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TURTLE POPULATIONS AT A HEAVILY USED RECREATIONAL SITE: ICHETUCKNEE SPRINGS STATE PARK, COLUMBIA COUNTY, FLORIDA

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***Abstract.*—Nearly 189,000 people visited Ichetucknee Springs State Park in 2002, a number 55,000 greater than 10 years prior. Because the number of visitors is likely to increase in the future, it is important to determine baseline population levels for turtle species inhabiting the springs. We studied the freshwater turtle fauna of a 5.16 km (10.99 ha) section of Ichetucknee Spring Run, Columbia County, Florida using mark-recapture methods. We compared turtle population estimates to historical data from Ichetucknee Spring Run and Rainbow Run, Marion County, Florida, USA. We developed a geographic information system (GIS) to analyze the spatial relationships of the turtle community. The turtle faunas of the two spring runs are nearly identical, but do have notable differences in species composition (e.g., *Trachemys scripta* at Ichetucknee Run is replaced by *Pseudemys floridana* at Rainbow Run). Population structure of *Pseudemys concinna* differs significantly between sites and may reflect take of large adults at Rainbow Run for human consumption. Although preliminary, population estimates of *Sternotherus minor* at Ichetucknee Run rival historical estimates. GIS analysis of the distribution of habitats and turtle captures along Ichetucknee Spring Run suggest the recognition of four distinct portions, or "reaches," that are relevant to turtle distributions. Identification of changes in the turtle community and consideration of possible causes can contribute to management strategies that will help to maintain the overall health of this icon among Florida's natural attractions.**

Key Words.—Florida; freshwater; Ichetucknee; *Pseudemys*; spring run; *Sternotherus*; *Trachemys*; turtle.

INTRODUCTION

Turtles are a highly visible and important component of spring ecosystems in Florida (Marchand 1942; Berry 1975; Cox and Marion 1979; Jackson and Walker 1997; Huestis and Meylan 2004). Ten species belonging to four families are regular inhabitants of Florida springs (Meylan 2006). For two species, the Loggerhead Musk Turtle (*Sternotherus minor*) and River Cooter (*Pseudemys concinna*), springs and spring runs appear to constitute optimal habitat. Turtles have been studied by biologists in Florida spring runs for more than 70 years because of their high visibility. In some cases, it has been possible to document changes in turtle populations over extended periods of time (Meylan et al. 1992; Huestis and Meylan 2004). Changes in turtle abundance can reflect a variety of factors from the health of the habitat (i.e., Shelby and Mendonça 2001), to the impact of harvest for consumption (i.e., Meylan and Moler 2006), or the pet trade (i.e., Close and Siegel 1997). Studies at Rainbow Run in Marion County, Florida suggest that there have been major reductions in the numbers of *Pseudemys* and major increases in *S. minor* since the 1940's (Meylan et al. 1992; Huestis and Meylan 2004). Casual observations at Ichetucknee Spring Run (henceforth Ichetucknee Run) suggested a major decline in *S. minor* over the same period (James Stevenson, pers. comm.; David Auth, pers. comm.). The goal of this study was to use the methods developed at Rainbow Run to investigate possible changes in the turtle community of Ichetucknee Run.

Ichetucknee Springs State Park is heavily used for recreational activity. Swimming, diving, canoeing, and fishing take place on the river, but these activities are dominated by tubing, especially in summer months. Bonn and Bell (Economic Impact of Selected Florida Springs on Surrounding Local Areas. Prepared for the Florida Department of Environmental Protection. Tallahassee, Florida, USA 2003) reported that almost 189,000 people visited the park in 2002, a number 55,000 greater than 10 years prior. By identifying changes to turtle populations, and considering their possible causes, we can develop management strategies that will help to maintain the overall health of turtle populations in the Ichetucknee Run.

Although some accounts of the abundance of turtles in Florida spring runs are published (Meylan et al. 1992; Huestis and Meylan 2004), others are thought to exist only in the field notes of biologists. Because of the proximity of Ichetucknee Run to the University of Florida, we were hopeful that some of the many biologists who have collected data and specimens from Ichetucknee Run might have documented their observations in unpublished field notes. Unfortunately,

our attempts at finding relevant field observations only revealed one useful observation. In his Master's thesis, Marchand (1942) stated: "The *Pseudemys* population of this stream is small and practically restricted to scattered patches of vegetation along the shore. The population of *S. minor*, however, is the largest that I have found anywhere. In a days goggling, 500 or more of these animals may easily be seen." The objective of our study was to determine if turtle numbers, particularly those of *S. minor*, have declined in Ichetucknee Run since Marchand's (1942) observation. Moreover, we documented the turtle fauna and compared our findings with similar studies in Rainbow Run.

MATERIALS AND METHODS

Sampling.—We captured and processed large numbers of turtles in a relatively short period of time by using the methods developed at Rainbow Run (Meylan et al. 1992; Huestis and Meylan 2004). Our method was only slightly modified for the Ichetucknee Run study. On 22 and 23 March, and 29 and 30 October 2007, groups of snorkelers collected all turtles encountered between Ichetucknee Spring (29.98400° N, 82.76180° W) and the take-out point for floating inner tubes at U.S. 27 (29.95475° N, 82.78450° W). The sampling area consisted of 5.16 km (10.99 ha) of spring run. The number of snorkelers varied slightly among sampling days. On 22 and 23 March there were 23 and 24 volunteers taking part, six of whom were in canoes at any given time, with the remainder snorkeling. On 29 and 30 October there were 35 and 30 volunteers, nine of whom were in canoes at any given time. Thus, the number of snorkelers per sampling day was 17, 18, 26 and 21, respectively.

For most captures, we recorded a GPS location in the proximity of the capture site. Turtles were released as close to their capture sites as possible. We individually marked turtles by inserting a passive integrated transponder (PIT) tag (American Veterinary Identification Devices Inc., Norco, California, USA) into connective tissue between the plastron and the pelvis. This area has proven to be a useful site for PIT tag insertion (Runyan and Meylan 2005). The only limitation of PIT tags is that turtles smaller than about 55 mm could not be marked, as the tags are 12 mm long. Turtles that were too small to be marked were still captured, measured, and recorded in the data set. Gender was recorded for larger individuals based on tail size and claw length.

Analytical methods.—The study was designed to collect both numerical counts that could be compared with previous counts of turtles, and data necessary to make preliminary estimates of population size and density using mark-recapture methods. Sampling was scheduled to provide three opportunities to make estimates of population size for the most common species using closed models (Lincoln-Peterson Index). Although immigration and emigration could occur at the downstream end of the study area, it was assumed that relatively little movement would occur in and out of the study area relative to the very long and narrow habitat (5.16 km of river; 10.99 ha) sampled. We attempted to minimize the impact of immigration and emigration (and birth and death) by sampling on successive days for two of the three estimates (22 and 23 March; 29 and 30 October). A third set of estimates of population size was made using closed models in which the data from the two March samples (spring) were the marking interval and two October dates (fall) the resampling interval. Thus, for each of the four most common species (*S. minor, S. odoratus, P. concinna*, and Yellow-bellied Slider [*Trachemys scripta*]), we made three separate estimates of population size for the study area. Combining our population estimates with geographic data permitted us to calculate the population density of these more common species per km and per ha of river.

We calculated species-specific encounter rates per unit time and unit distance for all sampling days using a geographic information system (GIS). Additionally, a GIS of the distribution of turtle captures among four portions of the river ("reaches") within the park allowed us to better understand habitat preferences of the seven species encountered. We used ArcGIS 9.2 (Environmental Systems Research Institute Inc., Redlands, California, USA) to plot GPS coordinates for capture locations and to identify and digitize four different portions of the river based on habitat type and river structure. Projection of these spatial data over an aerial raster image of the river enabled the investigation of spatial relationships. We estimated stream length and area measurements from maps adapted from those published in the Ichetucknee Springs State Park Approved Unit Management Plan (2000. Unpublished report by the Florida Department of Environmental Protection, Division of Recreation and Parks, District 2). Turtle density was calculated per unit distance and per unit area.

Comparative methods.—Given that few historical data were uncovered during our study, few comparisons to our data can be made. Nevertheless, we compared our estimates of the *S. minor* density by km and ha of river to recent data (2007–2008) from Rainbow Run (Peter Meylan, unpubl. data). We also compared straight carapace length (SCL) distributions for large adult (> 80 mm SCL) *S. minor* from our 2007 Ichetucknee Run data to those collected by Iverson (unpubl. data) at Ichetucknee prior to 1973 and to samples from Rainbow Run collected over the last decade (Huestis and Meylan

TABLE 1. Captures of seven species of turtles during four sampling sessions at Ichetucknee Run, Florida, USA, March and October 2007.

	22 March		23 March				29 Oct.			30 Oct.			
Species	**Total number captured**	**Number marked**	**Total number captured**	**Number of recaptures**	**Number of new marks**	**Total marks available**	**Total number captured**	**Number of recaptures**	**Number marked**	**Total number captured**	**Number of recaptures**	**Number of new marks**	**Total marks available after this sample**
Apalone ferox	0	0	0	0	0	0	0	0	0	1	0	1	1
Sternotherus minor	43	39	65	0	45	84	70	1	44	141	1	94	222
Sternotherus odoratus	3	3	5	0	5	8	2	0	2	11	1	9	19
Trachemys scripta	15	15	15	1	14	29	17	5	12	22	3	19	60
Pseudemys concinna	44	43	33	10	23	66	13	7	6	17	9	8	79
Pseudemys nelsoni	1	1	2	1	1	2	1	1	0	1	0	1	3
Chelydra serpentina	1	1	1	0	1	2	1	0	1	1	0	1	4
Totals	114		123			194	104			194			392

2004). Lastly, the population structure of *P. concinna* at Rainbow Run and Ichetucknee Runs were compared. Significance was set to $\alpha = 0.05$ for all tests.

RESULTS

Populations.—Four sampling sessions yielded 535 different turtles of seven species (Table 1). We tagged 392 different individuals (SCL > 55 mm) with uniquely numbered PIT tags. Nearly all of the captured turtles released untagged were juvenile *S. minor* that measured ≤ 55 mm. The largest number of turtles captured on a single day was 194 (30 October 2007), 141 of which were *S. minor*.

As anticipated, the riverine species *S. minor* and *P. concinna* were captured most frequently. However, after four sampling sessions, we had captured nearly as many *T. scripta* as *P. concinna* and population estimates for these two species suggest that *T. scripta* may be slightly more abundant within the park (Table 2). Four other species are generally not considered riverine forms and together make up only about 5% of the total sample. These species were the Snapping Turtle (*Chelydra serpentina*), Common Musk Turtle (*Sternotherus odoratus*), Florida Red-bellied Turtle (*Pseudemys nelsoni*), and Florida Softshell (*Apalone ferox*). The riverine Alligator Snapping Turtle (*Macrochelys temminckii*) is known to occur in the Ichetucknee Run but was not observed during our study. Moreover, Red-eared Sliders (*Trachemys scripta elegans*), which are an invasive exotic that can hybridize with *T. s. scripta*, were not observed.

Our first attempts to estimate population size for *Sternotherus* species suggest that there are very large numbers of *S. minor* in Ichetucknee Run (Table 2). The estimates of 4,230 ± 2,393 *S. minor* for the sample made on 30 October, and 11,676 ± 6,606 *S. minor* made by using March (mark period) and October (resampling period) samples, are both estimates of the number of individuals over 55 mm SCL for the entire 5.16 km (10.99 ha) study area. Based on the spring-fall capture-recapture periods, a conservative estimate for the minimum number of *S. minor* with SCL > 55 mm along 5.16 km of the Ichetucknee Run is 5,070 turtles (461 per ha).

We generated three estimates for the number of *P. concinna* in the study area (Table 2). Recapture rates for this species were relatively high (nearly 50% in the final sample), but the 95% confidence interval (CI) was large relative to the estimates. The three estimates in combination suggest that between 100 and 150 *P. concinna* occupy the 5.16 km of river in the park. Our best estimates for *T. scripta* suggest that this species may be somewhat more abundant than *P. concinna*. Based on a relatively small number of recaptures, we can say that there are probably several hundred individuals of this species present (Table 2). The low estimate (104.0 ± 58.7) for the number of *S. odoratus* seems reasonable, given the very few observations made.

Comparison of *S. minor* from this study to samples previously collected at Ichetucknee Run show that a subset of 31 males over 80 mm SCL (mean SCL = 93.6 ± 9.88 mm) and 47 females over 80 mm SCL (mean SCL = 90.2 ± 9.09 mm) captured during 2007 have a slightly smaller mean SCL than samples collected before 1973 (males 96.8 ± 13.35 mm, $n = 21$; females 92.7 ± 10.95 mm, $n = 23$; John Iverson, unpubl. data), but the difference is not significant (males $t = 1.01$, df = 50, $P = 0.327$; females $t = 1.02$, df = 68, $P = 0.317$). A significant difference in SCL for both genders over 80 mm exists between samples collected in this study and samples from Rainbow Run collected during the mid-1990's (males 103.0 ± 13.81 mm, $n = 44$; females 97.6 ±

TABLE 2. Three sets of population estimates for four species of turtles from Ichetucknee Run, Florida, during 2007. The first and second estimates use a one day marking interval followed immediately by a one-day resampling interval. The third set of estimates us the two March dates as the marking interval and the two October dates as the resampling interval.

Marking interval (period 1)	Resampling interval (period 2)	Species	Marked during period 1	Recaptured during period 2	Total captured during period 2	Population Estimate	95% C.I.
22 Mar	23 Mar	*S. minor*[1]	39	0	45	na	
		S. odoratus	3	0	5	na	
		P. concinna	43	10	33	141.9	± 61.9
		T. scripta	15	1	15	225.0	± 127.0
29 Oct	30 Oct	*S. minor*[1]	45	1	94	4,230.0	± 2,393
		S. odoratus	2	0	10	na	
		P. concinna	13	3	17	73.7	± 45.2
		T. scripta	17	0	22	na	
22–23 Mar	29–30 Oct	*S. minor*[1]	84	1	139	11,676.0	± 6,606.1
		S. odoratus	8	1	13	104.0	± 58.7
		P. concinna	66	13	27	137.1	± 47.2
		T. scripta	29	8	39	141.4	± 70.3

[1] markable size (> 55 mm) only

12.44 mm, $n = 34$; males $t = 3.29$, df = 73, $P = 0.002$; females $t = 2.49$, df = 47, $P = 0.003$).

Turtle community.—The overall turtle community in the two springs shows that most species occur in similar frequencies (Table 4). The only exception is the apparent replacement by *P. floridana* (8.28% of Rainbow Run turtles; 0.00% of Ichetucknee Run turtles) at the Rainbow Run site by *T. scripta* (0.23% of Rainbow Run turtles; 12.98% of Ichetucknee Run turtles) at the Ichetucknee Run.

Population structure of *P. concinna* differs greatly between sites (Fig. 1). The sample from Ichetucknee Run has a 1:1 sex ratio ($X^2 = 0.053$, df = 1, $P > 0.80$); whereas, the Rainbow Run sample is male-biased (1.67:1; $X^2 = 5.24$, df = 1, $P < 0.05$). Furthermore, the average female from Ichetucknee Run (mean SCL = 32.1 ± 4.5 cm) is significantly larger ($t = 119.5$, df = 60, $P < 0.001$) than the average female from Rainbow Run (mean SCL = 23.4 ± 8.8 cm).

Spatial relations.—A GIS analysis of the distribution of habitats and turtle captures along the river suggests the recognition of four distinct portions or "reaches" that

TABLE 3. Distribution of 447 turtle captures with GPS coordinates among four ecologically defined river reaches within Ichetucknee Run, Florida, with calculations of density in number of individuals per km and ha.

	Individuals per kilometer					Individuals per hectare				
Species	Headspring Reach (0.56 km)	Narrow Rice Reach (0.52 km)	Wide Rice Reach (1.17 km)	Floodplain Reach (2.91 km)	Total length (5.16 km)	Headspring Reach (0.71 ha)	Narrow Rice Reach (2.22 ha)	Wide Rice Reach (2.88 ha)	Floodplain Reach (5.18 ha)	Total area (10.99 ha)
Chelydra serpentina	1.79	1.92	0.85	0.34	0.78	1.41	0.45	0.35	0.19	0.36
Pseudemys concinna	7.14	28.9	22.2	18.2	19.0	5.63	6.76	9.03	10.2	8.92
Pseudemys nelsoni	0.00	1.92	0.00	1.03	0.78	0.00	0.45	0.00	0.58	0.36
Sternotherus minor	67.9	61.5	26.5	59.1	52.9	53.5	14.4	10.8	33.2	24.8
Sternotherus odoratus	0.00	5.77	3.42	1.03	1.94	0.00	1.35	1.39	0.58	0.91
Trachemys scripta	23.2	17.3	5.13	10.3	11.2	18.3	4.05	2.08	5.79	5.28
Total October 2007	42.9	40.4	19.7	54.00	43.6	33.8	9.46	7.99	30.30	20.47
Total March 2007	57.1	76.9	38.5	36.1	42.4	45.1	18.0	15.6	20.3	19.9
Total	100.0	117.3	58.1	90.0	86.1	71.8	19.8	14.2	39.6	31.0

TABLE 4. Percentage frequency of observations by turtle species in Ichetucknee Run and Rainbow Run, Florida (Meylan, unpubl. data), from three sampling intervals each during 2007 and 2008.

Species	Ichetucknee	Rainbow
Sternotherus minor	61.1	65.3
S. odoratus	2.24	1.15
Pseudemys concinna	21.9	21.2
P. nelsoni	0.89	2.30
P. floridana	0.00	8.28
Trachemys scripta	13.0	0.23[1]
Chelydra serpentina	0.89	0.46
Apalone ferox	0.22	1.15
Deirochelys reticularia	0.00	0.22

[1]One *Trachemys scripta elegans,* an introduced exotic

are relevant to turtle distributions: Headspring Reach, Narrow Rice Marsh Reach, Wide Rice Marsh Reach, and Floodplain Reach (Fig. 2). Length and area of each reach was estimated using maps published in the Ichetucknee Springs State Park Approved Unit Management Plan (2000. Unpublished report by the Florida Department of Environmental Protection, Division of Recreation and Parks, District 2). The Headspring Reach (0.56 km; 0.71 ha) extends from (and includes) Ichetucknee Spring and Blue Hole Spring (= Jug Spring) south to the convergence of their respective forks. Apart from the two headsprings, this reach is narrow (< 10 m) and shallow (< 1 m). This portion of river is characterized by an overhanging floodplain forest canopy and relatively high water velocity. Water hemlock (*Cicuta* sp.) is abundant along the margins and there are few basking sites.

The Narrow Rice Marsh Reach (0.52 km; 2.22 ha) extends from just below Blue Hole Spring to just below Mission Spring. Although there is some flow over a shallow floodplain in this reach, it is not as wide as below Mission Spring. The channel reaches depths of

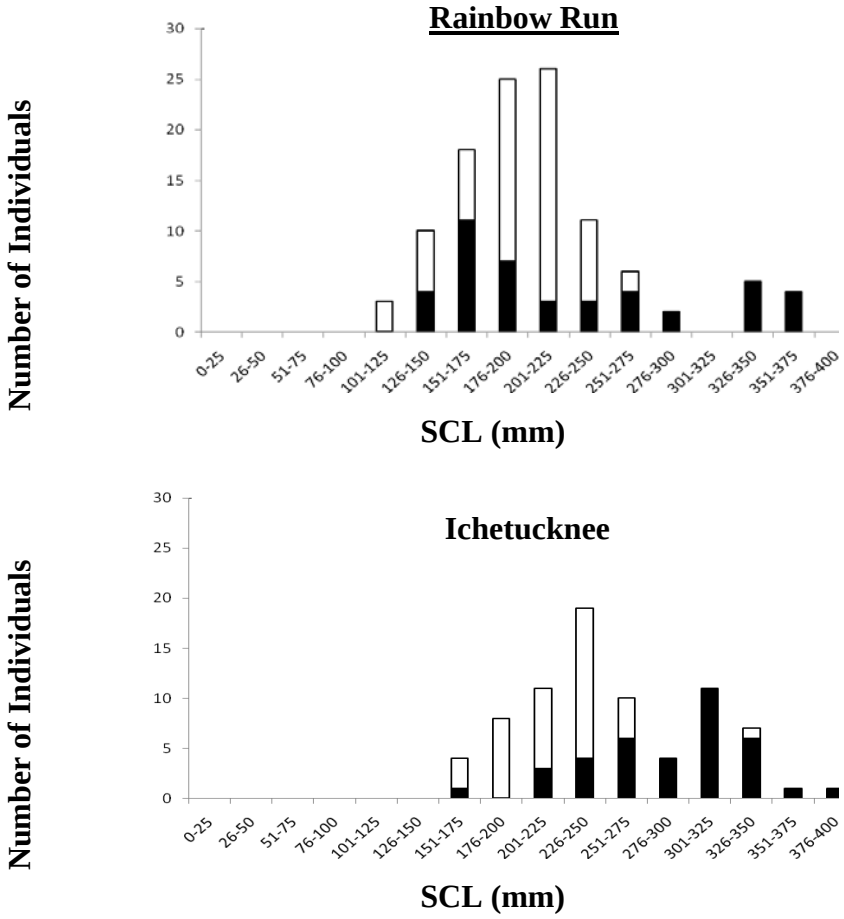

FIGURE 1. Comparison of the number of adult *Pseudemys concinna* by size class captured in 2007 at both Ichetucknee Run (this study) and Rainbow Run, Florida (Meylan, unpubl. data). (Key: Stacked bar chart; Black = females, white = males). Dark portions of bars are females, white portions are males.

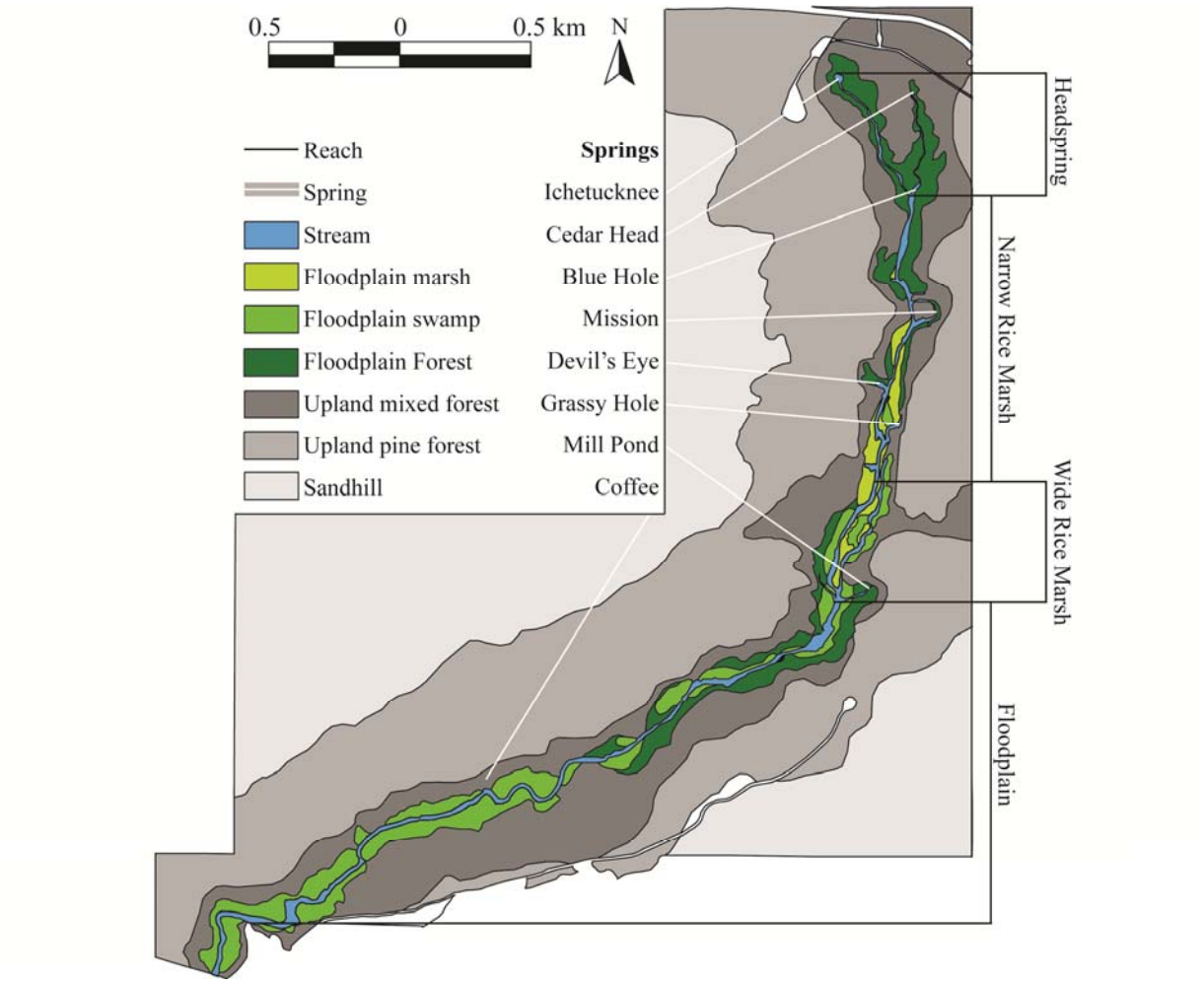

FIGURE 2. Ichetucknee Run within Ichetucknee Springs State Park, Columbia Co., Florida. Plant communities, springs, and the limits of four rivers are indicated. Map adapted from the Ichetucknee Springs State Park Approved Unit Management Plan (2000. Unpublished report by the Florida Department of Environmental Protection, Division of Recreation and Parks, District 2).

2–3 m and widths of 10–15 m, with banks as much as 60 m apart. The combined flow from the two major source springs makes the flow in this section much greater than in the Headspring Reach. Emergent vegetation (dominated by *Cicuta*) on either side of the channel forms large mats at the surface, but there are few other basking sites.

The Wide Rice Marsh Reach (1.17 km; 2.88 ha) extends from below Mission Spring to just below Mills Spring. This section includes a very wide and shallow floodplain on either side of the channel (not included in this reach's area estimate). In most places the floodplain is too shallow for snorkelers. The total width of the river is as much as 100 m, with the main channel from 10 to 20 m wide. This reach lacks overhanging canopy or potential basking sites near the main channel. Submergent vegetation (*Sagittaria* sp.) and algae that now cover much of the bottom of the river are particularly thick in this reach and form a continuous carpet on the bottom.

The Floodplain Reach (2.91 km; 5.18 ha) extends from Mills Spring to the tuber take-out point at U.S. 27. This reach consists of a confined channel through a gallery forest of large trees (mostly *Taxodium* and *Acer*). The channel narrows to 10–20 m and is 1–3 m deep. Floodplain marsh is absent; instead, floodplain swamp and floodplain forest dominate both banks. Except during flooding events, the river remains confined to the channel. The presence of the forest adjacent to the channel has resulted in many large tree falls that have produced complex snags and potential basking sites.

Most turtle captures with GPS locations (59% of 447) were made in the Floodplain Reach (Fig. 3 and 4), but this is also the longest of the four reaches (2.91 km).

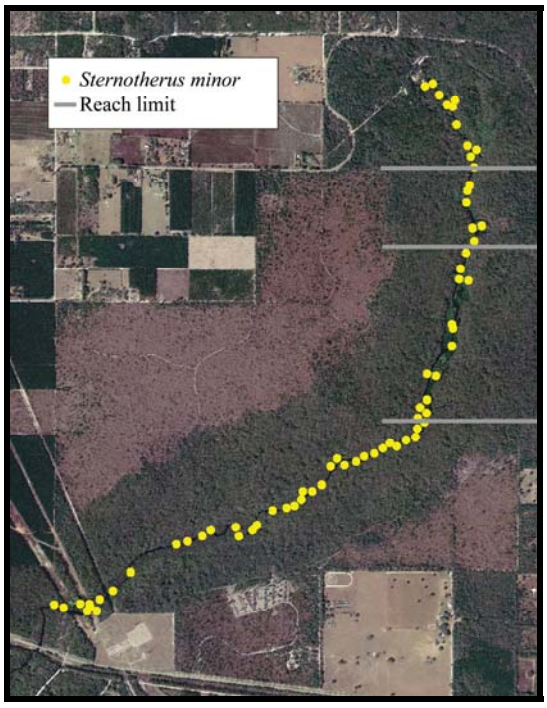

FIGURE 3. Ichetucknee Run within Ichetucknee Springs State Park, Florida showing the distribution of Loggerhead Musk Turtle (*Sternotherus minor*) captures made during this study. Aerial imagery provided by the Florida Department of Transportation (1989).

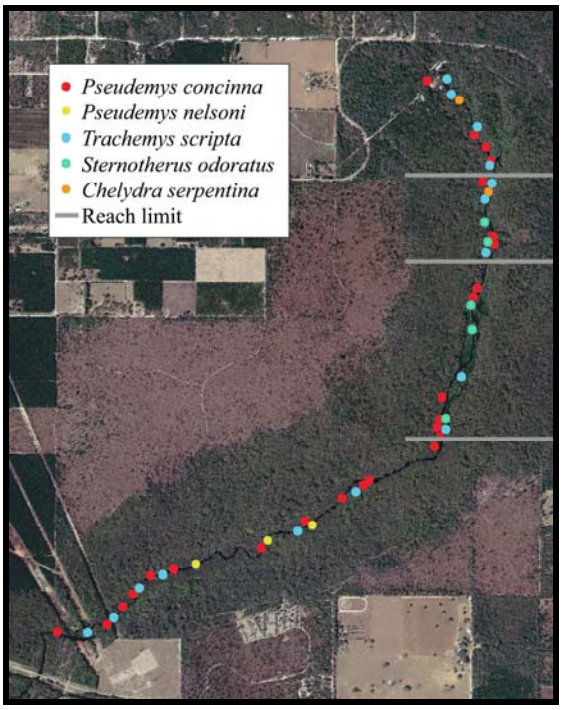

FIGURE 4. Ichetucknee Run within Ichetucknee Springs State Park, Florida, showing the distribution of captures made during this study of all turtle species other than the Loggerhead Musk Turtle, *Sternotherus minor*. Aerial imagery provided by the Florida Department of Transportation (1989).

The number of captures made over the four sampling sessions in this section of river was 90.0 turtles per km (Table 3). This was slightly less than that observed in the Head Springs Reach (100.0/km) and the Narrow Rice Reach (117.3/km). The fewest observations were made in the Wide Rice Reach, which had 58.1 captures per km (Table 3).

A goodness of fit test indicates a significant difference in captures of individuals per km among the four reaches when individuals of all species were considered collectively (X^2 = 20.30, df = 3, P < 0.001). Sample sizes for the species *P. concinna*, *T. scripta*, and *S. minor* were large enough (> 5 captures within each reach) for further testing. *Sternotherus minor* (X^2 = 19.18, df = 3, P < 0.005), *T. scripta* (X^2 = 13.44, df = 3, P < 0.005), and *P. concinna* (X^2 = 13.01, df = 3, P < 0.005) all vary significantly in density among the four reaches sampled.

DISCUSSION

Closed population estimation models assume that immigration, emigration, birth, and death are absent, that marks are not lost, and that marked individuals are randomly dispersed through the population (Pollock et al. 1990). For our spring-fall estimates, the most likely violation of assumptions is the potential for immigration-emigration. However, data on *Pseudemys* recaptures from Rainbow Run suggest that emigration in a spring run is minimal at 4.8% (Meylan, unpubl. data), at least for this species. PIT tag retention is generally very good. Based on 10 years of PIT tagging in Rainbow Run, only about 5% of doubly marked (PIT tagged and drilled) *P. concinna* had lost a tag at one point in their recapture history (Meylan, unpubl. data).

The first attempt to estimate the number of *S. minor* in Ichetucknee Run suggests that Run suggests that 11,676 ± 6606.1 individuals (461/ha) occupy the portion of the river within Ichetucknee Springs State Park. The very wide confidence limits for these estimates are the result of low recapture rates. Nevertheless, such low recapture numbers suggest that there are very large numbers of *S. minor* in Ichetucknee Run. The minimum estimate of 5,070 individuals (461/ha) is well within the limits known for other studies. At Rainbow Run, Meylan et al. (1992) estimated that *S. minor* occurs at a density of approximately 127/ha. The highest density known for *S. minor* is from Emerald Springs in the Florida panhandle, where Cox and Marion (1979) reported a density of 2,857 *S. minor*/ha. Thus, even the maximum estimate using our 95% CI (18,282 *S. minor* or 1,664/ha) falls within previously reported densities.

Although we could not repeat Marchand's (1942) observation of 500 *S. minor* in a single passage down the river, preliminary data suggest that it is not likely due to a decline in population size. An alternative explanation is a decline in detectability due to the marked increase in submergent vegetation in the river. Marchand (1942) noted that *Pseudemys* was limited to areas of the river where vegetation was present. Submergent vegetation now covers most of the bottom of the river (Kurz et al. 2003. Mapping and monitoring submerged aquatic vegetation in Ichetucknee and Manatee Springs. Final Report. Suwannee River Water Management District, Live Oak, Florida. 190 p.). During our sampling sessions, *S. minor* were often captured as they sat on top of beds of *Sagittaria* grass or in bare rocky areas along the lower reaches of the river. It seems likely that many *S. minor* are present but unobserved in the grass beds. The low numbers of *S. minor* observed in the Wide Rice Reach support this hypothesis. Because of the absence of canopy over the channel in this reach of the river, it has the most continuous and luxuriant coverage of submergent vegetation.

The small size of the *S. odoratus* population relative to *S. minor* is not surprising. However, the estimate and 95% CI in Table 2 should be considered preliminary. Berry (1975) included Ichetucknee Run among the sites in northern Florida where he thought *S. odoratus* occurred only occasionally. In fact, he considered it to be so rare that in his study of interactions between the two species, he treated Ichetucknee Run as one of his sites in which *S. minor* occurs "alone."

Higher recapture rates, and consequently better estimates of population size, were obtained for *Pseudemys* and *Trachemys*. Both were frequently captured in association with basking logs, and their much larger sizes make them more apparent, even in grass beds. To the casual observer, these species are likely to appear extremely abundant because they are seemingly on every log. However, the actual numbers (both have estimated densities of about 13/ha) are well below the highest densities reported for these species in Florida (741/ha for *P. concinna*; Jackson 1970; 361/ha for *T. scripta*; Auth 1975). The presence of many large adults of both species suggests that these populations have not been subjected to recent harvests. Nevertheless, the population structure of both species should be monitored regularly for evidence that large adults are being removed.

Relative to Ichetucknee Run, the population of *P. concinna* at Rainbow Run seems to include fewer and smaller females. It has been proposed that this is due to over-harvesting and possible illegal poaching at Rainbow Run (Giovanetto 1992; Heinrich et al. 2010). The largest *P. concinna*, and consequently most sought after for human consumption, are reproductive females.

The absence of *Macrochelys* from our Ichetucknee samples is notable. This large species is known from the Ichetucknee Run but likely occurs at low density. The sampling method used (day-time snorkeling) is not ideal for the study of this largely nocturnal species (Ewert et al. 2006). Future studies of the turtle community at this site should include overnight trapping to assess the status of this species.

Management recommendations.—Conservation of Ichetucknee Springs State Park has apparently resulted in a large and diverse community of turtles on a river that receives heavy public use. Eutrophication of Ichetucknee Run is a major problem (Kurz et al. 2003, *op. cit.*), but perhaps one side-effect is that smaller turtles are hidden from the public. Experienced snorkelers captured 222 of an estimated 5,070 *S. minor* (4.4%) but approximately 50% of the estimated total number of the larger species of *Trachemys* and *Pseudemys*. Thus, it seems that smaller turtles have an easier time avoiding being observed.

The large number of snags and basking logs that have been left in the river provide ample sites at which emydid turtles can be observed. The practice of retaining as many of these as possible is certainly to be encouraged and hopefully emulated by other state parks and aquatic preserves. Lindeman (1998, 1999) has demonstrated the value of "deadwood" basking sites for emydid turtles.

The greatest concern at this time is the vulnerability of the larger species to poaching (Heinrich et al. 2010). The density of large female *P. concinna* in the lower portions of the park will be an ever more tempting target for people involved in the illegal collection of this protected species for food. Park staff should continue to be vigilant for signs that people are catching turtles and should encourage park users to report any activity involving capture of turtles.

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