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The Relative Efficiency of Basking and Hoop Traps for Painted Turtles (*Chrysemys picta*)

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Trap efficiency, the rate at which a trap catches animals (Novak 1987), is an important factor when gathering quantitative data such as relative abundance. Different techniques may catch individuals at different rates making comparisons across studies difficult or impossible (Heyer et al. 1994). Different trap types may also capture classes of individuals at different rates and lead to an over or under representation of animals of a specific age, size or gender (Frazer et al. 1990; Koper and Brooks 1998; Ream and Ream 1966). Increasing trap efficiency is an important way to increase the precision of population size estimates from mark-recapture data. The precision of population size estimates is increased as a higher proportion of the population is captured and marked (Seber 1982) which will be achieved more readily using a maximally efficient trapping method. Efficient trapping is also important to researchers trying to maximize return for their effort in terms of time and money (Morton et al. 1988).

Several methods exist for trapping aquatic turtles but there have been few studies comparing the relative efficiency and practicality of different trap types. The two trap styles commonly used to capture aquatic turtles are basking traps and hoop traps. Basking traps, as the name suggests, take advantage of the basking behavior of turtles. There are several basking trap designs and most consist of a basking platform with a net or wire basket attached underneath. Turtles are captured in the net after leaving the platform. Hoop traps consist of a cylindrical frame covered in mesh; turtles, attracted by bait, enter the trap through a submerged, funnel-shaped opening. Lagler (1943) claimed that hoop traps were “the most efficient and practical kind of trap for turtles” although he offered no evidence for this claim. Basking traps have been shown to be more effective than hoop traps in capturing Map Turtles (*Graptemys geographica*) and Painted Turtles (*Chrysemys picta*) although both studies examined only single populations (Browne and Hecnar 2005; McKenna 2001). In this paper, I present a comparison of the relative efficiency of basking and hoop traps for catching Painted Turtles in 10 central Minnesota lakes over a two-year period.

Basking traps used for this study were modeled after traps used by local commercial turtle harvesters (Fig. 1). Traps consisted of a wood frame, 60 × 60 cm at the base, with a net basket underneath. Strips of styrofoam were attached to the bottom of the wood frame for buoyancy. The net basket, attached to the wood frame, was ca. 90 cm deep, 122 cm in circumference, and had 3.8 cm square mesh (Memphis Net and Twine, Tennessee, USA). The sides of the trap were sloped inward to facilitate entry and prevent escape. A cross board was attached to the top of the trap to provide additional basking area and to increase the probability of turtles entering the trap. Hoop traps, made by Memphis Net and Twine, contained a single opening and were 72 cm in diameter with 3.8 cm square mesh. Canned sardines packed in soybean oil were used as bait.

I trapped *C. picta* in 10 central Minnesota lakes that ranged in size from 6 to 64 ha. Trapping was conducted from 26 June to 31 August 2001 and 13 May to 30 August 2002. Basking traps and hoop traps were set simultaneously on each lake for 1–5 days at a time. Traps were typically checked and emptied every day (N = 95 days, range = 17–48 h/trap set, median = 24 h). Each lake was sampled at least seven times during the study (Table 1). Traps were set where turtles were observed to be most abundant which was near the shoreline, adjacent to cattails and other emergent

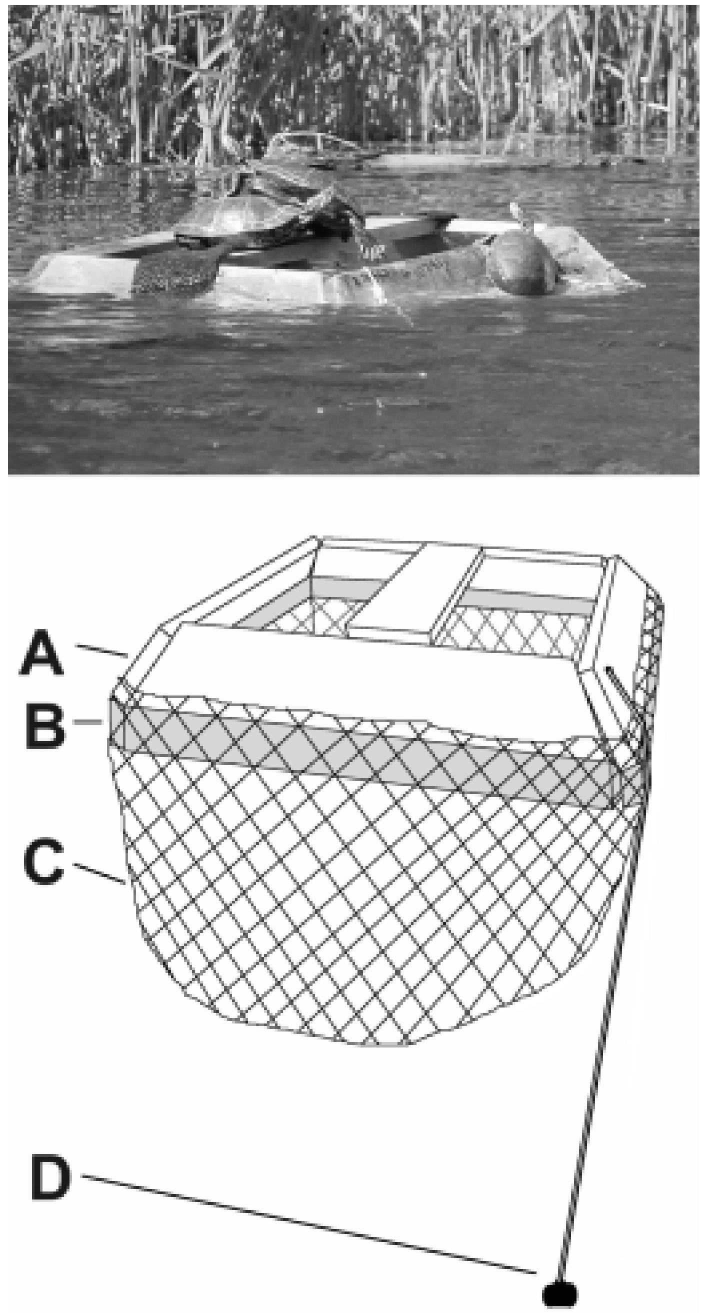

FIG. 1. Top: Painted Turtles (*Chrysemys picta*) on a basking trap in central Minnesota. Bottom: Basking trap design used in this study. A - wood frame; B - foam floats; C - net basket; D - anchor.

TABLE 1. Data summary comparing the mean catch-per-unit-effort (CPUE) of Painted Turtles (*Chrysemys picta*) captured in each lake for hoop and basking traps. Effort is measured in trap-hours. The number of traps is shown as the mean and the minimum and maximum number of traps used to sample each lake.

		Hoop Traps					Basking Traps				
Lake	# of samples	# of traps mean (min, max)	Total effort	Males/ trap-hr	Females/ trap-hr	Juveniles/ trap-hr	# of traps mean (min, max)	Total effort	Males/ trap-hr	Females/ trap-hr	Juveniles/ trap-hr
Bjorkland	8	4, (4,4)	870	0.0081	0.0000	0.0000	6, (4,10)	1370	0.0482	0.0216	0.0133
Gemini East	9	2.4, (0,5)	415	0.0037	0.0037	0.0000	5.9, (4,10)	1222	0.0158	0.0132	0.0155
Gemini West	9	2.8, (1,5)	748	0.0204	0.0139	0.0000	5.8, (3,9)	1518	0.0226	0.0149	0.0017
Half Moon	9	4.6, (3,7)	967	0.0335	0.0112	0.0000	8.8, (5,13)	1796	0.0188	0.0076	0.0052
Henschien	7	5, (4,6)	777	0.0195	0.0061	0.0000	12.3, (10, 15)	1927	0.0320	0.0076	0.0131
Lake 21	7	6, (5,9)	952	0.0065	0.0021	0.0009	11, (9,14)	1786	0.0593	0.0294	0.0230
Maria	17	7.3, (2,11)	3013	0.0417	0.0116	0.0005	15.5, (8,25)	6521	0.0944	0.0442	0.0186
Sagatagan	9	5.2, (4,7)	1175	0.0161	0.0074	0.0000	9, (4,16)	2139	0.0193	0.0083	0.0006
Spurzem	12	4.8, (2,9)	1560	0.0280	0.0051	0.0004	13.5, (6,24)	4188	0.0188	0.0050	0.0066
Stump	8	4.4, (2,6)	936	0.0101	0.0027	0.0005	10.1, (4,16)	2089	0.0211	0.0102	0.0070

vegetation, in May and June, and out from shore near floating mats of vegetation in July and August. Traps were also set near sites where *C. picta* were observed basking. Trap efficiency was quantified as catch-per-unit-effort (CPUE) with effort measured as trap-hours, the number of traps on a lake multiplied by the number of hours set. CPUE was calculated for both trap styles for every sample.

I recorded trap style, sex, and straight-line carapace length for every turtle captured. Front claw length and position of the cloaca relative to the rear edge of the carapace was used to classify each turtle as male or female. Juveniles were animals with no discernable secondary sex characteristics and a carapace length less than 10 cm (Ernst and Ernst 1973).

Two statistical analyses were conducted to determine whether catch differences between basking traps and hoop traps were significantly different. The first analysis tested the difference of mean CPUE for basking traps and hoop traps for every sample using a nonparametric Wilcoxon rank sum test for independent groups. A nonparametric test was used because mean CPUE was not normally distributed. The nonparametric analysis compared the relationship between the number of turtles captured and trap style, but it did not take into account the numerous environmental, seasonal, and gender-based factors that are thought to influence trapping success in painted turtles. The second statistical analysis, therefore, included several independent variables in a multiple linear regression model. Effort was analyzed as an independent variable because CPUE data were not normally distributed even after transformation. Independently examining variables that make up a ratio is one way to overcome normality problems (Sokal and Rohlf 1995). Catch data, the number of turtles captured in each sample, were transformed (ln[n+1]) to better fit a normal distribution. Normal quantile plots were inspected *a posteriori* to verify that residuals were normally distributed. The following linear regression model was used to analyze catch data: catch = trap style + lake + month + effort + sex + residual. Trap style was a categorical variable that identified traps as a floating basking trap or submerged hoop trap; lake was a categorical variable that accounted for the numerous individual differences of each lake such as area, productivity, and suitable nesting habitat; month was a categorical variable that accounted for seasonal differences in trappability; effort was measured as trap-hours, the number of traps multiplied by the number of hours they were set; and sex categorized turtles as males, females, and juveniles.

Possible seasonal and gender biases of the two trap types were also explored. I used a series of Chi-square goodness of fit tests to determine if male: female sex ratios differed significantly from 1:1 for each month for both trap types for each lake. The 1:1 sex ratio was chosen as an arbitrary reference point and was not meant to imply a 1:1 sex ratio actually exists in the populations under study. Statistical analyses were conducted using JMP IN Version 4.0.4 (Sall et al. 2001).

I marked 1690 *C. picta* and subsequently recaptured 426 *C. picta* (total captures = 2116). I captured 238 males, 72 females, and 5 juveniles in hoop traps (total = 315) and 1081 males, 464 females, and 256 juveniles in basking traps (total = 1801). Basking traps had a significantly higher CPUE than hoop traps ($\chi^2 = 79.3626$, df = 1, $P < 0.0001$) with a mean CPUE of 0.068 turtles per trap-hour in basking traps compared to 0.029 turtles per trap-hour in hoop

TABLE 2. Significance tests of the multiple linear regression comparing the number of Painted Turtles (*Chrysemys picta*) captured to individual lake effects (lake), seasonal effects (month), effort measured as trap hours (TH), trap style (either basking traps or hoop trap), and sex (male, female, or juvenile).

Source	*df*	Sum of Squares	F	*P*
Lake	9	42.596	9.24	< 0.0001
Month	3	2.654	1.73	0.1603
Effort (TH)	1	5.860	11.44	0.0008
Trap Style	1	49.298	96.24	< 0.0001
Sex	2	65.785	64.22	< 0.0001

TABLE 3. Results of the chi-square goodness of fit tests that examined whether Painted Turtle (*Chrysemys picta*) male: female sex ratios differed significantly from 1:1 for each month and lake for both basking traps and hoop traps. An asterisk notes samples that differed significantly from 1:1.

		Hoop Traps				Basking Traps			
Lake	Month	Males	Females	χ^2	*P*	Males	Females	χ^2	*P*
Maria	May	41	12	15.87	0.0001*	383	143	109.51	0.0001*
Spurzem	May	1	0	1.00	0.3173	15	2	9.94	0.0016*
Gemini East	June	0	0	N/A	N/A	12	6	2.00	0.1573
Gemini West	June	2	2	0	1	2	2	0	1
Henschien	June	1	0	1.00	0.3173	18	9	3.00	0.0833
Lake 21	June	1	1	0	1	7	11	0.89	0.3458
Sagatagan	June	6	6	0	1	6	8	0.29	0.593
Spurzem	June	3	1	1.00	0.3173	16	1	13.24	0.0003*
Stump	June	0	0	N/A	N/A	24	13	3.27	0.0705*
Bjorkland	July	3	0	3.00	0.0833	25	9	7.53	0.0061*
Gemini East	July	1	1	0	1	2	1	0.33	0.5637
Gemini West	July	0	0	N/A	N/A	2	0	2.00	0.1573
Half Moon	July	1	0	1.00	0.3173	3	2	0.20	0.6547
Henschien	July	0	0	N/A	N/A	14	5	4.26	0.0389*
Lake 21	July	2	1	0.33	0.5637	33	15	6.75	0.0094*
Maria	July	23	10	5.12	0.0236*	88	44	14.67	0.0001*
Sagatagan	July	7	3	1.60	0.2059	0	1	1.00	0.3173
Spurzem	July	9	2	4.45	0.0348*	16	10	1.38	0.2393
Stump	July	1	0	1.00	0.3173	3	1	1.00	0.3173
Bjorkland	August	1	0	3.00	0.0833	24	14	2.63	0.1048
Gemini East	August	1	1	0	1	6	8	0.29	0.593
Gemini West	August	0	0	N/A	N/A	18	14	0.50	0.4795
Half Moon	August	20	7	6.26	0.0124*	27	9	9.00	0.0027*
Henschien	August	12	4	4.00	0.0455*	30	1	27.13	0.0001*
Lake 21	August	3	0	3.00	0.0833	84	31	24.43	0.0001*
Maria	August	33	9	13.71	0.0002*	150	84	18.62	0.0001*
Sagatagan	August	9	1	6.40	0.0114*	40	9	19.61	0.0001*
Spurzem	August	24	3	16.33	0.0001*	20	7	6.26	0.0124*
Stump	August	13	3	6.25	0.0124*	15	6	3.86	0.0495*

traps. Basking traps caught more turtles per trap-hour in each age and sex class than hoop traps in most lakes (Table 1). The multiple linear regression analysis found the number of turtles captured was significantly correlated to trap effort, individual lake, turtle gender and age, and trap style, and the number of turtles captured was not correlated with the seasonal variable, month (Table 2).

Both trap types caught more males than females and basking traps caught substantially more juvenile *C. picta* than hoop traps. Male: female sex ratios differed significantly from 1:1 for both trap types consistently in several lakes, particularly Lake Maria (Table 3). Male: female sex ratios also differed from 1:1 in most populations during August. Because not all populations were sampled every month it was not possible to statistically compare seasonal differences in sex ratio across all lakes.

The basking trap design presented in this paper was substantially more efficient than hoop traps for catching *C. picta*, particularly juveniles. Basking traps captured twice as many turtles as hoop traps. The results presented here agree with other comparisons between basking traps and hoop traps in basking turtles (Browne and Hecnar 2005; McKenna 2001). The applicability of these results across the range of *C. picta* is unknown because sampling by either hoop trap or basking trap depends on the behavior of turtles, and geographic variation in behavior is common (Foster and Endler 1999). With this in mind, researchers wanting to maximize the return for their effort, particularly for mark-recapture studies, should consider the use of basking traps for capturing *C. picta*.

Four of the five variables examined in the multiple linear regression contributed to overall trap efficiency. The first variable was effort. Simply increasing the amount of time or the number of traps used increased the number of turtles captured. The second variable contributing to trap efficiency was differences between lakes. Environmental factors such as lake size, productivity, the availability of nesting areas, and proximity to roads can influence the relative abundance of turtles in the sampled population which should be related to hoop trap and basking trap efficiency (Cagle and Cheney 1950; Seber 1982). Operating under the assumption that the number of turtles caught was proportional to the effort used to catch them (Seber 1982), traps should be more efficient in lakes with abundant turtle populations. Bury (1979) and Zweifel (1989) noted large differences in population density between different *C. picta* populations with some populations having an order of magnitude more turtles per unit area than other populations. The CPUE of both hoop traps and basking traps differed significantly between lakes and was consistent with expected variation related to differences in the relative abundance of *C. picta* in different populations.

The third variable contributing to trap efficiency was sex. Significantly more males than females were captured in both trap types. The high capture rates of males implied: 1) the populations were male biased; 2) both trap types were male biased; or 3) a combination of a male biased population and trap bias. The consistent male capture bias in Lake Maria for both trap styles in every month suggests an actual male bias in that population. Several authors have suggested that hoop traps were male biased because of the attraction of males to captured females (Cagle and Cheney 1950; Frazer et al. 1990; Ream and Ream 1966, Vogt 1979). Because the ratio of males: females was roughly the same between trap styles basking traps were no more or less biased toward capturing males than hoop traps. Basking traps captured a larger proportion of juveniles than hoop traps suggesting that juveniles were either not as attracted to the bait as adults or that juveniles could more easily escape from hoop traps. It is also possible that juveniles were over-represented in basking traps. Because of their size, juveniles gain and lose heat more quickly than adult turtles (Lefevre and Brooks 1995) and may need to bask more frequently, resulting in more frequent captures in basking traps.

The fourth variable contributing to trap efficiency was the trap style. I observed both *C. picta* and *Chelydra serpentina* escaping from set hoop traps during this study, an occurrence also reported by Frazer et al. (1990). The decreased efficiency of hoop traps may have been related to the inability to retain captured turtles and not to differences in the attraction to the traps although these factors could not be separated here.

Hoop trap and basking trap efficiency are affected by the trap's ability to attract turtles (Novak 1987). Turtles can be attracted to traps for several reasons such as the need to bask on basking traps (Plummer 1979) and the bait in hoop traps (Cagle and Cheney 1950). My results may have been influenced by the choice of bait used, as some baits may be more effective at attracting *C. picta* than others (Jensen 1998), although Ernst (1965) found canned sardines, the bait used in this study, to be the most effective for trapping painted turtles. Male turtles may also be attracted to traps containing females and trap efficiency should increase for male turtles during periods of mate-searching activity (Cagle and Cheney 1950; Frazer et al. 1990; Thomas et al. 1999, Vogt 1979). The increased male capture bias during August was likely a result of mate searching behavior as copulation in *C. picta* most often occurs in the fall (Gist et al. 1990).

The ability to detect differences in basking trap efficiency, based on the seasonal and reproductive energy requirements of *C. picta*, was not confirmed here. Basking trap efficiency should increase as the need to bask increases. The primary purpose of basking is thermoregulation (Boyer 1965) and turtles bask more or less based on seasonal and reproductive energy requirements (Krawchuk and Brooks 1998; Lefevre and Brooks 1995; Ream and Ream 1966; Thomas et al. 1999). Egg development and nesting in females and mate-searching and spermatogenesis in males are energetically demanding and correlated with increased basking (Krawchuk and Brooks 1998; Thomas et al. 1999). Detecting differences in male basking behavior due to differing energy requirements was confounded by the possibility of male turtles being attracted to females already in the traps. Furthermore, monthly differences in the CPUE of male turtles were observed in both trap types and could have been related to mate-searching behavior. Additional work with a different experimental design would be needed to tease apart the influence of these behaviors on trap efficiency.

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Noninvasive Sampling Methods for Genotyping Amphibians: New Application for Conservation Genetics

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Amphibian species and populations are declining all over the world (Houlahan et al. 2000; Stuart et al. 2004). Hence, conservation of biodiversity is a globally crucial topic. Genetic characters are essential in order to promote conservation of biodiversity, because they contain much information about populations and species, such as intrinsic variability, population structure, historical patterns of gene flow, and phylogenetic relationships (Avise 2000). By using such information, we can define conservation units for each animal, and monitor genetic diversity.

As a genetic method, protein electrophoresis has been widely used in animals. This method requires fresh materials such as blood or other tissues (e.g., muscle, liver). DNA methods also have become popular since the polymerase chain reaction (PCR) was introduced in the late 1980s (Mullis and Faloona 1987; Saiki et al. 1985). PCR-based genotyping methods have highly progressed, and enable us to use a variety of materials including a small number of cells. These materials include hair, feces, urine, and buccal cells in mammals, feathers and eggshells in birds, and scales and fins in fishes (reviewed by Morin and Woodruff 1996).
In amphibians, both protein and DNA analyses have generally used materials obtained by sacrificing individuals. Therefore, sampling might have a serious impact on declining populations and species. Consequently, it is essential to establish sampling methods that avoid irreversible damage or viability reduction. Conservation genetic surveys should not contribute to the problem they seek to alleviate.

There are several studies that describe sampling methods without physical damage (Davis et al. 2002; Pidancier et al. 2003). Davis et al. (2002) used epidermis as DNA source material. Pidancier et al. (2003) used oral mucosa. In addition to these two materials, we employed molted skin and feces, and investigated four points: 1) collecting cells from oral mucosa, epidermis, molted skin, and fecal samples; 2) extracting DNA from each sample; 3) risk of contamination; 4) practicality of these methods. Materials were collected from Urodela and Anura in previous studies and Gymnophiona in the present study to include three orders of amphibians.