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Behavioral Responses of Siberian Chipmunks toward Conspecifics Applied Snake Scent

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ABSTRACT—Siberian chipmunks are known to gnaw snake-related objects such as skin, urine, feces and anal sac excretion, and apply the gnawed bits to their body fur repeatedly (SSA behavior). After SSA, chipmunks often rub their bodies on nearby wood stumps and branches. The SSA behavior is surmised to have function of information-spreading on snakes to neighboring chipmunks. In the present study, responses of the other chipmunks towards SSA individuals were experimentally analyzed to examine the possibility of this hypothesis. In the experiments, subject chipmunks were presented with 2 kinds of objects; (1) SSA-performed chipmunks in boxes and non-performed chipmunks in boxes, (2) wood boards to which the scent of SSA-performed chipmunks adhered and wood boards to which the scent of non-performed chipmunks adhered. In both cases of (1) and (2), subject chipmunks nosed significantly longer the scent from SSA-performed chipmunks and that they performed SSA only in the contact with the former.

INTRODUCTION

So far many studies have indicated the strong pressure of natural selection developing the defensive behaviors against snakes in various vertebrate species (e.g. Goodall 1968, Beason and Pattee 1975, Owings and Loughry 1985, Coss 1991, Griffiths *et al*. 1998). Snakes are one of important predators for Siberian chipmunks *Eutamias sibiricus asiaticus* (Kawamichi 1978, Snigirevskaya 1962). Siberian chipmunks show 2 types of anti-snake behaviors. One is the mobbing known as anti-predator response in many other animals (Altmann ,956; Kruuk,1972; Curio,1975; Owings and Coss 1977; Tamura, 1989). The other is the snake-scent application (SSA) behavior which was reported as a new type of anti-snake response by Kobayashi and Watanabe (1986a).

SSA behavior by Siberian chipmunks is performed with various snake-related objects; skin, urine, feces, slough, and anal gland secretion. It was not performed to objects from animals other than snakes (Kobayashi and Watanabe 1986a). When chipmunks encounter a snake-related object, they approach it cautiously, bite and gnaw the object, and apply the gnawed bits to their body fur repeatedly. Usually SSA behavior is continued for several tens of minutes, and the fur of the chipmunks becomes very wet, which suggest the serious function for chipmunks' lives.

As to the function of SSA, there have been suggested some hypotheses such as suppressing predatory attacks by snakes and carnivores, and information-spreading to conspecifics. In the present study, to test the possibility of the information-spreading hypothesis, responses of other chipmunks to the SSA performed chipmunk and materials adhered the scent of SSA-chipmunk were experimentally analyzed.

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METHODS

Experiment 1

A chipmunk was presented with urine of Japanese rat snakes *Elaphe climacophora* (total length 136 cm ♀, 125 cm ♀, reared by feeding one or two house mice per week) in small rearing cages (35×30×40 cm), and allowed to perform the SSA with the urine. This chipmunk which applied the snake urine on its body (experimental chipmunk) and another chipmunk which was not presented with snake urine, therefore, did not perform the SSA (control chipmunk) were individually put into cylindrical boxes made of wire netting (ca. ∅4 cm×15 cm) in which they could hardly move . These boxes were presented side by side ca.15 cm apart, on wooden boards (15×20 cm) in the naturalistic outdoor pens (3.5×7.0×1.8 m, 5.0×4.0×1.2 m) in each of which a male and a female chipmunks (subject chipmunks) were reared. Then boxes were placed on usual moving routes in the outdoor pen for each chipmunks. The placement sides of the experimental-chipmunk box and the control-chipmunk box were decided randomly.

Their behaviors were recorded with a video camera, and analyzed as to the duration times of nosing and the SSA behavior during one response bout from the first approach to boxes to leaving them. I judged that the chipmunks were nosing the boxes when they showed elongate posture (Kobayashi 1987 for the definition) with their noses less than ca.5 cm distant from them.

The experimental, the control and the subject chipmunks were all adult (1.5–3.0 years old), and the sex of the experimental and the control chipmunks presented together was the same in every trial. In the present study, 5 chipmunks (2 ♂ and 3 ♀) were used as experimental and control ones. Two of the 5 chipmunks were used as both experimental and control ones. When the chipmunks used as experimental chipmunks in a certain trial was used as control one in the next trial, at least one month was intervened to minimize the affect of snake-urine scent which had adhered to the fur in the use as

experimental chipmunks. New wire netting boxes and wooden boards were always used in each trial. After each trial, the boxes and the wooden boards were removed. Then the board was sealed in a plastic bag and kept at –5 to –10°C in a freezer without any treatment.

Experiment 2

To know whether chipmunks obtain information from the snake-scent trace on the wood stump or branch, the wooden board on which the experimental- or the control-chipmunk box had been placed was presented to the subject chipmunks. Onto the test wooden board, either of 2 kinds of scents is thought to adhere. One is the scent of chipmunk's body (from the control chipmunk), and the other is the mixed scent of the chipmunk's body and snake urine (from the experimental chipmunk). The former test wooden board and the latter one were presented in a pair, ca. 15 cm apart, with their placement sides chosen randomly in the outdoor pen of subject chipmunks. The response of the subject chipmunks to these 2 kinds of scent traces were recorded with a video camera, and analyzed as to the duration times of nosing and the SSA behavior.

In both of **Experiment 1** and **2**, the combinations between subject chipmunks and experimental·control chipmunks (or their scent traces) in trials were decided randomly, and more than 3 days intervened between trials for each subject chipmunk. Furthermore, the experiments were carried out from Jul. to Aug. (non-breeding season), therefore, I did not need to consider the breeding stage of the experimental and control chipmunks during the experimental period.

RESULTS AND DISCUSSION

Experiment 1 ***Response to chipmunks in boxes***

All the 4 subject chipmunks nosed longer, in mean time, the experimental chipmunks in wire netting boxes than control ones (Table 1). In 2 out of the 4 subject chipmunks the difference was statistically significant (binomial test; $p<0.05$). In contacts with the experimental chipmunks, subject chipmunks seemed to nose more often the lower half of the body of the experimental chipmunks than in contacts with the control chipmunks. Chipmunks usually applied more snake-scent substances on the lower half of the body during SSA than the upper half. Therefore, the more frequent nosing at the lower of the experimental chipmunks may indicate the subject chipmunk's interest in area with stronger snake scent.

As to the occurrence of the SSA, 3 subject chipmunks performed it for the experimental chipmunks in wire netting boxes, and none of the 4 did the SSA for the control chipmunks in the wire netting boxes. The rates of occurrences of the SSA by these 3 subject chipmunks for the experimental chipmunks were 50% (4/8), 60% (6/10), and 33% (1/3), respectively. In 7 cases among the 11 where SSA was performed, chipmunks seemed to use the snake urine powder which came from the body surface of experimental chipmunks in the wire netting box. They gnawed the urine powder on the box and applied it to their fur.

Experiment 2 ***Response to scent traces on wood boards***

Two subject chipmunks out of the 3 nosed significantly longer the scent traces of the experimental chipmunks than that of the control chipmunks (binomial test; $p<0.05$, Table 2). Two chipmunks out of the 3 also performed the SSA for the scent traces of the experimental chipmunks after nosing it, and did not at all for the scent traces of the control chipmunks. The rates of occurrences of the SSA by 2 subject chipmunks were 60% (3/5) and 44% (4/9),respectively.

In all the cases the SSA occurred, subject chipmunks touched the traces by mouth, and showed the applying movement. It seemed that they used snake urine powder on the trace for the SSA.

Siberian chipmunks are sensitive to scent. They can discriminate between their own urine-feces and other conspecifics' ones by odor (Kobayashi and Watanabe 1986b). They can also detect faint snake scent which adhered to ground or trees after snakes crawled on them (Kobayashi 1996). Therefore, the chipmunks may obtain some information about snakes from the snake scent applied to the SSA performed chipmunk. Furthermore, chipmunks may obtain some information about snakes from the snake scent which adhered to wood stamps and branches by body rubbing of the SSA- performed chipmunks. Chipmunks usually rub their bellies and thighs on nearby wood stumps and branches after finishing the SSA (Kobayashi and Watanabe 1986a). The belly and thighs are the areas to which the most snake scent materials are applied during the SSA behavior. By rubbing these areas,

Table 1. Responses by subject chipmunks to experimental and control chipmunks in boxes

	Nosing time (sec) (mean±SD)		SSA time (sec) (mean±SD)	
Subject chipmunk	Experimental chipmunk box	Control chipmunk box	Experimental chipmunk box	Control chipmunk box
A (♂)	25.4±13.9 (10)	16.2± 9.0 (10) *	7.4±4.9 (6/10)	0 (0/10) *
B (♂)	26.8±13.2 (8)	19.0±12.7 (8)	5.9±5.0 (4/8)	0 (0/8)
C (♀)	18.1±14.6 (7)	9.2± 5.1 (7) *	0 (0/7)	0 (0/7)
D (♀)	33.2±16.7 (3)	27.5±10.2 (3)	3.6±0 (1/3)	0 (0/3)
Total	24.9±19.3 (28)	16.4±13.6 (28)	4.7±5.5 (11/28)	0 (0/28)

Numbers in parentheses mean the numbers of trials in "Nosing time", and the numbers of occurrences / the numbers of trials in "SSA time". *: $p<0.05$ (binomial test) The binomial test was used for following reason. In the trials, an experimental chipmunk and a control chipmunk were presented in a pair.

Table 2. Responses by subject chipmunks to scent traces of experimental and control chipmunks

Subject chipmunk	Nosing time (sec) (mean±SD)		SSA time (sec) (mean±SD)	
	Experimental chipmunk box	Control chipmunk box	Experimental chipmunk box	Control chipmunk box
A (♂)	14.3± 9.6 (7)	7.0±5.8 (7) *	0 (0/7)	0 (0/7)
B (♂)	9.7± 7.3 (5)	13.2±8.3 (5)	4.1±7.2 (3/5)	0 (0/5)
D (♀)	17.1±11.6 (9)	8.4±5.2 (9) *	2.8±3.1 (4/9)	0 (0/9)
Total	14.1±13.9 (21)	9.1±9.6 (21)	2.1±3.5 (7/21)	0 (0/21)

Numbers in parentheses mean the numbers of trials in "Nosing time", and the numbers of occurrences / the numbers of trials in "SSA time". *: $p<0.05$(binomial test)

the snake scent will transfer to the surfaces of wood stumps and branches.

The result that the subject chipmunks performed the SSA for the experimental chipmunks and their scent traces shows that chipmunks certainly detect the snake scent in the contact with them, because it is clarified that the SSA is induced only by snake scent (Kobayashi and Watanabe 1986a). Further, the result that the subject chipmunks nosed the experimental chipmunks (and their scent traces) than the control chipmunks (and their scent traces) indicates that chipmunks pay attention to the snake scent from the body of the SSA-performed chipmunk and the area on which it rubbed the body. These results support the possibility of information- spreading function in SSA behavior.

It is yet unclear what information chipmunks obtain from the snake scents on the bodies of the SSA-performed chipmunks and their rubbed spots. One possible information is that snakes may exist around the place where the chipmunks encountered the SSA-performed chipmunks or the rubbed spots. By obtaining such information, chipmunks may become cautious to the potential snakes.

It is necessary to investigate the SSA behavior in the field, in order to get direct evidence of information-spreading hypothesis, as well as to test other hypothesis, that is suppressing predatory attacks by snakes and other enemy. Further, the experimental study will continue to clarify what kind of information is transferred from SSA individuals and what efficiency of SSA is expected to recipients.

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