

MICROHABITAT PARAMETERS AND LIFE-HISTORY CHARACTERISTICS OF *FALLICAMBARUS GORDONZ* FITZPATRICK, A CRAYFISH ASSOCIATED WITH PITCHER-PLANT BOGS IN SOUTHERN MISSISSIPPI

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A B S T R A C T

Fallicambarus gordonz, a crayfish found only in pitcher-plant bogs, is restricted to the DeSoto National Forest, Perry County, Mississippi, U.S.A. The species is active from late fall through late spring, and apparently estivates during the summer when bogs are dry. Ovigerous females were found in late fall and winter, and small juveniles were collected in February. Form I males were found throughout much of the year, except during summer months when no crayfish were collected. Burrows of *F. gordonz* are complex and similar in structure to those of *Fallicambarus fodiens*. Catch per unit effort ranged from 0.02-0.17, suggesting that counting burrow structures will not give an accurate population estimate of this imperiled animal.

Although life-history information is critical for the conservation of biodiversity, few studies of this type have been conducted on crayfishes. This is especially troubling, because approximately 48% of crayfishes are imperiled (Taylor *et al.*, 1996). Of the 13 species of *Fallicambarus*, only one, *Fallicambarus fodiens* (Cottle), has a significant range (Hobbs, 1989; Hobbs and Robison, 1989). Life-history data are available only for *F. fodiens* (see Williams *et al.*, 1974; Page, 1985; Norrocky, 1991) (although see life-history notes for some species in Hobbs and Robison, 1989). Most of the remaining species have limited ranges, including the study species, *Fallicambarus gordonz* Fitzpatrick, which is known only from the DeSoto National Forest in Perry County, Mississippi.

There are few literature references concerning the ecology and life-history of *F. gordonz*. According to Fitzpatrick (1991), *F. gordonz* is one of at least three species of *Fallicambarus* associated with pitcher-plant bogs, an imperiled habitat type (Folkerts, 1982). Although the status and distribution of *F. gordonz* are fairly well known (Fitzpatrick, 1991), no observations on the life history of this species have been published. Our objective is to obtain information on the life history, population demographics, and ecology of *F. gordonz* that will be useful for management and conservation efforts.

MATERIALS AND METHODS

Study Area.-The study site (T2N,R10W, sec. 8, Perry County, Mississippi; Fig. 1) is a pitcher-plant bog (approximately 40 m by 0.5 km), with a high density of cray-

fish burrows. The dominant pitcher plant at the study area is *Sarracenia alata* (Wood). *Sarracenia psittacina* Michaux, *Drosera* spp., and numerous species of herbaceous plants are also present in the bog. Pine trees and shrubs are common on the bog perimeter. Typically, the soil in the open bog is saturated with water, and areas of standing water are present from late fall to late spring. The bog dries during the late spring and summer months.

Sampling Methods.-Samples of *F. gordonz* were taken monthly from March 1995 to May 1996. Our sampling regime entailed excavating all burrows found in 1 m²-quadrats set out at S-m intervals (both sides) of 25-m long transects. During the summer, when the bog was dry, burrows were excavated with a shovel. Otherwise, all burrows were excavated by hand. The following data were taken for over 150 burrows: structure (chimney or mound) height, width of opening, number of connected structures, water and air temperature, and cavity morphology. Carapace length (CL) and width (CW) and chela length (CHL) and width (CHW) of crayfish were measured to the nearest 0.1 mm with dial calipers. The sex and reproductive condition of each specimen were also determined. Individuals less than 15-mm CL, or those for which sex could not be determined, were classified as juveniles. Eggs of ovigerous females were counted and measured to the nearest 0.1 mm with dial calipers. With the exception of 2 voucher specimens deposited at the Mississippi Museum of Natural Science, all individuals were released into burrows where they had been captured.

Analysis of variance and Duncan's multiple range test were used to assess differences in size among life stages. All statistical analyses were conducted using SPSS (version 6.1, 1995). Catch per unit effort (CPUE) is calculated as the total number of crayfish captured/total number of burrows examined.

RESULTS

Demographics and Reproductive Activity

Eighty-seven crayfish were captured during the course of the study. Individuals of *F. gordonz* were collected by excavating bur-

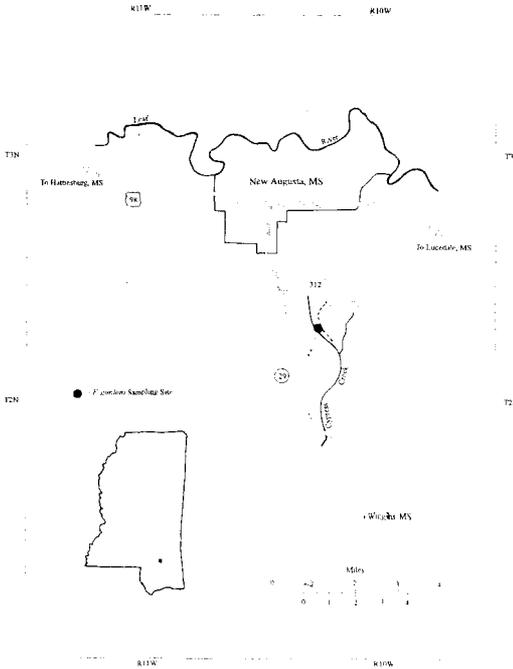


Fig. 1. Location of study site of *Fallicambarus gordonii* in Perry County, Mississippi.

rows during the late fall, winter, and early spring (Fig. 2). No crayfish were collected when the bog was dry (June-October), although burrows were excavated to over 60 cm. Juveniles (including very small individuals and specimens that could not be sexed) were present in the population during most of

the year, but were most frequently collected in late spring (Fig. 2). The smallest juveniles (3–5-mm carapace length) were found in February. Form I males were found in May, December, and January (Fig. 2); form II males were found in all months except April. Females were found in all samples except January (a small sample size); two ovigerous females were found in November and one was found in December (Fig. 2).

The number of eggs carried by a 25.7-mm (carapace length) female was 25, by a 25.1-mm female, 21, and by a 25.3-mm female, 7. The diameter of five eggs was 2.0 mm (25.7-mm female); 2.1 mm, 2.0 mm (25.1-mm female); 2.5 mm and 2.0 mm (25.3-mm female). In three instances juveniles shared burrows with females. On 4 April 1995, one juvenile was found in the same burrow as a female on two separate occasions. Four juveniles were found in the same burrow as one female on 7 February 1996. On three occasions two juveniles shared the same burrow (31 May 1995, 4 March 1996, and 18 April 1996).

With carapace length used as a measure of size, both ovigerous females (mean CL = 25.4 mm, SD = 0.30, range 25.1–25.7 mm) and form I males (mean CL = 25.4 mm, SD = 2.19, range 22.X–28.0 mm) were larger than females (mean CL = 19.4 mm, SD = 5.09, range 11.8–31.0), form II males (mean CL = 18.2 mm, SD = 4.32, range 10.4–26.0 mm), and juveniles (mean CL = 10.7 mm, SD =

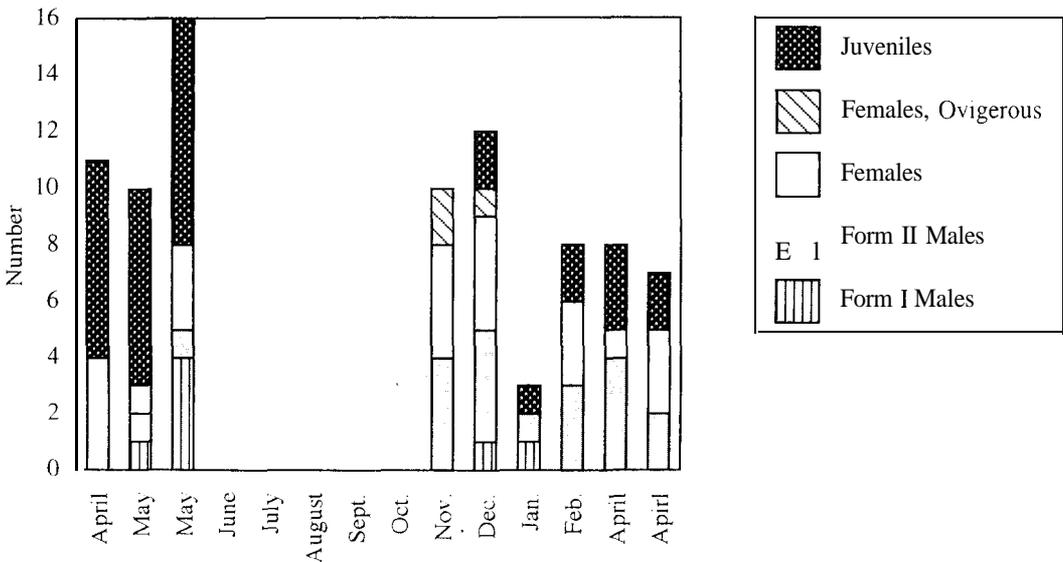


Fig. 2. Number of *Fallicambarus gordonii* of each life stage collected per month

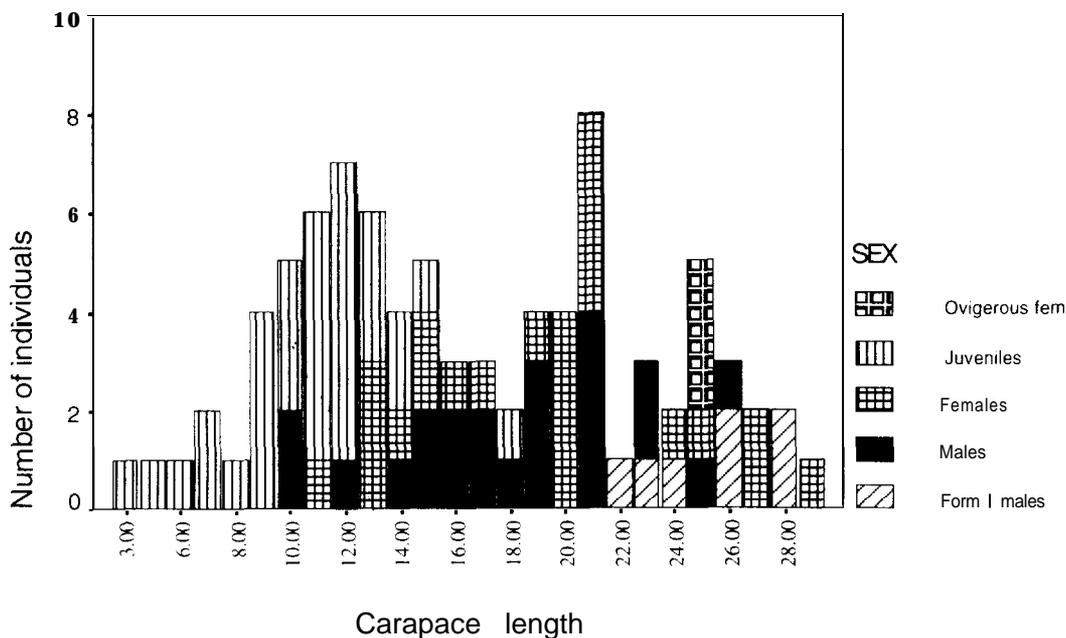


Fig. 3. Size distribution of life stages of *Fallicambarus gordonii*.

3.05, range 3.0-18.0 mm) ($F = 33.19$, $P = 0.0001$). Analysis of carapace-length frequency suggests that *F. gordonii* lives at least two, and perhaps three, years (Fig. 3).

The sex ratio, for all samples combined, is very slightly male-biased (1 female: 1.1 male). The catch per unit effort (CPUE), or number of crayfish captured/number of burrows examined, ranged from 0.02 (January 1996) to 0.17 (May 1995) (Table 1).

Burrow Characteristics

Burrow activity of *F. gordonii* was apparent throughout the study site. The number of burrows decreased with an increase in elevation, marked by a shift in the plant community from pitcher plants to shrubs and trees. Burrows are complex, with 1-4 openings, one resting chamber, and more than one tunnel. Three types of burrow entrances were observed: holes, chimneys, and mounds. Chimneys were the most commonly found structure (58%), followed by mounds (35%). Holes were relatively uncommon (8%). Both chimneys and mounds were open or closed. Fifty-five percent of the burrows measured had more than one opening (41% two openings, 12% three openings, 1% four openings). There was no apparent relationship between the number or types of openings and the like-

lihood of capturing a crayfish, or to the sex of crayfish. Chambers were 8-35 cm deep, and temperature within chambers was 16-18°C on 4 April 1995, 26-28°C on 31 May 1995, and 17-19°C on 8 November 1995.

During the dry season, most chimneys and mounds were closed, or plugged with mud. Fresh burrow activity was evident after periods of rain. The burrowing activity of juveniles, manifested as tiny chimneys (<1 cm) made of small pellets of mud, was evident in early March and April.

DISCUSSION

Some aspects of the life history of *F. gordonii* are similar to *Fallicambarus fodiens*, the only other species of *Fallicambarus* for which comparative data are published. Both species undergo a period of torpor, when they cannot be collected. For *F. fodiens*, this period is the winter months (Williams *et al.*, 1974; Page, 1985; Norrocky, 1991). *Fallicambarus gordonii* estivated during the summer, when bogs are dry. Our study site was completely dry from June-October. Although we attempted to sample during this period, no soil moisture was encountered deeper than 60 cm (we dug past the obvious depth of burrows, which are typically no deeper than 35 cm). Burrow openings were

plugged with soil during this time. We assume that the crayfish burrows farther down beneath the surface, but this is speculative. Since standing water was present at our study site, it was not possible for the crayfish to migrate to wetter areas.

Form I males of *F. gordonii* were found throughout the sampling year (samples could not be taken during the summer). In our samples, they were found in May, December, and January. Fitzpatrick (1987) reported them in samples from March and October. Norrocky (1991) found form I *F. fodiens* throughout the year in Ohio. The one ovigerous female examined by Fitzpatrick (1987) was found in November and had 36 eggs. We found ovigerous females in November and December, and two of them had similar fecundity (25 and 21 eggs). Page (1985) found form I male *F. fodiens* in April, ovigerous females in February and March, and females with young from February-April. The average number of eggs of *F. fodiens* ranged from 85 (Williams *et al.*, 1974) to 115 (Norrocky, 1991). Page (1985) reported the fecundity of three female *F. fodiens* as 48, 68, and 162, and egg diameter as 2.2-2.5 mm.

Mating of *F. gordonii* probably occurs in late spring, and females extrude eggs in late fall or winter, when the bogs are wet again. Mating and oviposition in *F. fodiens* occur during the summer-fall period in Ohio (Norrocky, 1991), but Crocker and Barr (1968) reported mating in fall and early spring, with ovulation in early spring in Canada. Although we did not capture females with attached young, young probably remain attached to the female for a period of time, as in other *Fallicambarus* (Page, 1985). The smallest juvenile *F. gordonii* were found in February, and juveniles were found in the same burrow as females from February to May. Cohabitation of burrows by females and young may be typical for *Fallicambarus* (Norrocky, 1991).

The sex ratio of *Fallicambarus* is not biased toward either sex (Hobbs and Robison, 1989). Our samples indicate that the sex ratio of *F. gordonii* is close to 1: 1, but may be slightly male-biased.

Our analysis of length-frequency suggests that *F. gordonii* lives two, or perhaps three years. Illinois populations of *F. fodiens* are also relatively short-lived, and may die after their second year (Page, 1985).

Results from our sampling for *F. gordonii*

Table 1. Catch per unit effort (CPUE) of *Fallicambarus gordonii* excavated from burrows. Data on CPUE were not taken for all sample dates, A single burrow may have had multiple openings, but these were counted as one burrow.

| Date | Number of burrows excavated | Number of crayfish | CPUE |
|---------------|-----------------------------|--------------------|------|
| 31 May 1995 | 95 | 16 | 0.17 |
| 8 Nov. 1995 | 76 | 10 | 0.13 |
| 6 Dec. 1995 | 119 | 12 | 0.10 |
| 18 Jan. 1996 | 133 | 3 | 0.02 |
| 4 March 1996 | 88 | 8 | 0.09 |
| 18 April 1996 | 88 | 7 | 0.08 |

suggest that the study site supports a large population. Our CPUE ranged from 0.02-0.17. Obviously, not every burrow sampled yielded a specimen, but whether this is due to sampling error or whether it suggests that many unoccupied burrows are present is unknown. This information suggests that it would be inappropriate to census these populations by simply counting burrows.

Burrow complexity is similar for *F. gordonii* and *F. fodiens*. A typical burrow of *F. fodiens* has 1-3 openings, an oval resting chamber, and an escape tunnel (Crocker and Barr, 1968; Williams *et al.*, 1974; Page, 1985). These descriptions are similar to our findings for most burrows of *F. gordonii*, although some burrows had as many as four openings. The burrows of *F. fodiens* may be deeper (all more than 1 m) than those of *F. gordonii* (up to 35 cm) (Norrocky, 1991). The deeper burrows of *F. fodiens* reflect differences in habitat. *Fallicambarus fodiens* is a floodplain species, and the water table is typically not as high as in pitcher-plant bogs. The burrows of *F. gordonii* are concentrated in the open-bog habitat where the water table is highest.

Our observations suggest that *F. gordonii* is a short-lived burrowing crayfish that estivates during the dry summer months, and is active during the winter and early spring. Concentrations of burrows exist only in the open pitcher-plant bog. Like many other unique species in the bog ecosystem, *F. gordonii* is apparently dependent on the maintenance of open-bog habitat for survival. Management for preservation of this habitat, which includes periodic burning, should also protect the habitat of this rare species of crayfish.

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