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# BODY SIZE AND SEXUAL SIZE DIMORPHISM OF BULLSNAKES (*PITUOPHIS CATENIFER SAYI*) IN WISCONSIN, USA

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***Abstract.*—Many studies exist on the evolutionary significance of sexual size dimorphism (SSD) in reptiles. Yet, this phenomenon has received little attention in members of the snake Genus *Pituophis*. I investigated if SSD occurs in Bullsnakes (*Pituophis catenifer sayi*) sampled at a site in southwestern Wisconsin, USA, by analyzing adult length and calculating the Sexual Dimorphism Index (SDI) for individuals encountered from 2003–2005. I found that male length in the population I studied was statistically larger than female length, which was previously unknown in this group of snakes. Where possible, I also calculated SDI for sizes reported by other studies on members of this genus. The calculated SDI had a male bias in 75% of these other studies. The male bias I found for my sample was greater than the values I calculated for other published reports on *Pituophis* species and subspecies.**

*Key Words.*—Bullsnakes; *Pituophis*; SSD; SDI; size; dimorphism

## INTRODUCTION

Numerous studies have attempted to understand the evolutionary significance of sexual size dimorphism (SSD) in reptiles (e.g., Shine 1978; Fitch 1981; Shine 1994; Lovich et al. 1998; King et al. 1999). These past studies reviewed the potential explanations for why SSD in body size occurs. In such instances, the cause of SSD was either sexual selection (i.e., females prefer males with large body size) or natural selection (i.e., large body size giving a survival advantage to the organism in its environment). Male-male combat for mating opportunities takes place in some groups of snakes (Shaw 1951; reviewed by Shine 1978, 1994). Therefore, an explanation for why SSD occurs in snake species is that sexual selection favors larger males who are more competitive in these wrestling bouts (Darwin 1871; Shine 1994; Gibbons 1972). Shine (1994) also lists other explanations for why SSD may occur in snakes.

A rather small amount of literature exists that includes information on body size or SSD in snakes of the genus *Pituophis*. Currently, site-specific summaries of body size for *Pituophis* spp. are available (Iverson et al. 2008; Stull 1940; Fitch 1981; Shine 1978, 1994; Table 1). The most recent detailed continental review of body size in this genus was by Stull (1940). Although dated, she provided one of the most thorough continent-wide treatises of the natural history of species in this genus to-date (see also Rodriguez-Robles and De Jesus-Escobar 2000; Rodriguez-Robles 2002).

Bullsnakes (*Pituophis catenifer sayi*) may be declining in many upper Midwestern states. They are a species of conservation concern in Wisconsin, Minnesota, and Iowa (Christoffel et al. 2000; Wisconsin Department of Natural Resources. 2005. Wisconsin's Strategy for Wildlife Species of Greatest Conservation Need. Madison, WI. Available from http://dnr.wi.gov/org/land/er/wwap/plan/ [Accessed 3 April 2009]; Iowa Department of Natural Resources. 2006. The Iowa Wildlife Action Plan. Iowa Department of Natural Resources. Available from http://www.iowadnr.com/wildlife/diversity/plan.html [Accessed on 3 April 2009]; Minnesota Department of Natural Resources. 2006. The bullsnake or gopher snake (*Pituophis catenifer sayi*). Available from http://www.dnr.state.mn.us/snapshots/snakes_turtles/bullsnake.html. [Accessed on 3 April 2009]), but little research exists for this region. Currently, most ecological information on this species in the upper Midwest comes from field guides (Vogt 1981; Oldfield and Moriarty 1994; Phillips et al. 1999; but see Moriarty and Linck 1998; Kapfer et al. 2008 a, b, c, 2009).

It appears that no published data on size (i.e., length) or comparisons of sizes between sexes exist for this species in this region. Adding new information to compilations of size and SSD data can improve our understanding about the life history, systematics, and evolution of these snakes (Shine 1994). Male *Pituophis* snakes engage in male-male combat (Shaw 1951; Bogert and Roth 1966; Shine 1978, 1994). This suggests that male *Pituophis* should be larger than females. Therefore, I gathered size and SDD data on wild *Pituophis catenifer sayi* in Wisconsin, to investigate if SDD exists. I also provide a summary of SSD data for snakes in this genus, calculated from existing literature, as a reference for future researchers. Based on past reports, I predicted

**TABLE 1.** Snout-to-vent lengths (SVL) and calculated sexual dimorphism indices (SDI) from published reports on adult members of the genus *Pituophis*.

| Species/Subspecies | Source | Location | Sex (N) | Mean SVL (cm) | SDI Value |
|---|---|---|---|---|---|
| *P. catenifer sayi* | Current Study | Wisconsin | Males (34) | 133.4 | -0.103 |
| | | | Females (18) | 120.9 | |
| *P. c. sayi* | Stull (1940) | Various[a] | Males (81) | 123.8 | -0.006 |
| | | | Females (53) | 123.1 | |
| *P. c. sayi* | Platt (1984) | Kansas | Males (105) | 99.1 | 0.023 |
| | | | Females (91) | 101.4 | |
| *P. c. sayi* | Fitch (1999) | Kansas | Males (42) | 131 | -0.022 |
| | | | Females (49) | 128.2 | |
| *P. c. sayi* | Iverson et al. (2008) | Nebraska | Males (618) | 108.3 | -0.009 |
| | | | Females (294) | 107.3 | |
| *P. catenifer* | Diller & Wallace (1996) | Idaho | Males (231) | 96 | 0.007 |
| | | | Females (90) | 96.7 | |
| *P. c. deserticoloa* | Stull (1940) | Various[a] | Males (28) | 110.5 | 0.018 |
| | | | Females (19) | 112.5 | |
| *P. c. deserticola* | Parker & Brown (1980)[b] | Utah | Males (59) | 106.3 | -0.065 |
| | | | Females (18) | 99.8 | |
| *P. c. deserticola* | Shewchuck (1996) | Canada | Males (103) | 80.5 | -0.069 |
| | | | Females (96) | 75.3 | |
| *P. m. melanoleucus* | Stull (1940) | Various[a] | Males (13) | 136.3 | 0.003 |
| | | | Females (13) | 136.7 | |
| *P. m. melanoleucus* | Fitch (1999)[c] | New Jersey | Males (42) | 133.2 | -0.039 |
| | | | Females (37) | 128.1 | |
| *P. m. melanoleucus* | Palmer & Braswell (1995) | North Carolina | Males (5) | 147.9 | -0.090 |
| | | | Females (4) | 135.6 | |
| *P. m. melanoleucus* | Gerald et al. (2006) | Tennessee | Males (6) | 137.4 | -0.004 |
| | | | Females (3) | 136.8 | |
| *P. melanoleucus mugitus* | Stull (1940) | Florida | Males (8) | 143.1 | -0.014 |
| | | | Females (10) | 141 | |
| *P. m. mugitus* | Franz (2005) | Forida | Males (3) | 140 | -0.014 |
| | | | Females (3) | 138 | |
| *P. ruthveni* | Himes et al. (2002) | Louisiana and Texas | Males (7) | 119 | -0.041 |
| | | | Females (3) | 114.3 | |

[a]Stull's (1940) numbers include measurements of individuals hailing from a wide range of locales, often spanning several states.
[b]Includes personal communication with W. S. Parker
[c]Includes personal communal communication with R. T. Zappalorti

that SSD would be male-biased at my study site and also in past studies.

## MATERIALS AND METHODS

I conducted surveys for *Pituophis catenifer sayi* on a property in southwestern Wisconsin, USA, described in Kapfer et al. (2008a). I conducted haphazard visual encounter surveys 3–7 d weekly, roughly 3–6 h per survey on various portions of this study area from April–October 2003, 2004, and 2005. These surveys followed previously published methods (Kapfer et al. 2008b), although I searched a larger area (i.e., not only the area designated for population surveys), albeit less consistently. On first capture, I measured the snout-vent length (SVL) of individuals to the nearest 0.1 cm using a squeeze box, and then probed individuals to determine sex. I conducted intersexual comparisons of SVL in adult *Pituophis catenifer sayi* that I captured during this research by an independent sample, one-tailed *t*-test ($\alpha = 0.05$; Zar 1984) in JMP IN V. 4.0.2 (Cary, North Carolina, USA). I measured Sexual Size Dimorphism (SSD) by employing the Sexual Dimorphism Index (SDI), which results in a negative value if populations are male-biased and a positive value if female-biased (Lovich and Gibbons 1992). In addition, I incorporated size data published in past reports to calculate SDI values for other populations. I decided arbitrarily to calculate SDI for past studies only if they reported body size for two or more individuals of each sex.

Although some sources report that this species matures from 90–96 cm total body length (TBL; reviewed by Ernst and Ernst 2003), most snakes found in my research (75%) had SVL measurements of ≥ 120 cm, and I considered snakes of this size at my site as adults. Because my goal was to report SVL and SDI among regions in adults only, I included only individuals reported to be over 100 cm in SVL from Stull (1940), but included smaller individuals from other published works if the authors categorized them as adults. Although Stull (1940) includes tables of data from individuals she analyzed, she did not report SVL for these specimens, but total body length (TBL) and tail length/TBL ratio. She also did not calculate means based

on snake sex. Therefore, I determined SVL for the individual specimens she analyzed (multiplying TBL by tail length/TBL ratio and subtracting the outcome from TBL), and summarized the results by sex. Of the subspecies reported by Stull (1940), I only summarized data for those that have more recently had size data published, for comparison.

## RESULTS

The number of snakes I encountered declined yearly. I captured 26 unique adults in 2003, 20 in 2004, and six in 2005. Male SVL (mean = 133.4 cm, SD = 13.2 cm) was larger than female SVL (mean = 120.9 cm, SD = 10.7 cm; $t$ = -3.872, df = 50, $P < 0.001$). I did not statistically compare my data to the results of other published reports because of differences in sample sizes and methods of collection. However, the measurements I recorded during my study were similar to these past reports (Table 1).

The calculated SDI was male-biased in the *P. c. sayi* that I sampled (-0.103). This bias was greater than values calculated for all other studies, although sample sizes varied (Table 1). Male-biased SDI values were present in 12/16 cases (75%), although this bias was not large in several of these instances. Female biases were present in 4/16 (25%) of SDI values, but these were generally weak.

## DISCUSSION

Male-biased SDI at the current study location, which corresponds with the results of many past studies (Table 1), supports my original prediction. Reports of significant differences between the SVLs of males and females are uncommon for members of this genus; although, males often average slightly larger than females, and the largest snakes found in several past studies were males (Parker and Brown 1980; Iverson et al. 2008). In addition, the SDI for many of these past studies is male-biased, although this bias is weak in several examples (Table 1). Fitch (1981) measured SSD in numerous reptile species, including snakes of this genus, as female to male ratios (FMR) expressed as a percentage, but he reported neither raw data nor mean sizes per sex. Therefore, I could not convert his data to SDI. Because of this, direct comparison to the data presented here was not possible, although his calculations reveal a bias towards larger females.

The statistically larger male SVLs I found are the first reported for *P. c. sayi* (Iverson et al. 2008) and contrasted with previous reports on *Pituophis* snakes from British Columbia, Idaho, and Kansas, in which mean female size was slightly larger (Platt 1984; Diller and Wallace 1996; Shewchuk 1996). The variation in results among studies is difficult to explain, but geographic and anatomical dissimilarity among subspecies or larger sample sizes obtained by the previous research projects could be contributing factors. Fitch (1999) suggests that differences in overall size of snakes within *Pituophis* from various geographic locales may have a genetic, as opposed to environmental (i.e., variability in food availability or climate), basis. Potential genetic drift because of the isolated nature and small size of many regional populations of this genus (Kapfer et al. 2008b) is also a possible explanation for the variation in size and SDIs.

After review of existing literature, Iverson et al. (2008) suggests that adult body size of *P. melanoleucus* in eastern North America and *P. c. deserticola* in western North America decrease with increasing latitude of study location. With reports of size only reported for Kansas, Nebraska, and now Wisconsin, not enough published size information is available for *P. c. sayi* populations from central North America to make a similar definitive statement about this subspecies. With inclusion of my data, a more complete, but still somewhat confusing, picture presents itself. Because past studies found snakes in northeastern Kansas (Fitch 1999) were larger than in south-central Kansas (Platt 1984) and Nebraska (Iverson et al. 2008), the trend seen in *P. melanoleucus* and *P. c. deserticola* is not clearly repeated in *P. c. sayi*. I found the average adult SVLs from a site in Wisconsin to be similar to those recorded in a northeastern Kansas population (Fitch 1999). There may not be much geographic variability in the size of *P. c. sayi*.

The evolutionary significance of these results is difficult to interpret. Large male size within populations can stem from natural selection favoring large males that win contests for breeding opportunities (Darwin 1871; Shine 1994). Although reports of wrestling bouts by *Pituophis* occur sporadically in the literature (Shaw 1951; Bogert and Roth 1966; Shine 1994) and there was a clear bias towards large males at my site, I did not witness any male contests in three years of visual surveys and radio-tracking of *P. c. sayi*. In addition, past research has rarely found a statistical difference between male and female SVL, although the largest individuals observed are often males (Iverson et al. 2008).

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**JOSHUA M. KAPFER** has been involved in field research on the ecology of upper Midwestern amphibians and reptiles for over a decade. Here, he is holding a Snapping Turtle (*Chelydra serpentina*) captured while conducting reptile inventories at a site in south central Wisconsin (USA). His primary research interests include habitat selection, spatial ecology, population ecology, and conservation of rare species. He is also interested in the influences of behavior on the speciation of African cichlid fishes from Lake Malawi. Josh has worked as a State Herpetologist with the Wisconsin Department of Natural Resources and a Wildlife Biologist with Natural Resources Consulting. He currently co-chairs the Society for the Study of Amphibians and Reptiles' Grants In Herpetology program with Erik Wild (UW-Stevens Point), and is currently an Assistant Professor in the Department of Environmental Studies at Elon University (North Carolina). He received is B.S. (1999) and M.S. (2002) in Biology from the University of Wisconsin-La Crosse. In 2007, he completed his doctoral degree in Ecology and Evolution at the University of Wisconsin-Milwaukee. His dissertation research focused on the ecology of Bullsnakes (*Pituophis catenifer sayi*) in upper Midwestern prairies. (Photographed by Max Kapfer).