FINAL REPORT

As Required by

THE ENDANGERED SPECIES ACT, SECTION 6

TEXAS
Project No: E-1-4

ENDANGERED AND THREATENED SPECIES CONSERVATION

Job No. 8

Houston Toad (Bufo houstonensis) Status Survey

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January 31, 1993

ABSTRACT

In 1992 no new Houston toad (Bufo houstonensis) populations were located. One new breeding pond was located in Robertson county approximately 2,200 meters from an already known breeding pond. Surveys were conducted in Dewitt, Goliad, Grimes, Harris, Lavaca, Montgomery, and Victoria counties. None of these counties appeared to have suitable habitat except Lavaca (which has a known population) and Dewitt. However, in Dewitt County the gulf coast toad (Bufo valliceps) was very abundant and in full chorus on March 4 (earliest survey). It is unlikely that the Houston toad could exist under such competitive conditions unless it breeds much earlier in that area (this will be checked in 1993).

The Houston toad is now known to occur in the following counties: Austin, Bastrop, Burleson, Colorado, Freestone, Lavaca, Leon, Milam, and Robertson. It probably occurs in Caldwell and Lee counties. It possibly occurs in Dewitt and Waller counties. It is not currently known or likely to occur in any other counties.

Based on the amount of habitat destruction and on extensive surveys the Houston toad has been extirpated from Fort Bend, Harris, and Liberty counties. Based on habitat type, extensive surveys, and the prevalence of close competitors the Houston toad does not occur east of the Trinity river, and it does not occur in following counties even though these counties fall between the two bands comprising the distribution of the Houston toad: Brazos, Fayette, Grimes, Gonzales, Madison, Montgomery, San Jacinto, Walker, and Washington.

Above average rainfall and temperatures preceding the breeding season contributed to enhanced numbers and activity of B. houstonensis; a total of 308 individual adult toads were captured at the two Bastrop study ponds during 1992. Overall recapture success of toads marked during 1990 was 24%. Eight male toads originally marked in 1990 were recaptured. The toads recaptured in 1992 were significantly larger in body size than in 1991; many newly marked toads were post-first-year breeders. The data continue to suggest that many adult toads travel long distances and breed at different sites from year to year, or that many adults do not breed every year. Long distance migration is supported by data on 4 recaptured individuals. Toads used temporary rain pools and other ephemeral breeding habitats more this year than in 1991 because more such habitat was available. Management guidelines for the B. houstonensis population in Bastrop State Park are outlined.

PERFORMANCE REPORT

STATE: Texas **PROJECT NO.:** E-1-4

PROJECT TITLE: Endangered and Threatened Species Conservation.

PERIOD COVERED: September 1, 1991 through August 31, 1992

JOB NUMBER: 8.0

JOB TITLE: Houston Toad (Bufo houstonensis) Status Survey

JOB OBJECTIVE: To investigate the current and potential distribution and the breeding habitat of the Houston Toad (Bufo houstonensis), assess the ecological requirements of the species, assess past and present land-use practices and other factors known or suspected to impact the species, and prepare a resource stewardship plan for the population in the Bastrop area.

SEGMENT OBJECTIVES:

1. Complete the distributional survey.
2. Conduct a Geographic Information System (GIS) feasibility study delineating habitat requirements for the species.
3. Continue the autecological study in the Bastrop area.

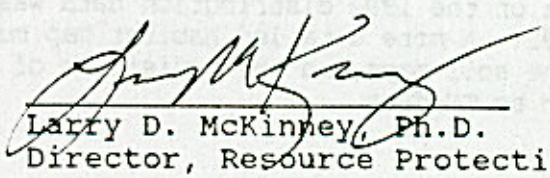
ACCOMPLISHMENTS

See attached reports.

SIGNIFICANT DEVIATIONS

None.

PREPARED BY: James H. Yantiss — November 12, 1992
Andrew H. Price, Ph.D. — January 22, 1993

APPROVED BY:  1/2/93

Larry D. McKinney, Ph.D. — Date
Director, Resource Protection Division

OBJECTIVES 1 & 2: Results of distribution study and GIS feasibility study.

I. Objective:

Systematically review current distribution and relative abundance of Houston toads and assess needs for specific habitat management actions.

II. Background:

An extensive comprehensive survey based on habitat type has never been conducted for the Houston toad. Additionally, some of the records are over 30 years old and have not been reverified. Changes due to land use could have extirpated the toad in some areas. Information is sketchy concerning the habitat of the Houston toad over the known range of the species, and especially over the entire potential range of the species. How the toad fits into the landscape ecology is poorly understood. The effects of land use practices on toad populations are incompletely known.

III. Procedures:

b. The original hard copy soil maps surrounding Houston toad breeding ponds were obtained from the Soil Conservation Service (SCS). Digitizing of these maps was not done due to work conflicts. Vegetation and pond information was not obtained, partly because of work conflicts but also because it appears that thematic mapper (TM) data may soon be availabe as a result of the neotropical bird initiative (Partners in Flight) and other Department ecosystem projects. Arrangements were made for the use of several GIS systems at little or no cost, including the latest versions of AGIS, ARC/INFO, ERDAS, and GRASS.

c. Several pages of comments were provided as requested to Resource Protection (RP) and Public Lands (PL) concerning the proposed golf course addition at Bastrop State Park and the possible impacts on the Houston toad and possible management and mitigation meaasures.

d. A project report on the 1992 distribution data was prepared by November 31, 1992. A more detailed habitat map must await the digitizing of the soil maps and the aquisition of digital landcover information such as TM data.

IV. & V. Findings, Analysis, and Management Implications:

A. Findings and Analysis.

In 1992 no new Houston toad populations were located. One new breeding pond was located in Robertson County approximately 2,200 meters from an already known breeding pond. For the fourth year in a row no Houston toads were heard at the historic location near Lake Woodrow in Burleson county. On February 13, 1992, spot checks of the Leon County location near Hilltop Lakes and the Robertson County location east of Blackjack determined that both were active and appeared to have more Houston toads than in 1991. No other known locations were checked except Lavaca County (discussed below).

A combined total of 900 listening stops were made in Dewitt, Goliad, Grimes, Harris, Lavaca, Montgomery, and Victoria counties. None of these counties appeared to have suitable habitat except Lavaca (which has a known population) and Dewitt. However, in Dewitt County the gulf coast toad was very abundant and in full chorus on March 4 (earliest survey). It is unlikely that the Houston toad could exist under such competitive conditions unless it breeds much earlier in that area (this will be checked in 1993). Work conflicts prevented conducting a survey in Dewitt County earlier than March 4. Spot checks on March 4 and March 16 of the known Lavaca county population found no Houston toads calling. An earlier survey is probably needed for this southern-most potential habitat.

The Houston toad is now known to occur in the following counties: Austin, Bastrop, Burleson, Colorado, Freestone, Lavaca, Leon, Milam, and Robertson. It probably occurs in Caldwell and Lee counties. It possibly occurs in Dewitt and Waller counties. It is not currently known or likely to occur in any other counties.

Based on the amount of habitat destruction and on extensive surveys the Houston toad has been extirpated from Fort Bend, Harris, and Liberty counties. Based on habitat type, extensive surveys, and the prevalence of close competitors the Houston toad does not occur east of the Trinity river, and it does not occur in following counties even though these counties fall between the two bands comprising the distribution of the Houston toad: Brazos, Fayette, Gonzales, Grimes, Madison, Montgomery, San Jacinto, Walker, and Washington.

B. Management Implications.

No information gathered in this segment indicated any habitat preferences different from what was reported in the 1991 report. Information increasingly supports the probability that the Houston toad is not a species of the coastal prairie. Site visits to the historic locations in Harris County found remnants of pine-oak-yaupon motts on deep sands at these locations. An engineer with the city of Houston stated that one of the Houston toad locations which currently is covered with clay soil was once a sand pit over 60 feet deep and that the topsoil was trucked in.

As a result of the new Private Lands Enhancement matching funds initiative, contacts with some owners of large tracts of land where Houston toads occur in Burleson, Milam, and Robertson counties revealed some potential ecosystem level management practices likely to favor the Houston toad; such as conservation of woodland, presribed burning, deferred rotation grazing on native savannah, and protection of natural small or ephemeral wetlands. This potential, plus the new prescribed burning/ecosystem management initiative at Bastrop State Park, could result in substantial conservation gains at the ecosystem level if coordination and cooperation are agressively pursued by the Texas Parks and Wildlife Department with support from the U. S. Fish and Wildife Service.

VI. Recommendations:

1. Funds not used in this segment should be rolled-over to the next segment for continued work on the habitat analysis, and to complete the investigation in Dewitt County, and to check out any new Houston toad reports from the general public. Approximately 20 mandays would be required.

2. The potential for ecosystem level managment for Houston toad habitat as a result of the Private Lands Habitat matching funds initiative should be fully exploited and vigoruosly pursued by Wildlife Branch staff.

VII. Prepared by: James H.Yantis
Biologist II

Date: November 12, 1992

OBJECTIVE 3: Results of autecological study.

The two study ponds censused for Bufo houstonensis activity and demographics during the 1990 and 1991 breeding seasons in Bastrop State Park were again censused during the 1992 breeding season. In addition, four satellite ponds formed as a result of increased rainfall were also censused. Both ponds and their satellites were visited every night from January 7 through April 30, and each post-metamorphic toad captured (with the exception of young-of-the-year) was implanted with a PIT tag unless already in possession of one. Qualitative observations of Houston Toad activity were made at several other locations in and around Bastrop State Park as time permitted. The following abiotic variables were also measured at each pond: maximum and minimum air temperatures during the preceding 24-hour period; air temperature at the time of visit; soil surface temperature; soil temperature 2 cm below the surface; water temperature; relative humidity; and barometric pressure. General weather parameters (e.g. rainfall, wind speed, cloud cover) were qualitatively assessed.

The year 1991 was the wettest on record in the central Texas area, with cumulative rainfall at the Austin U.S. Weather Bureau exceeding 51 inches. December 1991 was also the wettest ever, with cumulative monthly rainfall exceeding 14 inches, with most of that (12+ inches) falling during the week of December 15th. The wetted perimeter of pond #10 increased from 50 m during 1990 to 204 m prior to the initiation of breeding for this year by Bufo houstonensis, and numerous low-lying areas and minor

drainages retained standing water for the entire study period. A total of 308 individual B. houstonensis, 20% fewer than during 1991, were encountered at the two study ponds and their satellites (Fig. 1 & 2). In all probability the availability of standing water throughout the study area reduced the attractiveness of the permanent ponds as centers for breeding activities. Average captures remained the same or were significantly higher for both sexes when compared to 1991. Individual male Houston Toads were recaptured up to 8 times around pond #9 and 22 times around pond #10 during the course of the breeding season. Females were again infrequently recaptured, but were more active than in 1991; 43% of the 51 females captured were caught more than once and 8 individuals were caught 3 or more times. Thirteen additional Bufo houstonensis (no recaptures from 1991) at other sites and 7 Bufo valliceps (5 recaptures from 1991 and 2 from 1990) at the two study ponds were also captured and implanted with PIT tags if necessary. No hybrids were captured this year. Of the Houston Toads caught at the study ponds, 78 (70 males and 8 females, 25% of the total) were recaptures from 1991. Eight of these toads, all males, were originally marked in 1990. Thus, overall survival of marked toads from 1991 to 1992 was 24%. This is less than the 31% reported by Hillis et al. (1984) for one breeding site 10 years ago; however, they did not mark toads for individual identification and only marked toads during one night's chorus. Jacobson (1989) caught 379 toads at this site the following year.

Table 1. Total numbers and average captures of male and female Bufo houstonensis during the 1992 breeding season, sex ratios, and recaptures from the 1991 breeding season at two study ponds in Bastrop State Park.

	Pond 10	Pond 9
Amplectant males	37	10
average captures	5.97±3.22	5.10±2.47
Non-amplectant males	143	51
average captures	4.86±3.88	2.65±1.92
Females	38	13
average captures	1.76±1.11	1.46±0.50
Male / Female	4.74	4.69
Recaptured 1991 males	44	26
(percentage of total)	(21)	(26)
Recaptured 1991 females	5	3
(percentage of total)	(8)	(15)

Figures 3 and 4 show the size distribution of Bufo houstonensis at the two ponds. Amplexed and non-amplexed pond #10 males averaged 59.65 ± 3.63 mm and 58.98 ± 4.62 mm SUL, respectively; similar values at pond #9 were 60.50 ± 4.03 mm and 59.80 ± 5.38 mm SUL, respectively. There were again no significant size differences between amplexed and non-amplexed males at either pond; however, since a much smaller proportion of females was caught in amplexus this year than last, this result may be spurious. Pond #10 and pond #9 females averaged 68.24 ± 4.16 mm and 69.31 ± 2.49 mm SUL, respectively. There were again no significant size differences between the two ponds. The size distributions and the seasonal chronology for individual toads appearing at the breeding ponds again suggests that males less than 60 mm SUL are probably in their first breeding season. If

Quinn and Mengden (1984) are correct that females do not attain sexual maturity until they are 2 years old, then the maximum lifespan indicated for B. houstonensis is 4 years. Most toads breed only once, with many males and a few females surviving to breed a second time, and a few males a third time.

The breeding phenology of the Bufo houstonensis populations at the two ponds is shown in Figures 5-7. Differences in magnitude exist but the timing is basically similar to the previous 2 years. The increased activity manifested by Houston Toad breeding populations at both ponds in response to favorable environmental conditions preceding the season is reflected by the fact that maximum 1990 chorus sizes at pond #10 were again exceeded three times during 1992. Although correlations with the abiotic variables measured have yet to be quantified, the minimum temperature threshold of 14°C (58°F) reported by Hillis et al. (1984) and utilized in the distributional survey portion of this study is clearly insufficient to predict Bufo houstonensis chorusing activity. As detailed in last year's report, warm temperatures, high humidity, rainfall, and dark phases of the moon are proximate stimuli to breeding activity.

Barred Owls (Strix varia) are implicated as predators of Bufo houstonensis, as feathers from these birds were found next to partially-consumed carcasses around both study ponds during 1991 and 1992. Raccoons undoubtedly take their share; I discovered 9 Scaphiopus holbrooki and 1 B. houstonensis in a little drainage under a closed canopy on the night of April 17th.

The posterior half of the torso of each one had been eaten.

As reported last year and also by Jacobson (1989), many females were recaptured on consecutive nights, presumably still ovipositing. Four pairs of toads were found in amplexus on 2 consecutive nights and two pairs on 3 consecutive nights in 1992. In addition, two more pairs were found in amplexus over widely spaced intervals again this year. Toads 7F7F3B6109 (male) and 7F7F3B750D (female), and 7F7F3B6A13 (male) and 7F7F3B7C50 (female) were found in amplexus on February 23 and March 2 and 3 at pond #10; either they remained together during the interval or paired again during the second chorus.

Significant overland movement by adult individual Bufo houstonensis occurred again this year but was much less prevalent than last year, undoubtedly due to the saturation of surface topography with standing water discussed above. Male 7F7F274278, who made similar migrations last year, was captured at pond #9 on February 12th and pond #10 on March 2nd, a distance interval of 675 meters. Male 7F7F3B6E48 also traveled between ponds, having been captured on February 23rd and March 3rd at pond #9 and on March 4th, 5th, 17th and 18th at pond #10. Males 7F7F3B7B24 was captured at puddle #5 on February 22nd and 23rd and March 4th, and at pond #10 on March 5th and 12 nights thereafter, traveling 490 meters in a 24-hour period. It is doubtful that toads move in a straight line between ponds and puddles, however, so the true distances traveled are probably greater. Both figures eclipse the previous estimate of 400 meters given for maximum

distance traveled from a breeding site (D. M. Hillis, pers. comm.; R. F. Martin, pers. comm.). These figures reinforce the hypotheses discussed last year concerning the vagrant nature of adult toads and have important implications for conservation and management of Bufo houstonensis populations throughout the species' range; habitat fragmentation and isolation of breeding sites may have serious demographic consequences.

The use of temporary rain pools for breeding by individual Bufo houstonensis remained at least as significant this year as in 1991, only because there were more of them. Puddles #4, #5, and #6 formed in and around ruts at low-lying points on the sandy "two-track" leading south from Park Road 1C to the study ponds, as detailed in last year's report. These puddles retained water throughout the 1992 study period, except when the grader hired by TPWD periodically graded the road. In addition, a debris pile ponded water in a small drainage extending northeast of pond #9 ("NE #9"), and this held water throughout the season as well. 29 male and 5 female B. houstonensis were captured at puddle #6, 18 males and 3 females at puddle #5, 8 males and 2 females at puddle #4, and 8 males and 1 female at NE #9. Of these, 10 males and 3 females from puddle #5, 4 males and 1 female from NE #9, and 9 males and 3 females from puddle #6 were not captured at the nearby permanent study ponds. None of the toads at puddle #4 were captured anywhere else. One of the males captured exclusively at puddle #5 was also captured exclusively there during 1991. A female captured at puddle #5 on March 3rd was

recaptured in amplexus at NE #9 on April 18th. A male captured on March 5th at puddle #5 was recaptured at NE #9 on March 8th; another was caught at various times at puddle #5, pond #9, and NE #9.

Details of egg-laying and hatching phenology and success were not significantly different than they were in 1991.

MANAGEMENT OF THE HOUSTON TOAD IN BASTROP STATE PARK

The Bastrop County population of the Houston Toad remains the largest and best-known for the species, and is the only one which enjoys some measure of protection in that a part of it lies within Bastrop State Park. Land-use changes detrimental to this species have occurred in this region prior to designation of critical habitat and subsequently. These changes are expected to continue and to intensify with increased urbanization of the region, especially if the Austin International Airport moves to the former site of Bergstrom Air Force Base. A permit under Section 10(a) of the Federal Endangered Species Act is currently be prepared to allow for expansion of the Lost Pines Golf Course within the Park boundaries. Unfortunately it falls short of the biological mark in that toads outside of the Park in Bastrop County are not included; however, if it is implemented as it's drafter intends, the plan should be to the overall benefit and eventual recovery of the species.

Following are excerpts from the draft HCP for the Lost Pines

Golf Course expansion which outline management steps for the Houston Toad in Bastrop State Park.

The most likely reason for the unsuitability of the present golf course as habitat for Houston Toads is the creation of the golf course itself. Clearing and replacement of native vegetation with bermudagrass turf to create fairways and greens along with concomitant alteration in the existing topography makes toads easy targets for a wide variety of predators. An additional potentially significant but unknown factor is physical and chemical maintenance of the golf course. The aquatic life stage of many amphibians are known to be sensitive, directly or indirectly, to a variety of pollutants, including herbicides, pesticides and other organic compounds. A possible third factor is the cumulative effects of years of foot and vehicle traffic concentrated on and around the golf course.

Management needs will depend on the condition of the preserve lands acquired through outright fee title or conservation easements. The basic biological needs of the Houston Toad need to be met. The structural integrity of permanent or intermittent wetlands in which the species breeds should be maintained. Current artificial impoundments in which toads breed and which are stocked with predatory fish should have the fish or the dam eliminated, or be redesigned with sufficient shallow areas at all water levels to allow toads to breed successfully. The structure of natural drainages should be maintained as both juvenile and adult toads often disperse along

them initially from breeding sites. The vegetational and topographic profiles of areas linking breeding sites outside of natural drainages should be maintained or enhanced to provide dispersal, foraging and aestivating/hibernating habitat, and to prevent the unnatural invasion of congeners causing potential hybridization problems.

Vegetational communities such as the longleaf pine-oak series woodland (the "lost pines") in Bastrop State Park, which are naturally fire-maintained and in which the Houston Toad naturally occurs, should be returned to a prescribed burning regimen. This is important because this population is now effectively isolated from other known populations due to habitat fragmentation and other factors, and an uncontrolled fire could have catastrophic consequences for the species in this situation. The response of the Houston Toad population to this activity in the park will have to be carefully monitored (see below).

A Biological Information Group and Management Advisory Committee (BIGMAC) is proposed to be formed on an ad-hoc basis composed of members from the USFWS, Bastrop County Environmental Network, Lost Pines Golf Club, Bastrop Audubon Society, City and County of Bastrop and other interested parties as determined by the Plan Operator to act as an advisory group to the Plan Operator. This group will review all management reports and provide problem solving input to the Plan Operator. The mechanics of how the BIGMAC will function are described in greater detail in the Implementation Agreement.

Research activities that are proposed and that have already been conducted have been designed to significantly contribute to the overall knowledge base concerning the distribution, abundance, and life histories of the Houston Toad. This new knowledge will aid in understanding the status and survival requirements of the species, which will facilitate better decisions in designing management and conservation activities. This, in turn, will enhance the overall survival and recovery of the species.

Ongoing activities which need to be continued, and which should be facilitated through the funding mechanism of this HCP as envisioned, include the search for new populations within suitable habitat throughout the putative range of the species, and the monitoring of existing populations to ascertain their size and demographic characteristics. In particular, it is important to determine whether new populations are widespread or circumscribed in geographic extent, whether they are composed of a few or many individuals, whether or not they are successfully reproducing, and whether or not they are stable over the long-term. The development of GIS capability for the Houston Toad should be pursued and should aid in the search for new populations, the data from which in turn should refine the predictive powers of a GIS for this species as a large-scale management tool.

Long-term monitoring of the Bastrop State Park population of the Houston Toad should continue for no other reason than to

establish and maintain a baseline knowledge set with which to guage the remainder of the species' populations. In addition, if Bastrop State Park is to be burned as this HCP recommends, then the Houston Toad will be an integral component of the assessment of this activity on the biota of the park. It is recommended that breeding site populations be used to measure the effect of fire upon the Houston Toad. A minimum of two treatment and two control sites are to be established and a minimum census of two seasons is to be conducted prior to burning the treatment area. A controlled "cool" burn is envisioned and should be done outside of the breeding season, preferably during September, October or November. Finally a minimum of two years post-burn censusing should be conducted to assess the response of Houston Toads in the treatment area. Ideally this activity will include monitoring of other biotic and abiotic components of the environment in order to establish and develop a scientifically sound basis for further management needs and activities.

Other necessary and important research needs not yet begun relate to basic life-history information and the assessment of threats to environmental quality. A research program to determine the fecundity of individual female Houston Toads, the ratio of hatching success of eggs and survival of tadpoles to metamorphosis, and the recruitment of toadlets into the breeding population is necessary to build a life table for this species which in turn can be used to refine predictions concerning the long-term viability of populations. Additionally, a study

investigating the chemical composition of soils inhabited by Houston Toads and their relationship to water quality parameters at breeding sites would be useful, especially in light of the accruing information concerning amphibian declines and disappearances around the world. The effects of pesticides, herbicides and other anthropogenic compounds on the aquatic life stages of the Houston Toad are unknown and need to be addressed through a separate research program in order to correlate with background environmental conditions and predict the impacts of future management actions and development activities.

Most people, if they know of the existence of the Houston Toad at all, are completely ignorant of aspects of the life-history, distribution, and phylogenetic relationships of this species. This generalization holds for visitors to Bastrop State Park, which is the only place where this species is currently protected. There is no public educational display about the Houston Toad at this facility, and the information in the park brochure is inadequate and out-of-date. An interactive audio-visual public display, for which this species is admirably suited, should be constructed. In addition, guided tours for interested citizens by knowledgeable and qualified biologists during the breeding season, when these animals are most spectacularly visible, should be conducted. These tours could be in association with ongoing monitoring and research projects or separate from them, depending on circumstances.

LITERATURE CITED

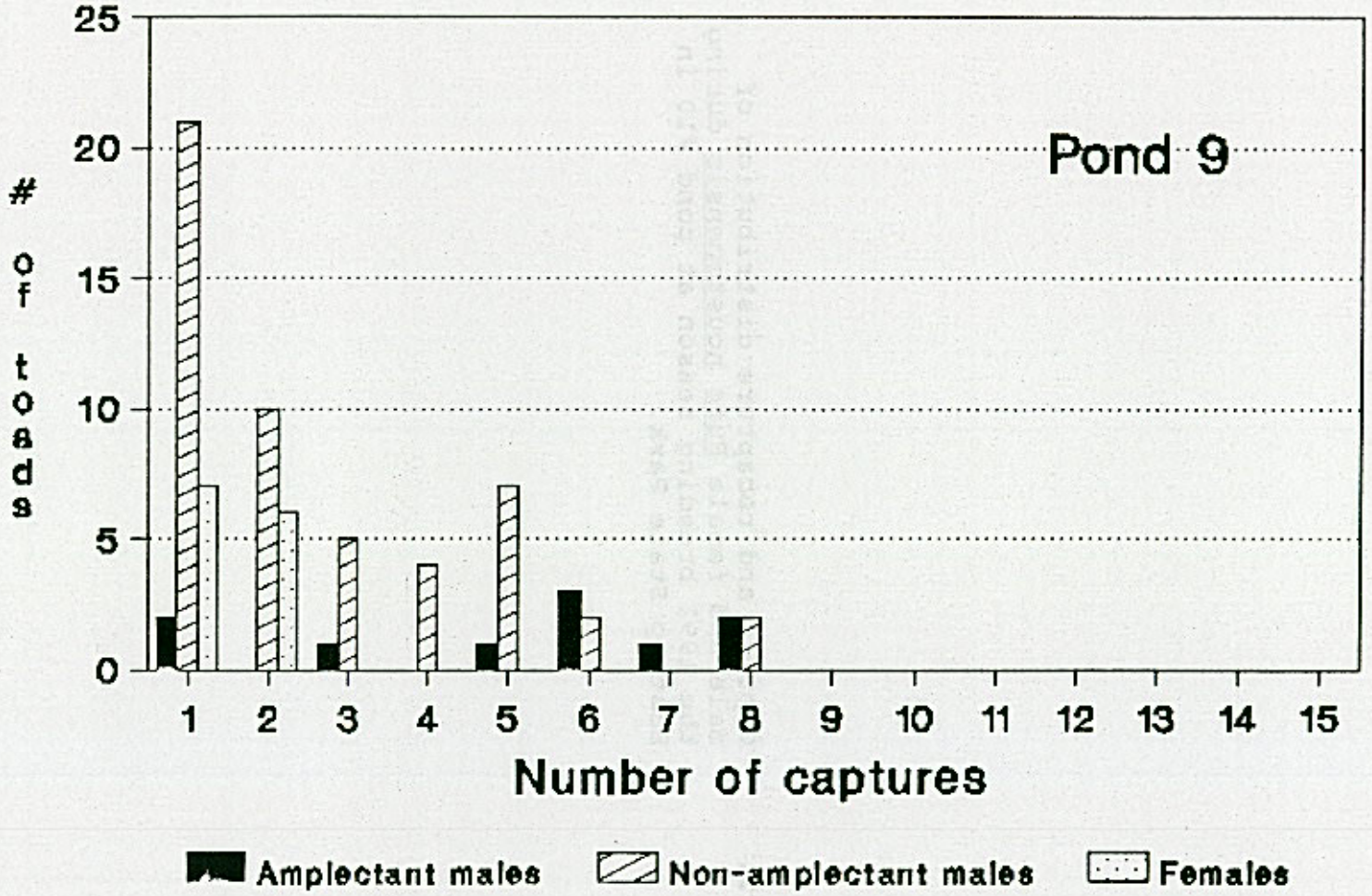
Jacobson, Nancy L. 1989. Breeding dynamics of the Houston Toad. Southwest. Nat. 34:374-380.

Hillis, David M., Ann M. Hillis, and Robert F. Martin. 1984. Reproductive ecology and hybridization of the endangered Houston Toad (Bufo houstonensis). J. Herpetol. 18:56-72.

Quinn, Hugh R. and Greg Mengden. 1984. Reproduction and growth of Bufo houstonensis (Bufonidae). Southwest. Nat. 29(2): 189-195.

FIGURE 1. Capture and recapture distribution of male and female Bufo houstonensis during the 1992 breeding season at pond #9 in Bastrop State Park.

1992 B. houstonensis Captures/Recaptures



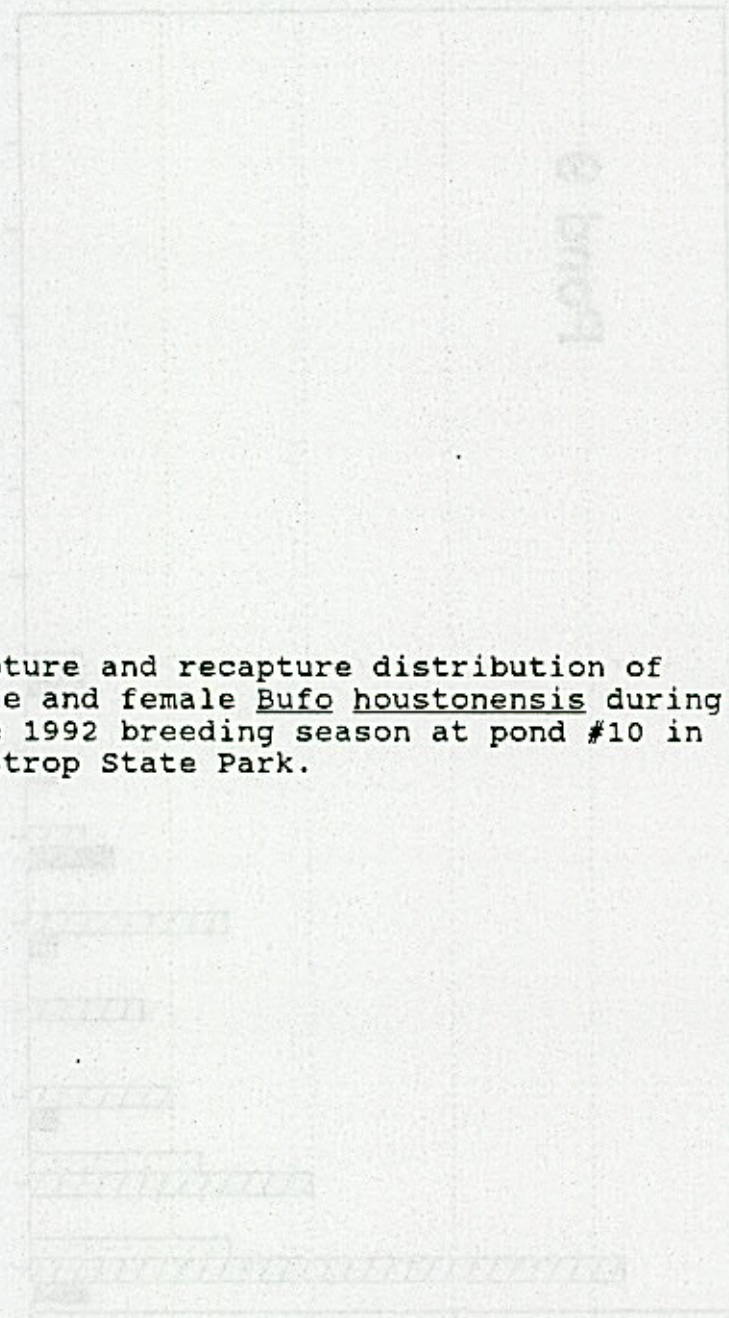
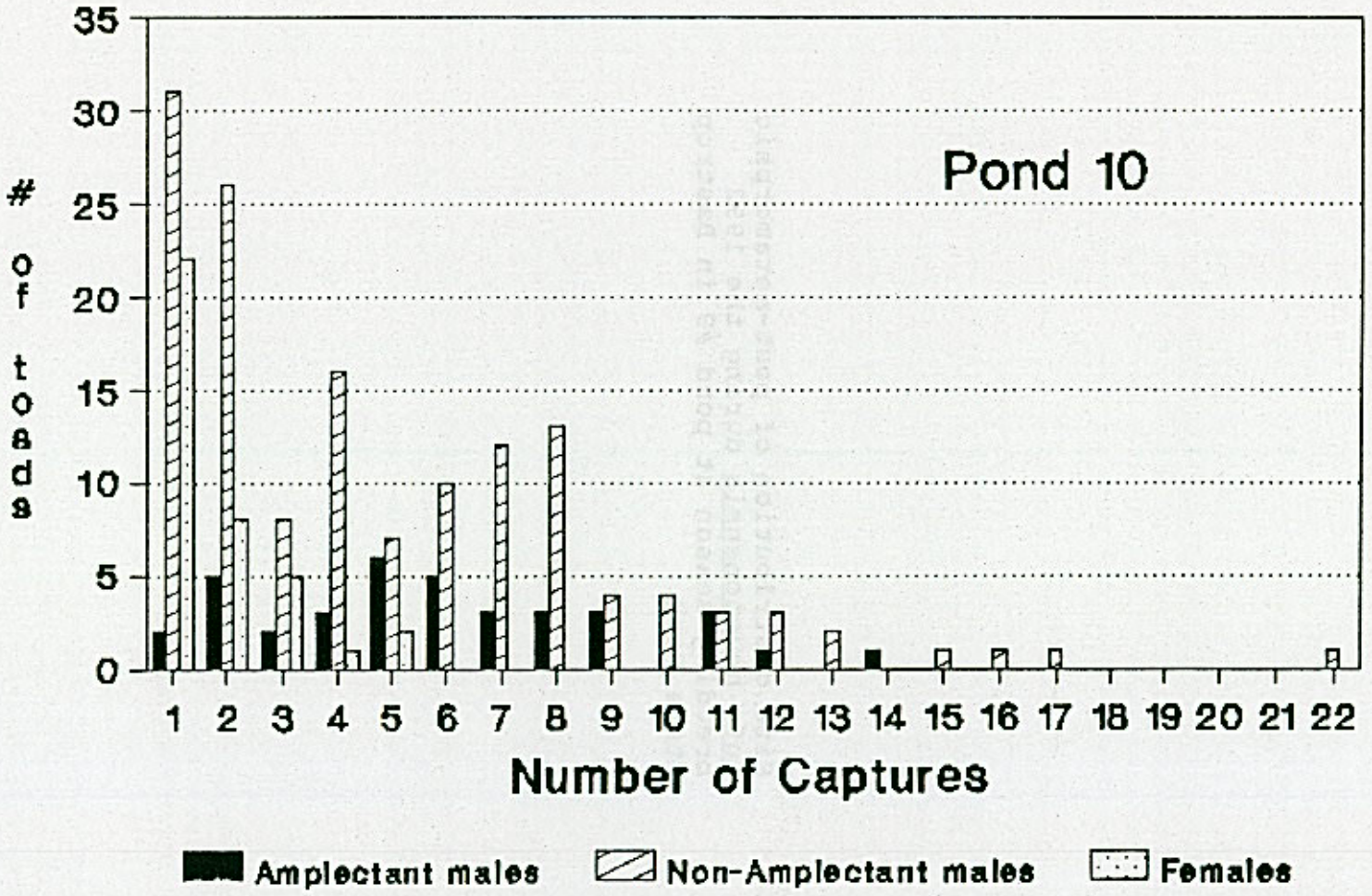


FIGURE 2. Capture and recapture distribution of male and female Bufo houstonensis during the 1992 breeding season at pond #10 in Bastrop State Park.

1992 B. houstonensis Captures/Recaptures



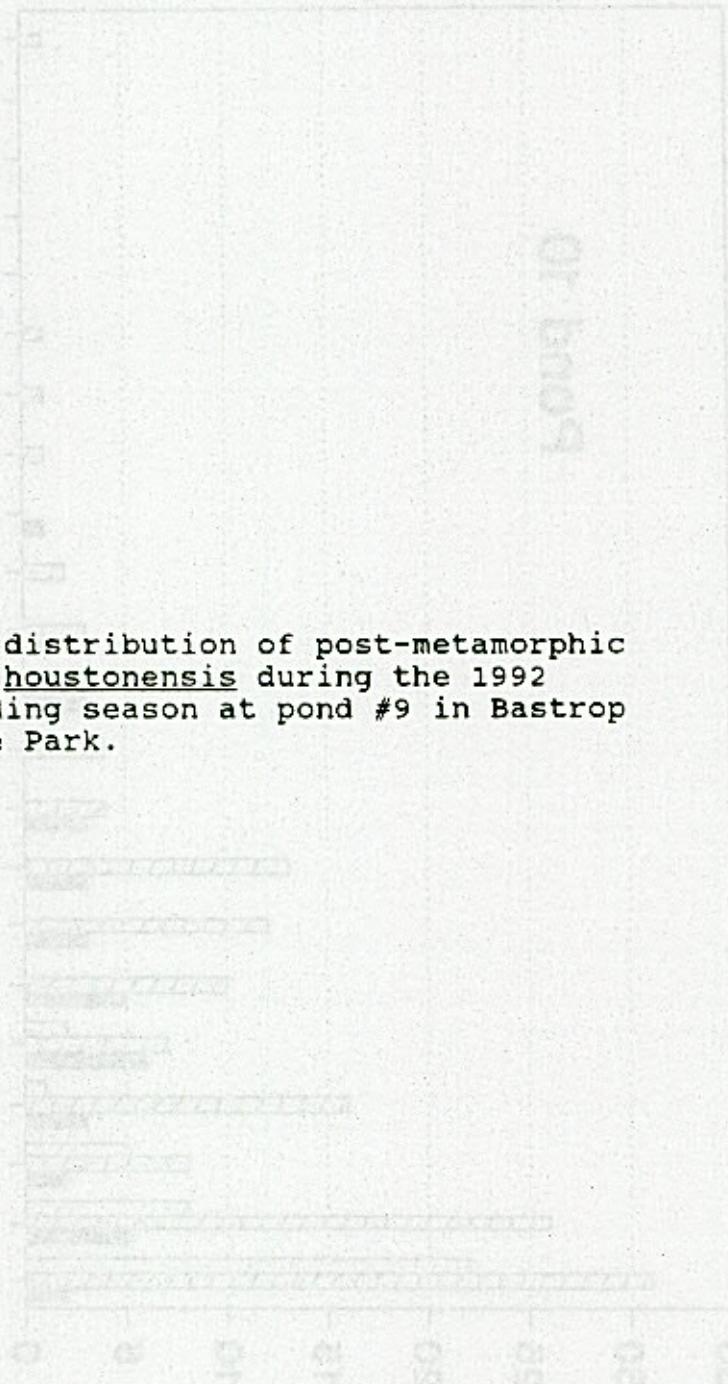
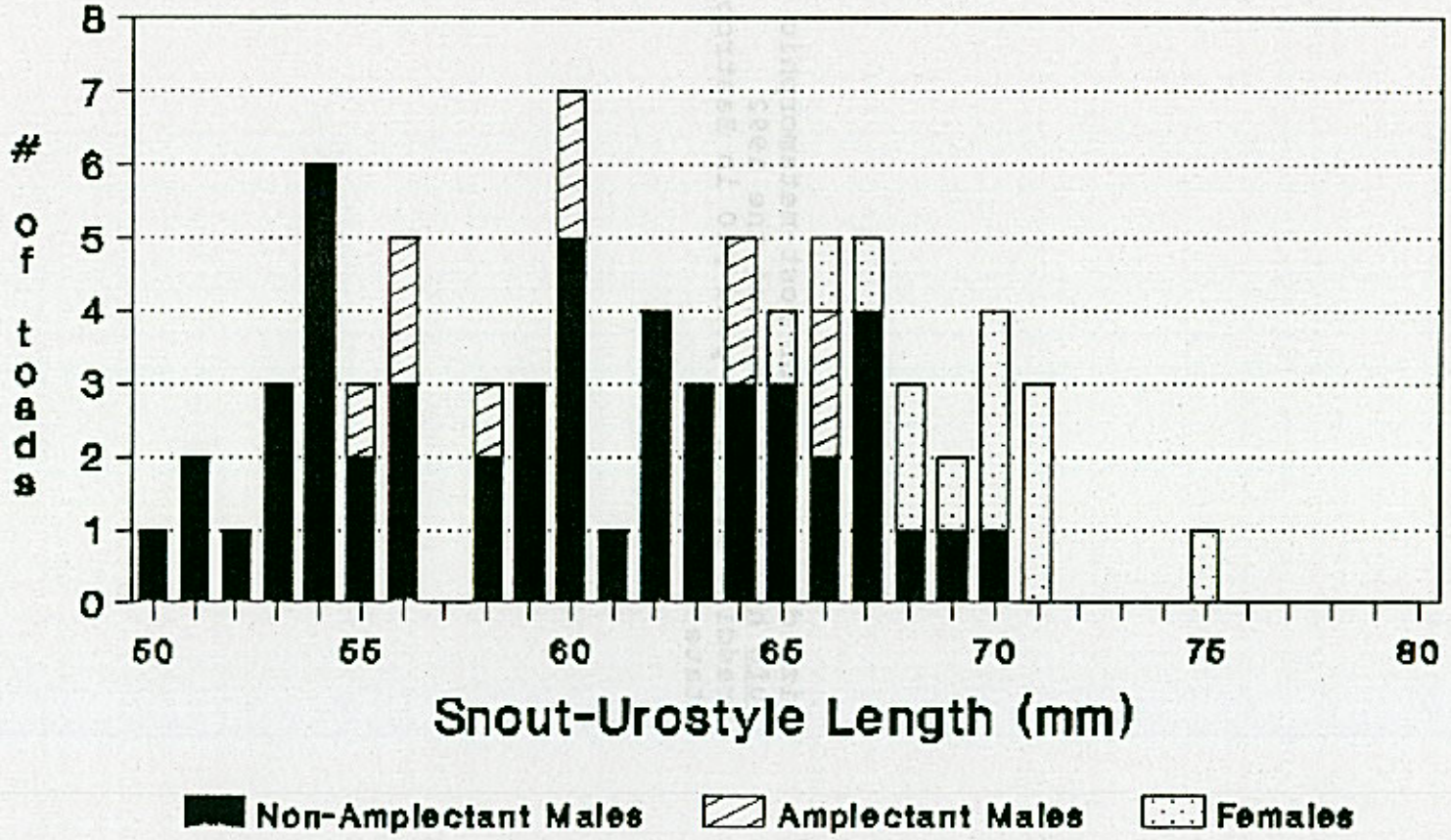


FIGURE 3. Size distribution of post-metamorphic Bufo houstonensis during the 1992 breeding season at pond #9 in Bastrop State Park.

1992 Bufo houstonensis size distribution
Pond 9



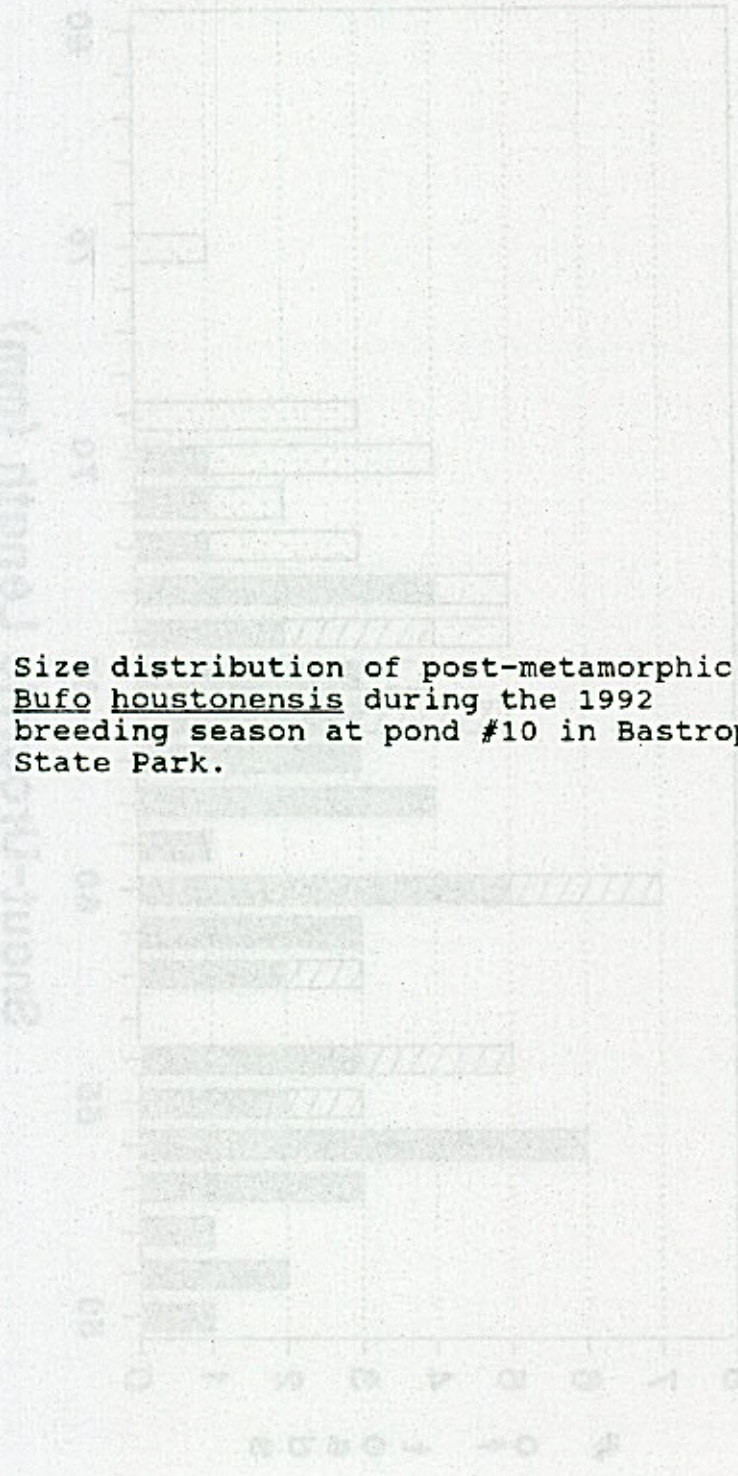
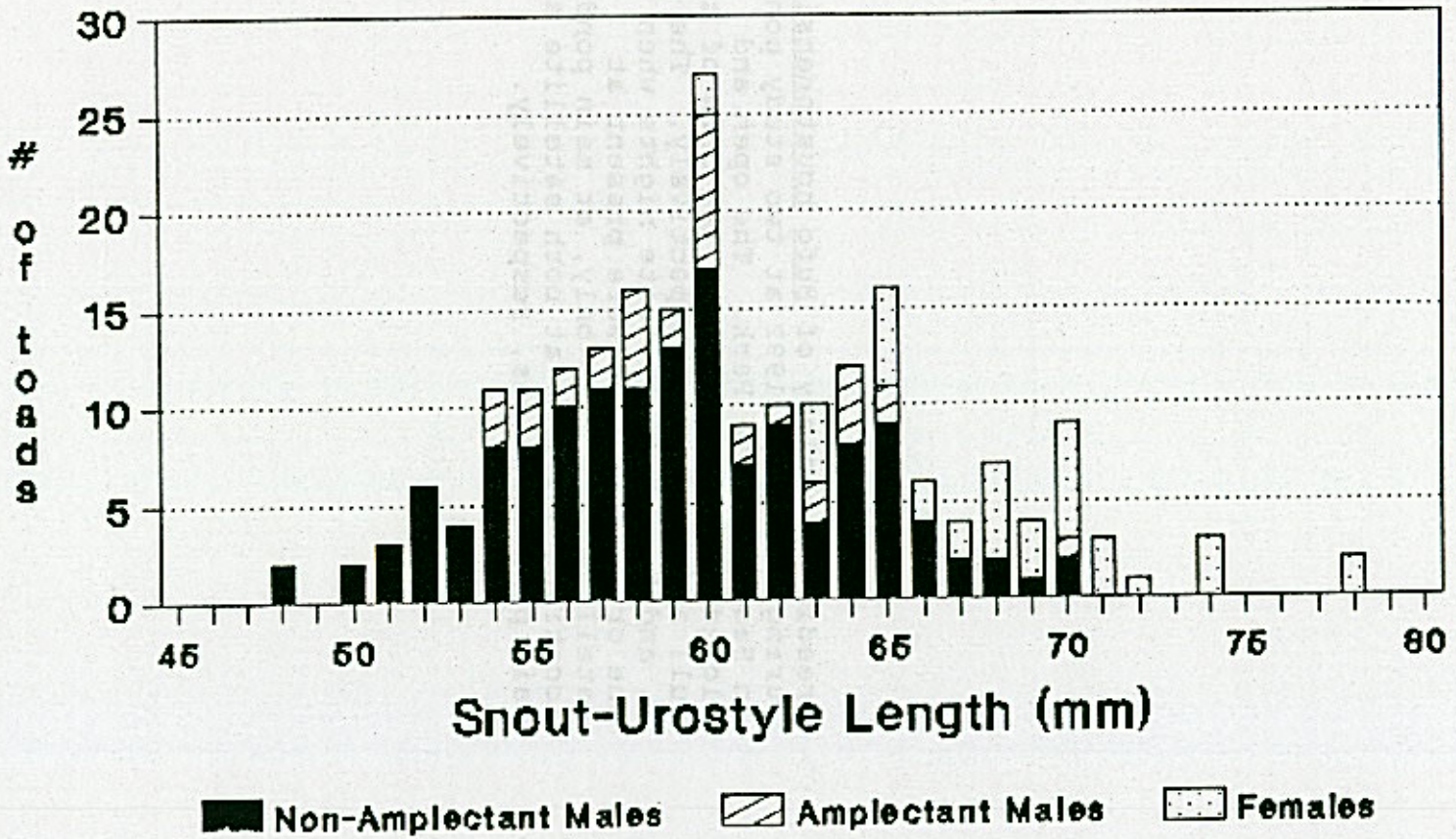


FIGURE 4. Size distribution of post-metamorphic Bufo houstonensis during the 1992 breeding season at pond #10 in Bastrop State Park.

1991 Bufo houstonensis size distribution

Pond 10



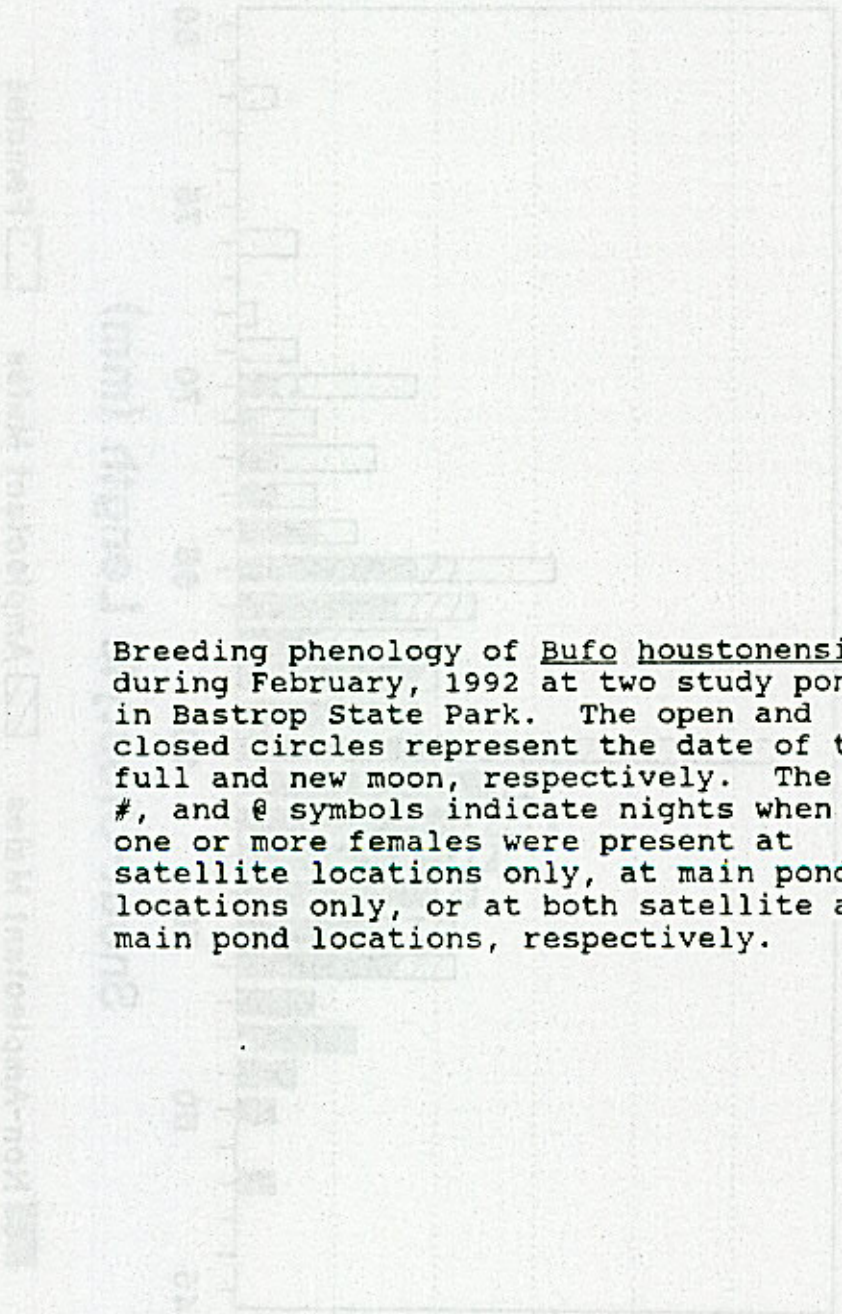
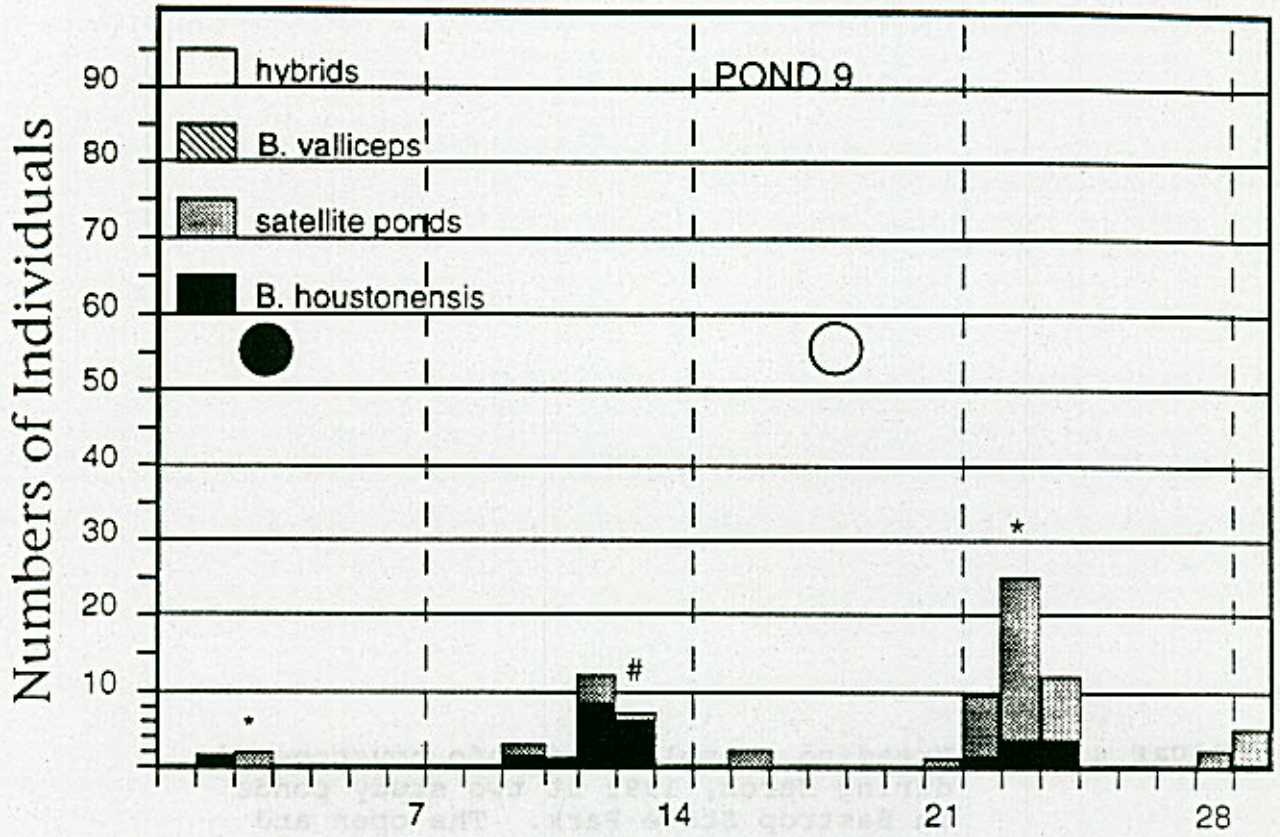


FIGURE 5. Breeding phenology of Bufo houstonensis during February, 1992 at two study ponds in Bastrop State Park. The open and closed circles represent the date of the full and new moon, respectively. The *, #, and @ symbols indicate nights when one or more females were present at satellite locations only, at main pond locations only, or at both satellite and main pond locations, respectively.

FEBRUARY 1992



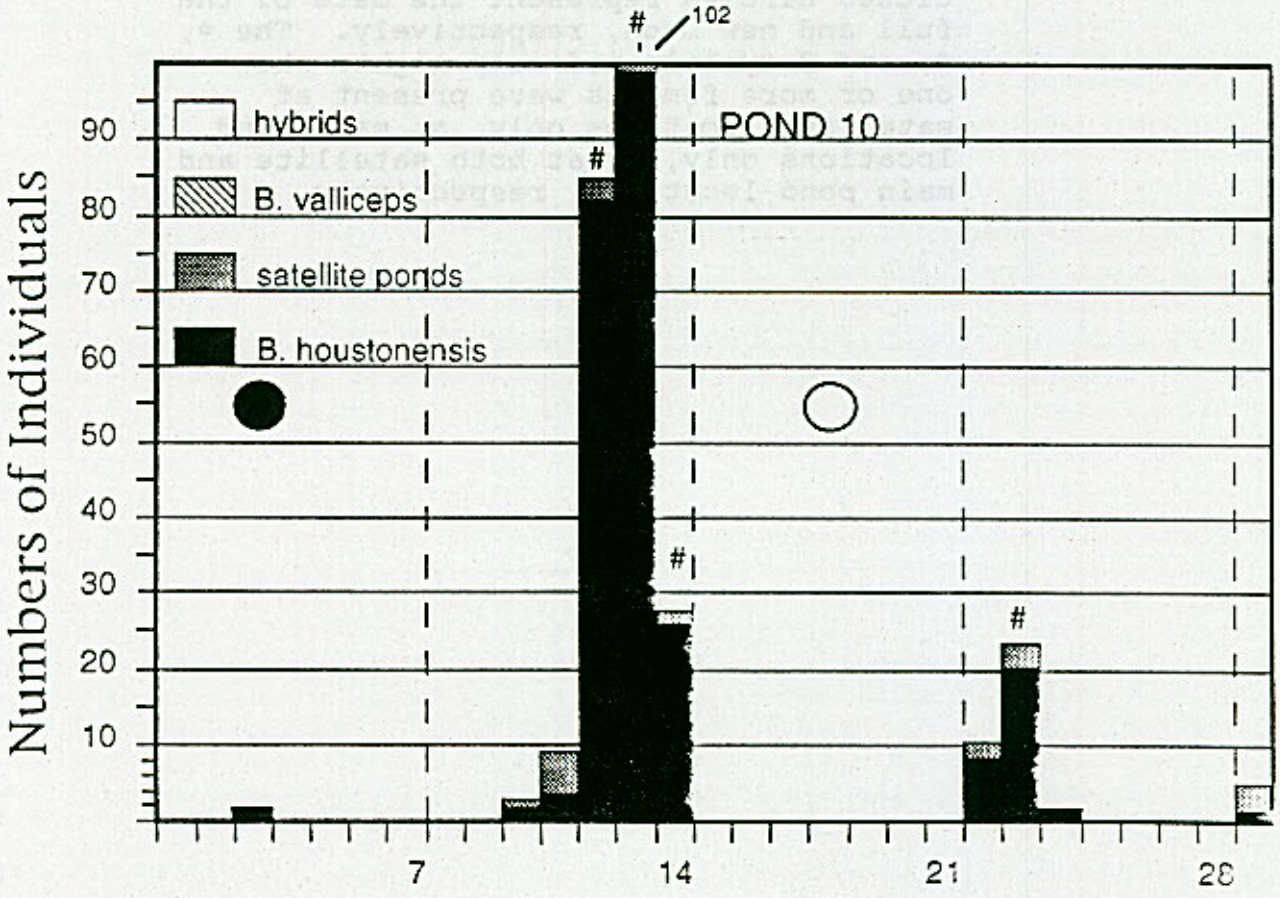
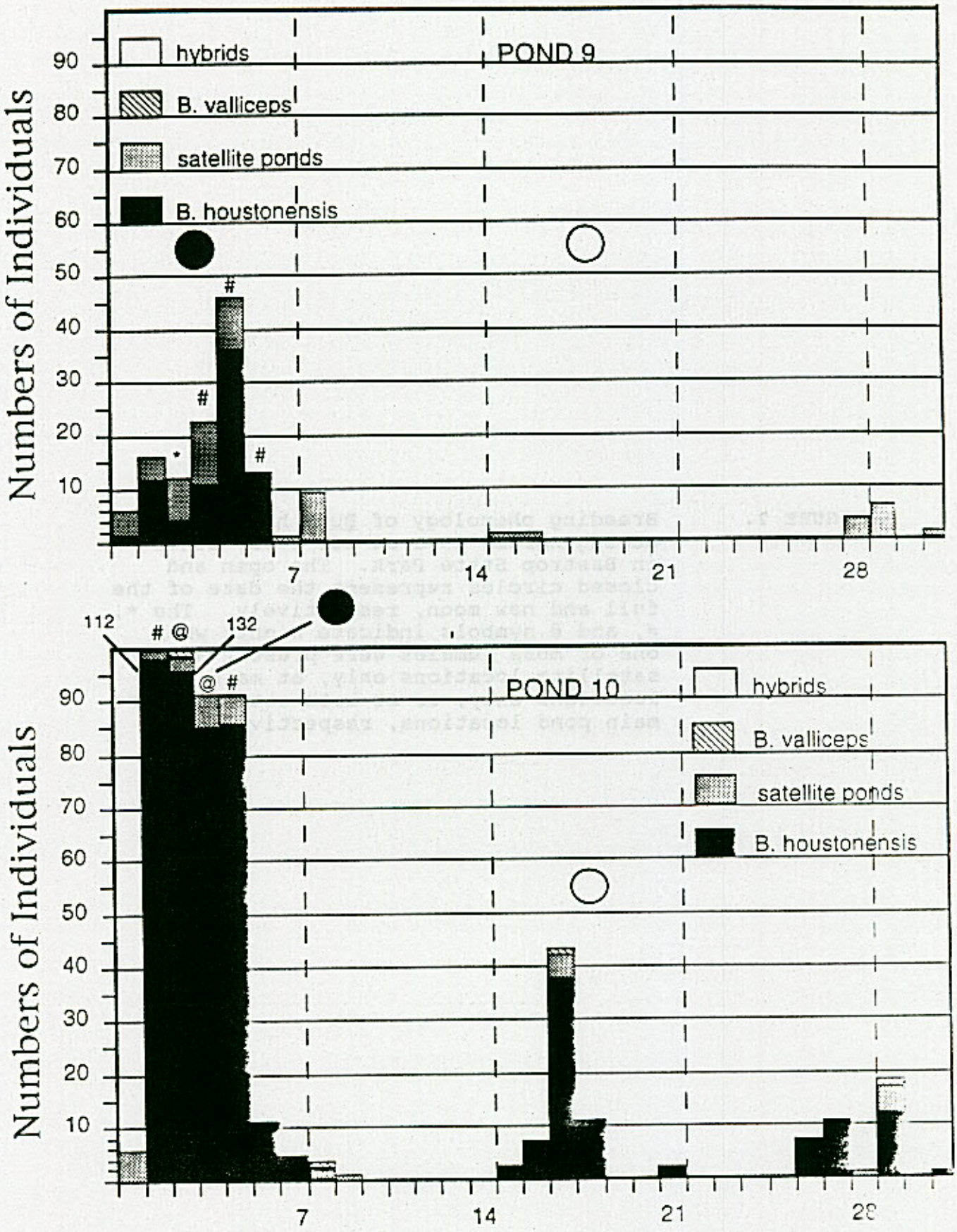


FIGURE 6. Breeding phenology of Bufo houstonensis during March, 1992 at two study ponds in Bastrop State Park. The open and closed circles represent the date of the full and new moon, respectively. The *, #, and @ symbols indicate nights when one or more females were present at satellite locations only, at main pond locations only, or at both satellite and main pond locations, respectively.

MARCH 1992


POND 9
hybrids
B. valliceps
satellite ponds
B. houstonensis
Numbers of Individuals
90
80
70
60
50
40
30
20
10
7
14
21
28
#
#
*
#
POND 10
112
@
132
@ #
hybrids
B. valliceps
satellite ponds
B. houstonensis
Numbers of Individuals
90
80
70
60
50
40
30
20
10
7
14
21

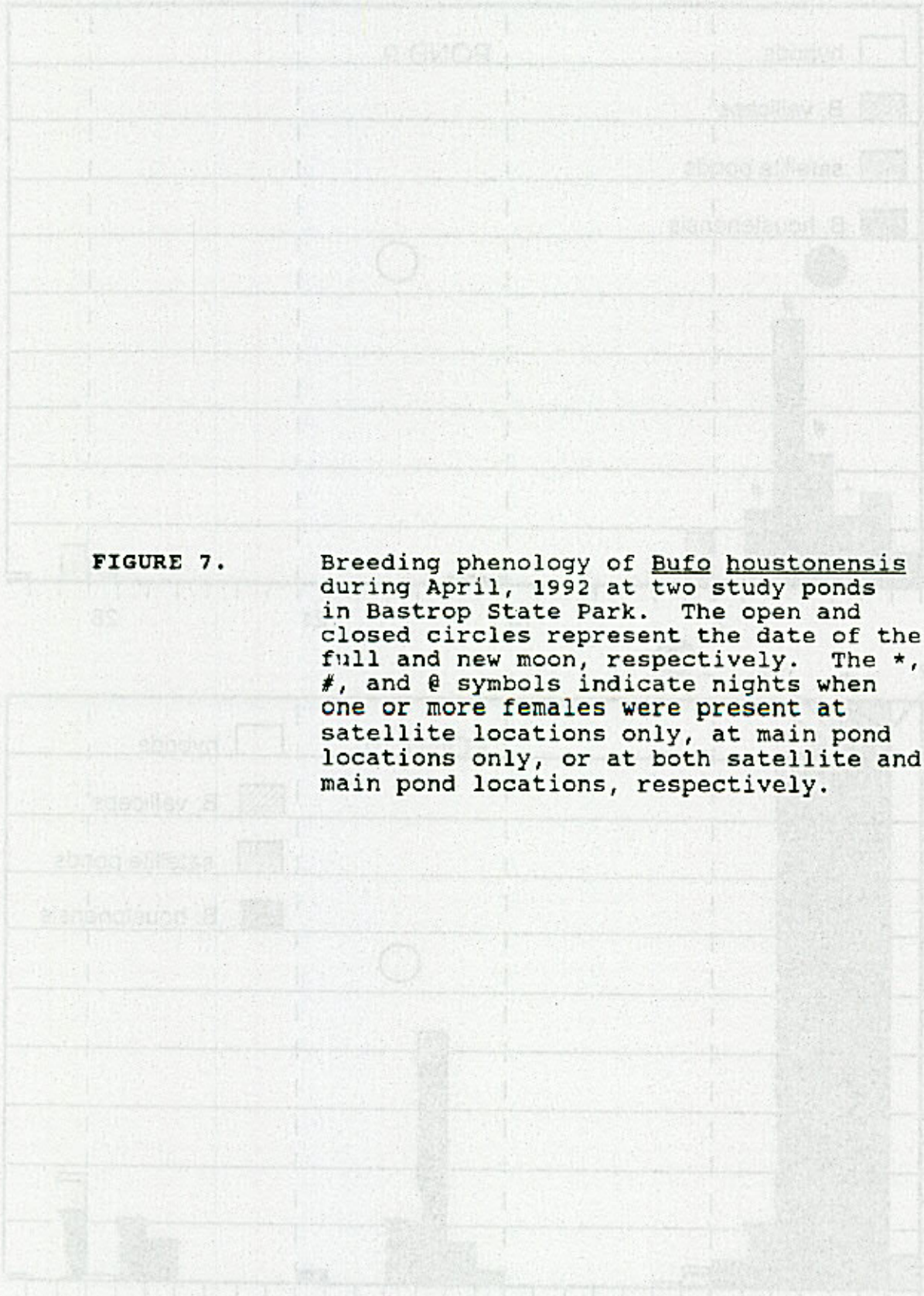
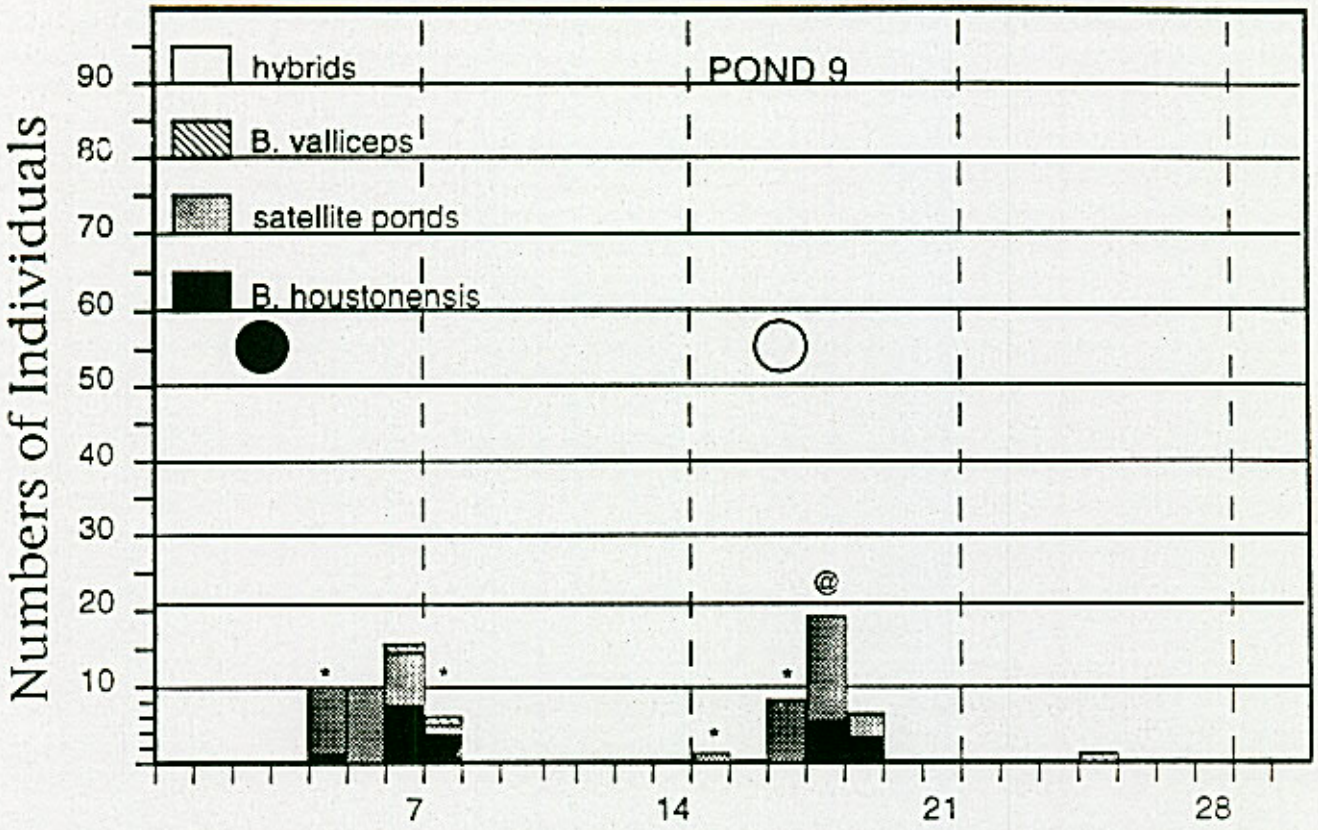
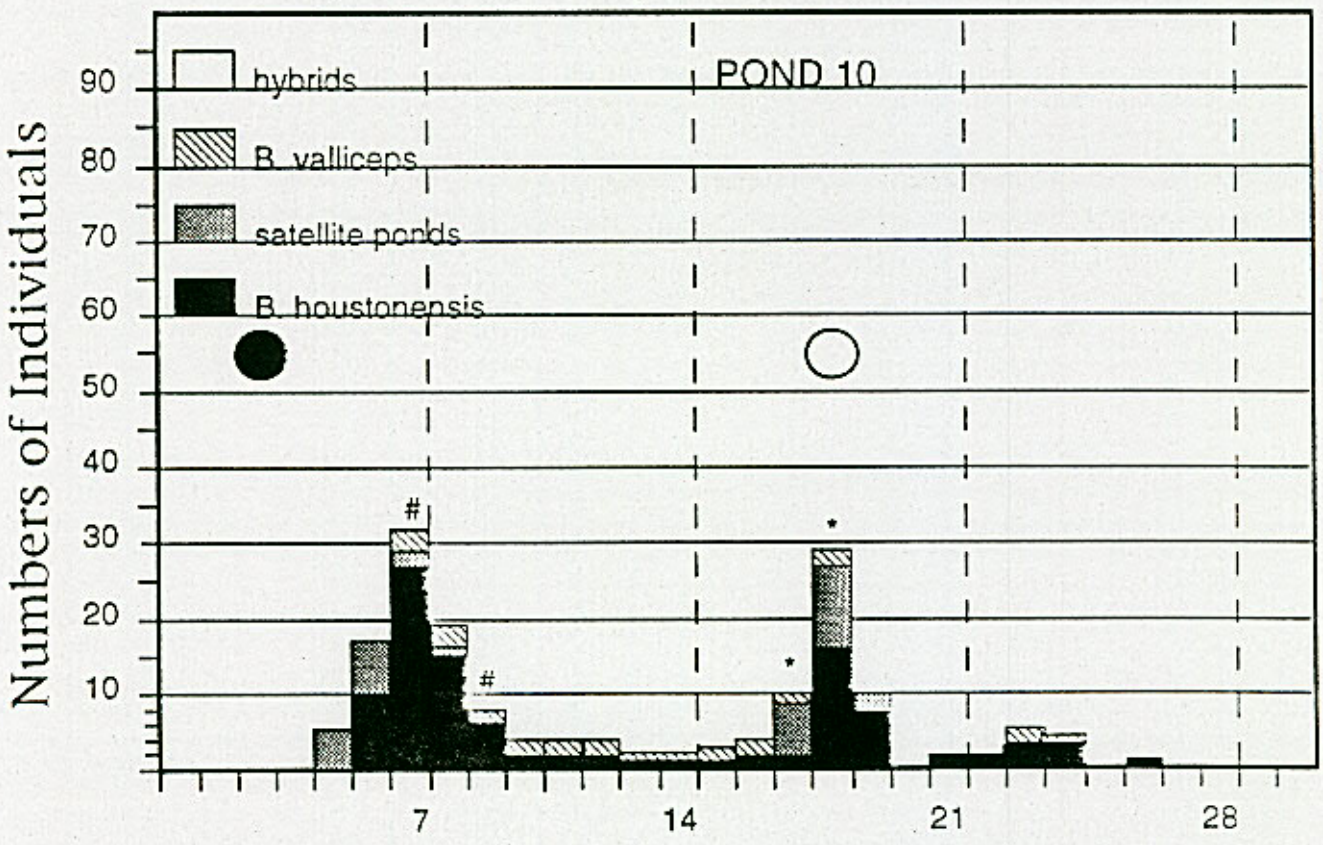


FIGURE 7. Breeding phenology of Bufo houstonensis during April, 1992 at two study ponds in Bastrop State Park. The open and closed circles represent the date of the full and new moon, respectively. The *, #, and @ symbols indicate nights when one or more females were present at satellite locations only, at main pond locations only, or at both satellite and main pond locations, respectively.

APRIL 1992


POND 9
hybrids
B. valliceps
satellite ponds
B. houstonensis
Numbers of Individuals
90
80
70
60
50
40
30
20
10
7
14
21
28
@
*


POND 10
hybrids
B. valliceps
satellite ponds
B. houstonensis
Numbers of Individuals
90
80
70
60
50
40
30
20
10
7
14
21
28
#
*