BEHAVIORAL RESPONSES TO POTENTIAL PREY THROUGH CHEMORECEPTION BY THE SHARP-TAILED SNAKE (*CONTIA TENUIS*)

ROBERT E WEAVER AND KENNETH V KARDONG

School of Biological Sciences, Washington State University, Pullman WA 99164 USA; kkardong@wsu.edu

ABSTRACT—The Sharp-tailed Snake (*Contia tenuis*) is a small (usually <30 cm total length), cryptic species found along the west coast of the United States and north into southwestern British Columbia. Because of its secretive nature, little is known about its behavioral ecology. We tested behavioral responses of 13 adult *C. tenuis* collected from a site in eastern Washington to potential invertebrate prey odors. We presented snakes with 2 control odors (water, cologne) and 2 possible invertebrate prey odors (earthworm, slug). Overall, there was a significant difference in both the time-to-first-tongue flick (latency) and mean tongue flick rate (number of tongue flicks/60 s trial) for the odors tested. The mean latency period was 6.0 ± 1.87 s for earthworm and 4.1 ± 1.57 s for slug. The mean tongue flick rates for earthworm and slug were 13.8 ± 4.09 flicks/s and 39.7 ± 15.79 flicks/s, respectively. These results support prior claims of a preference for slugs by *C. tenuis*. This preference for slugs may also explain the presence of *C. tenuis* in areas of anthropogenic disturbances with an abundance of slugs.

Key words: chemoreception, *Contia tenuis*, prey preference, Sharp-tailed Snake, slugs

Chemoreception plays an important role in several aspects of the behavioral ecology of vertebrates. For many vertebrate groups, the detection of prey is mediated through chemoreception (among other sensory modalities) and, in particular, for some groups such as squamate reptiles, via stimuli conducted to the vomeronasal organ (Schwenk 1993). Such vomerolfaction is facilitated in snakes by a highly modified tongue (Schwenk 1988).

The chemical ecology of just a few groups of snakes is well known. Most studies have focused on species that are medium- to large-bodied and easily collected in large numbers, such as viperids (Kardong 1993; Roth and others 1999; Kardong and Smith 2002) or natricines (Krause and Burghardt 2001; Waters and Burghardt 2005). To date, very few chemoreception studies have been conducted on small-bodied, cryptic species of snakes, and what is known is limited to studies on Australian elapids (Downes 1999, 2002). Such studies allow for insights into the behavioral ecology of these poorly known but often widespread species.

We investigated prey discrimination via chemoreception in a small (usually <30 cm total length) species of snake, the Sharp-tailed Snake (*Contia tenuis*). *Contia tenuis* is found along the west coast of the United States, from central California, north into western Oregon (and to a limited extent, eastern Oregon), northwestern and central Washington State, and southwestern British Columbia (St John 2002). Within this distribution, *C. tenuis* is found in a wide range of habitats, but is most often associated with oak savannah and open woodlands (St John 2002).

Based upon the association of *C. tenuis* with generally moist, cool habitats, anecdotal reports, and limited studies, *C. tenuis* is thought to feed primarily on slugs (Darling 1947; Cook 1960). Morphological evidence also suggests such a dietary predilection. The teeth of *C. tenuis* are narrow and strongly re-curved (Zweifel 1954; Britt and others 2009). It has been suggested that such teeth allow *C. tenuis* to grasp and swallow slippery prey such as slugs (Zweifel 1954). This preference for slugs has been referred to many times in regional field guides (Darda 1995), as well as more comprehensive guides (Stebbins 2003). However, no extensive dietary studies have been conducted. The few prey items (all slugs) that have been recorded have come from limited observations (Darling 1947). Furthermore, despite the abundance of *C. tenuis* in some parts of its range (Hoyer and others 2006),

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no studies have been conducted on the prey preference of *C. tenuis*. Therefore, we used the experimental design and statistical treatment established by Cooper (1989, 1994, 2003) to examine behavioral responses to likely non-prey and prey odors with the objective of detecting possible prey preferences in *C. tenuis*.

METHODS

Collection and Maintenance of Snakes

Thirteen adult specimens of *C. tenuis* (7 females and 6 males, mean snout-vent length ± SD = 224 ± 19.5 mm) were collected from a site in central Washington State (approximately 9.2 km WNW of Ellensburg, Kittitas County). Individual snakes were maintained in 26 × 31 × 51 cm glass aquaria with a peat moss-mulch bedding 15 mm deep. The snakes were kept in a room with a 12 h:12 h light:dark cycle and a relatively constant temperature of 28°C. Water was available *ad libitum*. Individuals were maintained in captivity for 1 mo prior to testing, and were not fed during this period. Prey items used during testing were earthworms (*Eisenia* spp.) and non-native slugs (*Arion* spp.) collected at the same locality as the snakes.

Behavioral Experiments

Each snake was tested in its cage to an odor presented on a 15-cm-long cotton swab. We recorded the latency period (time in seconds from the presentation of the cotton swab to 1st tongue flick) and the tongue flick rate (number of tongue flicks exhibited by a snake during 60 s after the 1st recorded tongue flick). Four odors in random order were presented to snakes on a cotton swab dipped in the odor: 1) demineralized water; 2) a 3:1 mixture of water and commercial pungent cologne (Aqua Velva brand); 3) odor obtained by rubbing a cotton swab moistened with demineralized water along the surface of a live earthworm; and 4) odor obtained from live slugs in the same way as that for earthworms.

To begin a trial, we removed the lid to the cage housing a snake. If a snake showed any unnatural movements interpreted as stress escape, we waited until it again settled into a motionless posture before continuing with the trial. A swab with 1 of the 4 odors was presented 10 to 15 mm anterior to the snout of a snake. We scored the latency period and the tongue flick rate. The cotton swab was held in front of the snake, even if the snake vigorously approached the swab, or retreated. If a snake reacted rapidly and moved away from the swab, the trial was terminated, the scores up to that point were not used, and the snake was retested at a later time. All trials were conducted during the nocturnal phase of the light and dark cycle (2000 to 2300) when *C. tenuis* has been observed to be active based upon field observations (Weaver 2002), and observations were made with the aid of a 20-watt red light.

Statistical Analysis

We used the non-parametric Kruskal-Wallis (*H*-test) statistical test to compare rates of tongue flicks and latency between odors. When this test resulted in statistical significance (α = 0.05), we performed a Tukey Test (*Q*-score) of multiple pair-wise comparisons to identify which trials were significantly different from each other.

RESULTS

All 13 snakes responded to each odor presented by exhibiting at least some tongue flick activity. No snake attacked a swab during trials. There was an overall significant difference for latency to 1st tongue flick among all tests, snakes, and odors ($H = 34.11$, $df = 3$, $P < 0.001$). Post-hoc analysis detected statistical differences between water and earthworm, water and slug, cologne and earthworm, and cologne and slug, (Table 1; Fig. 1). Mean tongue flick rates also differed significantly ($H = 39.72$, $df = 3$, $P < 0.0001$). These differences were between water and slug, cologne and slug, and earthworm and slug (Table 1; Fig. 2).

DISCUSSION

Based upon these results, this population of *C. tenuis* does show a preference for slug odors. This supports prior claims made by authors of such a preference (Cook 1960; Darda 1995). The latency period for slug and earthworm odors did not vary significantly, and is a result of snakes responding to both odors as novel. Snakes responded with a significantly higher mean tongue flick rate to the preferred slug odor than to earthworm odor.

TABLE 1. Significant differences between odor categories (all P-values ≤ 0.001; s = standard deviation).

Behavior	Category	Rate	Comparison	Q-value
Latency to 1st tongue flick (seconds)	Water	13.1, s = 5.36	Water – Earthworm	7.15
	Cologne	16.7, s = 4.69	Water – Slug	9.0
	Earthworm	6.0, s = 1.87	Cologne – Earthworm	10.76
	Slug	4.1, s = 1.57	Cologne – Slug	12.61
Mean tongue flick (flicks/1 min)	Water	12.0, s = 3.22	Water – Slug	27.69
	Cologne	6.2, s = 3.0	Cologne – Slug	33.53
	Earthworm	13.8, s = 4.09	Earthworm – Slug	25.92
	Slug	39.7, s = 15.79		

Slugs can be found in some of the arid portions of eastern Washington (Pearce and others 2004), allowing for *C. tenuis* to survive in such habitat usually considered atypical (Weaver 2002). Several introduced species of slugs (such as *Deroceras* and *Arion* spp., Gordon 1994) are present throughout the range of *C. tenuis*, especially in disturbed areas, including urban

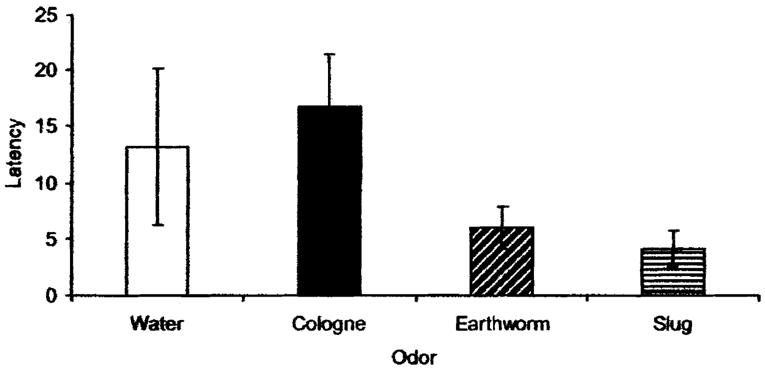

FIGURE 1. Latency period (time to 1st tongue flick in seconds ± s) for adult *Contia tenuis* (n = 13) in response to control odors (water and cologne) and 2 potential invertebrate prey odors (earthworm and slug).

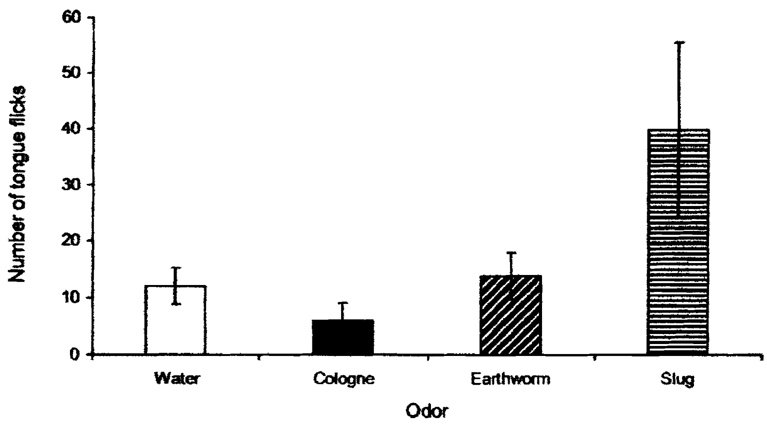

FIGURE 2. Mean number of tongue flicks (±s) during a 60 s trial for adult *Contia tenuis* (n = 13) in response to control odors (water and cologne) and 2 potential invertebrate prey odors (earthworm and slug). The 60 s period was measured from the 1st tongue flick.

areas. The availability of abundant prey may account for the ability of *C. tenuis* to persist in such areas, despite anthropogenic disturbances (Spalding 1995; Weaver and Darda 2003). Stomach contents and fecal samples collected from nearly 100 individuals have revealed no identifiable annelid or arthropod prey items (Weaver, unpub. obs.). Such samples have consisted of dark, watery feces with no chitinous remains. These observations and our experimental result showing preference for slugs based on tongue flick rate support previous suggestions that *C. tenuis* feeds primarily on slugs rather than on other invertebrates.

It is possible that *C. tenuis* also feeds on terrestrial snails. Snakes that feed on snails, such as North American natricine snakes of the genus *Storeria* (Rossman and Myer 1990), often have highly specialized morphological and behavioral features that allow them to extract the prey from its shell. *Contia tenuis* possesses at least 1 morphological similarity to *Storeria* spp., needle-like teeth on dentary (Zweifel 1954), and so it is possible that *C. tenuis* also feeds on snails. Future research on the prey preference of *C. tenuis* should include snails, as well as other invertebrates.

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