Transactions of the Illinois State Academy of Science
(2021) Volume 114, pp. 57-64

received 8/13/21
accepted 12/3/21

Diurnal Surface Activity in Ring-necked Snakes (*Diadophis punctatus*)

John G. Palis[1] and Joshua J. Vossler[2]
[1]Palis Environmental Consulting, P.O. Box 387, Jonesboro, Illinois 62952, jpalis@yahoo.com
[2]Morris Library, Southern Illinois University, Carbondale, Illinois 62901, jvossler@siu.edu

ABSTRACT

Diadophis punctatus (Ring-necked Snakes) are small, dorsally cryptic snakes that are frequently described as nocturnal, crepuscular, or both. From 2003 through 2019, we conducted pedestrian, visual-encounter surveys of snakes on a gravel road in southern Illinois that is seasonally closed to vehicular use. We observed 82 instances of diurnal, surface-active *D. punctatus* on 60 dates. A literature review revealed 109 sources that included information regarding *D. punctatus* diel behavior. Within the literature, author perceptions regarding *D. punctatus* diel activity patterns were biased towards nocturnal behavior, whereas direct observations of *D. punctatus* surficial activity in the field were skewed towards diurnal behavior. Additional study is needed to accurately describe diel patterns of surficial activity in *D. punctatus*.

INTRODUCTION

Diel activity patterns of animals often are correlated with daily light-dark cycles and can be described as diurnal (active during daylight), nocturnal (active at night), crepuscular (active at twilight), or arrhythmic (active anytime). Species' activity patterns may be ecologically fixed such that diel activity is reliably diurnal, nocturnal, or crepuscular. For example, *Coluber constrictor* (North American Racers) are only active diurnally (Ernst and Ernst 2003). Many other temperate zone snakes, however, alter their diel activity cycle depending upon season; for example, from diurnally-active in spring and autumn to nocturnally-active in summer (Heckrotte 1962, Landreth 1973, Sperry et al. 2013).

Diadophis punctatus (Ring-necked Snakes) are often characterized as nocturnal and/or crepuscular (e.g., Ditmars 1907, Gibbons 2017). During daylight hours, *D. punctatus* are typically discovered beneath surficial cover objects, such as rocks (Fitch 1999, Cox et al. 2018), sometimes in large numbers (Dundee and Miller 1968). Although they can be extremely abundant (e.g., exceeding 1000 individuals per ha; Fitch 1999), *D. punctatus* are small, cryptic both in dorsal coloration and in behavior, and are easily overlooked. Individuals active aboveground beneath leaf litter or low-growing herbaceous vegetation are unlikely to be detected by human observers, potentially limiting opportunities to observe diurnal surficial activity (Fitch 1975).

Although we do not contest crepuscular or nocturnal activity by *D. punctatus*, we have observed numerous instances of diurnal surficial movement by *D. punctatus*. Here, we share our observations of diurnal, surface-active *D. punctatus* that we made principally during spring and autumn walks on and adjacent to a gravel road in southern Illinois which is seasonally closed to vehicular use. In addition, we conducted a literature review of *D. punctatus* activity patterns to better understand the origin of the characterization of *D. punctatus* as crepuscular and/or nocturnal.

STUDY AREA

We recorded observations of *D. punctatus* on and near a 4.4-km length of Forest Road 345, Shawnee National Forest, Union County, Illinois (Figure 1). Four km of this 3-m wide north-south oriented gravel road is colloquially known as Snake Road. Snake Road is closed to vehicular traffic by means of gates twice annually—two months in spring and two months in autumn—to permit safe passage of snakes migrating to and from hibernacula (Vossler 2021). Although closed to vehicular traffic, pedestrian use is permitted. The road separates steep, forested hills and valleys and treeless limestone bluffs to the east from an extensive wetland/lowland forest complex to the west (see Palis 2016).

METHODS

We visually surveyed for surface-active *D. punctatus* by slowly walking Snake Road during spring (March 15th through May 15th) and autumn (September 1st through October 30th) road closure periods, as well as during periods when the road is open to vehicle use (March 1st through March 14th, May 16th through August 31st, and October 31st through November 15th). JGP surveyed from 2003 through 2019 (except 2004 and 2011) and JJV surveyed from 2017 through 2019. We initiated northward walks from the

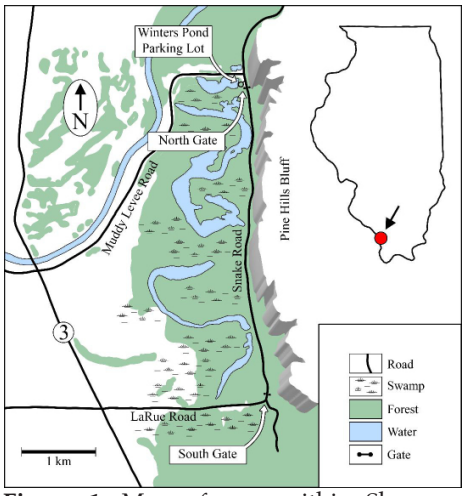

Figure 1. Map of area within Shawnee National Forest, Union County, Illinois, where visual encounter surveys for *Diadophis punctatus* were conducted from 2003 through 2019.

south gate and typically walked to the entrance of Winters Pond parking lot where we turned around and walked back to the south gate (Figure 1). We sometimes turned back before reaching Winters Pond or walked as far north as the levee before turning around (Figure 1). We began southward walks from Winters Pond and typically walked all the way to the south gate where we turned around and walked back to Winters Pond.

JGP recorded start and stop times for each walk, as well as the time each surface-active *D. punctatus* was detected. JJV captured time-stamped digital images of a subset of an undetermined number of surface-active *D. punctatus* that he encountered. JGP noted cloud cover and air temperature at the beginning and end of most hikes. Snake handling is not permitted at Snake Road, so we did not capture or otherwise disturb snakes.

We used the National Oceanic and Atmospheric Administration solar calculator (http://www.esrl.noaa.gov/gmd/grad/solcalc, time zone -6) to determine solar noon, sunrise, and sunset for each day a surface-active *D. punctatus* was detected. We factored Daylight Saving Time into sunset, sunrise, and solar noon where applicable. Because we did not have geo-coordinates for each *D. punctatus* observation, we selected a geo-coordinate roughly at the halfway point of Snake Road (37.566623N, 89.440383W) to use with the solar calculator. We define crepuscular snakes as those observed active on the surface 30 minutes before and after sunset or sunrise (i.e., twilight), diurnal snakes as those active on the surface after sunrise twilight and before sunset twilight, and nocturnal snakes as those active after sunset twilight and before sunrise twilight. Our definition of crepuscular is conservative relative to the definition of twilight: "the light from the sky between full night and sunrise or between sunset and full night" (www.merriam-webster.com). We included 30 minutes after sunrise and before sunset to account for reduced light levels resulting from shading by the tree canopy.

We conducted a thorough literature review of *D. punctatus* activity patterns to better understand the derivation of the belief that *D. punctatus* are principally crepuscular and/or nocturnal, and to collect existing evidence for various claims regarding diel activity patterns. We employed four subscription databases: Academic Search Ultimate, JSTOR, ScienceDirect, and Web of Science using the Boolean search string: ((((“Diadophis punctatus”) OR (“Coluber punctatus”)) OR (“Ringneck Snake”)) OR (“Ring-necked Snake”)). Additionally, we used Google's search engine, which turned up two bibliographies devoted to Ring-necked Snakes (https://reptile-database.reptarium.cz/species?genus=Diadophis&species=punctatus; https://www.repfocus.dk/Diadophis_bibliography.html). Our scope included scholarly and para-scholarly (such as various state herpetological society periodicals) literature, including articles, conference proceedings, and books that mentioned *D. punctatus* in North America and written in English or available in English translation. We excluded documents whose titles indicated that the subject matter focused on *D. punctatus* in captivity, in the paleontological record, or veterinary care, as documents pertaining to these subjects would either be irrelevant or might supply misleading information (e.g., captive *D. punctatus* may not behave naturally).

RESULTS

JGP walked Snake Road on 163 dates from 2003 through 2019. Walks were initiated between 0900 h and 2030 h (median = 1405 h) and terminated between 1130 h and 2340 h (median = 1730 h) for a total of 457 hours (374.5 hours during road closures periods, 82.5 hours when the road was open to vehicular use). JJV walked Snake Road on 100 dates during road closure periods from 2017 through 2019.

We accrued 89 observations of exposed *D. punctatus* active on the surface on 60 dates in 2003, 2007, 2010, and 2013 through 2019 (Figure 2). Our earliest surface-active *D. punctatus* detection in the year occurred on March 4th (2018) and our latest occurred on November 10th (2015) (Figure 3). We observed *D. punctatus* on relatively warm days (mean ± standard deviation = 22 ± 3.8°C) that varied from sunny to overcast. We detected *D. punctatus* between 1015 h and 2018 h (median = 1625 h), with most (94.4%) occurring between solar noon and sunset (Figure 3). We detected *D. punctatus* an average of 203 ± 117 minutes after solar noon and 189 ± 115 minutes before sunset. We classified 82 (92.1%) *D. punctatus* as diurnal, six (6.8%) as crepuscular, and one (1.1%) as nocturnal. All but three individuals—one lying atop a log and two on bare ground—were observed on the road. Of 48 diurnal individuals for which presence or absence of direct sunlight on the snake was noted, 10 (20.8%; all on the road) were complete-

Figure 2. Adult *Diadophis punctatus* crossing Snake Road at 1545 h on 25 April 2018 (Photograph by JGP).

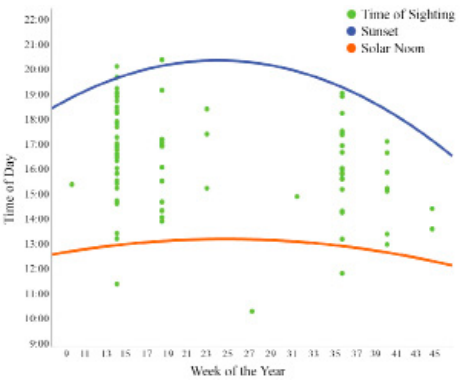

Figure 3. Sightings of diurnally surface-active *Diadophis punctatus* (with Daylight Saving Time and Standard Time accounted for).

ly or partially in sun; the remainder were observed in shade of trees or on overcast days.

Our literature review produced 1895 potentially relevant sources, 109 of which contained information regarding *D. punctatus* diel behavior. We summarized pertinent, literature-based *D. punctatus* diel-activity observations in two tables. In Table 1, we compiled literature citations in which authors delivered pronouncements regarding diel activity of *D. punctatus*. We organized these statements into the following seven categories of diel behavior: 1) nocturnal, 2) nocturnal and crepuscular, 3) nocturnal with diurnal, 4) crepuscular, 5) crepuscular with diurnal, 6) diurnal, and 7) arrhythmic (Table 1). "Nocturnal with diurnal" or "crepuscular with diurnal" are categories in which *D. punctatus* are defined by authors as either nocturnal or crepuscular but where diurnal behavior is occasionally observed. For example, Morris (1944:65) states that *D. punctatus* are "one of the most nocturnal of our serpents" that are "rarely" observed "out in the daytime." In Table 2, we summarized actual observations of *D. punctatus* that included specific statements regarding time-of-day (e.g., "night") or precise times-of-day one or more *D. punctatus* were observed active on the surface. Some citations are included in both lists because they contain declarations about diel activity and actual observations of diel activity. Author statements regarding *D. punctatus* diel activity patterns were skewed towards nocturnal behavior, whereas actual observations of *D. punctatus* reported in the literature were skewed towards diurnal behavior (Figure 4).

DISCUSSION

Diadophis punctatus are generally thought to be nocturnal and/or crepuscular (e.g., Ditmars 1907, Gibbons 2017) and—during daylight hours—are typically discovered beneath surficial cover objects. Opportunities to observe surficial diurnal behavior by *D. punctatus* are often curtailed by leaf litter or low-growing herbaceous vegetation (Fitch 1975). The characteristics of our study area, however, allowed for

Table 1. Author statements regarding *Diadophis punctaus* diel activity.

Diel Activity	Literature Source
Nocturnal (N = 35)	Babcock, (1929); Bartlett & Bartlett. (2009); Breckenridge (1944); Cook (1984); Cunningham & Nazdrowicz (2018); DeGraaf & Rudis (1983); Ditmars (1907); Forester et al. (2019); Gibbons (2017); Gibbons and Dorcas (2005); Gibbs et al. (2007); Gilhen (1970); Gilhen (2011); Green & Pauley (1987); Jackson (1914); Jensen et al. (2008); Johnson (1989); Krulikowski (2004); Logier (1939); Logier (1958); Martof et al. (1980); McCauley (1945); Mitchell (1994); Morse (1904); Neimiller et al. (2013); Oldfield & Moriarty (1994); Palmer & Braswell (1995); Parmalee (1955); Smith (1956); Tennant (2003); Vogt (1981); Weller & Oldham (1988); White & White (2002); Wright (1919); Wright & Bishop (1915)
Nocturnal and Crepuscular (N = 9)	Blanchard et al. (1979); Cupp (1994); Ernst et al. (2012); Gilhen (1984); Kelly et al. (1936); LeClere (2013); Lemm (2006); Linzey & Clifford (1981); Rowell (2012)
Nocturnal with Diurnal (N = 19)	Brattstrom (1965); Busby et al. (2005); Collins (1974); Ernst (1962); Ernst & Barbour (1989); Ernst & Ernst (2003); Ernst et al (2014); Fitch (1956); Haast & Anderson (1981); Hahn (1908); Harding (1997); Harding & Mifsud (2017); Hunter et al. (1992); Hunter et al (1999); Klemens (1993); Morris (1944); Surface (1906); Werler & Dixon (2000); Wright & Wright (1957)
Crepuscular (N = 4)	Cebek (1971); Corrington (1929); LeClere (1994); Ortenburger & Freeman (1930)
Crepuscular with Diurnal (N = 2)	Brennan & Holycross (2006); Holbrook (1942)
Diurnal (N = 4)	Brumwell (1951); Fitch (1975); Grismer (2002); Holycross & Mitchell (2020)
Arrythmic (N = 5)	Hulse et al. (2001); Meshaka & Layne (2015); Murphy (2018); Myers (1965); Rorabaugh & Lemos-Espinal (2016)

Table 2. Observations of *Diadophis punctaus* diel activity.

Diel Activity	Literature Source
Nocturnal (N = 6)	Bosworth et al. (2004); Gilhen (1970); Gilhen (1984); Jackson (1914); Krysko & Halvorsen (2010); Marion & Nowak (1985)
Crepuscular (N = 3)	Auth & Scott (1996); Van Denburgh & Slevin (1913); Wagner (1922)
Diurnal (N = 26)	Atsatt (1913), Bartareau & Meshaka (2013); Bauder (2008); Bishop (1927); Blanchard (1942); Burkhardt et al. (2001); Croulet (1965); Ernst et al. (2012); Evelyn & Hunt (2014); Gehlbach (1965); Gotte (2016); Hansen & Tobler (2010); Hedeen & Hedeen (1998); Holycross & Mitchell (2020); Ishimatsu (2020); Kats et al. (1998); Marcou (2018); Mendoza-Hernandez et al. (2009); Meshaka et al. (2008); Milanovich et al. (2005); Nelson et al. (2010); Neuharth et al. (2020); Palis & Boehler (2019); Parker & Brown (1974); Van Devender & Gómez-Limón (2014); Weaver (2012)
Arrythmic (N = 3)	Blanchard et al. (1979); Harris & Savage (2020); Rowell (2012)

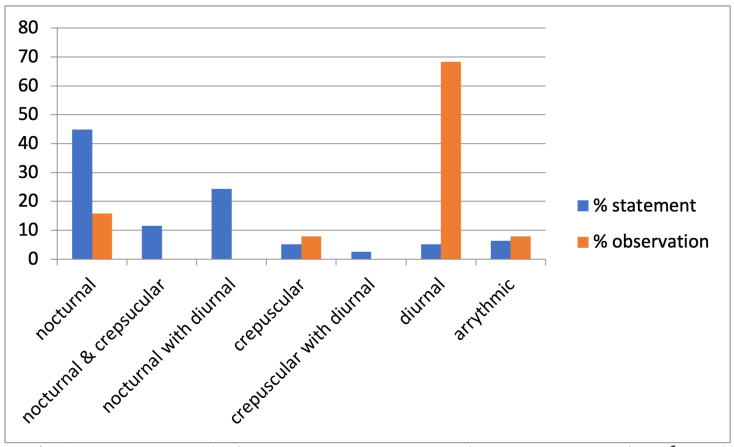

Figure 4. *Diadophis punctatus* diel activity: proportional comparison of author descriptions (blue) and observations made in the field (orange).

the detection of diurnally surface-active *D. punctatus* and we observed 82 (92.1%) instances of diurnal surface activity. We also conducted a literature review to better understand the characterization of *D. punctatus* as principally crepuscular and/or nocturnal. Reviewed sources contained contradictory information: authorial claims about *D. punctatus* diel activity patterns were skewed towards nocturnal behavior, whereas actual observations of *D. punctatus* were skewed towards diurnal behavior.

While most authors describe *D. punctatus* as nocturnal and/or crepuscular, many also mention infrequent observations of diurnal activity, often implying that such activity is unusual. For example, some authors who describe *D. punctatus* as nocturnal and/or crepuscular include statements in which they describe diurnal activity of *D. punctatus* as rare, occasional, or seldom observed (e.g., Morris 1944, Haast and Anderson 1981, Klemens 1993). Our observations and those summarized in Table 2 suggest that surficial diurnal activity in *D. punctatus* may not be an uncommon occurrence. We suggest that small size and cryptic behavior (e.g., proclivity to remain beneath leaf litter or herbaceous vegetation) may account for infrequent observations of aboveground diurnal behavior in *D. punctatus*. *Diadophis punctatus* may move horizontally beneath leaf litter or herbaceous vegetation during the day to avoid detection by predators. Even large snakes, such as pythons, are visually difficult to detect in complex environments (Dorcas and Willson 2013; Nafus et al. 2020). In fact, snake detectability is generally so low that complex mathematical occupancy models have been developed to account for difficulty of detection (Steen 2010; Durso et al. 2011).

In addition to our own observations and those of other investigators, *D. punctatus* predation by diurnal avian predators provides additional evidence of diurnal surficial activity in *D. punctatus*. *Diadophis punctatus* are documented prey of the following diurnally-active birds: American Robin (*Turdus migratorius*; Hedeen and Hedeen 1998), Boat-tailed Grackle (*Quiscalus major*; Rossi and Rossi 2003), Broad-winged Hawk (*Buteo platypterus*; Fitch 1975, Rosenfield 1984), Common Black Hawk (*Buteogallus anthracinus*; Etzel et al. 2014), Eastern Bluebird (*Sialia sialis*; Stanback & Mercadante 2009), Loggerhead Shrike (*Lanius ludovicianus*; Tyler 1991), Red-shouldered Hawk (*Buteo lineatus*; Gotte 2016, Ishimatsu 2020), and Red-tailed Hawk (*Buteo jamaicensis*; Fitch 1975, Fitch & Bare 1978).

Further evidence of diurnal activity includes foraging behavior. Diurnal feeding by *D. punctatus* in nature has been reported by Bartareau and Meshaka (2013), Burkhardt et al. (2001), Holycross and Mitchell (2020), Kats et al. (1998), Nelson et al. (2010), and Palis and Boehler (2019). Furthermore, use of trail cameras to detect snake presence has revealed several instances of surficial diurnal movements by *D. punctatus* (Harris and Savage 2020, Neuharth et al. 2020).

We suggest that the notion that *D. punctatus* are principally crepuscular and/or nocturnal may derive from observational bias and oft-repeated statements regarding diel activity in the literature. Some authors appear to assume *D. punctatus* are nocturnal because the only specimens they detected during the day were beneath cover objects. For example, Wright and Bishop (1915:153) who observed a total of three *D. punctatus* at Okefenokee Swamp in Georgia—all under logs—suggested the species was "as nocturnal in Okefinokee as our experiences with it elsewhere suggest." Blanchard et al. (1979:283), who observed two *D. punctatus* "in crawling position" at dusk, appear to assume all *D. punctatus* movements between cover objects occurs nocturnally. Others, such as Logier (1958:41) assumed *D. punctatus* are nocturnal because they "never seen it abroad before twilight, and specimens uncovered in the full light of day seem more concerned to avoid the light than to glide away." In other cases, authors classify *D. punctatus* as "crepuscular/nocturnal" despite their own observations of *D. punctatus* diurnal surficial activity (Ernst et al. 2012:27).

What could account for this bias in describing *D. punctatus* diel surface activity? We suggest two phenomena may be at play: confirmation bias and the streetlight effect. Confirmation bias is "the seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand" (Nickerson 1998:175). Confirmation bias can amplify weakly supporting evidence, making it feel more compelling than it really is. If researchers were predisposed to think that *D. punctatus* were nocturnal, confirmation bias would suggest that they might interpret evidence, even weak or irrelevant evidence, as being consistent with nocturnality. Additionally, information contradictory to existing beliefs, such as daytime observations of surficially-active *D. punctatus*, would be dismissed or minimized by qualifying the observation as being atypical or rare.

Claims regarding *D. punctatus* diel behavior go back at least as far as Morse (1904), and like Morse, most claims of strictly or predominantly nocturnal or crepuscular behavior are offered without explicit supporting evidence. Why did Morse and other researchers working in the early 20th century think that *D. punctatus* are principally nocturnal and/or crepuscular, or adhered to any diel activity cycle at all? Inferring from context, it seems plausible that in addition to actual observations of nocturnal and/or crepuscular activity, two other observations led them to this belief: 1) *D. punctatus* are rarely observed moving in the open during the day and 2) they are frequently found beneath cover objects during the day.

These two lines of evidence do not stand up to scrutiny. *Diadophis punctatus* are small, dorsally dark-colored snakes that can be easily overlooked even when in the open, including on a road (personal observations). More to the point, absence of evidence (few or no sightings) does not constitute evidence of absence (the species is not present or active). Not observing *D. punctatus* could be just as easily explained by issues of detection rather than their

absence. Given their semi-fossorial tendencies and small size, *D. punctatus* could move about during the day beneath leaf litter or herbaceous vegetation undetected. Finding *D. punctatus* beneath cover objects during the day offers little evidence in favor of or against any diel activity preference. Small snakes such as *D. punctatus* often thermoregulate beneath cover objects rather than basking directly in the sun (Fitch 1975), so finding one beneath a cover object cannot be said to relate to diel activity preference in any meaningful way. Confirmation bias offers an explanation for why weak evidence such as this would be accepted, and the conclusions based on it perpetuated.

The streetlight effect seems to apply here as well. The streetlight effect is an observational bias that occurs when investigators search the easiest places to look but not necessarily the best places to look. One of the most reliable means of finding *D. punctatus* during daylight hours is to search beneath cover objects. Therefore, searchers focus their attention on cover objects when seeking *D. punctatus* during this time. Searching for surface-active diurnal *D. punctatus* is—insofar as we are aware—a technique not typically employed. The relative ease with which *D. punctatus* are found under cover objects by day means that people look only there, which—possibly influenced by confirmation bias—strengthens the belief that because they are beneath cover objects by day, they must be surface-active at night.

We suggest that previous attempts to categorize *D. punctatus* surficial diel activity may be biased by human behavior, by the difficulty detecting small snakes in a complex environment, and perhaps by a pre-existing expectation that *D. punctatus* are nocturnal. The latter could subtly skew how data are interpreted, making weak or indirect evidence seem more compelling than it is, and making it easier to dismiss or explain away contradictory evidence. It is possible that *D. punctatus* are diurnally or nocturnally active on the surface seasonally, like *Nerodia* ssp. (Gibbons and Dorcas 2004), or may be surficially-active any time of day during their active-season, as suggested by Murphy (2018). Based on the findings of our observational study and review of the literature we suggest that additional investigations, especially ones that employ 24-hour sampling and statistical analysis, are warranted to accurately describe diel patterns of surficial activity in *D. punctatus*.

ACKNOWLEDGEMENTS

For accompanying us afield and contributing to our Ring-necked Snake sightings we thank Mary Boehler, Shawn Gossman, Forrest Palis, Erin Palmer, Jean Sellar, Christopher Smaga, and Elisabeth Turner. We also thank Cassidy Brunson, Cyrus Glenn, Mya Tatum, and Millicent Weber for assistance with data management and figure creation; Mike Dloogatch for alerting us to several obscure references; Ken Dodd, Mike Dloogatch, and Roger Repp for providing otherwise unavailable sources of information; and Andrew Durso and anonymous reviewers for commenting on the manuscript.

LITERATURE CITED

Atsatt, S.R. 1913. The reptiles of the San Jacinto area of southern California. University of California Publications in Zoology 12:31–50.

Auth, D.L. and C. Scott. 1996. Geographic distribution: *Diadophis punctatus acricus* (Key Ringneck Snake). Herpetological Review 27:33.

Babcock, H.L. 1929. The Snakes of New England Natural History Guide. Boston Society of Natural History 1:1–30.

Bartareau, T.M. and W.E. Meshaka. 2013. The handling and ingestion of a Brown Anole (*Anolis sagrei*) egg by a Southern Ringneck Snake (*Diadophis punctatus punctatus*). Collinsorum 2:16.

Bartlett, R.D. and P.P. Bartlett. 2009. Guide & Reference to the Snakes of Western North America (North of Mexico) and Hawaii. University Press of Florida, Gainesville. 277 pp.

Bauder, J.M. 2008. Geographic distribution: *Diadophis punctatus regalis* (Regal Ringnecked Snake). Herpetological Review 39:111.

Bishop, S.C. 1927. The Amphibians and Reptiles of Allegany State Park. New York State Museum Handbook 3. The University of the State of New York, Albany. 141 pp.

Blanchard, F.N. 1942. The ringneck snakes, genus *Diadophis*. Bulletin of the Chicago Academy of Science 7:3–144.

Blanchard, F.N., M.R. Gilreath, and F.C. Blanchard. 1979. The eastern ringneck snake (*Diadophis punctatus edwardsii*) in northern Michigan (Reptilia, Serpentes, Colubridae). Journal of Herpetology 13:377–402.

Bosworth, W.R., J.M. Meik, K. Setser, and C. Steele. 2004. The distribution of the Ringnecked Snake (*Diadophis punctatus*) in Utah. Herpetological Review 35:238–239.

Brattstrom, B.H. 1965. Body temperatures of reptiles. American Midland Naturalist 73:376–422.

Brennan, T.C. and A.T. Holycross. 2006. A field Guide to Amphibians and Reptiles in Arizona. Arizona Game and Fish Department, Phoenix. 150 pp.

Breckenridge, W.J. 1944. Reptiles and Amphibians of Minnesota. University of Minnesota Press, Minneapolis. 216 pp.

Brumwell, M.J. 1951. An ecological survey of the Fort Leavenworth Military Reservation. American Midland Naturalist 45:187–23.

Burkhardt, T., S. Winegarner, and R.W. Hansen. 2001. Natural history notes: *Batrachoseps stebbinsi* (Tehachapi Slender Salamander). Attempted Predation. Herpetological Review 32:245.

Busby, W.H., J.T. Collins, and G. Suleiman. 2005. The Snakes, Lizards, Turtles, and Amphibians of Fort Riley and Vicinity. Kansas Biological Survey. 76 pp.

Cebek, J.E. 1971. The herpetofauna of the Georgian Bay region. Part I: The terrestrial reptiles. Canadian Amphibian and Reptile Conservation Society Bulletin 9(3):1–4.

Collins, J.T. 1974. Amphibians and Reptiles in Kansas. University of Kansas Museum of Natural History, Lawrence. 283 pp.

Cook, F.R. 1984. Introduction to Canadian Amphibians and Reptiles. National Museum of Natural Sciences, Ottawa, Ontario, Canada. 200 pp.

Corrington, J.D. 1929. Herpetology of the Columbia, South Carolina, region. Copeia 172:58–83.

Cox, C.L., M.L. Logan, O. Bryan, D. Kaur, E. Leung, J. McCormack, J. McGinn, L. Miller, C. Robinson, J. Salem, J. Scheid, T. Warzinski, and A.K. Chung. 2018. Do ring-necked snakes choose retreat sites based upon thermal preferences? Journal of Thermal Biology 71:232–236.

Croulet, C.H. 1965. Evidence of conspecificity of the western ringneck snakes (genus *Diadophis*). Herpetologica 21:80.

Cunningham, H.R. and N.H. Nazdrowicz (eds.). 2018. The Maryland Amphibian and Reptile Atlas. Johns Hopkins University Press, Baltimore, Maryland. 283 pp.

Cupp, P.V. 1994. Salamanders avoid chemical cues from predators. Animal Behaviour 48: 232–235.

DeGraaf, R.M. and D.D. Rudis. 1983. Amphibians and Reptiles of New England Habitats and Natural History. The University of Massachusetts Press, Amherst. 85 pp.

Ditmars, R.L. 1907. The Reptile Book. Doubleday, Page and Company, New York. 472 pp.

Dorcas, M.E., and J.D. Willson. 2013. Hidden giants: problems associated with studying secretive invasive pythons. In W. Lutterschmidt, (ed.), Reptiles in Research: Investigations of Ecology, Physiology, and Behavior from Desert to Sea, pp. 367–585. Nova Science Publishing, Inc., Hauppauge, New York.

Dundee, H.A. and M.C. Miller, III. 1968. Aggregative behavior and habitat conditioning by the prairie ringneck snake, *Diadophis punctatus arnyi*. Tulane Studies in Zoology and Botany 15:41–58.

Durso, A.M., J.D. Willson, and C.T. Winne. 2011. Needles in haystacks: estimating detection probability and occupancy of rare and cryptic snakes. Biological Conservation 144:1508–1515.

Ernst, C.H. and R.W. Barbour. 1989. Snakes of Eastern North America. George Mason University Press, Fairfax, Virginia. 282 pp.

Ernst, C.H. and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, D.C. 668 pp.

Ernst, C.H., T.R. Creque, J.M. Orr, T.D. Hartsell, and A.F. Laemmerzahl. 2014. Operating body temperatures in a snake community of northern Virginia. Northeastern Naturalist 21:247–258.

Ernst, C.H., J.M. Orr, T.R. Creque, A.F. Laemmerzahl, and T.D. Hartsell. 2012. Annual and daily activity cycles of snakes in northern Virginia, USA. Herpetological Bulletin 121:23–28.

Ernst, S.G. 1962. Notes on the life history of the eastern ringneck snake. Turtox News 40:266–267.

Etzel, K.E., T.C. Theimer, M.J. Johnson, and J.A. Holmes. 2014. Variation in prey delivered to Common Black-hawk (*Buteogallus anthracinus*) nests in Arizona drainage basins. Journal of Raptor Research 48:54–60.

Evelyn, C.J. and L.E. Hunt. 2014. Geographic distribution: *Diadophis punctatus* (Ringnecked Snake). Herpetological Review 45:465.

Fitch, H.S. 1956. Temperature responses in free-living amphibians and reptiles in northeastern Kansas. University of Kansas Publications Museum of Natural History 8:417–476.

Fitch, H.S. 1975. A demographic study of the ringneck snake (*Diadophis punctatus*) in Kansas. University of Kansas Museum of Natural History Miscellaneous Publication 62:1–53.

Fitch, H.S. 1999. A Kansas Snake Community: Composition and Changes Over 50 Years. Krieger Publishing Company, Malabar, Florida. 165 pp.

Fitch, H.S. and R.O. Bare. 1978. A field study of the Red-tailed Hawk in Eastern Kansas. Transactions of the Kansas Academy of Science 81:1–13.

Forester, J.D., D.C. Forester, and J.M. Matkowski. 2019. Making the best of a bad situation: differential predator avoidance in a diminutive woodland salamander. Animal Behaviour 148:169–181.

Gehlbach, F.R. 1965. Herpetology of the Zuni Mountains region, northwestern New Mexico. Proceedings of the United States National Museum 116:243–332.

Gibbons, J.W. 2017. Snakes of the Eastern United States. The University of Georgia Press, Athens. 416 pp.

Gibbons, J.W. and M.E. Dorcas. 2004. North American Watersnakes: A Natural History. University of Oklahoma Press, Norman. 438 pp.

Gibbs J.P., A.R. Breisch, P.K. Ducey, G. Johnson, J.L. Behler, and R.C. Bothner. 2007. Amphibians and Reptiles of New York State: Identification, Life History, and Conservation. Oxford University Press, New York. 422 pp.

Gilhen, J. 1970. An unusual Nova Scotian population of the northern ringneck snake, *Diadophis punctatus edwardsii* (Merrem). Occasional Papers of the Nova Scotia Museum 9:1–13.

Gilhen, J. 1984. Amphibians and Reptiles of Nova Scotia. Nova Scotia Museum, Halifax. 162 pp.

Gilhen, J. 2011. The brown morph of the northern ringneck snake, *Diadophis punctatus edwardsii*, on Big Tancook Island, Mahone Bay, Nova Scotia. The Canadian Field-Naturalist 125(1):69–71.

Gotte, S.W. 2016. Natural history notes: *Diadophis punctatus* (Southern Ring-necked Snake). Predation. Herpetological Review 47:310.

Green, N.B. and T.K. Pauley. 1987. Amphibians and Reptiles in West Virginia. University of Pittsburgh Press, Pittsburgh, Pennsylvania. 241 pp.

Grismer, L.L. 2002. Amphibians and Reptiles of Baja California, Including Its Pacific Islands and the Islands in the Sea of Cortés. University of California Press, Berkeley. 399 pp.

Haast, W.E. and R. Anderson. 1981. Complete Guide to Snakes of Florida. Phoenix Publishing Company, Inc., Miami, Florida. 139 pp.

Hahn, W.L. 1908. Notes on the mammals and cold-blooded vertebrates of the Indiana University farm, Mitchell, Indiana. Proceedings of the United States National Museum 35:545–581.

Hansen, R.W. and D. Tobler. 2010. Geographic distribution: *Diadophis punctatus* (Ring-necked Snake). Herpetological Review 41:379.

Harris, S.A., and A.M. Savage. 2020. Observations of snakes associated with active nests of Allegheny mound ant (*Formica exsectoides*) in northeastern Pennsylvania. Northeastern Naturalist 27:585–595.

Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor. 378 pp.

Harding. J.H. and D.A. Mifsud. 2017. Amphibians and Reptiles of the Great Lakes Region, Revised Edition. The University of Michigan Press, Ann Arbor. 392 pp.

Heckrotte, C. 1962. The effect of environmental factors in the locomotory activity of the plains garter snake (*Thamnophis radix radix*). Animal Behaviour 10:193–207.

Hedeen, D.L. and S.E. Hedeen. 1998. Natural history notes: *Diadophis punctatus* (Ringneck Snake). Predation. Herpetological Review 29:103.

Holbrook, J.E. 1942. North American Herpetology; or, a Description of the Reptiles Inhabiting the United States, Volume 3. J. Dobson, Philadelphia. 248 pp.

Holycross, A.T., and J.C. Mitchell (eds.). 2020. Snakes of Arizona. ECO Herpetological Publishing, Rodeo, New Mexico. 837 pp.

Hulse, A.C., C.J. McCoy, and E.J. Censky. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca. 419 pp.

Hunter, M.L., Jr., J. Albright, and J. Arbuckle (eds.). 1992. The Amphibians and Reptiles of Maine. Maine Agricultural Experiment Station Bulletin 838. 188 pp.

Hunter, M.L., A.J.K. Calhoun, and M. McCollough. 1999. Maine Amphibians and Reptiles. University of Maine Press, Orono. 252 pp.

Ishimatsu, M.A. 2020. Natural history notes: *Diadophis punctatus* (Ringneck Snake). Predation. Herpetological Review 51:863.

Jackson, H.H.T. 1914. *Diadophis punctata* in Northern Wisconsin. Science, New Series 39:534–535.

Jensen, J.B., C.D. Camp, W. Gibbons, and M.J. Elliott (eds.). 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.

Johnson, R.R. 1989. Familiar Amphibians

and Reptiles of Ontario. Natural Heritage/Natural History, Inc., Toronto. 168 pp.

Kats, L.B., J.A. Goodsell, N. Matthews, C. Bahn, and A.R. Blaustein. 1998. Natural history notes: *Taricha torosa* (California Newt). Predation. Herpetological Review 29:230.

Kelly, H.A., A.W. Davis, and H.C. Robertson. 1936. Snakes of Maryland. Natural History Society of Maryland, Baltimore. 103 pp.

Klemens, M.W. 1993. Amphibians and Reptiles of Connecticut and Adjacent Regions. Bulletin State Geological and Natural History Survey of Connecticut 112:1–318.

Krulikowski, L. 2004. Snakes of New England: Photographic and Natural History Study. LuvLife Publishing, Old Lyme, Connecticut. 308 pp.

Krysko, K.L. and M.D. Halvorsen. 2010. Natural history notes: *Osteopilus septentrionalis* (Cuban Tree Frog). Prey. Herpetological Review 41:339–340.

Landreth, H.F. 1973. Orientation and behavior of the rattlesnake, *Crotalus atrox*. Copeia 1:26–31.

LeClere, J. 1994. Snakes of Minnesota: Ringneck snake (*Diadophis punctatus*). Newsletter of the Minnesota Herpetological Society 14:11–13.

LeClere, J. 2013. A Field Guide to Amphibians and Reptiles of Iowa. Eco Wear and Publishing, Rodeo, New Mexico. 252 pp.

Lemm, J.M. 2006. Field Guide to the Amphibians and Reptiles of the San Diego Region. University of California Press, Berkeley. 326 pp.

Linzey, D.W. and M.J. Clifford. 1981. Snakes of Virginia. University Press of Virginia, Charlottesville. 159 pp.

Logier, E.B.S. 1939. The Reptiles of Ontario. Royal Ontario Museum of Zoology, Handbook No. 4. University of Toronto Press, Toronto.

Logier, E.B.S. 1958. The Snakes of Ontario. University of Toronto Press, Toronto. 94 pp.

Marcou, Z.J. 2018. Geographic distribution: *Diadophis punctatus stictogenys* (Mississippi Ring-necked Snake). Herpetological Review 49:75–76.

Marion, K.R. and M.C. Nowak. 1985. Life history notes: *Diadophis punctatus* (Southern Ringneck Snake). Size. Herpetological Review 16:111.

Martof, B.S., W.M. Palmer, J.R. Bailey, Jr., and J.R. Harrison, III. 1980. Amphibians and Reptiles of the Carolinas and Virginia. The University of North Carolina Press, Chapel Hill. 264 pp.

McCauley, R.H., Jr. 1945. The Reptiles of Maryland and the District of Columbia. Robert H. McCauley, Hagerstown, Maryland. 194 pp.

Mendoza-Hernandez, A.A., E. Mocino-Deloya, and K. Setser. 2009. Natural history notes: *Diadophis punctatus* (Ringneck Snake). Ophiophagy. Herpetological Review 40:441–442.

Meshaka, W.E., Jr., B. Ferster, M.L. Meshaka, and M.L. Meshaka. 2008. Exotic species dominance in the herpetofaunal community of a new residential development in southern Florida: implications for faunal turnover rates. Florida Scientist 71:65–75.

Meshaka, W.E., Jr., and J.N. Layne. 2015. The herpetology of southern Florida. Herpetological Conservation and Biology 10 (Monograph 5):1–353.

Milanovich, J.R., S.E. Trauth, and M.N. Mary. 2005. Natural history notes: *Diadophis punctatus stictogenys* (Mississippi Ring-necked Snake). Diet. Herpetological Review 36:323–324.

Mitchell, J.C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, D.C. 352 pp.

Morris, P.A. 1944. They Hop and Crawl. The Jacques Cattell Press, Lancaster, Pennsylvania. 253 pp.

Morse, M. 1904. Batrachians and Reptiles of Ohio. Proceedings of the Ohio State Academy of Science 9:96–144.

Murphy, J.C. 2018. Arizona's Amphibians and Reptiles: A Natural History and Field Guide. JCM Natural History, Green Valley, Arizona. 316 pp.

Myers, C.W. 1965. Biology of the ringneck snake, *Diadophis punctatus*, in Florida. Bulletin of the Florida State Museum Biological Sciences 10(2):43–90.

Nafus, M.G., F.J. Mazzotti, and R.N. Reed. 2020. Estimating detection probability for Burmese Pythons with few detections and zero recaptures. Journal of Herpetology 54:24–30.

Neimiller, M., R.G. Reynolds, and B. Miller. 2013. The Reptiles of Tennessee. University of Tennessee Press, Knoxville. 347 pp.

Nelson, K.T., A.M. Durso, and R.V. Horan. 2010. Natural history notes: *Diadophis punctatus* (Southern Ring-necked Snake). Diet. Herpetological Review 41:90–91.

Neuharth, D.B., W.A. Ryberg, C.S. Adams, T.J. Hibbitts, D.K. Walkup, S.L. Frizzell, T.E. Johnson, B.L. Pierce, J.B. Pierce, and D.C. Rudolph. 2020. Searching for rare and secretive snakes: are camera-trap and box-trap methods interchangeable? Wildlife Research doi.org/10.1071/WR19230.

Nickerson, R.S. 1998. Confirmation bias: A ubiquitous phenomenon in many guises. Review of General Psychology 2:175–220.

Oldfield, B. and J.J. Moriarty. 1994. Amphibians and Reptiles Native to Minnesota. The University of Minnesota Press, Minneapolis. 237 pp.

Ortenburger, A.I. and B. Freeman. 1930. Notes on some reptiles and amphibians from western Oklahoma. Publications of the University of Oklahoma Biological Survey 2:175–188.

Palis, J.G. 2016. Snakes of "Snake Road." Bulletin of the Chicago Herpetological Society 51:1–9.

Palis, J.G. and M.B. Boehler. 2019. Natural history notes: *Plethodon dorsalis* (Northern Zigzag Salamander). Predation. Herpetological Review 50:756–757.

Palmer, W.L. and A.J. Braswell. 1995. Reptiles of North Carolina. University of North Carolina Press, Chapel Hill. 412 pp.

Parker, W.S. and W.S. Brown. 1974. Notes on the ecology of regal ringneck snakes (*Diadophis punctatus regalis*) in northern Utah. Journal of Herpetology 8:262–263.

Parmalee, P.W. 1955. Reptiles of Illinois. Illinois State Museum, Springfield. 88 pp.

Rorabaugh, J.C. and J.A. Lemos-Espinal. 2016. A Field Guide to the Amphibians and Reptiles of Sonora, Mexico. ECO Herpetological Publishing, Rodeo, New Mexico. 688 pp.

Rosenfield, R.N., M.W. Gratson, and L.B. Carson. 1984. Food brought by Broad-winged Hawks to a Wisconsin nest. Journal of Field Ornithology 55:246–247.

Rossi, J.V. and R. Rossi. 2003. Snakes of the United States and Canada Natural History and Care in Captivity. Krieger Publishing Company, Malabar, Florida. 520 pp.

Rowell, J.C. 2012. The Snakes of Ontario: Natural History, Distribution, and Status. Jeffrey Rowell, Winnipeg. 411 pp.

Smith, H.M. 1956. Handbook of Amphibians and Reptiles of Kansas, 2nd Edition. University of Kansas Museum of Natural History, Miscellaneous Publication 9:1–356.

Sperry, J.H., M.P. Ward, and P.J. Weatherhead. 2013. Effects of temperature, moon phase, and prey on nocturnal activity in ratsnakes: an automated telemetry study. Journal of Herpetology 47:105–111.

Stanback, M.T. and A.N. Mercadante. 2009. Eastern bluebirds provision nestlings with snakes. Journal of the North Carolina Academy of Science 125:36–37.

Steen, D.A. 2010. Snakes in the grass: secretive natural histories defy both conventional and progressive statistics. Herpetological Conservation and Biology 5:183-188.

Surface, H.A. 1906. The Serpents of Pennsylvania. Pennsylvania State Department of Agriculture, Division of Zoology, Monthly Bulletin 4:114–208.

Tennant, A. 2003. Snakes of North Ameri-

ca: Eastern and Central Regions. Revised edition. Lone Star Books, Bryan, Texas. 605 pp.

Tyler, J.D. 1991. Vertebrate prey of the loggerhead shrike in Oklahoma. Proceedings of the Oklahoma Academy of Science 71:17–20.

Van Denburgh, J. and J.R. Slevin. 1913. A list of amphibians and reptiles of Arizona with notes on the species in the collection of the academy. Proceedings of the California Academy of Science 3:391–454.

Van Devender, T.R. and E. Gómez-Limón. 2014. Geographic distribution: *Diadophis punctatus regalis* (Regal Ring-necked Snake). Herpetological Review 45:465.

Vogt, R.C.1981. Natural History of Amphibians and Reptiles of Wisconsin. The Milwaukee Public Museum, Milwaukee, Wisconsin. 205 pp.

Vossler, J.J. 2021. Snake Road: A Field Guide to the Snakes of LaRue-Pine Hills. Southern Illinois University Press, Carbondale. 168 pp.

Wagner, G. 1922. A Note on the Ring-necked Snake in Wisconsin. Copeia 108:54–56.

Weaver, R.E. 2012. Aspects of the ecology and life history of the ring-neck snake (*Diadophis punctatus*) in Washington State. Northwestern Naturalist 93:184.

Weller, W.F. and M.J. Oldham (eds.). 1988. Ontario Herpetofaunal Summary 1986. Ontario Field Herpetologists. 221 pp.

Werler, J.E. and J.R. Dixon. 2000. Texas Snakes Identification, Distribution, and Natural History. University of Texas Press, Austin. 437 pp.

White, J.F., Jr. and A.W. White. 2002. Amphibians and Reptiles of Delmarva. Tidewater Publishers, Centreville, Maryland. 248 pp.

Wright, A.H. The Snakes of Monroe and Orleans County, N.Y. 1919. Copeia 67:10–12.

Wright, A.H. and S.C. Bishop. 1915. A Biological Reconnaissance of the Okefinokee Swamp in Georgia. The Reptiles, Part II, Snakes. Proceedings of the Academy of Natural Sciences of Philadelphia 67:108–192.

Wright, A.H. and A.A. Wright. 1957. Handbook of Snakes of the United States and Canada. Volume 1. Comstock Publishing Associates, Cornell University Press, Ithaca, New York. 564 pp.