IRCF REPTILES & AMPHIBIANS
CONSERVATION AND NATURAL HISTORY

Lessons Learned: Notes on the Natural History of the Plains Hognose Snake (*Heterodon nasicus*) in Minnesota

Erica P. Hoaglund and Christopher E. Smith

Minnesota Department of Natural Resources, Division of Ecological and Water Resources – Nongame Wildlife Program, Saint Paul, Minnesota 55106, USA (Christopher.E.Smith@state.mn.us)

Abstract.—The Plains Hognose Snake (*Heterodon nasicus*) has been the focus of many studies due, in part, to this species' interesting morphological characteristics and death-feigning behavior. However, significant gaps exist in our understanding of this species' natural history. Often perceived to be a semi-fossorial species in the literature, our data suggest that this species spends the majority of its time during the active season above ground. In addition, we provide some of the first data on communal hibernation for this species. Also discussed are observations on nocturnality, oophagy, and reproduction. Given that the Plains Hognose Snake is imperiled in many of the states and provinces in which it occurs, additional research is needed to better inform *in-situ* conservation efforts.

Keywords: Behavior, *Heterodon*, hibernation, Hognose, Minnesota, natural history, oophagy, prairie, reproduction

The Plains Hognose Snake (*Heterodon nasicus*; fig. 1) has been the focus of many studies due, in part, to the interesting morphological characteristics and death-feigning behavior of this species (Platt 1969, Kroll 1977, Averill-Murray 2006; fig. 2). Yet significant gaps exist in our understanding of this species' natural history, making *in-situ* conservation efforts difficult to evaluate. At present, this species is listed as critically imperiled in Iowa and Manitoba, imperiled in Alberta, Illinois, and Montana, and vulnerable in Minnesota and Saskatchewan (NatureServe 2011).

The Plains Hognose Snake is considered a diurnal species and often perceived to be semi-fossorial, spending portions of each day in burrows below ground (Platt 1969, Wright and Didiuk 1998, Averill-Murray 2006). Platt (1969) also observed that individual Hognose Snakes kept in outdoor enclosures sought refuge in burrows overnight. Their diet

Figure 1. Typical coloration and pattern of Plains Hognose Snakes (*Heterodon nasicus*) from Minnesota. Photograph © Erica P. Hoaglund, MN DNR.

Figure 2. A Plains Hognose Snake exhibiting the death-feigning behavior for which snakes of this genus are known. Photograph © Christopher E. Smith.

Figure 3. Fall on remnant and restored sand prairie in central Minnesota. Photograph © Christopher E. Smith, MN DNR.

was reported to consist of frogs, salamanders, toads, lizards, small snakes, birds, and small mammals (Platt 1969). Little is known about their over-wintering strategy, but they are believed to over-winter individually in self-created and pre-existing burrows (Platt 1969).

The Plains Hognose Snake is listed as both a species of Special Concern and as a Species in Greatest Conservation Need (SGCN) in Minnesota (Minnesota Department of Natural Resources 2006). In Minnesota, observations are scattered across the west-central, east-central, and southeastern portion of the state (Oldfield and Moriarty 1994). Despite this seemingly wide distribution, occurrences in many counties are based on few observations. The Plains Hognose Snake often is restricted to sandy or gravelly areas in Minnesota (e.g., remnant prairie and oak savanna habitat). Many of these areas are managed using fire in an attempt to maintain, restore, and improve habitat. In addition, these areas typically support populations of Plains Pocket Gophers (*Geomys bursarius*). Plains Hognose Snakes utilize the loose soil created by these pocket gophers (i.e., mounds and burrows) for refugia (pers. obs.). Below, we report significant natural history information documented during a larger project aimed at elucidating micro- and macrohabitat use by this species.

Methods

As part of a larger project focused on SGCN across multiple taxonomic groups occurring within the increasingly uncommon oak savanna habitat of the Anoka Sand Plain Subsection of Minnesota (fig. 3), we surveyed for Plains Hognose Snakes between April 2010 and May 2012 at 12 sites in Sherburne County (see Hoaglund et al. 2012). The areas surveyed were composed of remnant and restored sand prairie and oak savanna habitat on federal and state-owned lands. Surveys consisted of timed visual encounter surveys focused primarily between the months of April to June but continued until winter ingress (typically October or November). Once captured, individuals were measured, weighed, sexed, and either PIT-tagged and/or photographed to allow for individual recognition. In addition, we implanted (subcutaneously) several individuals captured during 2010 and 2011 surveys with VHF radio-telemetry transmitters (VHF) from Advanced Telemetry Systems, Inc. (N = 14) or harmonic radar (HR) tags from Recco, AB (N = 13) to study their spatial ecology. We attempted to relocate individuals implanted with VHF transmitters and HR tags at least twice per week during the active season (1 May to 15 October). The active season excluded the time individual snakes moved in and out of burrows used during hibernation (i.e., spring egress and fall ingress). Relocated animals were handled once every 10–14 days to measure weight gain or loss, but no more frequently in order to avoid human-induced changes in behavior. The use of these technologies provided us with an opportunity to verify behaviors related to natural history that had been limited to speculation (Platt 1969), as well as document previously unpublished information.

Results

We observed 84 Plains Hognose Snakes (fig. 4) between April 2010 and April 2012. Of those, 70 were PIT-tagged. The earliest observation occurred on 28 March 2012 during record warm weather. The latest observation occurred on 11 November 2011. Individuals were observed feeding as late as 11 October 2011. Using data gathered during the 2011 active season aided by VHF radio-telemetry, we found that snakes spent approximately 71% of their time above ground (N = 472 observations). We found Plains Hognose Snakes above ground in a variety of weather conditions, including light to moderate rain. The lowest temperature at which we observed an individual above ground was 10 °C on 13 September 2010 and again on 17 April 2012. We observed several of the VHF-tracked snakes above ground during a heat wave on 7 June 2011 with air temperatures at 36.5 °C. On 23 June 2011, we observed an adult above ground (coiled) in light rain with an air temperature of 15.5 °C. On 30 August 2011, we observed another adult, this time a female, above ground (coiled) in moderate rain with an air temperature of 20 °C.

Although tracking after dark was not typical, we did so on a few occasions out of curiosity. On 6 June 2011, we observed one of the tracked adult males above ground and on the move at 2042 h; approximately 10 min before official sunset. On 27 July 2011, we observed one of the adult females above ground at 2300 h. She was found partially concealed and tightly coiled at the base of a tuft of grass at an air temperature at 22.5 °C. Because nocturnal activity for this species is rarely observed and even less frequently published, we included the following observation made by a colleague. On 12 July 2010, an adult female was observed crossing a

Figure 4. We observed Plains Hognose Snakes as early as 28 March during record warm weather in 2012. The latest observation was on 11 November 2011. Photograph © Erica P. Hoaglund, MN DNR.

road in southwestern Kansas at 0314 h (Chad Whitney, pers. comm.).

Communal Hibernation.—Between 25 April and 3 May 2011, three individual male and one female Plains Hognose Snakes were observed emerging from a single burrow. Air temperatures at the time of observation were 12.5–21.0 °C. Two of the three males and the single female were collected for implantation of VHF radio-telemetry transmitters. Shortly after spring egress, these tracked individuals moved away from the burrow, which subsequently filled with sand after a few rain showers. The individuals were tracked during the active season and moved several hundred meters away from their over-wintering location. However, all three individuals migrated back toward this location during the fall of 2011. By 24 October 2011, both males were found in a new burrow in the exact same location as the one used during the previous winter. However, the female over-wintered 35 m south of the previously used communal hibernaculum. In spite of record warm weather during early to mid-March 2012, during which several Bullsnakes (*Pituophis catenifer sayi*) were observed (suggesting that Hognose Snakes could have been active as well), the first two tracked snakes were observed at the communal hibernaculum on 2 April 2012. Air temperature was 21 °C with a soil surface temperature of 23 °C and below surface temperature of 21 °C (at 15 cm). Both individuals were male and were last observed near the location of capture on 28 September 2011, but had not been encountered since. On 12 April 2012, three additional males were observed at the communal hibernaculum. On 24 April 2012, another male was observed emerging from the communal hibernaculum; bringing the total number of individuals detected emerging from the single hole to eight.

On 28 March 2012, five male Plains Hognose Snakes, including one individual with a VHF radio transmitter, were observed basking within an area of approximately 3 m^2 at a location approximately 3.5 km south of the communal over-wintering location described above. Temperatures recorded at the time of observation were: 13 °C (air), 22 °C (soil surface), and 11 °C (15 cm below soil surface). However, several

burrow openings were present within this small area, including one in which a VHF radio-tracked snake overwintered. Between 2 April 2012 and 30 April 2012, we observed an additional 10 individuals emerging from the burrows located within the 3 m^2 area, bringing the total number of individuals detected emerging from the small area to 15. Within this small area, a total of 11 males and four females were observed sharing burrows, with individuals ranging from 8 g (previous year's neonate) to 135 g.

Reproductive Behavior.—Breeding was documented in both spring and fall. The earliest observation of breeding behavior occurred on 12 April 2012. In most instances, observations of breeding behavior included at least one of our VHF- or HR-tracked individuals. Many of the observed breeding behaviors were documented in the fall, which has rarely been reported for this species (Ernst and Ernst 2003). However, this is likely attributable to the fact that many individuals implanted with VHF transmitters or HR tags were implanted between mid-May and mid-June, likely after any spring breeding activity would occur. Fall breeding typically was observed in September. However, on 3 October 2011, two males were found courting a single female.

We observed gravid females most frequently in mid- to late June with ovipositing taking place during the first week of July. However, one of the snakes with a VHF transmitter was determined to have laid eggs during the first week of June in 2011. Producing two clutches of eggs within a single season (i.e., double-clutching), is well documented for this species in captivity (pers. obs.) and the disparity between documented ovipositing dates might be an indication of this phenomenon in wild populations of Plains Hognose Snakes. Because we were most interested in the spatial ecology of this species, we limited handling to once every 10–14 days and therefore had few opportunities to palpate individuals.

Oophagy.—Facultative oophagy has been documented in Plains Hognose Snakes and is known to include lizard, snake, and turtle eggs (Platt 1969, Durso et al. 2011). Oophagic snakes typically exhibit one of two feeding strategies to deal with the undigestable eggshell, ingestion of the entire egg with the shell then passed in fecal matter, or regurgitation of the eggshell after the contents have been forced into the

Figure 5. Photograph showing the eggshells (circled in red) found outside of a Plains Hognose Snake burrow (circled in white). Eggshells had not been disturbed at the time of the photograph. Distance between eggshells and burrow entrance is approximately 30 cm. Photograph © Erica P. Hoaglund, MN DNR.

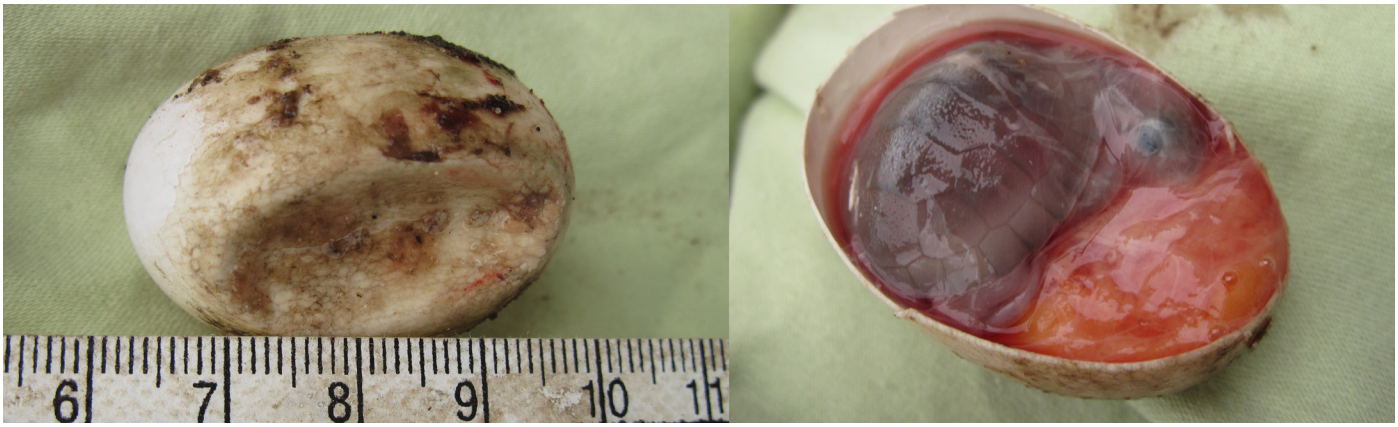

Figure 6. Photographs of the regurgitated egg from a tracked Plains Hognose Snake. Right is a photograph of the egg as regurgitated. Left is a photograph of the egg once dissected showing late-stage *Emydoidea blandingii* embryo. Photograph © Erica P. Hoaglund, MN DNR.

gut. The latter is more common in obligate oophagic snakes that specialize on avian eggs (e.g., Gans 1952, Queiroz and Rodriguez-Robles 2006).

Over the course of approximately one week in late July 2010, an HR-tagged female was observed moving repeatedly in and out of a single burrow. Outside this burrow we observed several dried and compressed eggshells not typical of reptilian nests depredated by mammalian predators (e.g., coyote, badger, etc.; fig. 5). We also noted similarly arranged eggshells several times outside tracked Plains Hognose Snake burrows in both 2010 and 2011, additional evidence that these snakes repeatedly visit and depredate reptilian nests (Durso et al. 2011). These compressed eggshells observed near the entrance of Plains Hognose Snake burrows lacked additional fecal matter, which could be an indication of regurgitation of the eggshells.

On 28 July 2010 another female being tracked using HR was captured by hand when observed above ground and was unintentionally made to regurgitate a fully formed egg (i.e., not collapsed) with a near fully developed Blanding's Turtle (*Emydoidea blandingii*) embryo (fig. 6). Upon initial inspection, the eggshell lacked slits typical of snakes that collapse and regurgitate eggshells. However, Mullin (1996) documented the ingestion of both collapsed and non-collapsed bird eggs by rat snakes. Given that our sample size is limited to a single regurgitated egg, additional research is needed to determine how Plains Hognose Snakes deal with such meals.

Figure 7. A Plains Hognose Snake seeking refuge following its release. Note the presence of feces, the release of which is one of many tactics used by this species to deter predators. Photograph © Erica P. Hoaglund, MN DNR.

Discussion

Despite its interest as a research subject, substantial gaps exist in our knowledge of Plains Hognose Snake natural history. The ongoing decrease in cost and size and the continued increase in battery life of wildlife-tracking technology are allowing researchers to test long-unanswered questions about species behavior and spatial ecology. Once thought to be a species that spends significant portions of time below ground, and therefore unavailable for detection, we found that Plains Hognose Snakes residing in sand prairie and oak savanna habitats in central Minnesota spend nearly 75% of their active season above ground (fig. 7). This contradicts J. Meltzer's observations from Sherburne County, Minnesota that suggested that this species only spends approximately one hour per day above ground (reported in Wright and Didiuk 1998). In addition, previous work suggested biphasic diurnal activity periods with peak activity occurring in the mornings and evenings with individuals retreating to under-ground refugia during the hottest part of the day and during the night (Platt 1969, Wright and Didiuk 1998, Averill-Murray 2006). However, we found that snakes spent most of the day above ground. Individuals were most often observed basking exposed to partially exposed in sparsely vegetated areas during the mornings and evenings, similar to the observations of others, but then moved to more densely vegetated areas during the heat of the day (fig. 8). In addition, on cool overcast days, we observed snakes basking exposed to partially exposed throughout the day. On several occasions, we observed individuals basking above ground during or immediately following light to moderate rainfall. We observed several of the tracked individuals above ground while air temperatures were as high as 36.5 °C and while in close proximity to burrows, suggesting they might be more tolerant to high temperatures than previously thought.

Often thought to be a solitary species (Platt 1969, Wright and Didiuk 1998), we provide evidence for self-constructed or modified hibernaculum-use by multiple individuals. In addition, we provide evidence for individuals migrating to and from communal over-wintering areas across multiple years. While over-wintering site fidelity appeared to occur, we failed to identify any unique macro- or microhabitat features for these sites that were unavailable in surrounding, seemingly suitable habitat. One plausible limiting factor not investigated during this project is sandy soil depth. We speculate that individuals might be selecting areas where sandy soils are deepest.

Figure 8. Photographs showing a Plains Hognose Snake seeking refuge in dense vegetation during the heat of the day. Some vegetation was pushed aside in the top photograph in which the red circle marks the location of the snake. The bottom photograph is of the same individual with some of the vegetation removed. Photograph © Christopher E. Smith, MN DNR.

Breeding was observed in both spring and fall, and typically included one male and one female. However, we observed two males courting a single female on multiple occasions in fall 2011. Pairs were often observed coiled together basking within 30 cm of a burrow entrance. Ovipositing occurred as early as the first week of June but typically occurred during the first week of July. Given the wide range of ovipositing dates and the propensity for producing two clutches of eggs in captivity, robust females might lay multiple clutches in the wild. However, females producing multiple clutches within a single year are rarely reported in wild squamates (Shine 1977, Tryon 1984, Ford and Karges 1987), and reports are even less common for temperate species. More work is needed to verify multiple clutches, but these data provide some indication for this phenomenon within a single year for Plains Hognose Snakes in Minnesota.

Given that Plains Hognose Snakes are imperiled in many of the states and provinces in which they occur, additional research is needed to better inform *in-situ* conservation efforts. The species' response to habitat fragmentation and common land-use practices is not clear. Even less is known about this species' population dynamics and population genetic structure, making long-term population monitoring difficult. In some remnant patches of habitat in Minnesota (this study) and Illinois (Kolbe 1999), populations appear quite dense, but little is known about their long-term viability.

Acknowledgements

We thank John Moriarty for comments on this manuscript. We also thank Dr. Stephen J. Mullin and Andrew Durso for discussions regarding oophagy, Liz Harper for support throughout this project, and the U.S. Fish and Wildlife Service for allowing us to work on federal lands with special-use permit number 32550-11009. The project was funded in part by a grant from the State Wildlife Grants Program administered by the U.S. Fish and Wildlife Service to state employees from the Minnesota Department of Natural Resources–Nongame Wildlife Program.

Literature Cited

Averill-Murray, R.C. 2006. Natural history of the Western Hog-nosed Snake (*Heterodon nasicus*) with notes of envenomation. *Sonoran Herpetologist* 19:98–101.

Durso, A.M., D.A. Warner, T.S. Mitchell, and A.M. Reedy. 2011. *Heterodon nasicus*. Diet. *Herpetological Review* 42:439–440.

Ernst, C.H. and E.M. Ernst. 2003. *Snakes of the United States and Canada*. Smithsonian Books, Washington, D.C.

Ford, N.B. and J.P. Karges. 1987. Reproduction in the Checkered Garter Snake, *Thamnophis marcianus*, from southern Texas and northeastern Mexico: Seasonality and evidence for multiple clutches. *The Southwestern Naturalist* 32:93–101.

Gans, C. 1952. The functional morphology of the egg-eating adaptations in the snake genus *Dasypeltis*. *Zoologica* (New York) 37:209–244.

Hoaglund, E.H., C.E. Smith, and H. Texler. 2012. *Microhabitat Components of Key Habitat Types in the Anoka Sand Plain that Influence Habitat Selection among Species of Greatest Conservation Need*. Final Report, Division of Ecological and Water Resources, Minnesota Department of Natural Resources, Saint Paul.

Kolbe, J.J. 1999. Size and demographic structure of an isolated population of Western Hognose Snakes, *Heterodon nasicus*, in northwestern Illinois. *Bulletin of the Chicago Herpetological Society* 34:149–152.

Kroll, J.C. 1976. Feeding adaptations of Hognose Snakes. *The Southwestern Naturalist* 20:537–557.

Minnesota Department of Natural Resources. 2006. *Tomorrow's Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife, Comprehensive Wildlife Conservation Strategy*. Division of Ecological Services, Minnesota Department of Natural Resources, Saint Paul.

Mullin, S.J. 1996. Adaptations facilitating facultative oophagy in the Gray Rat Snake, *Elaphe obsoleta spiloides*. *Amphibia-Reptilia* 17:387–394.

NatureServe. 2011. NatureServe Explorer: An Online Encyclopedia of Life. Version 7.1. NatureServe, Arlington, Virginia (http://www.natureserve.org/explorer).

Oldfield, B. and J.J. Moriarty. 1994. *Amphibians and Reptiles Native to Minnesota*. University of Minnesota Press, Minneapolis.

Platt, D.R. 1969. Natural history of the Hognose Snakes *Heterodon platyrhinos* and *Heterodon nasicus. University of Kansas Publications, Museum of Natural History* 18:253–420.

Shine, R. 1977. Reproduction in Australian elapid snakes II. Female reproductive cycles. *Australian Journal of Zoology* 25:655–666.

Tryon, B.W. 1984. Additional instances of multiple egg-clutch production in snakes. *Transactions of the Kansas Academy of Science* 87:98–104.

Queiroz, A. and J.A. Rodriguez-Robles. 2006. Historical contingency and animal diets: The origins of egg eating in snakes. *The American Naturalist* 167:684–694.

Wright, J. and A. Didiuk. 1998. *Status of the Plains Hognose Snake (Heterodon nasicus nasicus) in Alberta*. Alberta Environmental Protection, Fisheries & Wildlife Management Division, and Alberta Conservation Association, Wildlife State Report No. 15, Edmonton, Alberta.