AN ABSTRACT OF THE THESIS OF

Margaret Schulenberg Ptacek for the Master of Science degree

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Title: Reproductive Ecology and Habitat Analysis of the Northern Spring Peeper (Hyla c. crucifer) in Southeastern Kansas

Abstract approved: [signature]

The breeding ecology and habitat requirements of the Northern Spring Peeper (Hyla c. crucifer) were investigated in this study. Observations were made on reproductive activities and behaviors within an established population in Cherokee County, Kansas. The status of populations in all ponds described in a 1982 study by Collins was determined. One hundred seven calling male Hyla crucifer were found from 18 February to 27 April 1984 in ten ponds. A habitat study, including vegetational analysis and water composition, was conducted for each of the ponds, plus three additional ponds found to contain Spring Peepers. Factors critical to the maintenance of breeding colonies included presence of pond edge and emergent vegetation, stands of trees in close proximity to the pond, and presence of mats of filamentous algae as a food source for tadpoles. Based upon these factors, five ponds were determined to contain optimal breeding habitat for Spring Peepers.

REPRODUCTIVE ECOLOGY AND HABITAT ANALYSIS OF THE NORTHERN SPRING PEEPER (*HYLA C. CRUCIFER*) IN SOUTHEASTERN KANSAS

A Thesis
Submitted to
the Division of Biological Sciences
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In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Margaret Schulenberg Ptacek
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Robert J Clarke
Approved for Major Department

Frank Elliott
Approved for Graduate Council

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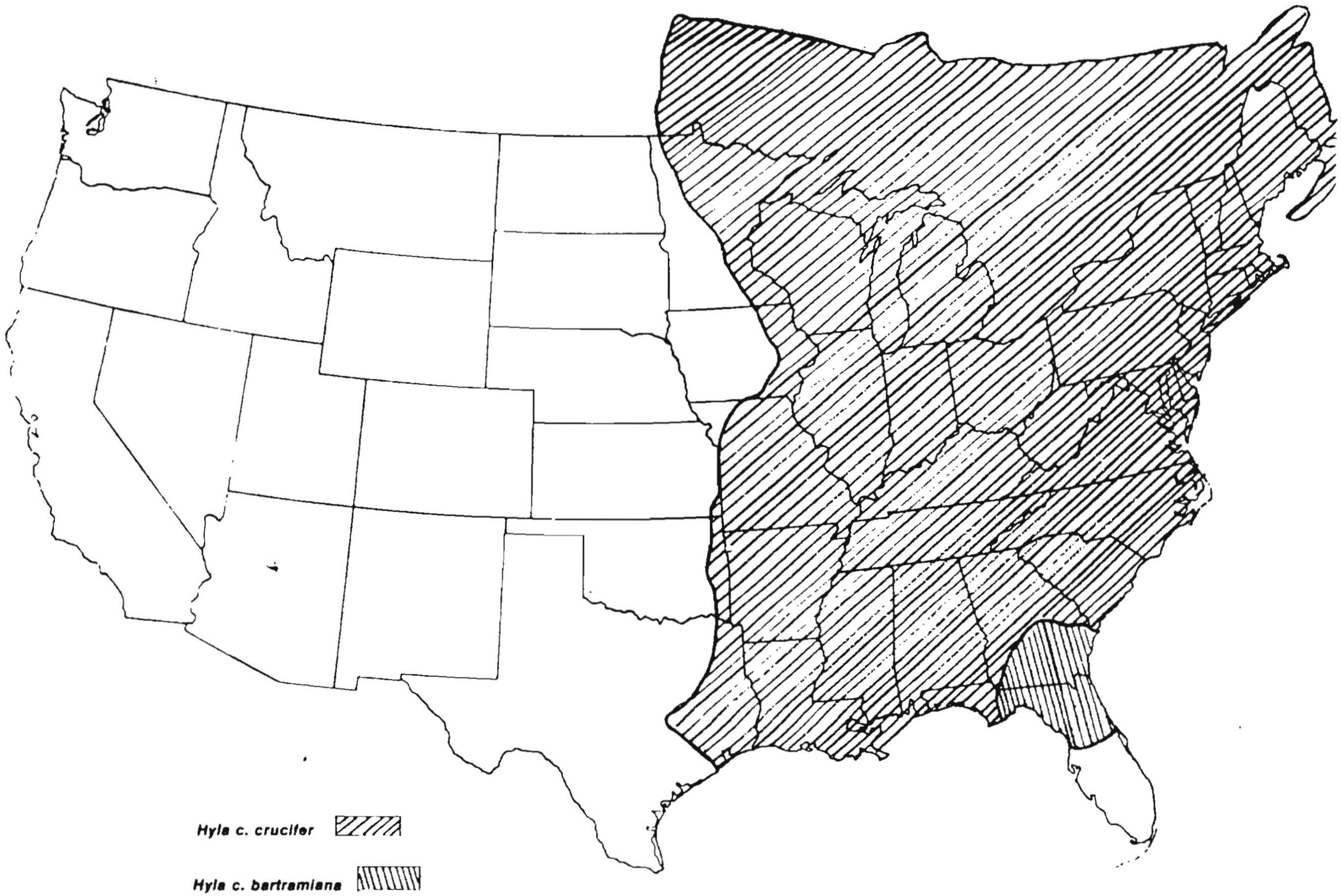
INTRODUCTION

Peripheral populations are of interest to biologists. Some evolutionary theorists (Mayr, 1963; Futuyma, 1979) believe that such populations may lead to speciation. Mayr (1963) believes that divergence occurs primarily in peripheral populations formed by colonization at the edge of a species range. Delzell (1958) has shown, with highly mobile species, that a mixing of the population is produced which tends to inhibit the evolution of new forms. The Spring Peeper (Hyla crucifer) is such a mobile species and occupies one of the largest geographical ranges (Figure 1) of any North American amphibian (Delzell, 1958; Conant, 1975). Populations in Cherokee County, Kansas, are on the western edge of the Spring Peeper's range.

This study was initiated to examine these peripheral populations. Eleven trips were made to Cherokee County from 18 February to 14 June 1984. The study had three objectives. First, to make observations on reproductive activities and behaviors within an established population. Second, to determine the status of populations in all ponds described by Collins (1982b). Third, to conduct a thorough habitat study of these ponds and of three additional ponds found to contain Spring Peepers in order to determine factors critical to the maintenance of breeding colonies. This habitat evaluation included a vegetational survey and water composition analysis.

Identification and common and scientific names used in this study were taken from the following: aquatic plants, Fassett (1957); trees, Stephens (1969); other plants, Bare (1979); aquatic insects, Merritt and Cummins (1978); fishes, Pflieger (1975); amphibians and reptiles, Collins (1979a); birds, AOU Checklist (1982). Scientific

Figure 1. Distribution of *Hyla crucifer* in North America. (Map taken from Conant, 1975).


Hyla c. crucifer
Hyla c. bartramiana

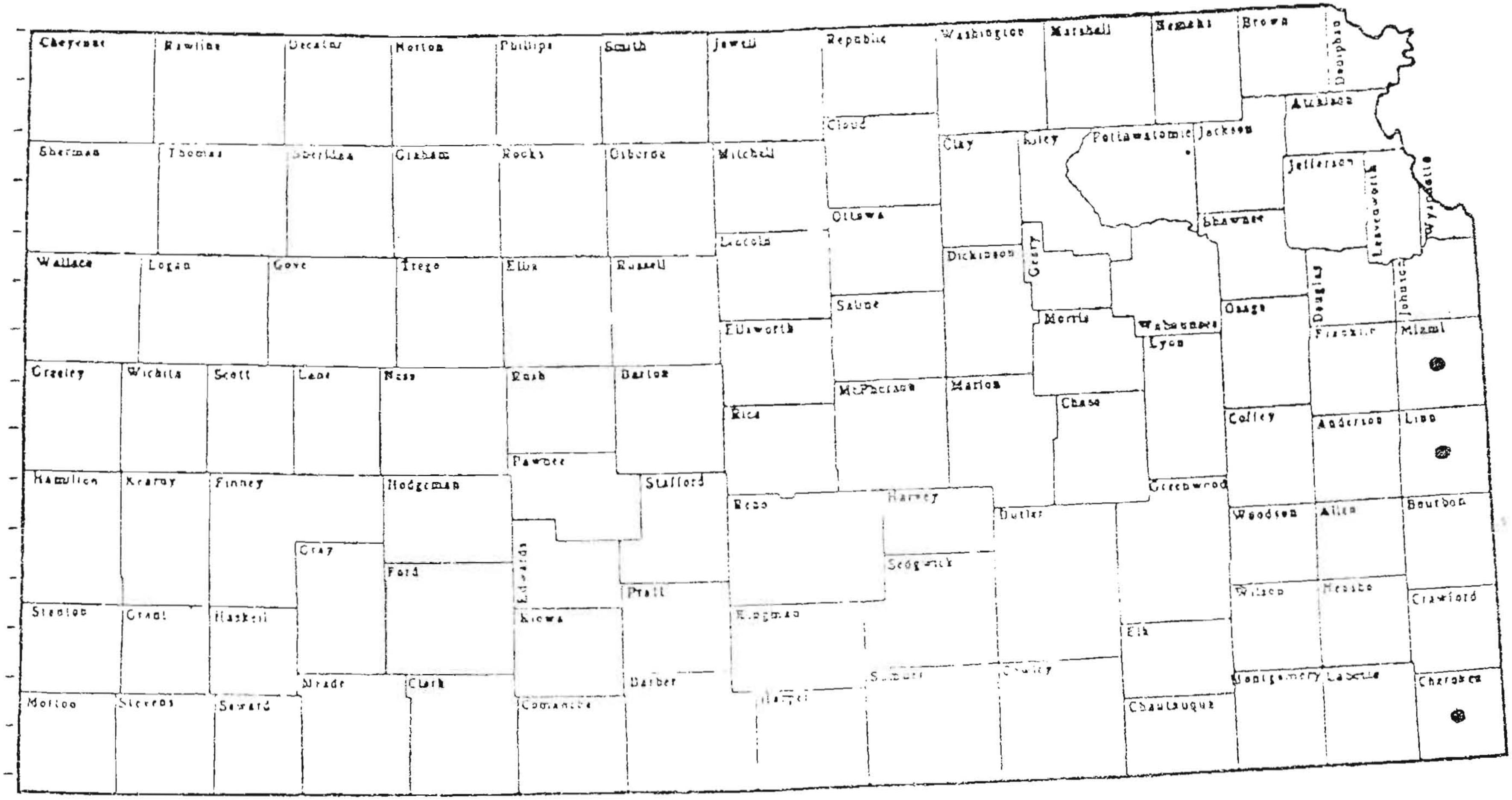
names of plants are found in Appendix 4.

Description of species and range in Kansas

Hyla crucifer is a small, slender frog, ranging, when adult, from two to three cm in length. The Spring Peeper possesses adhesive discs on the ends of its toes, a characteristic of the family Hylidae, and is distinguished from other species of treefrogs by its small size and a dark cross on the back, usually in the form of an X. The dorsal color of this species varies under different environmental conditions from pale tan to darker tan to dark olive drab. The limbs, especially the hind limbs, are marked with narrow bands of brown or gray. Two subspecies of this frog occur. *H. c. crucifer* is characterized by a plain white or cream ventral region, whereas the southern subspecies, *H. c. bartramiana* exhibits a venter strongly marked with dark spots (Conant, 1975). Secondary sexual dimorphism does not occur, except during the breeding season, when males differ from females by having an olive-brown gular region (Delzell, 1958; Oplinger, 1966; Collins, 1982a).

The Northern Spring Peeper (*H. c. crucifer*) has been recorded from Miami, Linn, and Cherokee Counties in Kansas (Figure 2). Gloyd, in 1932, found numerous specimens near an open marsh in Miami County from 21 April to 23 September. A single specimen from Linn County was taken near the Miami County line in 1936 (Collins, 1982b). Since those reports, no specimens have been collected from either of the counties and Collins (1982a) believes that these records came from populations no longer extant due to habitat destruction. Spring Peepers have been reported in Cherokee County in 1977, 1978, 1980, 1982, and in the present study (Rundquist and Collins, 1977; Collins, 1982a, 1982b).

Figure 2. Historic distribution of _Hyla_ _c._ _crucifer_ in Kansas. (Map taken from Collins, 1982a).



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Rawlins
Decatur
Norton
Phillips
Smith
Jewell
Republic
Washington
Marshall
Nemaha
Brown
Doniphan
Atchison
Cloud
Clay
Riley
Pottawatomie
Jackson
Sherman
Thomas
Sheridan
Graham
Rooks
Osborne
Mitchell
Jefferson
Leavenworth
Wyandotte
Ottawa
Shawnee
Lincoln
Dickinson
Geary
Wallace
Logan
Gove
Trego
Ellis
Russell
Saline
Douglas
Johnson
Ellsworth
Morris
Wabaunsee
Osage
Lyon
Franklin
Miami
Greeley
Wichita
Scott
Lane
Ness
Rush
Barton
McPherson
Marion
Chase
Rice
Coffey
Anderson
Linn
Pawnee
Hamilton
Kearny
Finney
Hodgeman
Stafford
Reno
Harvey
Greenwood
Butler
Woodson
Allen
Bourbon
Gray
Ford
Sedgwick
Edwards
Pratt
Wilson
Neosho
Crawford
Stanton
Grant
Haskell
Kiowa
Kingman
Elk
Meade
Clark
Barber
Sumner
Cowley
Montgomery
Labette
Cherokee
Morton
Stevens
Seward
Comanche
Harper
Chautauqua

METHODS AND MATERIALS

Study areas

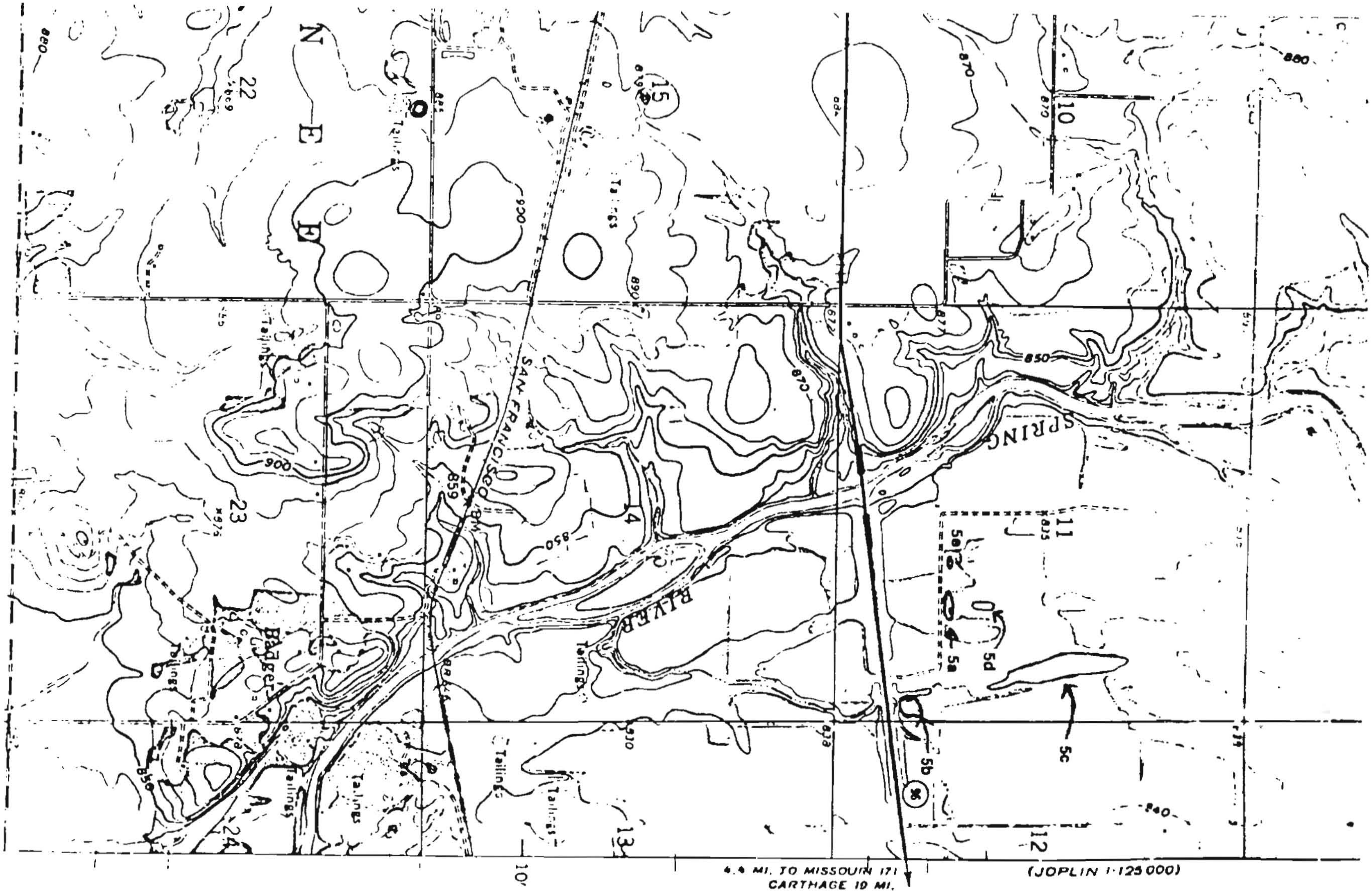
The main study areas were located off Highway 96, 0.8 km east of the Spring River, Cherokee County, Kansas (NE¼ of T35S, R25E), and 25.75 km south and 6.44 km east of Pittsburg. This site was discovered by Collins in 1982 and was designated Pond 5 (Collins, 1982b). The immediate area contained four ponds of chorusing males, subsequently referred to as 5a, b, c, and d. Two calling males were found at another site, 5e, during this study.

Area 5 consisted of three wooded tracts, surrounded by wheat fields. A T-shaped gravel road separated the woods into two tracts to the north and one to the south (Figure 3). Ponds 5a and 5b were located in the northwest wood lot, Pond 5b in the south, and 5c on the edge of the northeast tract. Area 5 ponds were chosen as the principal study sites because they contained the greatest number of calling males in 1982 (Collins, 1982b). Property owners are listed in Appendix 1.

Reproductive data and behavioral observations were recorded at Pond 5a. It was chosen because of its easy access from the road and because Collins (1982b) considered it to be the optimal site for numbers of chorusing males. Pond 5a, a 323 m^2 area, consisted primarily of one species of sedge along the northern edge with clumps of Southern Blue Flag interspersed with open water throughout the rest of the pond. Center depth averaged 26 cm, but the pond was ephemeral and was completely dry by 14 June 1984. By 9 May, it was estimated that seventy-five percent of the total water surface was covered with Waterwort, Creeping Waterprimrose, and filamentous algae.

Directly adjoining the northern boundary of the pond was a 1.86

Figure 3. Location of study ponds in Cherokee County, Kansas, in 1984.


SAN FRANCISCO
SPRING
RIVER
Badger
Tailings
5a
5b
5c
5d
4.4 MI. TO MISSOURI 171
CARTHAGE 10 MI.
(JOPLIN 1:125 000)

hectare stand composed primarily of oak species and Green Ash. This area was flooded until 24 May.

A clearing of open water and sedge, 5d, was located in the center of the wooded area. This 224 m^2 pond was not previously recorded as a breeding site for Spring Peepers. It was dominated by sedges around the perimeter, with open water in the center. Mats of filamentous algae were interspersed among the emergent sedges. The pond had a center depth of 19 cm on 14 April, and was completely dry by 24 May.

Pond 5b, located in the southeast woods, was a permanent shallow pond of human construction. The 932 m^2 pond had an average center depth of 34 cm. Heavy pond edge vegetation was primarily sedge, Southern Blue Flag, and Spike Rush. Fifteen clumps of emergent Swamp Dogwood, less than two m in height, were dispersed throughout the pond. It was estimated that by mid-June seventy-five percent of the water surface was covered with filamentous algae, American Lotus, and Water Smartweed. The pond was surrounded by an oak, elm, and Green Ash woods.

Located at the northern edge of the northeast stand of trees, Pond 5c was a shallow-edged oxbow of the Spring River, locally referred to as Cramer Lake. This pond was approximately 500 m in length and 200 m wide, with a depth of 11.5 cm one m from shore on 13 April. Center depth at that time was greater than three m. By 9 May, the water surface was completely covered with American Lotus, Water Smartweed, Pickerelweed, Duckweed, and filamentous algae. The pond was surrounded by a narrow band of trees, primarily willows, Eastern Redbud, Red Elm, Pin Oak, Green Ash, and American Basswood. The peepers were concentrated at the southeast shoreline in patches of sedge and Southern Blue Flag.

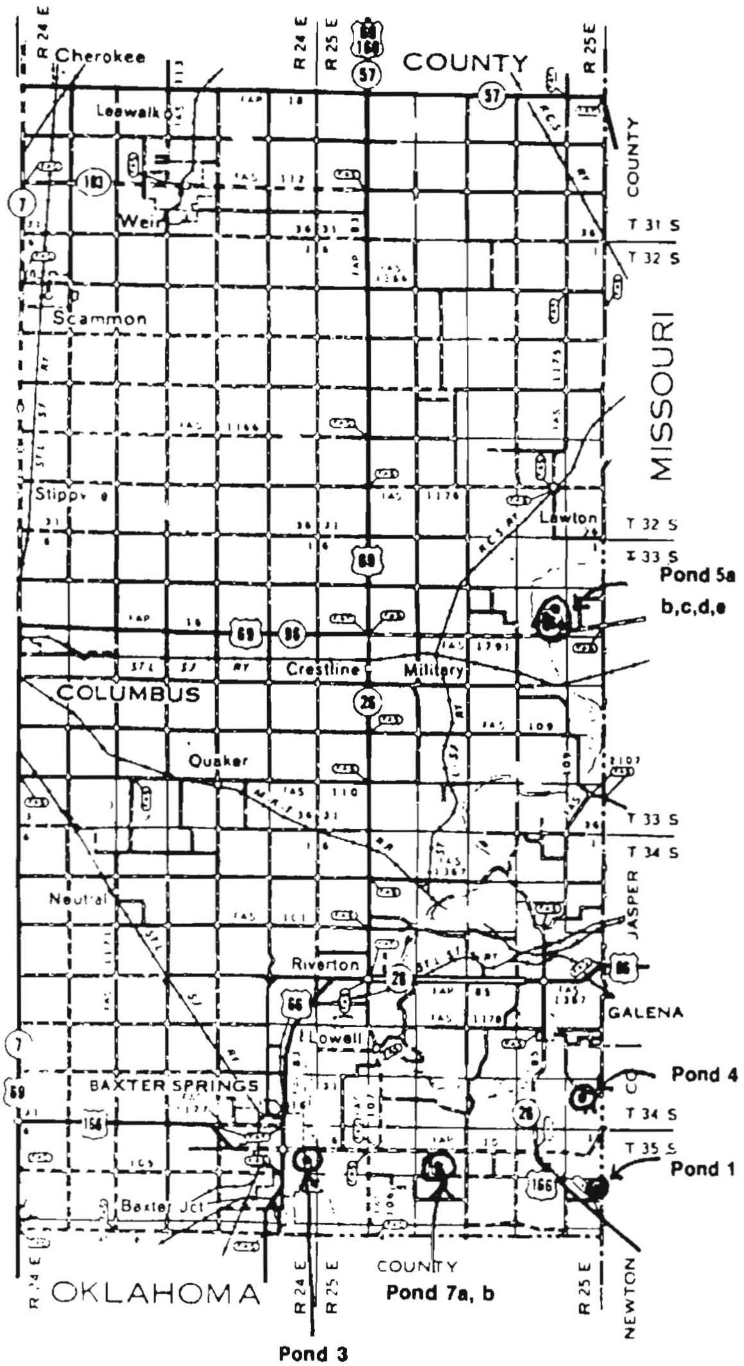
Pond 5e was located in a flooded wooded area 200 m west of 5a. On 12 April, two males were calling from this pond. These frogs were not heard subsequently. The area was similar in size and vegetational composition to 5d.

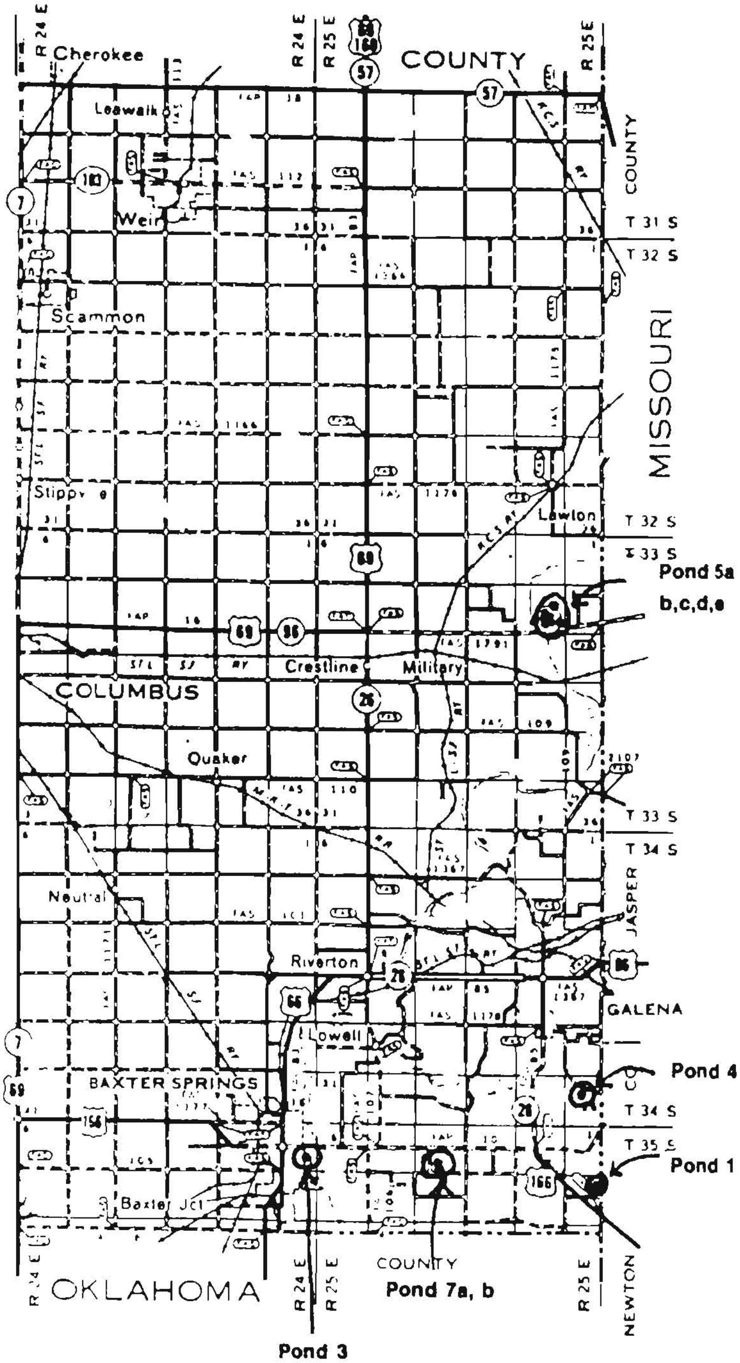
Of the remaining eight ponds (Figure 4) described by Collins (1982b), four were found to contain calling Spring Peepers. Pond 1 was located north of Highway 166, 7.2 km south and east of Galena, Kansas, on the Kansas-Missouri line (NE¼ of T35S, R25E). This pond was of human construction with a center depth greater than three meters. The shoreline lacked vegetation, except for one stand of Common Cattail in the eastern corner from which two male Spring Peepers called. The nearest trees, Bur Oak, White Oak, and Post Oak were 40 meters from the pond. This stand of trees was on the Missouri side of the state line and contained two small ephemeral pools from which calling Spring Peepers were heard.

Pond 3 was located south of Highway 166, between the city limits of Baxter Springs, Kansas, and the Spring River (T35S, R24E). The pond, a natural backwater oxbow of the Spring River was approximately 750 m in length and 250 m wide. The center depth was 54 cm on 13 June. Peepers were concentrated in the 1200 m^2 of flooded shallow wetland on the west edge. This edge was heavily vegetated with Common Bulrush, sedge, Spike Rush, Sloughgrass, and Buttonbush. A Green Ash, American Elm, and hickory woods bordered the eastern edge of the pond. This pond has supported a population of Spring Peepers for at least five years (C. Hildreth, pers. com.)

Pond 4 was a 1,152 m^2 pond of human construction located 4.0 km south of Galena and 1.2 km east of Highway 26 (SE¼ of T34S, R25E). Its pond edge vegetation was only sparse patches of Spike

Figure 4. Locations of the ten ponds containing calling male Spring Peepers in Cherokee County in 1984.


Cherokee
Leawalk
Weir
Scammon
Stippy
COLUMBUS
Crestline
Military
Quaker
Neutral
Riverton
Lowell
BAXTER SPRINGS
Baxter Jct
Lawton
GALENA
JASPER
COUNTY
MISSOURI
OKLAHOMA
NEWTON
R 24 E
R 25 E
T 31 S
T 32 S
T 33 S
T 34 S
T 35 S
Pond 5a
b,c,d,e
Pond 4
Pond 1
Pond 7a, b
Pond 3



Cherokee
COUNTY
Leawalk
Weir
Scammon
Stippville
MISSOURI
Lawlon
Pond 5a
b,c,d,e
Crestline
Military
COLUMBUS
Quaker
Neutral
Riverton
JASPER
GALENA
Lowell
BAXTER SPRINGS
Pond 4
Pond 1
Baxter Jct
OKLAHOMA
COUNTY
Pond 7a, b
NEWTON
Pond 3
R 24 E
R 25 E
T 31 S
T 32 S
T 33 S
T 34 S
T 35 S

sedge. Center depth was estimated to between three and five meters. The distance from the pond to the nearest stand of Green Ash, oak, and American Elm was 100 meters.

Site 7 was located 3.6 km east of Baxter Springs and 0.40 km south of Highway 166 (T35S, R25E). It consisted of two small ponds. Pond 7a, the smaller of the two, was 35 m^2 in size and filled with Water Plantain and filamentous algae. The center depth on 27 April was 39 cm, but the pool was ephemeral. This pond lacked edge vegetation. One White Oak, three Bur Oaks, and one Pin Oak grew on the shore, but the nearest large stand of trees was greater than 100 m away.

Pond 7b located just south of 7a was 240 m^2 in total area. The pond edge lacked cover, but emergent vegetation included American Lotus and Creeping Waterprimrose, and a ten percent algae cover on the water surface. Center depth was not measured. Distance from the pond to the nearest stand of Post Oak, Kentucky Coffee Tree, and Bur and Red Oak was five m.

Reproductive data and census techniques

A total of 55 hours was spent at Pond 5a making observations on number of calling males, time at initiation of calling, temperature at initiation of calling, frequency and estimated intensity of calling, position of calling males throughout the area, and behavioral observations on calling males. Ambient air temperatures along the shoreline, at ground level, and shoreline water temperatures were recorded hourly in degrees Celsius. On three occasions during the study period, all males that could be located were captured. Snout-ischium length and weight were recorded, and, after 12 April, they were toe clipped for individual identification. On two occasions, these data were recorded for individuals captured in 5d.

Individuals were located by seeking out each calling male. Male Hyla crucifer emit a high, piping whistle, often called a peep, as their breeding call (Rosen and Lemon, 1974). The distinctness of this call facilitates location of males. Without consistent calling by males, their location could not be determined. When calling persistently, males did not seem to be disturbed by my presence or the use of a flashlight with a red filter. A similar search technique was used with success by Fellers (1979a).

After capture by hand, individuals were weighed to the nearest one-half g with a five g Pesola scale, and snout-ischium length was recorded to the nearest mm by flattening the frog against a plastic ruler. This measurement, rather than snout-vent length was used by Collins (1975) and Fellers (1979a), who found it to be a more feasible method for measuring such small frogs. Adults were sexed according to the presence or absence of an olive-brown vocal sac found only in the male. For future recognition, some frogs received a unique mark by clipping one of the toes, following a system modified after George (1940) and Collins (1975). Due to the small number of frogs marked in this manner, only one toe needed to be clipped. Collins (1975) and Delzell (1958) found that clipping two to four toes to mark Hyla crucifer had no effect on the motility of marked animals nor was regeneration of the excised digits observed.

The position of each calling male located was marked with a red survey flag. Males were located by starting at one end of the pond and working towards the other end. By flagging the actual position or close approximate position of each calling male, one could return to the area during daylight and measure the distance between calling males. Nearest neighbor analysis (Clark and Evans, 1954) was used to determine type of spatial distribution. Counting the number of flags also double-checked the number of calling males recorded. Due to the small size of population, this method worked well and gave an accurate determination of the number of calling males. Behavioral observations were made by using a red light and watching calling males from a position one meter away.

The area was searched for females and an attempt was made to locate eggs by searching the undersides of dead sedges. Tadpoles were collected for identification. Several tadpoles were sacrificed and mouth structure examined for species identification.

Fifteen hours were spent checking all ponds described by Collins (1982b) for the presence of calling Spring Peepers. Each pond was checked at least twice during three surveys. Presence or absence of calling males was determined by listening at each area between dusk and 2300 hours from close proximity. No pond contained more calling males than could be counted by individual voice.

One trip was made to the Marais des Cygnes Wildlife Management Area, Linn County, on 19 April. Three areas indicated as possible peeper habitat by M. Schwilling (pers. com.) were checked for calling males by listening at each area between dusk and 2200 hours.

<u>Habitat analysis</u>

Habitat analysis consisted of two parts: vegetation surveys and water composition. Vegetation surveys began on 9 May with Pond 5a. Quadrat analysis vegetational sampling technique outlined by Prophet (1972) was used to determine density and species composition at the pond. One hundred one m^2 quadrats were established and 26 of these randomly chosen and sampled. Stem counts per m^2 were used to determine density.

A similar method was used to survey species and density of the wooded area bordering 5a. Ten 10 m^2 plots were sampled. Five transects were run at ten m intervals north-south through the woods. Two quadrats were selected at random distances along each transect and sampled. Density, species composition, and breast height diameter of trees were determined from these quadrats. This method was modified from Phillips (1959).

Ponds 5b, c, and d, and the eight other ponds described by Collins (1982b) were included in vegetational analysis. The species composition of each pond was determined by identification of plants in and around the ponds. All ponds, except two, were small enough to allow this method to be adequate. The two large ponds had their calling Spring Peepers concentrated in one area, so the vegetational composition of this smaller region was determined. Since relative species composition was used as an index to compare similarities and differences between ponds, it was felt that this method of determination was acceptable. A similar method was used for associated woodlands. Two transects were walked within each woods and tree species were identified. This was used for comparison between areas.

Physical and chemical properties of pond water were determined both in the field and from samples. Shoreline data included air temperature at ground level, water temperature, and dissolved oxygen content near shoreline, measured with a field temperature-dissolved oxygen meter (YSI Model 51B). Temperature was measured in degrees Celsius and dissolved oxygen in parts per million. Water depth one meter from shore was measured in three different places and an average depth was determined in centimeters. Center of pond data measured air temperature at water surface, surface water temperature, bottom water temperature, dissolved oxygen content, and center depth from estimated deepest point.

pH was also determined in the field with a Mini pH meter (Model 47). Samples were collected in gallon jugs from shoreline water and brought to the laboratory for further analysis. Samples were refrigerated overnight if they could not be analyzed immediately.

Laboratory analysis included measuring alkalinity, chlorophyll content, turbidity, and conductivity. Alkalinity and chlorophyll content were measured according to the methods outlined in Appendix 2 and 3. Turbidity was measured in Jackson Turbidity Units determined from percent transmission of a Spectronic 20 with blue-sensitive photocell set at 450 nm. Conductivity was measured in micro MHO's/cm with a Beckman Instruments conductivity meter.

Water data were collected weekly from Ponds 5a and 5b where breeding populations were established. Ponds 5a and b were both sampled because they represented two different types of breeding habitat, one an ephemeral pool and the other a permanent pond. Samples were made on a weekly basis to detect seasonal changes. The eight other ponds were sampled once and water composition for each sample was compared with that of 5a and 5b in an attempt to determine differences.

RESULTS

Arousal of Spring Peepers

Two male Spring Peepers were first heard in Cherokee County on 18 February calling from leaf litter in the woods surrounding Pond 5b. Ambient air temperature was 8 C. By the next census on 25 February, two calling males were heard from 5b's shoreline, but peepers were not heard at any other ponds. Air temperature was 10 C and water temperature, 8 C.

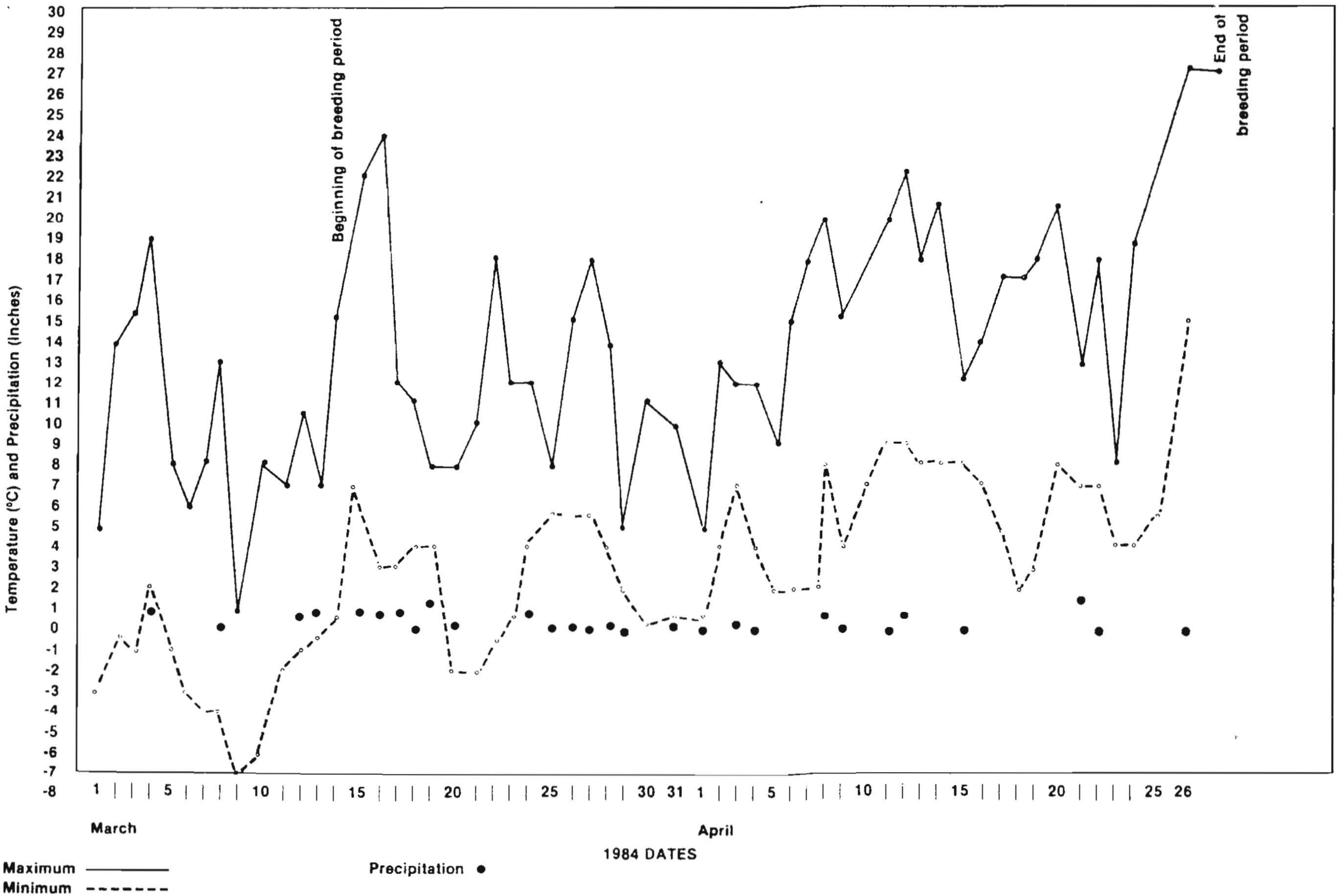
Chorusing Spring Peepers were first recorded at all area 5 ponds on 14 March. Approximately 30 males were calling from 5a. From 14 to 19 March, a temperature increase, with a maximum of 24 C, was associated with 2.51 inches of precipitation (Figure 5). The only appreciable rainfall prior to this period occurred on 4 March when one inch fell, with an associated high of 19C. Minimum temperature on that day, however, was 2 C and temperature fell again the next day to 6 C. Minimum temperatures were higher during the 14-19 March period, averaging 4.2 C.

Intensity and frequency of calling

Intensity and frequency of calling were estimated to be highest during the 14 March survey when ambient temperature was 13 C. Males were first heard calling at 1645 and continued to call until 0700 the next day. They called continuously from 1830 to 2200 and then began calling in waves of three to five minutes in duration, with three to five minutes between choruses. Frogs seemed undisturbed by my presence or light.

In subsequent surveys, intensity of calling was lower than that of the 14 March census. Temperature did not again reach 13 C on a census until 6 April (Figure 5). Calling was continuous for the first hour, came in three to five minute intervals for the next two to two and

Figure 5. Daily maximum and minimum temperatures and precipitation for March and April, 1984. (Data from National Weather Service, Columbus, KS)


Temperature (°C) and Precipitation (inches)
Beginning of breeding period
End of breeding period
March
April
1984 DATES
Maximum
Minimum
Precipitation

one-half hours, and became sporadic or ceased entirely by 2200. Intervals between choruses increased as temperature dropped. Males were undisturbed by my presence during the first hour of continuous calling, after which any movement caused the chorus to cease.

Factors affecting duration of nightly chorusing

Initiation of calling appeared to be affected by diminishing light. A few males began calling intermittently before dusk. Number of calling males increased as light intensity decreased, and with total darkness the maximum number of males were calling continuously.

Decreasing temperature seemed to affect the duration of chorus. Except for the 14 March census when males called until dawn of the next day, in all other censuses, chorusing became sporadic at approximately the same time. On three of these censuses a decrease in temperature was associated with this decline. Table 1 shows time of chorus initiation and associated temperature, and time and temperature when calling became sporadic.

Calling period

Males were heard in 5a or 5d from 14 March to 27 April. A total calling period of 44 days was reported for these populations.

Effect of water temperature on number of chorusing males

Figure 6 illustrates a comparison between water temperature and number of calling males. In most instances, an increased water temperature correlated with an increase in number of calling males. By 13 April the breeding season was almost finished and number of calling males steadily declined despite increasing temperatures.

Census results

Calling male *Hyla crucifer* were found on thirteen nights from 18

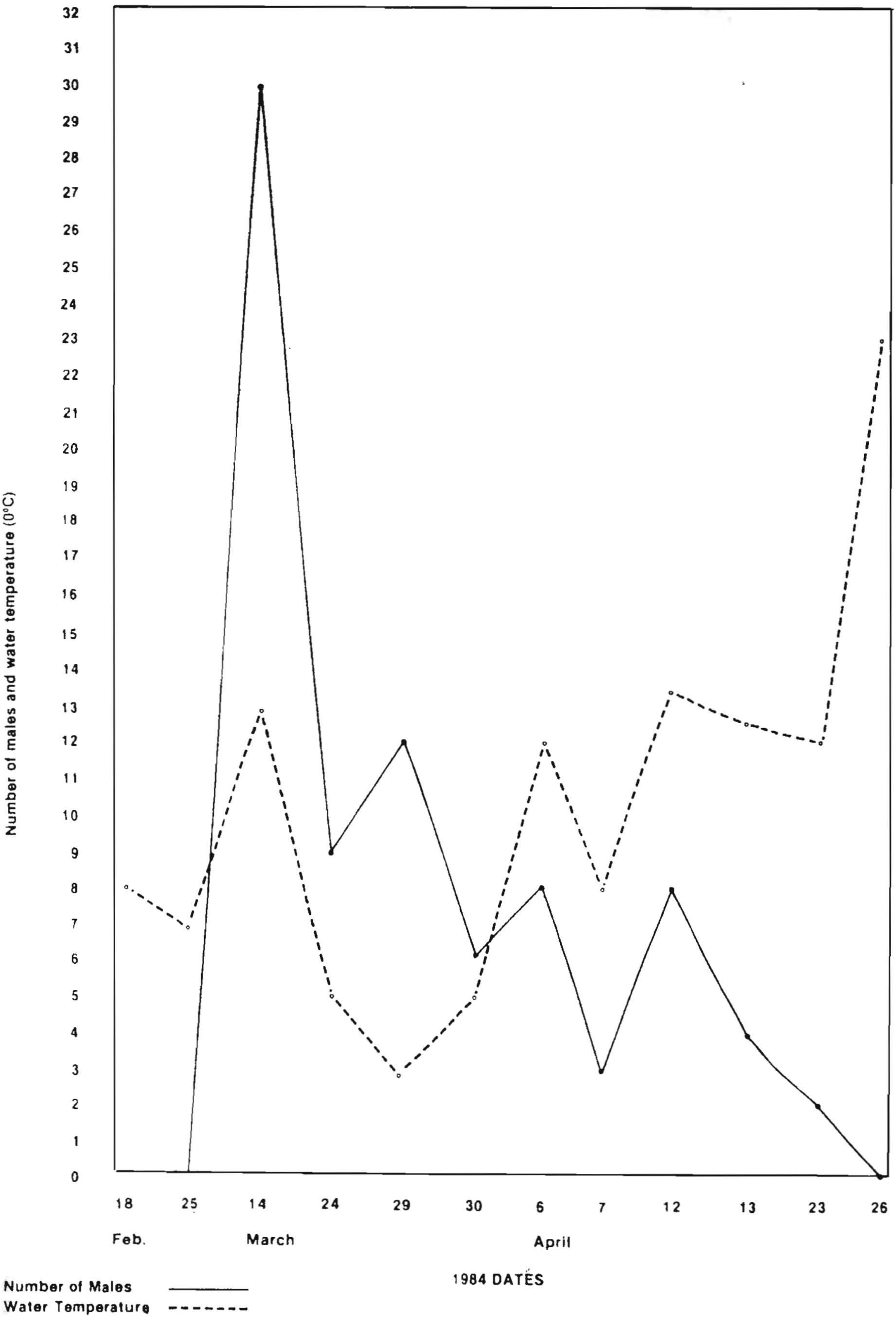
Table 1. Times and temperatures when chorusing of Spring Peepers began and became sporadic in Pond 5a in 1984.

Date	Time at Start	Temp. C air/water	Sporadic	Temp. C air/water
14 March	1830	15/15	*	*
24 March	1845	5/5	2230	4.5/5
29 March	1845	8/8	2200	3/3.5
6 April	1800	13/12	2200	12/11
12 April	1800	14/16.5	2200	10/10.5
13 April	1830	13.5/15	1930	11/12.5
23 April	1900	12/12	-	-

*: males called throughout the night

-: no data

Figure 6. Relationship between number of calling Spring Peeper males and water temperature for Pond 5a population in 1984.



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5
4
3
2
1
0
Number of males and water temperature (0°C)
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25
14
24
29
30
6
7
12
13
23
26
Feb.
March
April
1984 DATES
Number of Males
Water Temperature

February to 27 April in Cherokee County. A total of ten ponds was found to contain calling males. Three of these ponds constituted newly recorded sites for the Spring Peeper in Kansas. Two ponds on the Missouri side of the state line contained calling males, and peepers could be heard calling approximately 0.40 km east into Missouri. Total number of calling males at each pond for each survey is shown in Table 2. Population fluctuations over the three month period for ponds 5a and d are shown in Figure 7. A maximum of 30 frogs in 5a, 25 frogs in 5b, 12 frogs in 5c, 10 frogs in 5d, 2 frogs in 5e, 2 frogs in 1c, 15 frogs in 3, 7 frogs in 4, 1 frog in 7a, and 3 frogs in 7b was recorded for a total of 107 frogs throughout the three month period in Cherokee County. No Spring Peepers were recorded during the 19 April census at the Marais des Cygnes Wildlife Area in Linn County.

Spatial distribution of calling males

Males were spaced throughout the sedge in groups of three to five, dueting and trioing. One to three males called singly at the peripheries. The males were spaced 77 cm or more apart. Table 3 shows distance to nearest calling male for one survey of eight individuals and another with 12 individuals. Nearest neighbor analysis (Table 4) shows that spacing was even for both densities. Results of a t test at $p = .05$ showed no significant difference between mean distances to nearest neighbor. Larger males (25-27 mm snout-ischium length) grouped in the central sedges while the smaller males (21-22.5 mm snout-ischium length) called singly from peripheral clumps. Based upon three recaptures, males appeared to remain in the same general calling area, but did not use the same perch. Males flagged at one location were, within the hour, relocated three to five cm from their original perch.

Table 2. Number of calling Spring Peeper males at Ponds 1 through 9 for each survey in 1984.

Date	Pond	Number of calling males
18 February	5b	2
25 February	5b	2
14 March	5a	30
14 March	5b	25
14 March	5c	10
14 March	5d	9
24 March	5a	9
24 March	5b	10
24 March	5c	12
24 March	5d	1
29 March	5a	12
29 March	5b	*
29 March	5c	*
29 March	5d	*
30 March	5a	6
30 March	5d	4
30 March	3	15
30 March	1c	2
30 March	4	7
6 April	5a	8
6 April	3	5
7 April	5a	3
7 April	5d	1
12 April	5a	8
12 April	5e	2
13 April	5a	4
13 April	5c	12
13 April	5d	10
13 April	4	2
23 April	5a	2
23 April	5b	1

Table 2. (Continued)

Date	Pond	Number of calling males
23 April	5d	0
23 April	7a	1
23 Arpil	7b	3
26 April	5a	0
26 April	5b	0
26 April	5c	0
26 April	5d	5
27 April	5d	1
9 May	5d	0

* males were calling but were not counted

Figure 7. Population fluctuations from 18 February to 9 May, 1984, for calling Spring Peeper males in Ponds 5a and 5d.

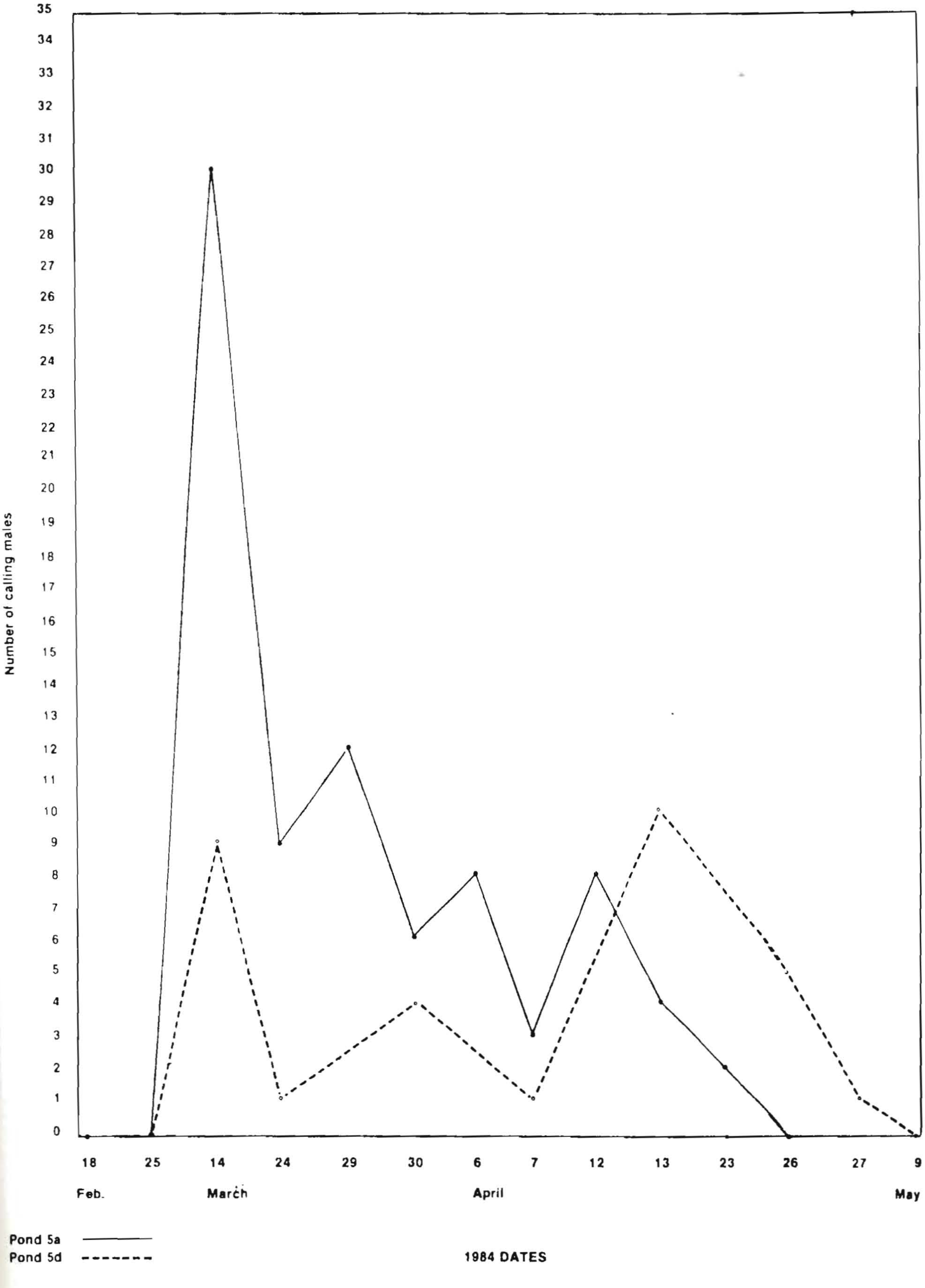
Number of calling males
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
18
25
14
24
29
30
6
7
12
13
23
26
27
9
Feb.
March
April
May
Pond 5a
Pond 5d
1984 DATES

Table 3. Distance to nearest calling male for population of Spring Peepers in Pond 5a in 1984.

Males/323 m^2	Distances to nearest neighbor (cm)
8	291
	266
	129
	179
	687
	653
	941
	Mean = 449.4 ± S. D. 309.0
12	385
	310
	160
	105
	293
	77
	120
	453
	246
	393
	373
	Mean = 265.0 ± S. D. 131.8

Table 4. Nearest neighbor analysis for *Hyla crucifer* at two different densities in Pond 5a in 1984.

Males/323 m^2	Mean dist. between males (cm)	Standard error	Expected	N	Spacing
8	449.43	0.6273	3.18	7	even
12	265.00	0.4069	2.58	11	even

Length and weight of males

A total of 14 males had a mean snout-ischium length of 24.6 mm $\pm$ S. D. 1.9. Eleven males had a mean weight of 1.3 g $\pm$ S. D. 1.4. Actual lengths and weights are shown in Table 5.

Behavioral observations of calling males

Males began calling at dusk, often using a trill for the first few calls before beginning to peep. Before dusk, males called from within dense clumps of sedges; as it became darker they moved out into the open. The majority of males called at ground level at the water's edge, often partially emersed, adjacent to or just under a sedge. Most males called from a crouched horizontal position, with the only detectable movement the ballooning in and out of the gular sac. Only one male was observed calling above ground level. It was on a fallen log in 5d.

Males were occasionally heard in the daytime calling in the denser stands of sedges along the pond's shore. At no time during the study were encounters between males observed, nor were females, eggs, or tadpoles of the Spring Peeper found.

Results of vegetation analysis

Quadrat analysis of vegetation in 5a showed an area of few species with low densities. Five species of plants characterized the region of standing water. The 100 m^2 area sampled was dominated around the edge by a single species of sedge, with a density of $5.46/m^2$. Poor Man's Pepper had a density of $3.62/m^2$; Southern Blue Flag a density of $0.81/m^2$; and Creeping Waterprimrose a density of $0.38/m^2$. It was estimated that 75 % of the total water surface was covered with Waterwort and filamentous green and blue-green algae.

Results of quadrat analysis of the adjacent woodlot are shown in

Table 5. Snout-ischium length and weight for calling male Spring Peepers at Pond 5a in 1984.

	Snout-ischium length mm	Weight
	25	1.2
	27	1.4
	24	1.4
	23	1.6
	27	1.4
	26	1.5
	26	1.1
	22.5	1.4
	26	1.3
	21	1.0
	25	1.1
	26	
	23	
	22.5	
Mean	24.6 ± S. D. 1.9	1.3 ± S. D. 1.4

Table 6. Green Ash had the highest density, 8.0/10 m^2; followed by Pin Oak, 6.3/10 m^2; Silver Maple, 3.7/10 m^2; and Red Elm, 1.8/10 m^2. Seventy-four percent of the trees sampled had a breast height diameter of less than two cm.

Other ponds exhibited the following vegetational composition: Pond 1 lacked edge or emergent vegetation, with the exception of one clump of cattail. The nearest stand of trees (40 m from the pond) consisted primarily of Bur Oak, White Oak, and Post Oak.

Pond 2 was recently reconstructed on the site of a previous pond described by Collins (1982b). The pond lacked edge or emergent vegetation. The nearest stand of trees (45 m from the pond) was primarily Pin Oak. No Spring Peepers were heard calling from this pond.

Pond 3 was a large pond with an area of flooded marsh along the western edge. This wetland was characterized by Spike Rush, sedge, Creeping Waterprimrose, Arrowhead, Waterwort, Sloughgrass, Bulrush, Coontail, and Water Plantain. An estimated 90 % of total water surface was covered with filamentous algae. Emergent Buttonbush grew around the pond's edge. Tree species adjacent to the pond included Green Ash, Red Elm, American Elm, and hickory sp.

Pond 4 lacked edge or emergent vegetation except for a few small clumps of Spike Rush. The nearest stand of trees (100 m from the pond) contained Green Ash, Chinquapin Oak, Bur Oak, American Elm, Sycamore, and Pin Oak.

Edge vegetation in Pond 5b was dominated by clumps of sedge, Southern Blue Flag, Spike Rush, and Bulrush. Emergent vegetation consisted of American Lotus and Smartweed. Fifteen clumps of Swamp Dogwood were scattered throughout the pond. Seventy-five percent of total water

Table 6. Results of quadrat analysis of woodlot adjacent to Pond 5a.

Species	Density/10 m^2
Green Ash	8.0
Pin Oak	6.3
Silver Maple	3.7
Red Elm	1.8
Riverbank Grape	1.2
Swamp Dogwood	0.5
Trumpet Creeper	0.3
Raccoon Grape	0.3
Pecan	0.3
Vine Poison Ivy	0.3
White Ash	0.3
Bitternut Hickory	0.2
Boxelder	0.1
Bur Oak	0.1
American Elm	0.1

surface was covered with filamentous algae. The surrounding woods were dominated by Green Ash, Red Elm, Pin Oak, and Bur Oak, but included American Elm, Hackberry, Walnut, Honey Locust, Redbud, American Basswood, and hickory sp. River Birch and willow grew around the pond's perimeter.

In Pond 5c, the edge where calling peepers were concentrated was characterized by clumps of sedge and Southern Blue Flag. Emergent vegetation included American Lotus, Water Smartweed, Pickerelweed, Duckweed, and filamentous algae. The surrounding woods contained Redbud, Red Elm, Pin Oak, Green Ash, American Basswood, Tree-of-Heaven, and willow sp. along the shore.

Pond 6, an ephemeral pool, contained Bulrush and Spike Rush around the perimeter. The nearest stand of trees (5 m from the pond) included Red Elm, Hackberry, Honey Locust, and Pin Oak. No Spring Peepers were reported calling from this pond.

Pond 7a was filled with Water Plantain. Ninety percent of the water surface was covered with filamentous algae. The pond lacked edge vegetation. One White Oak, one Pin Oak, and three Bur Oaks grew adjacent the pond, but distance to the nearest stand of trees was greater than 100 m.

Pond 7b lacked edge vegetation, but American Lotus and Creeping Waterprimrose grew in the water around the perimeter. Water surface had a ten percent algae coverage. A stand of trees located within five m of the water's edge included Post Oak, Kentucky Coffee Tree, Bur Oak, and Red Oak.

Pond 8 was an ephemeral pool of 1,755 m^2. Edge vegetation consisted of Spike Rush and Bulrush. The nearest stand of trees (five m from the pond) contained Red Elm, Hackberry, Honey Locust and Pin Oak. No calling peepers were recorded for this pond.

Pond 9 was a large pond (2,457 m^2) of human construction. Sparse edge vegetation consisted of Spike Rush and Bulrush. A stand of White Oak and Pin Oak was located greater than 100 m from the water's edge. No calling peepers were recorded from this pond.

Results of Water analysis

Results of water component analyses for Ponds 5a and b from 18 February to 9 May are shown in Table 7. Water component analyses for ephemeral pools are shown in Table 8 and permanent ponds in Table 9.

Potential Predators

An attempt was made to identify potential predators of both adult Spring Peepers and tadpoles. Possible vertebrate predators observed at Pond 5a included Green-backed Heron (Butorides striatus), one observed feeding along the ditch pond running parallel to 5a; Raccoon, many tracks were observed in the 5a area; Common Snapping Turtle (Chelydra serpentina), one large individual (55 cm) observed twice near 5d and two small juveniles observed in 5a; Central Newt (Notophthalmus viridescens), several adults observed in 5a and b; Narrow-mouthed Salamander (Ambystoma texanum) larvae observed in 5a and d. One Great Blue Heron (Ardea herodias) was observed feeding in 5c. Fish species were found in all but two ponds that contained peepers. Large Bullfrog tadpoles (Rana catesbeiana) were found in Pond 1c.

Results of seining revealed the following invertebrates as potential predators of tadpoles: Whirligig Beetle (Dineutus americanus), Predaceous Diving Beetle larvae (Dytiscidae), Giant Water Bug (Lethocerus americanus), Dragonfly naiads (Aeschindae and Libellulidae), Water Strider (Gerris remigis), Water Boatman (Sigara alternata), and Backswimmer (Notonecta undulata). Small Crayfish (Crustacea) were found in seven of the ponds.

Table 7. Results of water component analysis for Ponds 5a and b from 18 February to 15 June 1984.

Date	Pond	Dis. oxygen ppm	pH	Alkalinity ppm HCO_3	Chlorophyll content micrograms/l	Turbid. JTU's	Sp. Cond. Micromhos/cm Ref. Temp 25 C	Shore temp. C	Bottom temp. C
2-18	5a	10.1	6.3	32	1.7	61	115	10	9.8
	5b	10.1	6.3	36	trace	36	99	8	10
2-25	5a	8.6	6.3	36	trace	36	120	7.5	6
	5b	9.6	6.4	34	1.6	36	90	10	8
3-15	5a	7.0	5.7	34	1.82	84	100	13	12
	5b	10.0	5.8	32	3.0	61	99	14	12
3-24	5a	8.0	7.1	36	trace	211	120	5	5
	5b	9.2	6.8	43	2.14	84	140	5.5	6.5
3-30	5a	6.3	6.5	37	1.92	211	125	11	8
	5b	10.0	6.7	43	3.2	36	145	11	10
4-7	5a	10.1	6.6	36	trace	106	89	8	8
	5b	10.0	6.7	46	trace	36	135	10	10.5
4-14	5a	8.4	6.3	45	0.54	61	120	9	9
	5b	9.0	6.6	54	0.54	36	155	10.5	12
4-23	5a	10.0	6.5	37	0.32	84	115	13	14.5
	5b	8.8	6.7	44	0.32	36	120	16	16
4-27	5a	8.0	7.1	77	0.32	168	165	21.5	24.5
	5b	8.0	6.7	53	0.22	106	139	21	23

Table 7. (Continued)

Date	Pond	Dis. oxygen ppm	pH	Alkalinity ppm HCO_3	Chlorophyll content micrograms/l	Turbid. JTU's	Sp. Cond. Micromhos/cm Ref. Temp 25C	Shore temp. C	Bottom temp. C
5-9	5a	-	7.6	79	0.22	273	160	27.5	25.5
	5b	8.9	6.7	60	1.60	134	140	19	19
6-15	5b	-	6.0	42	1.06	211	110	28	30

- no data

Table 8. Results of water component analysis for ephemeral pools.

Date	Pond	Dis. oxygen ppm	pH	Alkalinity ppm HCO_3	Chlorophyll content micrograms/l	Turbid. JTU's	Sp. Cond. Micromhos/cm Ref. Temp 25 C	Shore temp. C	Bottom temp. C
4-14	5d	8.2	6.4	38	1.38	168	120	13.5	-
	*1a	8.9	4.8	3.5	1.38	36	50	16.5	14.5
	*1b	10.2	5.2	5.0	3.2	106	78	16	11.5
4-27	7a	8.6	6.3	18	0.32	84	69	23	22.5
6-15	8	6.6	6.0	60	1.6	395	161	34	32
	6	6.4	5.7	5	0.86	36	50	37	36

* Ponds were located in Missouri
\- no data

Table 9. Results of water component analysis for permanent ponds.

Date	Pond	Dis. oxygen ppm	pH	Alkalinity ppm HCO_3	Chlorophyll content micrograms/l	Turbid. JTU's	Sp. Cond. Micromhos/cm Ref. Temp 25 C	Shore temp. C	Bottom temp. C
4-14	5c	9.0	6.2	36	1.38	168	120	13.5	-
4-27	7b	7.3	6.4	10	0.1	61	50	24	23
5-9	2	8.5	6.6	90	1.06	0	259	-	-
				12 ppm CO_3					
6-15	3	6.8	7.2	97	1.18	168	270	33	26
	1c	6.2	5.4	9	1.18	134	59	32	28
	4	6.1	6.9	94	0.42	61	230	29	29
	9	6.2	6.7	34	trace	36	105	32	-

- no data

Five ponds did not contain predatory fish: 2, 3, 5d, 6, 7a, and 8. Of these five, 5d and 7a had chorusing male Spring Peepers. Other ponds contained fish species as follows:

Pond 1c: Channel Catfish (*Ictalurus punctatus*)

Pond 4: Channel Catfish, Crappie (*Pomoxis*, sp.), Small-mouthed Bass (*Micropterus dolomieui*), Largemouth Bass (*M. salmoides*), Bluegill (*Lepomis macrochirus*), Green Sunfish (*L. cyanellus*), Darter (*Percidae*)

Pond 5a: Plains Killifish (*Fundulus kansae*)

Pond 5b: Mosquitofish (*Gambusia affinis*), Bluegill

Pond 5c: Mosquitofish

Pond 7b: Green Sunfish

Pond 9: Largemouth Bass, Channel Catfish, Bluegill, Green Sunfish

Of the ponds containing fish, chorusing Spring Peepers were recorded at 1c, 4, 5a, 5b, 5c, and 7b.

DISCUSSION

Environmental influences on calling behavior

Earliest signs of male Spring Peeper activity consisted of scattered calling from under leaf cover throughout the forest area (Delzell, 1958). Delzell (1958) and Fellers (1979b) believed that an increase in temperature associated with rainfall triggered the first choruses of *Hyla crucifer* and *Hyla versicolor*. An increase in temperatures and associated rainfall from 14 to 19 March in Cherokee County was thought to trigger the chorusing of Spring Peepers first recorded on 14 March at Pond 5a.

Males were reported chorusing on every census thereafter until 27 April, despite temperatures as low as 3 C. Therefore, it appeared that once chorusing began, it continued throughout the breeding season despite temperature fluctuations.

Temperature is known to affect the frequency and intensity of calling. As temperature decreases, the interval between calls increases (Fellers, 1979a). Garton and Brandon (1975) found that Green Treefrog (*Hyla cinerea*) choruses would cease when temperatures dropped below a certain level. Although peepers have been reported calling at air temperatures as low as 0.4 C (Gerhardt, 1973), Delzell (1958) found that air temperatures below 13 C severely curtailed chorusing and at 7 C calling generally stopped or became sporadic with extended periods of silence. Temperatures throughout this study were well under Delzell's minimum range. This may have accounted for the sporadic nature of the calling of 5a peepers.

Temperature has been shown to affect nightly chorusing activity. Collins (1975) commented that within the total length of the breeding season, the extent of breeding activities on a given night is highly variable and depends mainly on local weather conditions.

Duration of chorus may also be time dependent. In 5a, peepers began calling at dusk, approximately 1830, triggered by decreasing light, and called continuously until approximately 2030. Chorusing then came in waves of variable duration with increasingly longer periods of silence as the evening progressed. By approximately 2200 at every census, chorusing had become highly sporadic or had ceased all together.

Males were heard in 5a or d from 14 March to 17 April for a total calling period of 44 days. This corresponds with Collins' (1975) report of 44 days and Rosen and Lemon (1974), who cited a breeding season of 45 to 50 days. Length of calling period may, in part, be controlled by the length of time that the appropriate breeding temperature occurs. Gerhardt (1973) reported that most reproductive activity of Hyla crucifer occurred at night when air temperatures were below 18 C. This temperature restriction was evident for all nights through April 27, but after that, air and water temperatures were 23 C and higher. After 27 April, no Hyla crucifer were recorded calling.

Temperatures, especially water temperature, may also affect the number of males calling on a given night. Brown and Brown (1975) concluded that water temperature most closely approaches the true frog body temperature. Most of the frogs in this study called with parts of their bodies in contact with water. Delzell (1958) reported a variable number of calling males on different nights throughout the breeding season. Pond 5a males were observed to sit silently at the calling station when temperature dropped. At the low temperatures experienced during this breeding period, many males may have failed to call.

Status and distribution of the Cherokee County population

The Spring Peeper population in Cherokee County declined in the 5 area, increased slightly in Pond 3, and remained stable or absent in the other ponds when compared with Collins' (1982b) data. Collins estimated over 100 calling males in the three ponds combined at site 5. He collected 15 specimens, including one female from 5a. The population must have been considerably larger in 1982, since the present study found a maximum of 12 individuals calling in 5a on any census after 14 March.

There are several possibilities for the decline of the Pond 5 populations. Spring of 1984 was characterized by below normal temperatures. Low temperatures may reduce the number of males calling at the pond on a given night. Due to this, more males could actually have been present than were censused by voice count. This could also account for the higher number of males at the beginning of the study than on any other census. However, males counted on 14 March were not individually flagged. Calling intensity was high due to warm temperatures and an overestimation of numbers could possibly have been made.

On 18-19 March 1984, all parts of Kansas experienced a storm that left a thick layer of ice on the ground for several days. Shallow water areas such as Pond 5a may have been frozen. Frogs protected only by sedges around the pond may not have survived this storm. Eggs laid prior to the storm may also have been frozen. This may explain the decrease from 30 calling males on 14 March to nine calling males on 24 March.

Hyla crucifer is known to overwinter under leaf litter in forested areas (Delzell, 1958). Under normal winter conditions, snow blankets the ground, forming an insulative layer and freezing temperatures do not penetrate to the torpid frogs. The winter of 1983-84 was marked by record low temperatures with below -17 C conditions for five consecutive days in December 1983. Torpid peepers may have experienced freezing temperatures that led to mortality in the overwintering population.

To understand the distribution of Spring Peepers in Cherokee County, one must look at their life history. Delzell (1958) made an extensive study of the movements of Spring Peepers in Michigan. He found that adults aroused in the spring and moved towards breeding ponds. Since peeper populations are confined to areas of understory cover, a peeper must traverse hundreds of meters or more in some instances to reach a breeding site. Once males reached the breeding pond, they established a territory and began calling. Females entered the pond during this period, chose a mate, laid eggs, and returned to the woods. Males remained at the breeding pond for several weeks or through the entire chorusing period. After the breeding season, adults returned to the forest to previously established home ranges. They remained there throughout the summer. Fall weather again triggered movement in the adults causing them to wander about but remaining within the forest in a pattern similar to pre-breeding behavior. With the onset of cold weather, a wintering place underneath leaf litter was established, where the peepers remained until the following spring.

Tadpoles reached metamorphosis 90 to 100 days after hatching. Upon metamorphosis, the movement of young peepers consisted of a rapid progression away from the larval aquatic area into a region of higher vegetation. This was thought to be a response to lower light intensities and effects of dessication. Subadults did not set up home ranges but wandered extensively for the first two years. They did not engage in breeding activity in the spring following their metamorphosis. Sexual maturity was reached at a snout-ischium length of 18 to 20 mm, which does not normally occur until the second year. A few males may reach maturity the first spring; this accounts for small males found at breeding ponds. These males may not successfully breed, though (Gatz, 1981). No such males were located in 5a.

Due to the movement of both adult and juvenile peepers a mixing of the gene pool occurs. Delzell (1958) felt that this might explain the wide geographic range of Spring Peepers and the presence of only two subspecies. Males seldom return to the same pond for two seasons and probably not to the pond of their hatching. Delzell (1958), in three years of study, had one male return to the same pond twice. Collins (1979) felt that most adults did not survive the third year to a second breeding. Different sites are being colonized each year by new groups of two year old males. This is an important factor in the geographic distribution of the Spring Peeper and may likely account for the scattered populations in Cherokee County.

During this study male Spring Peepers were heard calling from a site approximately 0.40 km into Missouri. Two breeding ponds were located on the Missouri side of the Kansas state line and two colonizing males were heard calling from a pond immediately across the road in Kansas. The proximity of peepers in these ponds suggests that wanderers may be emigrating from Missouri in a steady westward progression until they reach the edge of the Ozarkian plateau where suitable habitat ends. Calling Spring Peepers were heard approximately 0.40 km east in Missouri. T. Johnson (pers. com.), Missouri State Herpetologist, has reported the species to be common in Barry County (one county east of Jaspter) and further east and southeast in Missouri, large breeding aggregations occur. The extensive wandering of subadults could carry them into Cherokee County.

Why the Spring Peeper is restricted to Cherokee County is still uncertain. The ecological conditions in Cherokee County best resemble the Ozarkian regions of Missouri from where the population is thought to be spreading. Large populations of peepers do not exist on the Kansas-Missouri border. The spread northward of peepers in Kansas does not appear to be occurring.

Although the Spring Peeper is known to breed at a higher density than other Hylids (Gerhardt, 1973), Delzell (1958) and Fellers (1979a) found that in smaller pools and wetlands density varied from 30-35 individuals. Most of the Cherokee County sites are small pools. In the larger ponds, calling areas were restricted to those shallow regions with suitable vegetative cover preferred by calling males. This causes densities of the frogs to be lower despite the larger size of the pond. This may explain in part, the number of scattered small choruses of males, rather than a few areas of high density.

Breeding behavior

Results of nearest neighbor analysis showed that males at densities of 8/323 m^2 and 12/323 m^2 were spaced in an even distribution. Fellers (1979a) reported an even distribution for densities of 1-9 males/20 m^2 and 10-19 males/20 m^2 in his nearest neighbor analysis for *Hyla crucifer* in Maryland. He reported distances of greater than 100 cm between calling males at densities of 1-9. With increasing densities the distances to nearest neighbor decreased. Fellers reported a mean distance of 113.38 cm between males for densities of 1-9 and a mean distance of 62.25 cm for densities of 10-19. For eight individuals in Pond 5a, the mean distance to nearest calling male was 449.4 cm and for 12 individuals, mean distance was 265.0 cm. Fellers' mean distances were considerably less than mean distances for the 5a population. Fellers' data were recorded from a pond where males were only able to utilize the shoreline for calling territories. Pond 5a was a wetland with a large percentage of the vegetated area only a few cm under water. Thus, in 5a, frogs were able to spread out and utilize the larger available habitat, accounting for the large distances between calling males.

Males in Pond 5a called in groups of two to three throughout the central region of the sedges, with two to three males calling singly at the periphery. Groups of males were dueting and trioing. The mating call of the Spring Peeper is a single 80 to 165 ms note with 0.4 to 1.0 s pause between calls (Fellers, 1979a). The pause is sufficiently long that two other males are able to insert their calls without any temporal overlap. This strategy allows two to three males to call in close proximity without vocal interference and enables greater utilization of breeding habitat by permitting larger breeding densities.

In Pond 5a, larger males (25-27 mm snout-ischium length) grouped in the central sedges while the smaller males (21-22.5 mm snout-ischium length) called singly from peripheral clumps. The vegetation was heaviest in the center, providing dense cover. Toward either end of the pond, vegetation became sparse and cover was poor. Gatz (1981) showed that larger males occupied areas where the highest number of matings occurred and were presumed to be choice sites, while smaller males mated less and occupied less desirable sites.

Territoriality has been reported for male Spring Peepers by Delzell (1958), Fellers (1979a), and Collins (1975). Territories are believed to be defended mainly by voice, but fighting can also occur (Fellers, 1979a). Toe-clipped males were recaptured on successive nights in the same general area, but not at the exact same location. This supports the findings of Delzell (1958) and Fellers (1979a), who state that a territory is defended, but different calling perches are used within it. In this study, males were observed to change calling perches within the same evening. At no time during this study were encounters between two males observed. Densities were low for the 5a population and available calling space was large. This allowed males to be spaced greater than 100 cm apart, so competition for territory may have been reduced.

The results of this study show that Spring Peepers are breeding in Cherokee County, or at least have bred successfully in prior years. Since males begin chorusing in their second spring after metamorphosis (Delzell, 1958), it is presumed that offspring from males recorded by Collins in 1982b were calling at sites censused during this study. Whether males bred this year is unknown. Due to the small size of the population, the relative infrequency of visits to the area, and the extreme difficulty of locating frogs in the dense sedge cover unless they were calling, the probability of finding females was remote. A more open situation with a definite shoreline would have made the detection of females easier.

Spring Peepers lay their eggs singly on the under side of vegetation (Delzell, 1958; Oplinger, 1966; Collins, 1975; Collins, 1982a) and the eggs are virtually impossible to locate without destroying habitat unless discovered while being laid (Delzell, 1958; Collins, 1975). An attempt was made to find eggs by looking through the dead sedges but no eggs were located.

Several attempts were made to identify peeper tadpoles. Size could not be used as a determinant because Southern Leopard Frogs (<u>Rana</u>

utricularia) had used the area prior to and during the first part of the peeper breeding season and tadpoles in various stages of development were present. Several tadpoles were sacrificed and mouth structure examined, but all were Rana utricularia. Once the spring rains ceased, the area dried rapidly. No newly metamorphosed froglets were observed. Since the subadults leave the aquatic area rapidly and move towards higher vegetation, and since observations were not made on a daily basis, it was easy to miss newly transformed frogs.

Although there are no data to confirm it, I believe that most Hyla crucifer bred in 5a during the 14 and 19 March period when temperatures were optimal. This is likely as females and males arrive at the breeding ponds at the same time (Delzell, 1958). According to Collins (1982a), eggs hatch in four to five days and tadpoles metamorphose in 90 to 100 days. By 13 June, 5a was completely dry. In order for Spring Peepers to have successfully metamorphosed they would have had to have hatched by the third week in March. Temperature can affect growth rate in larval amphibians (Wilbur and Collins, 1973) and the increase in temperature beginning on 27 April could have lessened the time to metamorphosis and allowed some tadpoles hatched later to successfully metamorphose. Since no peeper tadpoles or newly transformed froglets were ever discovered, this is all merely speculation. Also, the effects of the 18-19 March ice storm may have destroyed eggs laid prior. Only the presence of calling males in 5a in 1986 will indicate that peepers bred successfully this year. These two year old males hatched in 1984 will be breeding for the first time in 1986.

Habitat factors critical to reproduction

The second part of the present study dealt with habitat analysis and water composition of each pond described by Collins (1982b). All additional ponds containing Spring Peepers were included.

Examining the analyses for the ponds, five factors appeared important in affecting the success of breeding Spring Peepers. First, was the presence of pond edge vegetation, including shoreline and emergent vegetation growing around a shallow water perimeter. This vegetation was important to both adults and larvae.

Spring Peepers preferred calling from ponds where emergent vegetation occurred (Delzell, 1958; Collins, 1975; Conant, 1975; Fellers, 1979a; and Collins, 1982b). Males were often associated with dense stands of sedges (Delzell, 1958) or mats of dead grass (Fellers, 1979a). Males in Pond 5a called at dusk from under dense clumps of sedges and then moved out into the open as it grew darker. During the daytime, males moved back from the pond periphery into the densest stands of sedges. This vegetation seemed to offer concealment and protection from predators during the breeding season.

Amphibian mortality is highest during the larval and metamorphic stages of their life history (Calef, 1973; Heyer, 1976). Frog larvae with small body size such as Hyla crucifer were able to minimize encounters with predators due their ability to exploit more hiding areas in the habitat (Collins, 1975). Areas with dense vegetation in shallow water created ample hiding places for tadpoles and were relatively inaccessible to large predatory fish.

Secondly, the presence of stands of trees around or near the pond was important. Adult peepers set up home ranges in the understory of forests in summer and fall and utilized leaf litter under which to overwinter. Cover of debris on the ground surface or living vegetation controlled moisture loss as well as provided shelter and protection from predation. Wind movements were hindered under cover and surface evaporation reduced during summer. A dense leaf litter from under which a hibernaculum could be established was necessary in order for survival during the winter (Delzell, 1958).

Upon metamorphosis, young peepers rapidly progressed away from the larval aquatic area into a region of higher vegetation (Delzell, 1958). In areas surrounded by forest, the movement occurred from all parts of the pond and no accumulation of subadults was observed. In regions with no nearby tall vegetation, movement was disoriented and an accumulation of juveniles occurred (Delzell, 1958). This made them more susceptible to predators by making their exposure time longer while moving to higher vegetation and understory cover. The same is true of adults that must traverse great distances to reach breeding ponds, increasing their chances of predation by long treks through open areas (Delzell, 1958). Ponds with trees nearby greatly enhance the chances of survival of adults and newly metamorphosed young during their movements to and from breeding ponds.

The species of trees did not appear important, since Spring Peepers breed in deciduous forests from northern Michigan to Florida (Conant, 1975). The oak species found at all breeding ponds in Cherokee County did, however, form a thick litter of dead leaves that might enhance overwinter survival.

Collins (1982b) felt that the presence of predatory fish was an important limiting factor in the success of eggs and tadpoles. Several invertebrates are also known to predate on amphibian larvae (Heyer, 1976) and eggs (Licht, 1969). Predators such as leeches (Brockelman, 1969), predaceous diving beetle larvae (Young, 1967; Brodie, et al., 1978), giant water bugs (Brodie, et al., 1978), and dragonfly naids were especially important in small pond communities devoid of fish (Formanowicz and Brodie, 1982). Collins (1975) and Licht (1969) found that salamander larvae prey on Hyla crucifer tadpoles.

No ponds were predator-free and most contained predatory fish. Heavy edge vegetation increased hiding places, and the shallow water regions preferred by the smaller-sized peeper tadpoles lessen the influence of predation.

A factor that did not appear critical in this study but was found important in other studies was the duration of standing water in ephemeral pools (Collins, 1975). He and Conant (1975) stated that H. crucifer may prefer ephemeral pools, but Delzell (1958) and Fellers (1979a) have also found them breeding in permanent pools. In this study, three of the ponds containing peepers were ephemeral, whereas the rest were shallow, permanent ponds. These ephemeral pools, however, allowed time for metamorphosis. Pools which dry too soon will not be successful.

A pond must provide a food source for growing tadpoles. Anuran larvae ingest epiphytic algae (Dickman, 1968), epibenthic algae (Calef, 1973), and algae in their own fecal pellets (Steinwascher, 1978). Tadpoles can also remove particles, including phytoplankton from suspension by gill filters and a mucous entrapment mechanism (de Jongh, 1968; Gradwell, 1972; Wassersug, 1973). Seale and Beckvar (1980) found that tadpoles are relatively indiscriminate suspension feeders, eating both green algae and blue-green algae. Results of water analysis showed that suspended algae particles were low in all ponds, but mats of filamentous algae were found in all ponds containing calling Spring Peepeers and unidentified tadpoles. These tadpoles were observed grazing on such mats and it was assumed to be the major food source. Those ponds appearing most successful contained seventy-five percent or greater algae coverage of total water surface by mid May.

Water composition did not appear to be an important factor in determining the presence or absence of peepers. Unidentified tadpoles were found in all ponds except Pond 2.

The pH value and alkalinity contents were lower for the Cherokee County ponds than for other Kansas ponds (C. Prophet, pers. com.). Welch and Hambleton (1982) reported similar pH and alkalinity results from sites in southeastern Kansas where water drained from farmland. All ponds analyzed in this study were near cultivated fields.

Chlorophyll content was low for the ponds analyzed. This type of analysis measures only chlorophyll content of suspended algae. The major source of algae in the study ponds was mats of filamentous algae. Their chlorophyll content would not have been measured.

Major differences in any parameter measured were not detected between ponds or ephemeral pools. No factor was present or absent in ponds containing Spring Peepers and those which did not. Few changes were noted in chemical composition of Ponds 5a or 5b over the three month period. As water temperatures increased, alkalinities and conductivities were slightly higher.

Based upon the results of habitat analysis, Pond 3 was the only pond other than area 5 ponds determined to contain suitable habitat for breeding Spring Peepers. It contained dense edge vegetation in a flooded region and was bordered on one side by trees. Mats of filamentous algae covered ninety percent of the pond's surface. Deeper portions of the pond contained predatory fish, but they did not appear to invade the shallows where peepers were calling. Collins (1982b) reported five calling males from this pond and 15 males were heard calling in this study.

SUMMARY

The breeding ecology and habitat requirements of the Northern Spring Peeper were investigated from 18 February to 15 June in Cherokee County, Kansas.

Investigation of calling behavior of males indicated that temperature affects the arousal of males in the spring, the frequency and intensity of chorusing, the duration of nightly chorus, the duration of calling season, and the number of calling males on a given night.

Increased temperature associated with rainfall was found to trigger the first choruses of males. Lower temperatures decreased frequency and intensity of chorusing, duration of nightly chorus, and number of males calling on a given night. The calling season was restricted to the number of days when temperatures were below 18 C.

One hundred seven frogs were recorded at 10 of 14 ponds investigated.

Habitat analysis, including vegetational analysis and water composition, was conducted for the 14 ponds. Factors determined to be important to the maintenance of breeding colonies were: pond edge and emergent vegetation, close proximity to a stand of trees, few potential predators, presence of filamentous algae mats, and standing water until the end of May. Based upon these habitat requirements, Ponds 5a, 5b, 5c, 5d, and 3 were believed to be optimal breeding ponds.

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APPENDIX 1

Property owners in Cherokee County

Ponds 1a and b:	Mr. Robert Burrows, Route 5, Box 452, Joplin, MO 64801
Pond 1c:	Mr. C. K. Brown, Box 400, Route 2, Galena, KS 66739
Pond 2:	Mr. G. H. Wilkins, Sr., Route 1, Galena, KS 66739
Pond 3:	Mr. H. D. Youngman, 1406 Fairview, Baxter Springs, KS 66713
Pond 4:	Mrs. Ruby Carver, Route 2, Box 146, Galena, KS 66739
Pond 5a, c, d, and e:	Mr. Sam Ross, Route 1, Box 192, Galena, KS 66739
Pond 5b:	Mr. Norman D. Clark, Route 1, Galena, KS 66739
Pond 6:	Unknown
Pond 7a and b:	Mr. Ralph Culver, 44 Oak Crest Circle, Baxter Springs, KS 66713
Pond 8:	Mr. Norman Meyers, Route 2, Box 462, Galena, KS 66739
Pond 9:	Mr. James Dowty, Route 2, Box 315, Galena, KS 66739
Pond 10:	Unknown

APPENDIX 2

Alkalinity

Materials

N/50 sulfuric acid
Phenolphthalein indicator solution
Methyl orange indicator solution (or bromcresol green-methyl red solution)
Graduate cylinder, 100 ml
Flask, 250 ml (or white porcelain evaporating dish)
Buret, 25 ml
Stirring rod or motor

Procedure

1. Deliver 100 ml of the water sample into a 250 ml flask or porcelain dish.
2. If a pH meter is available, measure and record the pH of the sample. If the pH is greater than 8.3, add N/50 sulfuric acid, drop by drop, until the pH of the sample is adjusted to 8.3. The sample must be gently stirred as the acid is added to insure mixing. If a pH meter is not available add 3-4 drops of the phenolphthalein indicator solution and if a pink color apears (as will be the case if the pH of the water is greater 8.3) titrate with N/50 sulfuric acid until the color disappears. Record the milliliters of acid used. This volume times 10 is equal to ppm phenolphthalein alkalinity. If the pH of the sample is 8.3 or less, or no color developed when the indicator solution was added, phenolphthalein alkalinity is zero; continue with step #3.
3. If a pH meter is being used, the 100 ml sample used in step #2 is now titrated to a pH of 4.3; otherwise add 3-4 drops of methyl orange indicator solution and if an orange color develops titrate with N/50 sulfuric acid until a faint pink color develops. Record the milliliters of acid used. The volume of acid used to adjust the pH of the sample from 8.3 to 4.3 times 10 equals the ppm of methyl orange alkalinity.
4. Total alkalinity in ppm is the total volume of acid used in steps #2 and #3 times 10.

Calculation of Alkalinity Relationships:

It is often desirable to know whether alkalinity is due primarily to the presence of hydroxides (OH), normal carbonates (CO_3), or bicarbonates (HCO_3). Data from the following table are then used. T = total ml acid used. P = ml of acid used in titration with phenolphthalein.

Result	ppm Ca CO_3		
	OH	CO_3	HCO_3
P = 0	0	0	T x 10
P ½T	0	2P x 10	(T-2P) x 10
P = ½T	0	2P x 10	0
P ½T	(2P-T) x 10	2(T-P) x 10	0
P = T	T x 10	0	0

APPENDIX 3

Chlorophyll Method

The following method is based on the SCOR/UNESCO procedure which was adapted from the Richards and Thompson Procedure (J. Mar. Res., 11:156, 1956).

Collection and Concentration of Sample

The total amount of water to be collected will depend upon the quality of the water and phytoplankton densities present (collect at least one liter). It is best to store the water on ice after collection until the water can be filtered. To lessen pigment decomposition add about 0.1 g $MgCO_3$ to the sample and shake.

Although the sample can be centrifuged, better retention of phytoplankters is accomplished with filtration. Either 4.2 cm millipore filters (HA) or Whatman glass filters (GF/C), having a pore size of approximately 0.45-0.65 microns can be used. After filtration the filters and residue extracted in 90 % acetone for 18-20 hours (dark and refrigerated), and absorbances at specific wavelengths are read. After correction for degradation products, the concentration of chlorophyll per volume can be calculated.

Procedure

1. Filter a known volume of sample through a 4.25 cm Whatman GF/C glass filter. Although only 100-200 ml of highly turbid water can be filtered through a single filter, a sufficient volume can be processed if the original water sample is concentrated before filtration (i.e. strain large volume of water through a plankton net and transfer this concentrated sample to a storage bottle). If the sample has been concentrated be sure to record the original volume of water sampled.

2. Transfer the damp filter to a large centrifuge tube and add 10 ml of 90 % acetone. The volume of acetone used will have to be determined by experience for any given aquatic system.

3. Cap the filter and acetone preparation and store under refrigeration for 18-20 hours, shake or stir to assist the extraction process.

4. Centrifuge extracts for 5-10 minutes, then decant to cuvette.

5. Read absorbances of 10 ml of extract in a Spectronic 20 at 665 in a 10 cm-path-length.

6. Add two drops of dilute HCl to each cuvette, mix, and remeasure absorbances at 665.

7. Concentrations by the following equations.

$$\text{Micrograms/liter chlorophyll a} = \frac{26.7\ (665_0 - 665_A) \times v}{V \times 1}$$

$$\text{Micrograms/liter phaeo-pigments} = \frac{26.7\ (1.7\ [665_A] - 665_0) \times v}{V \times l}$$

where 665_0 is absorbance before acidification, 665_A is absorbance after acidification, v is volume of 90 % acetone (in ml) used for extraction, V the original volume (in liters) of water filtered, a l is the light path length of the cuvette (cm).

APPENDIX 4

List of common and scientific names of plants used in this text.

Common Cattail. . . . . Typha latifolia
Water Plantain. . . . . Alisma
Arrowhead . . . . Sagittaria latifolia
Sloughgrass . . . . Spartina pectinata
Spike Rush. . . . . Eleocharis obtusa
Great Bulrush . . . . Scirpus validus
Sedge . . . . Carex frankii
Duckweed. . . . . Lemna
Pickerelweed. . . . . Pontederia cordata
Southern Blue Flag. . . . . Iris virginica
Willow. . . . . Salix
Black Walnut. . . . . Juglans nigra
Hickory . . . . Carya
Pecan . . . . Carya illinoensis
Bitternut Hickory . . . . Carya cordiformis
River Birch . . . . Betula nigra
White Oak . . . . Quercus alba
Post Oak. . . . . Quercus stellata
Bur Oak . . . . Quercus macrocarpa
Chinquapin Oak. . . . . Quercus muehlenbergii
Red Oak . . . . Quercus rubra
Pin Oak . . . . Quercus palustris
Oak . . . . Quercus
Red Elm . . . . Ulmus rubra
American Elm. . . . . Ulmus americana
Hackberry . . . . Celtis occidentalis
Water Smartweed . . . . Polygonum punctatum
Coontail. . . . . Ceratophyllum demersum
American Lotus. . . . . Nelumbo lutea
Poor-Man's Pepper . . . . Lepidium virginicum
Sycamore. . . . . Platanus occidentalis
Kentucky Coffee Tree. . . . . Gymnocladus dioica
Honey Locust. . . . . Gleditsia triacanthos
Eastern Redbud. . . . . Cercis canadensis
Tree-of-Heaven. . . . . Ailanthus altissima

Poison Ivy. . . . . Rhus radicans

Silver Maple. . . . . Acer saccharinum

Box Elder . . . . Acer negundo

Raccoon Grape . . . . Amepelopsis cordata

River-Bank Grape. . . . . Vitis riparia

American Basswood . . . . Tilia americana

Waterwort . . . . Elatine americana

Creeping Waterprimrose. . . . . Jussiaea repens

Swamp Dogwood . . . . Cornus amomum

White Ash . . . . Fraxinus americana

Green Ash . . . . Fraxinus pennsylvanica

Trumpet Creeper . . . . Campsis radicans

Buttonbush. . . . . Cephalanthus occidentalis