure and patterns of aquatic and terrestrial movement of farm pond populations of the eastern mud turtle in east-central Alabama:

1. The densities of the populations associated with closely situated ponds may differ markedly and probably depend on a number of factors such as habitat diversity, competition, predators, and available food and nesting sites.

2. Although the densities of local populations may vary from one pond to the next, their relative compositions probably remain about the same, particularly for individuals above 50 mm CL. Among individuals whose secondary sexual characteristics are recognizable, females seem to outnumber males, whereas throughout the entire population sexable individuals appear to outnumber the unsexable ones.

3. Spatially, farm pond populations occupy an area including a narrow zone of aquatic habitat along the pond's shoreline plus an irregularly shaped region of terrestrial habitat extending for varying distances outward around the pond. Within this area individuals are fairly evenly distributed but may be slightly more concentrated in the more favorable habitats such as heavily vegetated shoreline or marshy ground outside the pond.

4. The seasonal activity period begins during late winter when water and burrow temperatures have reached 18-19 C and continues uninterrupted until temperatures have dropped below 15-16 C, generally in the late fall. Terrestrial activity begins slightly earlier and lasts slightly later than aquatic activity.

5. Movements of individuals within the local population are restricted and occur mainly in an area that includes contiguous aquatic and terrestrial habitats. The aquatic portion of this area where feeding occurs is a narrow section of shoreline habitat which appears to be about equal in size (average length about 85 m) for males and females, but possibly somewhat smaller for unsexable juveniles (average length about 50 m). The terrestrial portion of this area where egg laying, hibernation and possibly some feeding occurs is a much larger space extending outward from the aquatic range for varying distances, the maximum recorded being 100 m.

6. Individuals displaced from their aquatic ranges to other parts of the pond show a strong tendency to return to their home areas, usually within one or two days after release.

7. Hatchlings normally begin approaching the aquatic habitat during late winter and early spring after having spent the winter on land, either in the nest or near it burrowed in ground litter. Hatching may occur at any time from November through March.

8. The amount of interchange occurring between populations occupying closely situated ponds appears to be rather limited and seems to involve a predominantly one-way exchange of individuals. Apparently

some animals are residents of one pond but travel to the vicinity of an adjacent pond to lay their eggs, and then return to their native pond.

9. Terrestrial movement seems to be substantially influenced by two physical factors: temperature and rainfall. Temperature determines the duration of the terrestrial activity period. Rainfall, through a positive linear relationship, determines the amount of terrestrial movement occurring during this period.

10. When alien individuals are introduced into the local population their initial response is to attempt to leave the area. Those failing to leave take up residence and behave as natives.

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APPENDIX

The following pages contain the raw data used in the correlation analysis between terrestrial movement and various environmental variables. The data are tabulated on a monthly basis for the main activity period (March-November) and include information from two sources. Water temperatures, air temperatures, rainfall, water levels and number of drift fence captures are from records maintained on the study area. The remaining data are from the nearest official weather station in Auburn, Alabama.

SEPTEMBER 1972

| Date | Water Temp (C) * | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (racnos) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28 | 29 | 18 | 0 | -9 | [illegible]76 | .28 | 56.1 | 71.0 | 770 | 0 |
| 2 | 26 | 30 | 14 | 0 | -9 | [illegible]60 | .26 | 35.6 | 62.5 | 768 | 0 |
| 3 | 30 | 32 | 15 | 0 | -9 | [illegible]23 | .25 | 25.7 | 67.0 | 766 | 0 |
| 4 | 31 | 33 | 17 | 0 | -10 | [illegible]93 | .19 | 21.2 | 68.0 | 764 | 0 |
| 5 | 27 | 23 | 18 | 0.30 | -10 | [illegible]93 | .22 | 38.3 | 89.0 | 761 | 7 |
| 6 | 25 | 21 | 15 | 0 | -10 | [illegible]60 | .09 | 33.5 | 93.0 | 760 | 1 |
| 7 | 24 | 29 | 13 | 0 | -11 | [illegible]91 | .08 | 37.8 | 74.0 | 758 | 1 |
| 8 | 25 | 28 | 14 | 0 | -11 | [illegible]95 | .22 | 31.3 | 72.5 | 756 | 2 |
| 9 | 26 | 31 | 18 | 0 | -11 | [illegible]26 | .16 | 27.0 | 74.0 | 754 | 3 |
| 10 | 26 | 29 | 19 | 0 | -12 | [illegible]44 | .25 | 80.0 | 73.5 | 753 | 1 |
| 11 | 27 | 29 | 16 | 0 | -12 | [illegible]79 | .26 | 69.5 | 64.5 | 751 | 2 |
| 12 | 24 | 30 | 13 | 0 | -13 | [illegible]94 | .24 | 52.6 | 58.5 | 749 | 0 |
| 13 | 25 | 33 | 13 | 0 | -14 | [illegible]75 | .26 | 28.9 | 56.5 | 747 | 0 |
| 14 | 25 | 33 | 14 | 0 | -15 | [illegible]48 | .25 | 21.6 | 64.0 | 744 | 0 |
| 15 | 30 | 34 | 16 | 0 | -15 | [illegible]32 | .26 | 27.6 | 54.5 | 742 | 0 |
| 16 | 31 | 34 | 17 | 0 | -16 | [illegible]71 | .26 | 34.6 | 61.5 | 741 | 1 |
| 17 | 31 | 33 | 21 | 0 | -17 | [illegible]54 | .30 | 44.5 | 68.0 | 739 | 1 |
| 18 | 30 | 28 | 18 | 6.55 | -14 | [illegible]37 | - | 36.0 | 99.0 | 737 | 22 |
| 19 | 32 | 30 | 17 | 0 | -14 | [illegible]52 | - | 30.9 | 77.5 | 735 | 1 |
| 20 | 32 | 32 | 20 | 0 | -14 | [illegible]75 | .22 | 56.2 | 70.0 | 733 | 1 |
| 21 | 29 | 32 | 19 | 0 | -15 | [illegible]61 | .28 | 65.2 | 81.0 | 731 | 1 |
| 22 | 32 | 31 | 15 | 0 | -15 | [illegible]07 | .13 | 27.2 | 75.5 | 729 | 2 |
| 23 | 32 | 32 | 16 | 0 | -16 | [illegible]40 | .21 | 26.1 | 68.5 | 727 | 1 |
| 24 | 29 | 29 | 18 | 0 | -16 | 417 | .21 | 31.0 | 65.0 | 725 | 0 |
| 25 | 29 | 30 | 18 | 0 | -17 | [illegible]40 | .20 | 44.1 | 66.5 | 723 | 0 |
| 26 | 30 | 30 | 23 | 3.40 | -14 | [illegible]04 | .18 | 53.1 | 88.5 | 722 | 13 |
| 27 | 33 | 32 | 19 | 0 | -14 | 401 | .12 | 30.7 | 75.5 | 720 | 0 |
| 28 | 32 | 32 | 18 | 0.08 | -14 | 433 | .20 | 58.1 | 75.5 | 718 | 3 |
| 29 | 31 | 31 | 19 | 0 | -15 | 373 | .27 | 22.0 | 80.5 | 716 | 0 |
| 30 | 26 | 23 | 9 | 5.89 | 0 | 129 | - | 67.5 | 94.0 | 713 | 9 |

OCTOBER 1972

| Date | Water Temp (C) | Air Temp (C) | | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (rudons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | | | | | | | | |
| 1 | 23 | 20 | 5 | 0 | 0 | 442 | .12 | 88.5 | 71.0 | 711 | 0 |
| 2 | 22 | 29 | 9 | 0 | 0 | 378 | .17 | 58.6 | 68.0 | 710 | 0 |
| 3 | 24 | 25 | 14 | 0 | -1 | 358 | .21 | 81.2 | 70.0 | 709 | 4 |
| 4 | 25 | 27 | 15 | 0 | -1 | 356 | .22 | 68.4 | 71.0 | 706 | 0 |
| 5 | 28 | 25 | 16 | 0 | -1 | 280 | .11 | 36.0 | 88.5 | 704 | 0 |
| 6 | 23 | 24 | 11 | 0 | -2 | 394 | .12 | 40.8 | 70.5 | 702 | 1 |
| 7 | 22 | 24 | 10 | 0 | -2 | 377 | .22 | 75.1 | 71.0 | 700 | 3 |
| 8 | 24 | 25 | 6 | 0 | -3 | 441 | .23 | 71.2 | 62.5 | 698 | 0 |
| 9 | 24 | 28 | 5 | 0 | -3 | 424 | .16 | 40.2 | 51.0 | 696 | 0 |
| 10 | 22 | 24 | 10 | 0 | -3 | 338 | .19 | 55.0 | 58.0 | 695 | 0 |
| 11 | 23 | 24 | 10 | 0 | -4 | 434 | .25 | 86.1 | 57.5 | 693 | 0 |
| 12 | 24 | 25 | 8 | 0 | -5 | 306 | .15 | 58.6 | 60.5 | 690 | 1 |
| 13 | 24 | 26 | 10 | 0 | -5 | 317 | .15 | 26.1 | 79.5 | 688 | 0 |
| 14 | 26 | 27 | 12 | 0 | -5 | 317 | .15 | 30.2 | 75.5 | 687 | 3 |
| 15 | 25 | 24 | 11 | 1.73 | -4 | 330 | .18 | 44.1 | 75.5 | 685 | 12 |
| 16 | 25 | 26 | 8 | 0 | -4 | 376 | .18 | 46.0 | 69.5 | 683 | 3 |
| 17 | 25 | 29 | 14 | 0 | -4 | 312 | .16 | 24.6 | 81.5 | 681 | 2 |
| 18 | 26 | 28 | 16 | 0 | -4 | 332 | .12 | 38.2 | 79.5 | 680 | 1 |
| 19 | 21 | 18 | 5 | 3.06 | -5 | 167 | .16 | 33.4 | 86.5 | 678 | 0 |
| 20 | 18 | 16 | 5 | 0 | -5 | 373 | .14 | 117.3 | 63.5 | 675 | 0 |
| 21 | 17 | 19 | 5 | 0 | -6 | 204 | .24 | 98.7 | 49.5 | 673 | 0 |
| 22 | 18 | 26 | 10 | 0 | -7 | 357 | .11 | 82.3 | 56.5 | 672 | 1 |
| 23 | 19 | 22 | 18 | 0.25 | -7 | 63 | .09 | 53.3 | 93.5 | 670 | 3 |
| 24 | 20 | 23 | 11 | 0 | -7 | 265 | .11 | 49.5 | 76.0 | 668 | 2 |
| 25 | 18 | 18 | 4 | 0 | -7 | 377 | .18 | 67.3 | 71.0 | 666 | 1 |
| 26 | 18 | 18 | 3 | 0 | -8 | 322 | .15 | 69.9 | 83.0 | 665 | 0 |
| 27 | 18 | 20 | 15 | 3.31 | -2 | 58 | .04 | 67.2 | 99.0 | 663 | 6 |
| 28 | 17 | 16 | 12 | 0 | -2 | 102 | .03 | 92.2 | 85.5 | 661 | 0 |
| 29 | 18 | 20 | 13 | 0 | -2 | 174 | .05 | 44.7 | 86.0 | 659 | 1 |
| 30 | 19 | 24 | 12 | 0 | -2 | 251 | .05 | 41.9 | 76.5 | 657 | 0 |
| 31 | 20 | 26 | 15 | 0 | -2 | 241 | .11 | 55.2 | 77.0 | 655 | 2 |

NOVEMBER 1972

| Date | Water Temp (C) | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (ralons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *19 | 23 | 16 | 0.03 | -2 | 82 | .10 | 50.7 | 95.0 | 654 | 1 |
| 2 | 22 | 27 | 17 | 0 | -2 | 219 | .03 | 44.7 | 83.0 | 653 | 2 |
| 3 | 21 | 24 | 16 | 0.89 | -1 | 109 | .01 | 60.3 | 84.5 | 651 | 4 |
| 4 | 20 | 23 | 8 | 0 | -1 | 106 | .08 | 31.3 | 66.5 | 649 | 0 |
| 5 | 19 | 20 | 7 | 0 | -2 | 144 | .18 | 75.4 | 64.0 | 647 | 3 |
| 6 | 16 | 17 | 13 | 0.05 | -2 | 78 | .07 | 55.4 | 91.5 | 646 | 0 |
| 7 | 16 | 16 | 11 | 1.55 | -1 | 59 | .04 | 79.4 | 91.0 | 644 | 4 |
| 8 | 17 | 20 | 5 | 0.03 | -1 | 129 | .11 | 59.8 | 68.0 | 643 | 1 |
| 9 | 18 | 22 | 1 | 0 | -1 | 143 | .12 | 60.0 | 63.5 | 641 | 2 |
| 10 | 16 | 19 | 5 | 0.05 | -1 | 164 | .09 | 19.5 | 82.5 | 640 | 1 |
| 11 | 17 | 18 | 5 | 0 | -1 | 184 | .03 | 55.0 | 72.5 | 638 | 0 |
| 12 | 19 | 23 | 8 | 0 | -1 | 120 | .11 | 55.5 | 59.5 | 637 | 0 |
| 13 | 17 | 20 | 9 | 1.63 | +2 | 88 | .11 | 33.2 | 85.5 | 635 | 3 |
| 14 | 16 | 16 | 9 | 1.42 | +2 | 137 | .14 | 75.1 | 73.5 | 634 | 0 |
| 15 | 15 | 13 | 1 | 0 | +1 | 107 | .18 | 90.2 | 62.5 | 632 | 2 |
| 16 | 14 | 12 | 2 | 0 | +1 | 174 | .13 | 30.5 | 76.5 | 631 | 0 |
| 17 | 13 | 11 | -1 | 0 | +1 | 208 | .06 | 104.0 | 75.0 | 629 | 0 |
| 18 | 12 | 12 | -2 | 0 | +1 | 170 | .06 | 55.4 | 75.5 | 628 | 0 |
| 19 | 12 | 17 | 7 | 1.70 | +2 | 84 | .05 | 81.2 | 98.0 | 627 | 0 |
| 20 | 11 | 6 | 3 | 0 | +1 | 92 | .03 | 88.7 | 92.0 | 626 | 0 |
| 21 | 11 | 12 | 5 | 0 | +1 | 215 | .05 | 74.4 | 76.5 | 624 | 0 |
| 22 | 10 | 9 | 0 | 0 | +1 | 154 | .10 | 35.3 | 76.0 | 623 | 0 |
| 23 | 10 | 8 | -1 | 0 | +1 | 209 | .02 | 66.2 | 75.5 | 621 | 0 |
| 24 | 10 | 9 | -3 | 0 | +1 | 212 | .08 | 75.4 | 67.5 | 620 | 0 |
| 25 | 12 | 12 | 3 | 3.05 | +3 | 33 | .02 | 66.6 | 88.5 | 620 | 0 |
| 26 | 9 | 10 | 4 | 0 | +2 | 230 | .04 | 166.0 | 67.5 | 619 | 0 |
| 27 | 10 | 18 | -4 | 0 | +2 | 310 | .06 | 120.0 | 58.0 | 617 | 0 |
| 28 | 10 | 14 | 4 | 0.08 | +2 | 138 | .15 | 82.3 | 99.5 | 616 | 0 |
| 29 | 10 | 13 | 3 | 0 | +1 | 237 | .05 | 91.4 | 68.5 | 615 | 0 |
| 30 | 9 | 9 | 6 | 0.53 | +1 | 131 | .07 | 66.0 | 98.5 | 614 | 0 |

MARCH 1973

| Date | Water Temp (C) * | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (radians) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12 | 18 | 5 | 0 | +2 | 310 | .16 | 64.8 | 66.0 | 690 | 0 |
| 2 | 11 | 18 | 10 | 1.07 | +3 | 117 | .14 | 89.4 | 79.0 | 692 | 0 |
| 3 | 15 | 23 | 11 | 0 | +3 | 232 | .03 | 72.7 | 80.0 | 694 | 1 |
| 4 | 15 | 19 | 11 | 1.17 | +3 | 139 | .10 | 32.9 | 97.5 | 696 | 4 |
| 5 | 16 | 25 | 11 | 0 | +3 | 119 | .02 | 35.9 | 100.0 | 698 | 1 |
| 6 | 18 | 24 | 14 | 0.58 | +4 | 272 | .11 | 43.6 | 88.5 | 699 | 5 |
| 7 | 19 | 25 | 15 | 1.27 | +5 | 217 | .13 | 102.0 | 86.0 | 701 | 6 |
| 8 | 21 | 26 | 15 | 0 | +5 | 313 | .10 | 52.1 | 75.5 | 703 | 5 |
| 9 | 19 | 21 | 17 | 0.05 | +5 | 210 | .18 | 42.4 | 95.0 | 706 | 8 |
| 10 | 18 | 22 | 16 | 0 | +5 | 170 | .09 | 68.9 | 95.0 | 707 | 9 |
| 11 | 18 | 21 | 11 | 2.67 | +6 | 78 | .09 | 107.5 | 100.0 | 709 | 4 |
| 12 | 21 | 21 | 7 | 0.76 | +3 | 434 | - | 47.1 | 67.5 | 711 | 5 |
| 13 | 23 | 27 | 8 | 0 | +3 | 317 | .16 | 24.7 | 81.5 | 713 | 4 |
| 14 | 22 | 26 | 18 | 0 | +2 | 219 | .15 | 62.2 | 84.0 | 715 | 9 |
| 15 | 23 | 28 | 20 | 0 | +2 | 211 | .12 | 75.3 | 83.0 | 717 | 10 |
| 16 | 21 | 24 | 10 | 0.28 | +4 | 110 | .17 | 100.7 | 94.0 | 719 | 8 |
| 17 | 15 | 12 | 4 | 2.54 | +4 | 414 | - | 171.0 | 63.5 | 721 | 3 |
| 18 | 16 | 18 | -1 | 0 | +3 | 513 | .23 | 121.7 | 59.0 | 723 | 0 |
| 19 | 17 | 23 | 1 | 0 | +3 | 439 | .16 | 40.8 | 65.0 | 725 | 0 |
| 20 | 16 | 15 | 11 | 1.65 | +4 | 71 | .19 | 51.3 | 100.0 | 727 | 1 |
| 21 | 15 | 15 | 18 | 0 | +3 | 374 | .14 | 89.6 | 85.0 | 729 | 0 |
| 22 | 17 | 18 | -1 | 0 | +3 | 511 | .13 | 94.5 | 51.0 | 730 | 0 |
| 23 | 17 | 22 | 3 | 0 | +3 | 511 | .21 | 77.0 | 48.5 | 733 | 0 |
| 24 | 15 | 17 | 9 | 0 | +3 | 236 | .22 | 65.3 | 50.5 | 735 | 0 |
| 25 | 15 | 24 | 12 | 2.82 | +8 | 333 | .20 | 148.8 | 80.5 | 737 | 0 |
| 26 | 15 | 15 | 11 | 0 | +3 | 137 | .19 | 80.7 | 81.5 | 739 | 0 |
| 27 | 17 | 19 | 8 | 0 | +3 | 412 | .11 | 85.2 | 73.5 | 741 | 0 |
| 28 | 17 | 22 | 8 | 0 | +3 | 314 | .13 | 36.1 | 64.5 | 743 | 0 |
| 29 | 15 | 14 | 13 | 0.30 | +3 | 116 | .20 | 100.2 | 100.0 | 745 | 0 |
| 30 | 13 | 15 | 11 | 4.39 | +11 | 111 | .08 | 79.3 | 100.0 | 747 | 0 |
| 31 | 18 | 23 | 15 | 6.86 | +19 | 136 | - | 100.3 | 100.0 | 749 | 8 |

APRIL 1973

| Date | Water Temp (C) | Air Temp (C) | | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (radons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | | | | | | | | |
| 1 | 19 | 24 | 14 | 2.29 | +7 | 342 | .19 | 98.8 | 67.0 | 751 | 14 |
| 2 | 20 | 23 | 5 | 0 | +3 | 583 | .28 | 82.2 | 47.5 | 753 | 3 |
| 3 | 18 | 17 | 6 | 0.41 | +3 | 199 | .23 | 48.0 | 93.5 | 755 | 0 |
| 4 | 16 | 15 | 5 | 0 | +3 | 511 | .05 | 73.2 | 77.5 | 756 | 1 |
| 5 | 16 | 17 | 2 | 0 | +3 | 517 | .17 | 84.1 | 68.0 | 758 | 1 |
| 6 | 18 | 19 | 2 | 0 | +3 | 106 | .20 | 54.6 | 60.5 | 760 | 0 |
| 7 | 15 | 18 | 10 | 6.15 | +13 | 170 | .26 | 74.3 | 96.0 | 763 | 2 |
| 8 | 17 | 18 | 9 | 0 | +4 | 589 | .08 | 34.1 | 73.0 | 764 | 0 |
| 9 | 16 | 17 | 6 | 0 | +3 | 391 | .14 | 92.4 | 97.5 | 766 | 0 |
| 10 | 15 | 13 | 3 | 0 | +3 | 599 | .17 | 110.5 | 46.5 | 768 | 1 |
| 11 | 15 | 15 | -4 | 0 | +3 | 495 | .23 | 97.0 | 46.5 | 770 | 0 |
| 12 | 17 | 21 | -1 | 0 | +3 | 572 | .21 | 62.4 | 52.5 | 772 | 0 |
| 13 | 19 | 21 | 7 | 0 | +3 | 581 | .24 | 80.5 | 61.0 | 774 | 0 |
| 14 | 20 | 23 | 6 | 0 | +3 | 558 | .33 | 159.9 | 34.0 | 775 | 0 |
| 15 | 20 | 23 | 7 | 0 | +3 | 423 | .21 | 47.3 | 69.5 | 777 | 1 |
| 16 | 21 | 21 | 14 | 0 | +3 | 195 | .18 | 78.5 | 64.5 | 779 | 6 |
| 17 | 20 | 21 | 14 | 0 | +3 | 474 | .22 | 77.1 | 79.5 | 781 | 0 |
| 18 | 18 | 20 | 15 | 0.30 | +4 | 233 | .13 | 85.8 | 90.0 | 783 | 4 |
| 19 | 23 | 26 | 14 | 1.30 | +5 | 145 | .10 | 98.6 | 79.0 | 785 | 6 |
| 20 | 24 | 26 | 15 | 0 | +3 | 561 | .28 | 88.0 | 76.0 | 786 | 1 |
| 21 | 25 | 26 | 15 | 0 | +3 | 512 | .20 | 58.9 | 70.0 | 788 | 4 |
| 22 | 22 | 25 | 15 | 0 | +3 | 416 | .22 | 57.6 | 55.0 | 790 | 1 |
| 23 | 23 | 24 | 15 | 0 | +3 | 146 | .22 | 56.2 | 85.0 | 792 | 3 |
| 24 | 25 | 27 | 18 | 0 | +2 | 190 | .13 | 49.2 | 75.1 | 794 | 4 |
| 25 | 21 | 19 | 17 | 4.95 | +6 | 122 | - | 67.7 | 100.0 | 796 | 5 |
| 26 | 20 | 19 | 15 | 3.56 | +9 | 173 | - | 46.3 | 100.0 | 797 | 1 |
| 27 | 18 | 17 | 8 | 0 | +5 | 213 | - | 80.4 | 88.0 | 799 | 1 |
| 28 | 19 | 19 | 6 | 0 | +4 | 632 | .23 | 89.8 | 80.5 | 801 | 2 |
| 29 | 23 | 23 | 8 | 0 | +4 | 624 | .27 | 56.5 | 61.0 | 803 | 0 |
| 30 | 25 | 26 | 6 | 0 | +3 | 607 | .20 | 26.9 | 68.5 | 804 | 1 |

MAY 1973

| Date | Water Temp (C) | Air Temp (C) | | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (radons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | | | | | | | | |
| 1 | 25 | 26 | 12 | 0 | +3 | 474 | .20 | 26.9 | 75.0 | 806 | 2 |
| 2 | 24 | 25 | 16 | 0 | +3 | 303 | .25 | 88.0 | 74.0 | 807 | 0 |
| 3 | 22 | 22 | 15 | 0.33 | +3 | 171 | .12 | 50.4 | 92.5 | 809 | 2 |
| 4 | 24 | 23 | 5 | 0 | +3 | 635 | .09 | 78.3 | 63.0 | 810 | 1 |
| 5 | 25 | 25 | 3 | 0 | +3 | 606 | .34 | 83.1 | 45.5 | 812 | 0 |
| 6 | 21 | 20 | 7 | 0 | +3 | 359 | .31 | 31.7 | 71.5 | 814 | 2 |
| 7 | 22 | 25 | 14 | 0 | +3 | 296 | .10 | 50.2 | 74.5 | 816 | 2 |
| 8 | 21 | 25 | 18 | 3.68 | +6 | 250 | .10 | 91.2 | 97.0 | 817 | 0 |
| 9 | 25 | 27 | 14 | 0 | +4 | 530 | .19 | 59.7 | 88.0 | 819 | 2 |
| 10 | 27 | 30 | 11 | 0 | +3 | 537 | .30 | 41.0 | 71.0 | 820 | 2 |
| 11 | 28 | 30 | 17 | 0 | +3 | 537 | .29 | 55.4 | 71.0 | 821 | 2 |
| 12 | 26 | 25 | 15 | 0.08 | +3 | 332 | .29 | 60.5 | 83.0 | 823 | 1 |
| 13 | 23 | 23 | 14 | 0 | +3 | 333 | .29 | 86.5 | 62.5 | 825 | 0 |
| 14 | 24 | 24 | 10 | 0 | +2 | 533 | .11 | 53.0 | 50.5 | 826 | 1 |
| 15 | 23 | 23 | 7 | 0 | +2 | 395 | .32 | 77.3 | 50.0 | 827 | 1 |
| 16 | 23 | 23 | 3 | 0 | +2 | 636 | .30 | 90.0 | 49.0 | 829 | 3 |
| 17 | 23 | 25 | 6 | 0 | +2 | 636 | .27 | 43.0 | 72.0 | 830 | 0 |
| 18 | 23 | 23 | 6 | 0 | +2 | 533 | .29 | 91.7 | 44.5 | 831 | 1 |
| 19 | 21 | 27 | 8 | 0.64 | +3 | 332 | .20 | 40.0 | 83.0 | 833 | 2 |
| 20 | 25 | 26 | 15 | 1.32 | +3 | 395 | .29 | 76.7 | 80.5 | 834 | 1 |
| 21 | 26 | 28 | 13 | 0 | +2 | 514 | .12 | 37.0 | 76.5 | 835 | 1 |
| 22 | 29 | 30 | 14 | 2.36 | +5 | 332 | .27 | 38.1 | 78.5 | 836 | 3 |
| 23 | 28 | 30 | 20 | 0 | +3 | 415 | .22 | 47.5 | 80.0 | 838 | 4 |
| 24 | 26 | 27 | 17 | 2.03 | +5 | 316 | - | 93.8 | 92.5 | 839 | 6 |
| 25 | 23 | 28 | 13 | 0.74 | +5 | 217 | .19 | 61.9 | 89.0 | 840 | 0 |
| 26 | 23 | 27 | 18 | 0.97 | +5 | 260 | .14 | 35.6 | 100.0 | 841 | 5 |
| 27 | 27 | 30 | 18 | 0.03 | +4 | 250 | .11 | 75.2 | 92.5 | 842 | 1 |
| 28 | 27 | 30 | 18 | 1.32 | +6 | 461 | .22 | 125.3 | 87.5 | 842 | 2 |
| 29 | 29 | 27 | 17 | 0 | +6 | 393 | .30 | 98.5 | 81.0 | 843 | 4 |
| 30 | 30 | 29 | 14 | 0 | +6 | 593 | .24 | 41.8 | 71.0 | 844 | 1 |
| 31 | 32 | 31 | 15 | 0 | +4 | 514 | .28 | 34.5 | 69.0 | 845 | 3 |

JUNE 1973

| Date | Water Temp (C) * | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (ralons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 | 25 | 18 | 3.35 | +11 | 571 | .28 | 31.4 | 88.5 | 846 | 3 |
| 2 | 31 | 30 | 15 | 0 | +6 | 575 | .12 | 26.4 | 73.5 | 847 | 1 |
| 3 | 31 | 31 | 17 | 0 | +4 | 511 | .22 | 33.1 | 83.0 | 848 | 7 |
| 4 | 31 | 29 | 18 | 0 | +3 | 570 | .25 | 34.7 | 72.0 | 848 | 2 |
| 5 | 31 | 31 | 20 | 0 | +2 | 432 | .30 | 41.8 | 80.0 | 849 | 4 |
| 6 | 28 | 25 | 20 | 1.05 | +4 | 564 | .17 | 41.0 | 100.0 | 849 | 4 |
| 7 | 28 | 28 | 20 | 0 | +4 | 445 | .25 | 44.7 | 85.5 | 850 | 1 |
| 8 | 28 | 29 | 19 | 1.27 | +4 | 513 | .18 | 47.6 | 89.0 | 851 | 4 |
| 9 | 29 | 30 | 21 | 0 | +3 | 472 | .26 | 74.3 | 81.0 | 852 | 3 |
| 10 | 30 | 30 | 19 | 0.03 | +3 | 466 | .19 | 44.3 | 82.5 | 852 | 3 |
| 11 | 31 | 31 | 20 | 0 | +3 | 532 | .16 | 46.9 | 79.0 | 853 | 4 |
| 12 | 29 | 30 | 22 | 0 | +2 | 224 | .25 | 33.7 | 85.0 | 853 | 6 |
| 13 | 30 | 30 | 20 | 0.18 | +2 | 463 | .13 | 35.4 | 86.0 | 854 | 3 |
| 14 | 30 | 32 | 20 | 1.52 | +4 | 403 | .20 | 22.4 | 83.0 | 854 | 2 |
| 15 | 32 | 32 | 19 | 0 | +2 | 604 | .16 | 29.7 | 76.0 | 854 | 1 |
| 16 | 32 | 32 | 20 | 0 | +2 | 550 | .32 | 44.7 | 80.0 | 854 | 1 |
| 17 | 33 | 32 | 21 | 1.40 | +3 | 417 | .28 | 45.3 | 76.0 | 854 | 6 |
| 18 | 33 | 32 | 19 | 0 | +2 | 534 | .23 | 42.9 | 80.0 | 855 | 1 |
| 19 | 34 | 34 | 19 | 0 | +2 | 516 | .22 | 27.4 | 81.5 | 855 | 3 |
| 20 | 31 | 30 | 20 | 2.26 | +3 | 419 | .05 | 48.0 | 85.0 | 855 | 5 |
| 21 | 33 | 32 | 19 | 0 | +2 | 510 | .32 | 29.9 | 81.0 | 855 | 5 |
| 22 | 32 | 31 | 19 | 0 | +2 | 516 | .24 | 35.1 | 78.0 | 854 | 0 |
| 23 | 31 | 30 | 16 | 0 | +2 | 377 | .33 | 62.1 | 69.0 | 854 | 2 |
| 24 | 29 | 31 | 16 | 0 | +2 | 618 | .27 | 47.1 | 65.5 | 854 | 1 |
| 25 | 29 | 30 | 16 | 1.65 | +2 | 512 | .02 | 42.8 | 79.0 | 855 | 6 |
| 26 | 32 | 33 | 15 | 0 | +2 | 533 | .26 | 33.7 | 70.5 | 855 | 0 |
| 27 | 32 | 32 | 19 | 0 | +2 | 519 | .20 | 22.7 | 76.0 | 854 | 4 |
| 28 | 31 | 30 | 21 | 0 | +2 | 4 5 | .28 | 32.7 | 80.5 | 854 | 2 |
| 29 | 31 | 29 | 18 | 0 | +1 | 648 | .22 | 58.1 | 68.0 | 853 | 3 |
| 30 | 32 | 32 | 16 | 0 | +1 | 5 2 | .24 | 47.4 | 66.5 | 853 | 1 |

JULY 1973

| Date | Water Temp (C) | Air Temp (C) | | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (r. dums) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | | | | | | | | |
| 1 | 31 | 32 | 18 | 0 | +1 | 352 | .24 | 20.2 | 72.0 | 853 | 1 |
| 2 | 33 | 34 | 19 | 0 | +1 | 495 | .16 | 15.5 | 72.0 | 853 | 3 |
| 3 | 34 | 35 | 20 | 0 | +1 | 551 | .26 | 27.4 | 71.0 | 852 | 2 |
| 4 | 34 | 35 | 20 | 0 | +1 | 539 | .23 | 33.7 | 72.5 | 852 | 1 |
| 5 | 34 | 33 | 21 | 0 | +1 | 520 | .31 | 42.2 | 70.0 | 851 | 4 |
| 6 | 32 | 31 | 21 | 0 | +1 | 381 | .29 | 33.3 | 79.0 | 850 | 0 |
| 7 | 33 | 32 | 20 | 3.30 | +4 | 528 | .25 | 30.5 | 81.0 | 849 | 2 |
| 8 | 33 | 32 | 21 | 0 | +2 | 556 | .25 | 30.5 | 81.0 | 849 | 2 |
| 9 | 32 | 29 | 20 | 0 | +2 | 553 | .25 | 30.5 | 82.5 | 848 | 2 |
| 10 | 34 | 32 | 20 | 2.84 | +2 | 527 | .21 | 49.5 | 81.0 | 848 | 2 |
| 11 | 32 | 30 | 19 | 1.55 | +3 | 92 | .43 | 48.8 | 87.0 | 847 | 5 |
| 12 | 32 | 31 | 20 | 0 | +2 | 553 | .20 | 70.0 | 95.0 | 846 | 2 |
| 13 | 31 | 33 | 22 | 0 | +2 | 277 | .24 | 63.7 | 81.0 | 845 | 1 |
| 14 | 30 | 29 | 23 | 1.63 | +4 | 224 | .23 | 51.8 | 100.0 | 844 | 5 |
| 15 | 31 | 31 | 22 | 0 | +3 | 501 | .22 | 36.6 | 81.0 | 843 | 0 |
| 16 | 31 | 32 | 19 | 0.76 | +3 | 352 | .21 | 31.0 | 82.0 | 842 | 0 |
| 17 | 33 | 33 | 22 | 0 | +1 | 487 | .24 | 41.0 | 82.0 | 841 | 2 |
| 18 | 30 | 30 | 22 | 1.14 | +3 | 369 | .28 | 37.7 | 100.0 | 840 | 2 |
| 19 | 28 | 30 | 22 | 1.47 | +4 | 329 | .24 | 39.7 | 91.5 | 830 | 2 |
| 20 | 33 | 32 | 20 | 0 | +3 | 567 | .18 | 40.4 | 80.5 | 837 | 0 |
| 21 | 34 | 33 | 19 | 0 | +2 | 461 | .27 | 25.4 | 77.0 | 836 | 0 |
| 22 | 34 | 34 | 21 | 0 | +2 | 487 | .25 | 22.5 | 81.0 | 835 | 1 |
| 23 | 35 | 34 | 21 | 0 | +2 | 396 | .24 | 17.0 | 76.0 | 834 | 0 |
| 24 | 35 | 33 | 22 | 0 | +2 | 461 | .33 | 36.6 | 77.0 | 833 | 0 |
| 25 | 32 | 32 | 22 | 0.15 | +2 | 435 | .24 | 38.1 | 98.0 | 832 | 0 |
| 26 | 33 | 31 | 20 | 0.13 | +2 | 356 | .18 | 24.6 | 88.0 | 831 | 0 |
| 27 | 32 | 32 | 21 | 0.84 | +3 | 352 | .24 | 21.2 | 86.0 | 829 | 1 |
| 28 | 32 | 33 | 21 | 0.03 | +2 | 487 | .21 | 34.5 | 86.0 | 827 | 0 |
| 29 | 34 | 34 | 20 | 0 | +2 | 527 | .30 | 39.6 | 71.0 | 826 | 0 |
| 30 | 33 | 34 | 22 | 0.97 | +2 | 353 | .28 | 15.2 | 80.0 | 825 | 2 |
| 31 | 35 | 34 | 21 | 0 | +2 | 329 | .20 | 20.8 | 86.5 | 824 | 0 |

AUGUST 1973

| Date | Water Temp (C) | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (radons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * 30 | 32 | 22 | 0.33 | +2 | 250 | .24 | 40.3 | 91.5 | 822 | 0 |
| 2 | 28 | 29 | 22 | 1.93 | +4 | 437 | .18 | 36.3 | 100.0 | 821 | 2 |
| 3 | 30 | 30 | 19 | 1.35 | +2 | 448 | .14 | 25.6 | 69.0 | 820 | 1 |
| 4 | 30 | 31 | 19 | 0 | +2 | 451 | .25 | 34.3 | 77.5 | 818 | 0 |
| 5 | 30 | 31 | 22 | 0 | +2 | 343 | .17 | 17.9 | 89.0 | 816 | 0 |
| 6 | 30 | 33 | 23 | 0 | +2 | 435 | .15 | 15.7 | 85.0 | 815 | 0 |
| 7 | 32 | 30 | 20 | 0.94 | +3 | 408 | .19 | 25.3 | 100.0 | 813 | 1 |
| 8 | 33 | 31 | 23 | 0.18 | +2 | 422 | .16 | 30.4 | 84.0 | 811 | 1 |
| 9 | 36 | 33 | 20 | 0 | +1 | 461 | .17 | 18.4 | 83.0 | 810 | 0 |
| 10 | 34 | 32 | 21 | 1.27 | +2 | 527 | .23 | 18.6 | 80.0 | 808 | 3 |
| 11 | 33 | 31 | 21 | 0 | +2 | 514 | .14 | 27.4 | 93.5 | 806 | 1 |
| 12 | 32 | 31 | 22 | 0 | +2 | 250 | .20 | 26.8 | 85.5 | 805 | 1 |
| 13 | 32 | 32 | 20 | 0.25 | +2 | 435 | .19 | 33.0 | 83.5 | 803 | 0 |
| 14 | 32 | 31 | 20 | 0 | +2 | 356 | .18 | 33.4 | 81.5 | 802 | 1 |
| 15 | 32 | 31 | 21 | 0.06 | +2 | 359 | .21 | 43.5 | 80.5 | 800 | 0 |
| 16 | 32 | 31 | 20 | 0.33 | +2 | 527 | .24 | 30.1 | 96.0 | 798 | 1 |
| 17 | 32 | 31 | 21 | 1.17 | +2 | 395 | .21 | 20.0 | 84.0 | 796 | 3 |
| 81 | 32 | 30 | 20 | 0.46 | +2 | 514 | .25 | 32.1 | 87.5 | 795 | 1 |
| 19 | 33 | 32 | 18 | 0 | +1 | 408 | .17 | 38.5 | 72.5 | 793 | 0 |
| 20 | 34 | 32 | 18 | 0 | +1 | 290 | .23 | 25.6 | 74.0 | 792 | 1 |
| 21 | 32 | 31 | 19 | 0 | +1 | 435 | .26 | 35.5 | 86.5 | 790 | 1 |
| 22 | 29 | 29 | 15 | 0 | +1 | 457 | .38 | 11.5 | 63.0 | 788 | 0 |
| 23 | 30 | 30 | 16 | 0 | +1 | 553 | .30 | 57.3 | 76.0 | 786 | 0 |
| 24 | 30 | 30 | 17 | 0 | +1 | 461 | .22 | 46.7 | 71.5 | 784 | 1 |
| 25 | 30 | 30 | 18 | 0.03 | +1 | 461 | .24 | 45.3 | 71.5 | 782 | 4 |
| 26 | 30 | 31 | 20 | 0 | +1 | 461 | .20 | 46.0 | 78.5 | 781 | 3 |
| 27 | 32 | 33 | 20 | 0 | 0 | 448 | .16 | 31.6 | 76.0 | 779 | 0 |
| 28 | 33 | 34 | 19 | 0 | 0 | 514 | .14 | 24.6 | 73.5 | 777 | 2 |
| 29 | 32 | 33 | 20 | 0 | 0 | 461 | .32 | 25.7 | 74.5 | 775 | 2 |
| 30 | 32 | 33 | 19 | 0 | 0 | 487 | .44 | 51.1 | 72.5 | 774 | 0 |
| 31 | 29 | 31 | 21 | 1.19 | +1 | 369 | .28 | 39.1 | 93.0 | 772 | 0 |

SEPTEMBER 1973

| Date | Water Temp (C) | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (rncons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * 29 | 31 | 22 | 0.10 | +1 | 382 | .24 | 84.7 | 80.0 | 770 | 2 |
| 2 | 29 | 31 | 20 | 0 | +1 | 332 | .27 | 61.5 | 79.5 | 768 | 0 |
| 3 | 30 | 32 | 19 | 0 | +1 | 527 | .19 | 59.6 | 72.0 | 766 | 0 |
| 4 | 31 | 32 | 19 | 0 | 0 | 408 | .23 | 35.2 | 69.0 | 764 | 0 |
| 5 | 29 | 31 | 20 | 0 | 0 | 316 | .25 | 60.3 | 59.0 | 761 | 0 |
| 6 | 29 | 33 | 21 | 0 | 0 | 356 | .21 | 54.9 | 80.0 | 760 | 1 |
| 7 | 33 | 32 | 21 | 0.68 | 0 | 369 | .22 | 28.9 | 71.0 | 758 | 1 |
| 8 | 32 | 35 | 20 | 0 | 0 | 359 | .19 | 18.5 | 72.5 | 756 | 1 |
| 9 | 33 | 33 | 20 | 0 | 0 | 395 | .24 | 19.4 | 78.0 | 754 | 1 |
| 10 | 32 | 34 | 23 | 0 | 0 | 198 | .15 | 39.4 | 87.0 | 753 | 0 |
| 11 | 28 | 33 | 21 | 0 | 0 | 395 | .24 | 32.7 | 85.0 | 751 | 0 |
| 12 | 30 | 35 | 20 | 0 | 0 | 329 | .19 | 32.3 | 80.0 | 749 | 0 |
| 13 | 29 | 29 | 24 | 0.18 | 0 | 237 | .17 | 30.2 | 94.0 | 747 | 2 |
| 14 | 31 | 32 | 24 | 0.18 | 0 | 356 | .19 | 75.8 | 86.0 | 744 | 0 |
| 15 | 30 | 33 | 18 | 0 | 0 | 395 | .19 | 38.7 | 79.0 | 742 | 0 |
| 16 | 29 | 31 | 19 | 0.13 | 0 | 329 | .23 | 33.2 | 77.5 | 741 | 1 |
| 17 | 29 | 30 | 20 | 0.71 | 0 | 263 | .16 | 35.0 | 84.5 | 739 | 3 |
| 18 | 29 | 29 | 17 | 0 | 0 | 382 | .12 | 25.1 | 80.5 | 737 | 0 |
| 19 | 27 | 28 | 10 | 0 | 0 | 501 | .21 | 59.7 | 66.0 | 735 | 2 |
| 20 | 29 | 30 | 11 | 0 | 0 | 462 | .21 | 37.8 | 58.5 | 733 | 0 |
| 21 | 28 | 33 | 16 | 0 | 0 | 322 | .22 | 52.5 | 61.0 | 731 | 0 |
| 22 | 30 | 32 | 23 | 0 | 0 | 395 | .18 | 33.5 | 69.5 | 729 | 0 |
| 23 | 30 | 32 | 18 | 0 | -1 | 408 | - | - | 72.0 | 727 | 1 |
| 24 | 29 | 32 | 17 | 0 | -1 | 472 | .38 | 45.6 | 72.0 | 725 | 0 |
| 25 | 27 | 31 | 18 | 0 | -1 | 395 | .20 | 37.8 | 77.5 | 723 | 1 |
| 26 | 25 | 31 | 25 | 0.13 | -2 | 32 | .26 | 95.0 | 89.5 | 722 | 1 |
| 27 | 24 | 32 | 22 | 0 | -1 | 276 | .02 | 88.0 | 78.0 | 720 | 0 |
| 28 | 25 | 30 | 22 | 1.40 | -1 | 250 | .24 | 59.8 | 85.0 | 718 | 3 |
| 29 | 29 | 31 | 19 | 0 | -1 | 343 | .13 | 27.0 | 78.5 | 716 | 0 |
| 30 | 24 | 30 | 19 | 2.54 | -2 | 290 | .17 | 27.0 | 81.5 | 713 | 2 |

OCTOBER 1973

| Date | Water Temp (C) | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (ridons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * 26 | 24 | 19 | 1.37 | +3 | 132 | .29 | 40.4 | 100.0 | 711 | 0 |
| 2 | 29 | 28 | 19 | 0 | +2 | 290 | - | 26.5 | 84.0 | 710 | 0 |
| 3 | 30 | 30 | 17 | 0 | +1 | 369 | .15 | 18.9 | 74.0 | 708 | 0 |
| 4 | 29 | 31 | 17 | 0 | +1 | 392 | .17 | 25.3 | 71.5 | 706 | 0 |
| 5 | 29 | 31 | 16 | 0 | +1 | 472 | .20 | 22.7 | 92.0 | 704 | 1 |
| 6 | 29 | 30 | 17 | 0 | 0 | 461 | .20 | 53.2 | 70.0 | 702 | 0 |
| 7 | 28 | 29 | 16 | 0 | 0 | 435 | .22 | 50.2 | 71.0 | 700 | 0 |
| 8 | 28 | 29 | 15 | 0 | 0 | 474 | .17 | 29.8 | 65.5 | 698 | 0 |
| 9 | 26 | 28 | 15 | 0 | 0 | 422 | .20 | 34.7 | 72.5 | 696 | 0 |
| 10 | 26 | 29 | 15 | 0 | 0 | 382 | .19 | 44.7 | 74.0 | 695 | 0 |
| 11 | 25 | 27 | 14 | 0 | -1 | 395 | .20 | 43.8 | 73.0 | 693 | 0 |
| 12 | 24 | 26 | 14 | 0 | -1 | 303 | .22 | 65.7 | 74.5 | 690 | 1 |
| 13 | 26 | 27 | 13 | 0 | -2 | 369 | .17 | 64.3 | 71.0 | 688 | 0 |
| 14 | 24 | 24 | 15 | 0 | -2 | 211 | .15 | - | 90.0 | 687 | 0 |
| 15 | 25 | 27 | 14 | 0 | -2 | 395 | .05 | 60.2 | 87.5 | 685 | 1 |
| 16 | 23 | 21 | 12 | 0 | -2 | 105 | .16 | 26.1 | 60.0 | 683 | 0 |
| 17 | 22 | 20 | 10 | 0 | -3 | 356 | .12 | 64.1 | 45.5 | 681 | 0 |
| 18 | 23 | 24 | 4 | 0 | -3 | 395 | .21 | 83.4 | 36.0 | 680 | 0 |
| 19 | 22 | 25 | 4 | 0 | -3 | 409 | .16 | 42.3 | 40.5 | 678 | 0 |
| 20 | 23 | 26 | 6 | 0 | -4 | 382 | .23 | 58.6 | 47.5 | 675 | 0 |
| 21 | 22 | 27 | 7 | 0 | -4 | 395 | .17 | 36.8 | 57.5 | 673 | 0 |
| 22 | 21 | 28 | 9 | 0 | -4 | 250 | .15 | 42.4 | 70.0 | 672 | 0 |
| 23 | 23 | 26 | 9 | 0 | -5 | 329 | .15 | 40.6 | 71.5 | 670 | 0 |
| 24 | 22 | 26 | 8 | 0 | -5 | 343 | .15 | 21.9 | 66.5 | 668 | 0 |
| 25 | 22 | 25 | 7 | 0 | -5 | 323 | .14 | 29.4 | 65.0 | 666 | 0 |
| 26 | 22 | 28 | 9 | 0 | -5 | 293 | .14 | 24.9 | 69.0 | 665 | 0 |
| 27 | 19 | 27 | 9 | 0 | -6 | 329 | .07 | 21.6 | 67.0 | 663 | 0 |
| 28 | 19 | 19 | 8 | 0.03 | -6 | 132 | .21 | 24.7 | 93.5 | 661 | 0 |
| 29 | 18 | 14 | 3 | 0 | -6 | 356 | .12 | 47.4 | 74.0 | 659 | 0 |
| 30 | 18 | 18 | -1 | 0 | -7 | 169 | .11 | 47.3 | 73.0 | 657 | 0 |
| 31 | 16 | 15 | 7 | 1.07 | -6 | 92 | .13 | 40.6 | 99.0 | 655 | 7 |

NOVEMBER 1973

| Date | Water Temp (C) * | Air Temp (C) Max | Air Temp (C) Min | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (r.dons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 19 | 22 | 2 | 0 | -6 | 343 | .12 | 62.9 | 70.0 | 654 | 0 |
| 2 | 19 | 24 | 3 | 0 | -6 | 359 | .14 | 14.9 | 74.0 | 653 | 2 |
| 3 | 21 | 25 | 10 | 0 | -6 | 237 | .11 | 27.2 | 79.0 | 651 | 1 |
| 4 | 21 | 26 | 9 | 0 | -6 | 276 | .11 | 15.8 | 75.0 | 649 | 0 |
| 5 | 19 | 23 | 15 | 0.25 | -6 | 194 | .11 | 21.2 | 95.0 | 647 | 6 |
| 6 | 18 | 18 | 3 | 0 | -7 | 290 | .15 | 91.7 | 75.0 | 646 | 0 |
| 7 | 17 | 15 | 5 | 0 | -7 | 145 | .09 | 34.2 | 90.0 | 644 | 0 |
| 8 | 18 | 19 | 13 | 1.24 | -5 | 105 | .12 | 23.0 | 100.0 | 643 | 3 |
| 9 | 18 | 18 | 5 | 4.09 | +2 | 211 | - | 33.7 | 77.5 | 641 | 3 |
| 10 | 16 | 12 | -1 | 0 | +1 | 303 | .16 | 97.7 | 59.0 | 640 | 0 |
| 11 | 15 | 13 | -2 | 0 | +1 | 356 | .15 | 65.3 | 43.0 | 639 | 0 |
| 12 | 15 | 18 | -2 | 0 | +1 | 290 | .05 | 34.2 | 51.5 | 637 | 0 |
| 13 | 16 | 23 | 2 | 0 | +1 | 290 | .09 | 17.8 | 74.5 | 635 | 0 |
| 14 | 16 | 24 | 8 | 0 | 0 | 302 | .10 | 24.0 | 82.5 | 634 | 0 |
| 15 | 17 | 23 | 10 | 0.29 | +3 | 159 | .07 | 21.2 | 92.5 | 632 | 0 |
| 16 | 16 | 19 | 3 | 0.51 | +3 | 321 | .08 | 53.9 | 71.5 | 631 | 0 |
| 17 | 15 | 17 | 2 | 0 | +3 | 341 | .20 | 76.9 | 50.5 | 629 | 0 |
| 18 | 16 | 21 | 3 | 0 | +3 | 300 | .10 | 53.9 | 87.5 | 628 | 0 |
| 19 | 16 | 24 | 3 | 0 | +3 | 304 | .06 | 23.5 | 70.0 | 627 | 0 |
| 20 | 17 | 20 | 10 | 0.03 | +3 | 225 | .08 | 28.6 | 99.5 | 626 | 0 |
| 21 | 17 | 20 | 10 | 3.05 | +4 | 279 | .08 | 86.3 | 100.0 | 624 | 0 |
| 22 | 18 | 24 | 14 | 0 | +2 | 314 | .09 | 33.7 | 90.0 | 623 | 1 |
| 23 | 18 | 19 | 11 | 0.05 | +1 | 202 | .05 | 23.2 | 100.0 | 621 | 0 |
| 24 | 19 | 20 | 13 | 0.05 | +1 | 87 | .04 | 33.9 | 100.0 | 620 | 0 |
| 25 | 20 | 25 | 16 | 0 | +1 | 100 | .02 | 67.0 | 85.0 | 620 | 0 |
| 26 | 21 | 24 | 10 | 0.03 | +1 | 237 | .03 | 49.5 | 97.5 | 619 | 0 |
| 27 | 22 | 25 | 18 | 0.08 | +1 | 230 | .08 | 87.1 | 87.0 | 617 | 0 |
| 28 | 19 | 19 | 3 | 2.24 | +1 | 321 | .20 | 98.7 | 81.0 | 616 | 0 |
| 29 | 16 | 13 | -1 | 0 | +2 | 347 | .16 | 75.8 | 64.0 | 615 | 0 |
| 30 | 11 | 19 | -1 | 0 | +2 | 349 | .11 | 56.0 | 48.5 | 614 | 0 |

MARCH 1974

| Date | Water Temp (C) | Air Temp (C) | | Rainfall (cm) | Water Level (cm above or below capacity) | Solar Radiation (radons) | Evaporation (inches) | Wind (miles/day) | Relative Humidity (%) | Photo-period (minutes) | No. of Drift Fence Captures |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | | | | | | | | |
| 1 | 17 | 22 | 6 | 0 | +3 | 263 | .16 | 58.9 | 54.0 | 690 | 0 |
| 2 | 15 | 22 | 6 | 0 | +3 | 209 | .25 | 43.4 | 62.0 | 692 | 0 |
| 3 | 18 | 24 | 11 | 0 | +3 | 216 | .03 | 61.4 | 71.0 | 694 | 0 |
| 4 | 18 | 25 | 10 | 0 | +3 | 300 | .14 | 73.8 | 61.0 | 696 | 0 |
| 5 | 19 | 27 | 15 | 0 | +3 | 270 | .24 | 102.0 | 63.0 | 698 | 1 |
| 6 | 20 | 27 | 10 | 0 | +3 | 289 | .13 | 65.5 | 62.0 | 699 | 3 |
| 7 | 21 | 26 | 10 | 0 | +3 | 320 | .25 | 53.8 | 63.0 | 701 | 1 |
| 8 | 21 | 28 | 8 | 0 | +3 | 312 | .14 | 39.4 | 59.5 | 703 | 1 |
| 9 | 22 | 29 | 12 | 0 | +3 | 322 | .22 | 41.3 | 56.5 | 706 | 1 |
| 10 | 23 | 30 | 12 | 0 | +3 | 313 | .24 | 36.2 | 51.5 | 707 | 0 |
| 11 | 23 | 28 | 14 | 0 | +3 | 293 | .16 | 41.0 | 47.5 | 709 | 4 |
| 12 | 21 | 26 | 13 | 0 | +2 | 194 | .24 | 64.7 | 57.0 | 711 | 9 |
| 13 | 18 | 16 | 5 | 0 | +2 | 172 | .26 | 118.1 | 53.0 | 713 | 1 |
| 14 | 19 | 19 | 3 | 0 | +2 | 351 | .21 | 67.6 | 52.5 | 715 | 1 |
| 15 | 18 | 21 | 5 | 0 | +2 | 125 | .17 | 42.7 | 40.5 | 717 | 0 |
| 16 | 17 | 17 | 6 | 0.10 | +4 | 99 | .20 | 80.4 | 70.5 | 719 | 1 |
| 17 | 16 | 15 | -1 | 0 | +4 | 64 | .20 | 111.6 | 40.5 | 721 | 0 |
| 18 | 17 | 22 | 0 | 0 | +4 | 273 | .14 | 56.1 | 44.5 | 723 | 0 |
| 19 | 17 | 18 | 11 | 1.45 | +6 | 43 | .16 | 56.9 | 86.0 | 725 | 2 |
| 20 | 19 | 26 | 14 | 2.97 | +6 | 65 | .09 | 68.1 | 95.0 | 727 | 2 |
| 21 | 15 | 21 | 3 | 0 | +4 | 126 | - | 95.2 | 68.0 | 729 | 0 |
| 22 | 17 | 18 | -2 | 0 | +4 | 198 | .18 | 93.7 | 57.0 | 730 | 0 |
| 23 | 18 | 20 | 4 | 0 | +4 | 310 | .14 | 58.7 | 64.5 | 733 | 0 |
| 24 | 16 | 13 | 8 | 0 | +3 | 287 | .13 | 32.8 | 72.5 | 735 | 0 |
| 25 | 13 | 9 | 3 | 0.33 | +5 | 172 | .11 | 16.0 | 56.0 | 737 | 0 |
| 26 | 14 | 11 | 6 | 0.48 | +6 | 92 | .06 | 87.8 | 96.5 | 739 | 0 |
| 27 | 14 | 16 | 9 | 1.32 | +6 | 84 | - | 46.6 | 100.0 | 741 | 0 |
| 28 | 19 | 15 | 13 | 0 | +3 | 233 | .07 | 37.8 | 89.0 | 743 | 1 |
| 29 | 20 | 26 | 15 | 1.17 | +4 | 421 | - | 50.5 | 77.0 | 745 | 1 |
| 30 | 19 | 24 | 10 | 0 | +4 | 430 | .32 | 102.8 | 45.5 | 747 | 0 |
| 31 | 21 | 29 | 6 | 0 | +3 | 346 | .43 | 105.5 | 35.0 | 749 | 0 |