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Short communication

First observation on courtship behavior of short-tailed viper snake, *Gloydius saxatilis* (Squamata: Viperidae) in Korea

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ABSTRACT

Most reptile species have their own mating patterns. Therefore, courtship behaviors are important factors in understanding taxonomic features and species-specific breeding habits in the genus. This study explores the mating behaviors of the short-tailed viper snake (*Gloydius saxatilis*) which has never been reported. From September 2012 to August 2013, we observed the courtship behaviors of short-tailed viper snakes in Chunma Mountain County Park, Namyangju City, Gyeonggi Province, South Korea. In this study, 10 courtship behaviors from three snake couples were considered and compared. The results showed that, in general, most courtship behaviors of *G. saxatilis* were similar to those of other species of the family Viperidae. However, the most remarkable behavior of female short-tailed viper snakes was "quivering," which had not yet been reported in females from the other species of the family Viperidae. These results can provide valuable information for research in systematics of short-tailed viper snakes.

Introduction

Reptiles exhibit a variety of mating and courtship behaviors during breeding season (Kim et al 2012; Senter et al 2014). The suborder Serpentes generally shows courtship behavior that includes the male's initial approach, contact of the cloaca, and intromission. However, the pattern of these mating rituals among snakes contains a wide variety of behaviors such as chasing, mounting, jerking, and others (Gillingham 1987). Courtship behavior is one of the important factors used in understanding a species-specific life cycle (Andren 1982); therefore, it can provide valuable information for research in systematics (Senter et al 2014).

Short-tailed viper snakes (*Gloydius saxatilis*) belong to the family Viperidae, subfamily Crotalinae, and are found throughout South Korea (except Jeju Island), Russia, Northern China, and Mongolia. Adult males generally have a total length of 47.0–75.7 cm, a tail length of 6.5–10.0 cm, and a weight of 57.0–437.0 g. Adult females have a total length of 61.3–75.1 cm, a tail length of 6.2–8.2 cm, and a weight of 65.0–375.0 g (Daming et al 1989). Both males and females carry a deadly poison that contains a strong cytolysin and neurotoxin (Shim et al 1998). This species lives along the ridges in mountains and alpine regions (Beack and Shim 1999), and its major food source is rodents (Mori et al 1989). They spawn three to eight snakes in August the following year and go into hibernation in October (Zhao 1998).

Few studies have been conducted on the courtship behaviors of reptiles in South Korea (Lee 2011; Kim et al 2012). Short-tailed viper snakes have rarely been observed in the wild, resulting in a lack of information regarding their courtship behaviors (Lee et al 2011). This study reports their mating patterns for the first time.

Materials and methods

Field observation

We observed the courtship behaviors of three short-tailed viper snake couples in Chunma Mountain County Park, located in Hwado-eup, Namyangju-si, Gyeonggi-do, Korea (37°40′50″N, 127°16′22″E), from September 2012 to August 2013. Their behavior was filmed using a digital camera (EOS 600D; Canon Corporation, Tokyo, Japan) and a camcorder (HDR-CX150; Sony Corporation, Tokyo, Japan), which were placed within a 5 m radius of their habitat to record their behaviors (total observation time: 4 hours 29 minutes; video recording time: 3 hours 55 minutes). A ball-tip probe was used to determine their sex. Each body mass was weighed with a spring/balance (to 0.1 g). The and snout–vent

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length were measured with a flexible ruler (to 0.1 cm). To check whether the female snakes were pregnant, our hands were used to touch from their abdominal segments to their cloaca. It was found that no snakes in this study were pregnant. This study was conducted under appropriate licenses for capturing of wild snakes (Namyangju-si license No. 12-01 for Jeong-Chil Yoo, No. 12-03 for Min Seock Do).

Analysis of courtship behavior

Behaviors of the short-tailed viper snakes were classified by their sex. This was done based on previous studies regarding the courtship patterns of copperheads (*Agkistrodon contortrix*) and common European adders (*Vipera berus*), both in the family Viperidae (Andren 1982; Schuett and Gillingham 1988). Courtship behaviors of male short-tailed viper snakes were classified as follows: (1) trailing-approach (TA): slowly advancing to the female; (2) touch mounting (TM): making contact with a female with the snout, and the male's head and neck are elevated and placed on the female's dorsum; (3) tongue flicking (TF): flicking the tongue quickly (1–2 flicks/s) while the male vibrates his head and neck; (4) following retreat (FR): wandering after coming down from the female's body and retrying contact with the female; (5) orienting (OR): maintaining elevation and placing his head on the female's head; and (6) vent press: placing the cloaca section on the female's cloaca and putting pressure on it. Courtship behaviors of female short-tailed viper snakes were classified as follows: (1) advancing (AD): crawling forward; (2) head raising (HR): elevating the head 1–3 cm from the substrate; (3) quivering (QV): vibrating the head or the body rapidly in a short time when a male moves; and (4) chin rub (CR): making contact and rubbing the snout or chin with the male's skin.

Results

The detailed courtship behaviors of the three couples of short-tailed viper snakes are as follows (Table 1 and Figure 1). We observed the courtship behaviors of the first couple for 34 minutes beginning at 12:55 PM on September 4, 2012 (Figure 1A). The two individuals were observed for the first time at 12:55 PM, and the female coiled up and the male was crawling toward the female. The two snakes were about 10 m apart. At 1:06 PM, the male slowly approached the female and came within about 2 m (TA step; Figure 2A). At 1:09 PM, the coiled up female elevated her head (HR) and, simultaneously, the male stopped moving. At 1:16 PM, the male crawled toward the female and made contact with the female's dorsum using his snout. The male elevated his head and neck and placed it on the female's dorsum (TM). The female advanced forward (AD) at 1:20 PM. At 1:25 PM, the male approached the female's dorsum and made contact with his snout (TM). At 1:26 PM, the female was vibrating its body rapidly for a short time period (QV), and the male came down from the female's dorsum. At 1:29 PM, the two separated.

Table 1. Morphological characteristics and behaviors of the short-tailed viper snake in Chunma Mountain.

Event date	Sex	TL (cm)	SVL (cm)	Body mass (g)	Behavioral type
Sept 4, 2012	Male	78.0	67.0	238.1	TA TM
	Female	75.0	69.0	273.3	HR AD QV
Aug 1, 2013	Male	82.6	72.5	305.4	TF TM OR VP
	Female	62.0	55.0	163.7	HR CR QV
Aug 14, 2013	Male	69.0	64.0	137.3	TF OR FR
	Female	64.2	60.1	118.0	AD QV

AD = advancing; CR = chin rub; FR = following retreat; HR = head raising; OR = orienting; QV = quivering; SVL = snout–vent length; TA = trailing approach; TF = tongue flicking; TL = touch mounting; VP = vent press.

The courtship behaviors of the second couple were observed for 2 hours and 42 minutes starting on August 1, 2013 (Figure 1B). When observation began at 3:55 PM, the male and female were coiled up and their bodies made contact. At 4:08 PM, the male moved its head toward the female's head and, simultaneously, the head of the female was elevated and maintained for 3.2 seconds (HR). At 4:19 PM, the female moved under the head of the male, made contact, and rubbed her snout with the body of the male for 10.1 seconds (CR). At 4:31 PM, after moving his body, the male flicked his tongue quickly for 6.9 seconds on the female's dorsum and vibrated his head (TF). Simultaneously, the body of the female vibrated rapidly for 3.0 seconds (QV). At 4:41 PM, the male stopped moving; the female made contact with and rubbed her chin against the male's dorsum for 11.1 seconds (CR), and coiled up on the male's dorsum. At 5:00 PM, immediately after the male's movement, the female vibrated rapidly for 1.0 second (QV). At 5:24 PM, whenever the male moved and crawled, the body of the female vibrated rapidly three times for 2.0 seconds, 2.1 seconds, and 1.9 seconds (QV). At 5:41 PM, after making contact with the female with the snout, the head and neck of the male were elevated and placed on the female's dorsum for 6 minutes 36.1 seconds (TM; Figure 2B). At 5:49 PM, the male elevated and placed his head on the female's head, and maintained the posture for 34.8 seconds (OR; Figure 2D). At 6:11 PM, after crawling in a different direction, the male placed its cloaca region above the female's cloaca region and pushed that region for 5.1 seconds (vent press; Figure 2E). At 6:13 PM, the body of the female vibrated rapidly for 0.9 seconds, when the cloaca regions of the two individuals were separated (QV). At 6:31 PM, the male began to move away from the female, resulting in the detachment of their coiled tails. At 6:37 PM, the male coiled up beside the female and the two individuals completely separated.

The mating behaviors of the third couple were observed on August 14, 2013 for 1 hour 13 minutes beginning at 3:04 PM (Figure 1C). At that time, the male was on the female's dorsum. At 3:11 PM, the male crawled toward the female's head and flicked his tongue for 12.1 seconds while vibrating his head and neck (TF; Figure 2C). At 3:16 PM, the male elevated and placed his head on the female's head and maintained this posture for 6.0 seconds (OR). Simultaneously, the body of the female vibrated rapidly for 0.9 seconds (QV). At 3:17 PM, after stopping her movement, the male came down from the female's body and their bodies were separated. At 3:37 PM, the male approached the female once again after wandering around the female (FR). Then, at 3:46 PM, the male moved to the female's head and neck and flicked his tongue rapidly for 10.2 seconds while vibrating his head and neck (TF). Simultaneously, the head of the female vibrated rapidly for 1.0 seconds (QV). The male stopped moving, and at 3:57 PM the female crawled forward and stopped moving (AD). At 4:03 PM, the male moved around the female's neck and rapidly flicked his tongue for 17.1 seconds while vibrating his head and neck (TF). At 4:04 PM, the head of the female vibrated rapidly for 2.4 seconds (QV) and, simultaneously, the male stopped moving. At 4:17 PM, the male began to move and separated from the female.

Discussion

Even though the courtship behavior patterns of short-tailed viper snakes in this study varied among individuals, most behavioral patterns included in their mating rituals were common

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