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Home Ranges of Spotted Turtles (*Clemmys guttata*) in Southwestern Ohio

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ABSTRACT. – The number of spotted turtles (*Clemmys guttata*) has declined in Ohio and elsewhere in their range, primarily as a result of loss of wetland habitat, over-collection, and increased predation. Information on home ranges is necessary for management and protection of this species. We recorded locations of 27 spotted turtles using radiotelemetry during 4 years of study (1991–93 and 1995) at Prairie Road Fen in Clark County, Ohio. We analyzed locations using core activity areas (50% adaptive kernel) and total home ranges (95% adaptive kernel and minimum perimeter polygon). Kernel analysis is a non-parametric home range estimator that incorporates the density of known animal locations, giving weight to heavily used areas. The minimum perimeter polygon determines home range size by emphasizing the outer most points of the area traveled, and is more common in earlier published literature. Turtles had mean core activity areas of 0.14 ha, 95% activity areas of 1.79 ha, and minimum perimeter polygon home ranges of 1.30 ha. Females had significantly larger median core activity areas than males (0.083 and 0.037 ha, respectively, $p = 0.0171$), most likely due to nest-searching behavior. Moreover, core activity areas and minimum perimeter polygon measures differed significantly for 7 females with > 12 observations before and after the reproductive season ($p = 0.0215$, $p = 0.0342$, respectively). Extended movements by turtles may be a response to sub-optimal habitat.

KEY WORDS. – Reptilia; Testudines; Emydidae; *Clemmys guttata*; turtle; ecology; telemetry; home range; Ohio; USA

Spotted turtles (*Clemmys guttata*) are small, semi-aquatic turtles that occupy shallow bodies of water including ponds, small streams, marshes, bogs, and drainage ditches (Ernst et al., 1994). *Clemmys guttata* can be found in an east-west band extending from Indiana, Illinois, and the southern portion of Michigan and Ohio east through southern Ontario and Quebec, Canada, and Pennsylvania and New York to Maine, and southward (generally east of the Appalachian Mountains) through Virginia, the Carolinas and Georgia, to northern Florida (Ernst, 1976; Ernst et al., 1994). Spotted turtle populations are declining in many portions of their range (Stearns et al., 1990). Furthermore, *C. guttata* is listed as an endangered species in Canada (Cook et al., 1980) and is listed as endangered, threatened, or of special interest or concern in 10 of the 21 U.S. states in which it has been found (Mauger, 1988, cited in Graham, 1995).

In Ohio, the spotted turtle is listed as a species of special interest, suggesting that, while apparent low population numbers are of concern, more information must be gathered to determine if the species warrants legal protection (Ohio Department of Natural Resources, 1992). Destruction of wetland habitat in Ohio has resulted in widely scattered, relict populations of *C. guttata* (Lovich, 1987). Furthermore, over-collection, and possibly heightened levels of predation in some areas, have contributed to the decline of *C. guttata* populations (Lovich, 1987; Stearns et al., 1990). In order to protect an adequate amount of *C. guttata* habitat from further loss, it is essential to gain information on intrapopulational movements of this species.

Intrapopulational movements can be described in terms of an organism's home range, defined as the area in which an animal carries out its daily activities over the course of any specified length of time such as a seasonal or a life-time home range (Burt, 1943). The size of the home range is closely related to the energy budget of a particular organism and may be used to determine possible constraints on an organism's energy acquisition (White and Garrot, 1990; Rowe and Moll, 1991). Moreover, because environmental factors such as temperature, nutrient supply, and vegetative cover influence home range size, home ranges can be used as indicators of changes in habitat quality. Finally, since organisms spend the majority of their time within a home range, areas encompassed by the composite home range of a population reflect critical habitat that may need to be protected and managed. Several studies have described the home range sizes of various emydid turtles (Ernst, 1970, 1977; Chase et al., 1989; Stickel, 1989; Doroff and Keith, 1990; Ross and Anderson, 1990; Quinn and Tate, 1991; Ross et al., 1991; Rowe and Moll, 1991; Graham, 1995; Kaufmann, 1995). However, only a few have focused on the home range of *C. guttata* (Ernst, 1970; Graham, 1995).

Using radiotelemetry data from 1991–95 (excluding 1994), we studied the home ranges of *C. guttata* at Prairie Road Fen, a preserve in southwestern Ohio that harbors the largest known population of spotted turtles in the state (J. Windus, *pers. comm.*). The results of this study may prove useful in the development of management strategies for this species.

MATERIALS AND METHODS

Study Area. — Prairie Road Fen (PRF) is a 39.29 ha preserve located along Buck Creek in Moorefield Township, northern Clark County, Ohio (39°59'N, 83°42'W). Since 1981, the preserve has been owned by the Army Corps of Engineers and has been under the management of the Division of Natural Areas and Preserves, Ohio Department of Natural Resources. The preserve contains sedge meadow, wet prairie, shrub, and abandoned field habitat types along with approximately 5 ha of fen habitat (Lewis and Ritzenthaler, 1997).

Fens are minetrophic peatlands characterized by percolating ground water, enriched with ions dissolved from mineral soil, with an alkaline pH and a high calcium carbonate concentration (Ingram, 1967; Giller and Wheeler, 1986; Wassen et al., 1990). These alkaline wetlands occur throughout the glaciated portions of North America (Stuckey and Denny, 1981). At PRF, the water supply for a number of small streams is provided by several seeps. The soil composition at PRF consists of compacted clay covered by 1–2 m of unconsolidated marl and a 10 cm organic muck layer. Stuckey and Denny (1981) provide a more complete description of Ohio fens.

Methods. — During springs of 1991–95 (excluding 1994), we collected and radio-tagged 27 different turtles, some in as many as three different years (36 turtle-years) by trapping and both systematic and random searches. All traps had dimensions of 10 x 10 x 40 cm and were baited with canned cat food. Each captured turtle was weighed to the nearest 1 g, and the carapace and plastron lengths were measured along the midline to the nearest 1 mm with calipers. We used eye color, plastron shape, and the position of the cloaca relative to the edge of the carapace to determine the sex of individuals (Ernst et al., 1994). Since distinctive plastral shape and eye color develop with age, pre-reproductive turtles, defined as those with carapace length < 60 mm, were not sexed (Carr, 1952; Ernst et al., 1994). Individuals were identified by notches carved with a triangular file in the marginal scutes, with each scute assigned a unique number (Cagle, 1939).

We affixed radio transmitters (Advanced Telemetry System, Isanti, MN) to mature turtles with carapace lengths > 50 mm and weights > 60 g. Transmitters were either trailing or, after the first year of study, attached directly to the carapace. Trailing transmitters weighed < 10 g and were attached to a caudal marginal scute by a cable threaded through a drilled hole (Doroff and Keith, 1990). Carapace-mounted transmitters weighed < 5 g and were affixed to a rear costal or marginal scute using quick-drying epoxy. We released turtles at the location of their capture. We replaced transmitters every 30–60 days depending on battery type. All transmitters were removed in late September or early October.

We tracked turtles to within 1 m throughout the active season (March – October), plotted their locations on aerial photographs of the preserve and digitized the locations using ROCKWORKS (RockWare Incorporated, Wheat Ridge, CO). Turtles with 12 or fewer locations were eliminated from further study (Ernst, 1970), leaving 22 different turtles with 27 seasons of study. These turtles averaged 33.2 locations each. Next we used CALHOME (Kie et al., 1996) to calculate the home ranges of each turtle. We determined three different measures of home range. We calculated the minimum perimeter polygon (MPP: Mohr, 1947) which is the area of a convex polygon formed by connecting the outermost animal locations. We calculated two home ranges using kernel analysis, which computes probabilities of locations, based on density of locations, giving weight to areas used more heavily (Worton, 1987). We used both a 95% area, which eliminates the outermost locations, and a 50% kernel, which allows for identifying the most heavily used core area.

We tested for differences using one-way ANOVA on natural log-transformed data to compare home range differences between turtle sex, weight, size, and year of study. We checked for differences using all calculated home ranges and again eliminating home ranges for years subsequent to the first year of capture to check for the effects of non-independent sampling. Differences between pre-nesting (March – June) and post-nesting (July – October) home ranges were tested using paired t-tests on natural log-transformed data. Finally, we examined the mean distance between plotted locations for each year. Statistical p values were considered significant at the alpha = 0.05 level.

Individuals with overlapping core areas were considered to be exhibiting site fidelity. We considered extended movements to be excursions outside of a contiguous system of fen, stream, and ditch habitats that contained the majority of locations.

RESULTS

Of the 22 turtles for which we recorded 27 summer home ranges, 15 were female and 7 male (Table 1). Mean MPP at PRF was 1.30 ha, mean 95% adaptive kernel home range was 1.79 ha, and mean 50% core adaptive kernel was 0.14 ha. Home ranges were not restricted to fen habitat and included abandoned field, shrub, flooded ditch, and other habitat types.

We found no significant differences between males and females for the MPP or 95% adaptive kernel ($p > 0.05$). However, core activity areas of females (median 0.083 ha) had significantly larger core activity areas than males (median 0.031 ha, $p = 0.0171$). Home ranges did not differ based on turtle size or mass ($p > 0.05$), but 1991 home ranges were significantly smaller than later years ($p = 0.016$ for MPP, $p = 0.037$ for 95% kernel, and $p = 0.045$ for 50% kernel). No other differences in groups were affected by inclusion or exclusion of the 1991 data.

Home ranges were centered within streams, flooded ditches, or fen habitat in all 4 years. Two of 7 individuals followed in more than one year exhibited site fidelity.

We detected no significant differences ($p = 0.0703$) in the 95% adaptive kernel between the periods during (March – June) and after (July – October) reproductive activity for

Table 1. Home ranges of spotted turtles (*Clemmys guttata*) at Prairie Road Fen in Clark County, Ohio, by year and turtle. The dates of locations used in the home range analysis as well as the number of locations (n) for each home range are included. The minimum perimeter polygon (MPP) measures the convex polygon that encompasses all of the animal locations while the kernel home ranges give weight to areas of most turtle activity. The 50% kernel calculates the core activity areas. Maximum distances moved are excursions beyond the regularly occupied habitats.

Year	Turtle No.	Sex	n	Dates of Locations	MPP (ha)	95% Kernel (ha)	50% Kernel (ha)	Max. Dist. (m)
1991	6	f	18	26 Apr - 1 Jun	0.05	0.00	0.00	
	102	f	25	16 Apr - 21 Aug	0.04	0.05	0.01	
	202	f	21	22 Apr - 16 Jul	0.13	0.25	0.03	
	510	f	17	26 Apr - 4 Jun	0.03	0.04	0.01	
	800	f	16	27 Apr - 4 Jun	0.03	0.05	0.01	
	2002	f	14	26 Apr - 23 May	0.25	0.00	0.02	
1992	4	f	59	11 Mar - 19 Sep	11.33	13.19	0.88	720
	6	f	43	11 Mar - 29 Aug	1.24	0.96	0.10	280
	13	m	15	11 Mar - 21 May	0.04	0.10	0.01	
	32	f	42	11 Mar - 19 Aug	0.48	1.97	0.02	220
	707	f	43	11 Mar - 16 Aug	0.93	0.78	0.04	220
	800	f	23	11 Mar - 11 Jul	0.83	1.24	0.05	
	7004	f	28	22 Mar - 25 Jul	0.40	0.38	0.17	
	8000	f	17	11 Mar - 19 May	1.37	0.00	0.00	310
1993	4	f	21	6 Jun - 15 Jul	0.12	0.20	0.07	
	8	m	20	28 Jun - 7 Aug	0.28	0.95	0.01	
	27	f	50	7 Jun - 8 Sep	1.94	2.15	0.12	200
	107	m	41	2 Jul - 8 Sep	0.33	0.37	0.05	
	110	m	54	7 Jun - 8 Sep	0.49	1.00	0.00	
	800	f	54	12 Jun - 8 Sep	0.64	1.32	0.03	
	1002	f	45	12 Jun - 12 Sep	0.23	0.38	0.05	
	2007	m	52	7 Jun - 12 Sep	9.22	9.20	0.05	540
1995	9	m	33	29 Apr - 11 Oct	0.09	0.15	0.02	
	110	m	42	12 Apr - 11 Oct	0.60	1.08	0.10	
	204	f	33	12 Apr - 13 Oct	0.93	2.86	1.23	350
	1800	f	35	12 Apr - 13 Oct	2.41	2.97	0.54	260
	4007	m	35	9 Apr - 12 Oct	0.80	1.24	0.13	
Means:					1.30	1.79	0.14	

the 7 female turtles with > 12 plotted locations in each period. However, core activity areas and MPP measurements were significantly smaller after the nesting period ($p = 0.0215$ and $p = 0.0342$, respectively).

We found no differences in the mean distance between plotted locations between sexes nor between the nesting and post-nesting periods ($p > 0.05$). Extended movements beyond fen habitat by individuals occurred in every year of the study. Females made 10 of the 11 observed excursions (mean straight-line distance = 322 m). The longest straight-line distance measured 712 m but was 1.5 km in actual distance traveled (Table 1). These journeys took place in all months from April to September, and the duration ranged from less than a week to as many as 3 months.

DISCUSSION

Seasonal home ranges (MPP and 95% adaptive kernel) of *C. guttata* at PRF were larger than those reported by Ernst (1970) for spotted turtles in Pennsylvania and by Graham (1995) in Massachusetts (Table 2). Elimination of the 1991 data from this study, which were significantly smaller than the other years, would make this difference even more pronounced. Furthermore, the turtles studied by Ernst (1970) showed surprisingly little individual variation in home range size compared to those at PRF. Changes in research methodologies seem unlikely to account for these different results, however, variations in habitat size or quality, interspecific competition, and population density may explain the observed differences. *Clemmys guttata* home ranges at PRF are comparable to those of other emydids (Table 2).

Home range studies of emydid turtles have traditionally focused on reporting measures of overall home range size (Ernst, 1970, 1977; Chase et al., 1989; Stickel, 1989; Doroff and Keith, 1990; Ross et al., 1991; Graham, 1995; Kaufmann, 1995) or activity centers (Ross and Anderson, 1990; Quinn and Tate, 1991; Rowe and Moll, 1991) With the exception of Chase et al. (1989), these studies found no significant differences between overall male and female home range sizes or activity areas. However, these studies did not explore possible differences between the sexes in core (50%) activity areas. Although we found no differences between the sexes in overall home range size, we observed that female *C. guttata* at PRF utilize larger core activity areas. This suggests that measurements of core activity areas are not necessarily proportional to measures of overall home range size.

Larger female core activity areas at PRF may be the result of searches for appropriate nesting sites. The assertion is given added weight by the fact that female core activity areas decreased significantly after the nesting period. It is unlikely that mate-searching behavior can explain the difference in core activity areas during and after the reproductive season. During the breeding season, males may augment

Table 2. Some previously reported home ranges of turtles in the family Emydidae.

Species	Sex	Location	Home Range (ha)	Source
Clemmys guttata		Pennsylvania	0.52	Ernst, 1970
C. guttata		Massachusetts	0.75	Graham, 1995
Clemmys muhlenbergii		Pennsylvania	1.28	Ernst, 1977
C. muhlenbergii	female	Maryland	0.07	Chase et al., 1989
C. muhlenbergii	male	Maryland	0.18	Chase et al., 1989
Clemmys insculpta		Pennsylvania	3.30	Kaufmann, 1995
C. insculpta		Canada	24.30	Quinn and Tate, 1991
C. insculpta	female	Wisconsin	0.54	Ross et al., 1991
C. insculpta	male	Wisconsin	0.25	Ross et al., 1991
Emydoidea blandingii	female	Wisconsin	0.56	Ross and Anderson, 1990
E. blandingii	male	Wisconsin	0.94	Ross and Anderson, 1990
E. blandingii		Illinois	1.30	Rowe and Moll, 1991
Terrapene carolina	female	Maryland	1.13	Stickel, 1989
T. carolina	male	Maryland	1.20	Stickel, 1989
Terrapene ornata		Wisconsin	8.70	Doroff and Keith, 1990

their reproductive fitness by increasing their activity and seeking multiple mates (Morreale et al., 1984; Gibbons et al., 1990). Female turtles, on the other hand, gain no reproductive advantage from increased mate-searching activity (Morreale, 1984; Gibbons et al., 1990; Brown and Brooks, 1993). Therefore, it seems likely that nest-searching rather than mate-searching, leads to larger female core activity areas. Moreover, female and male *C. guttata* at PRF are comparable in size (TLL, unpubl. data). Thus it is improbable that females require greater core activity areas to meet their metabolic needs. However, an alternative explanation is that females expand their home ranges to provide the increased energy necessary to produce and lay eggs.

Males of other turtle species heighten their activity during the mating season, and male *Chelydra serpentina* have even been known to travel to "bottlenecks" passed by nesting females (Morreale et al., 1984; Brown and Brooks, 1993). Since males possess smaller core activity areas than females at PRF, it is reasonable to assume that males do not increase their home range size while searching for mates. In fact, since there is considerable overlap in home ranges between the sexes, males do not need to travel to mate with multiple females. Lovich (1990), however, reported two male spotted turtles with possible mate-searching extended travels in South Carolina. In addition, fen habitat, streams and hibernacula, which represent the centers of most turtles' home ranges, are concentrated in a relatively small portion of PRF.

We noted several extended movements by *C. guttata* during the study period. Such excursions have been reported for a number of emydid species (Ernst, 1976; Williams and Parker, 1987; Stickel, 1989; Eckler et al., 1990; Gibbons et al., 1990; Ross and Anderson, 1990; Rowe and Moll, 1991; Graham, 1995; Kaufmann, 1995); some of these movements were apparently associated with nesting behavior (Ernst, 1976; Williams and Parker, 1987; Rowe and Moll, 1991). However, Kaufmann (1995) and Rowe and Moll (1991) described long range movements by *Clemmys insculpta* and *Emydoidea blandingii*, respectively, that were not related to nesting. Moreover, extrapopulational movements have been reported for males as well as females (Gibbons et al., 1990).

Since extended movements by female *C. guttata* at PRF went beyond known nest sites, these excursions may not have been associated with nesting. One explanation is that movements by *C. guttata* at PRF represent an instinctive behavior that allowed for genetic exchange between populations in adjoining wetlands (Kiester et al., 1982). However, these movements are now blocked by flooding behind a 1970s dam along Buck Creek. However, females, which would not increase their fitness by migrating in search of mates, made all but one of the observed excursions. Furthermore, the male made its movement in August, well after the breeding season.

Alternatively, these extended movements may represent reactions to reductions in habitat quality (Plummer and Shirer, 1975; Gibbons et al., 1990). Natural or anthropogenic succession may be reducing the number of appropriate nesting or foraging sites at PRF, thereby forcing individuals to seek more favorable habitats. Moreover, we have observed a reduction in the water level in the fen, as have others (T. Snyder, *pers. comm.*). To confirm this, future research should use our data as a baseline to examine temporal and spatial changes in spotted turtle home ranges at PRF.

Since core activity areas of both sexes of *C. guttata* at PRF tend to center on fen habitat, the protection of these areas is essential. Future management plans should seek to prevent further succession of fen habitat and encroachment by exotics. In addition, the overall home range measurements and extended movements at PRF underscore the importance of protecting habitat types outside of the fen. Because spotted turtles occupy a variety of habitats throughout the year, including meadows, ponds, and wooded areas, it is essential that biologists consider the entire habitat when constructing management schemes for wetlands inhabited by *C. guttata*.

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