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SHORT COMMUNICATIONS

A CASE OF PROTOCOOPERATION BETWEEN THE PITVIPER *Gloydius ussuriensis* AND THE GROUND BEETLE *Carabus granulatus telluris*

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Cases of positive symbiotic interrelations (commensalism, protocooperation, mutualism) between snakes and other living organisms are rather seldom (Odum, 1986; Allee, 1951). An interesting example is the coexistence of the long-eared owl *Asio otus* (Linnaeus, 1758) and the blind snake *Leptotyphlops dulcis* Stejneger, 1891 brought to the owl's nest as food. The nestlings, unable to tear apart the hard scales of the snake, leave it alone, and the snake eagerly begins to hunt multiple insects that live in the nest. Specialists have found out that the nestlings living together with snakes have the strongest health (Downer et al., 2002; Gehlbach and Baldridge, 1987).

There have been many recent evidences of the symbiosis between the dabb lizard *Uromastyx acanthinura* Bell, 1825 and the horned desert viper *Cerastes cerastes* Linnaeus, 1758 (Sheremet, 2009). The more areas humans occupy, the harder is for *C. cerastes* to find a refuge, and these snakes often choose deep dabb lizards' burrows, where they live in peace with the hosts. The dabb lizards are believed to derive benefit from their neighbors, as the vipers are always ready to defend themselves and their hosts from humans, their enemies. The use of dabb lizards' burrows by horned desert vipers was described as far back as in the 19th century by Tristram (1860), who heard about the fact from Bedouins.

There have been no examples of protocooperation between snakes and invertebrates found in the known literature on the subject. Protocooperation is a type of interaction by two organisms, through which they mutually benefit, but which is often not obligatory, but just casual (Dediu, 1990). The present publication describes a previously unknown case of this form of symbiosis between a snake and an insect, namely between the pitviper *Gloydius ussuriensis* Emelianov, 1929 and the ground beetle *Carabus granulatus telluris* Bates, 1883.

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Case description

The case was recorded on a homestead land situated 50 m from the Korean pine-broad-leaved forest, at the foot of the western slope of a gently sloping mountain (Kaimanovka Village, Ussuri rayon, Primorsky Krai, Russia; 43°37′52.73″ N 132°14′09.25″ E). For years during warm seasons several snake species (the pitviper *G. ussuriensis*, the tiger keelback *Rhabdophis tigrinus* (Boie, 1826), and the Amur rat snake *Elaphe schrenkii* (Strauch, 1873)) have been using a heap of old boards in the yard as a place to rest and to hide, either inside the heap or over the boards.

On July 18, 2011 in the afternoon (cloudy, calm weather, warm and damp) a ground beetle *C. granulatus* appeared between the boards near an adult *G. ussuriensis*, which had been lying coiled motionless for several hours. The beetle was eager to find a prey, ran to and fro between the boards, and thoroughly examined all the corners and holes. Suddenly it climbed the piviper's body and began to look for prey on its surface. It shoved the head between the snake's scales and eagerly ate up ectoparasites, possibly the larvae of ticks. When the ground beetle moved along the reptile's body or tried to force its way between the coils, the snake changed its pose making a new region of the body accessible for the beetle (Figs. 1, 2). The whole "session" lasted for less than 15 min. We were taking pictures, but when we tried to approach with a camera, *G. ussuriensis* got uneasy, making closer photos impossible.

Fig. 1. A ground beetle *Carabus granulatus* is looking for prey on body surface of pitviper *Gloydius ussuriensis*.

DISCUSSION

Ground beetles are polyphages (Zaslavsky and Sugonyaev, 1967). They mainly hunt for food on the forest floor, where numerous ixodid ticks and gamasid mites develop and live (Bobrovskykh and Uzenbaev, 1987).

The ground beetles of the genus *Carabus* eliminated up to 100% of satisfied larvae and nymphs of ixodid ticks during *in vitro* experiments (Krivolutsky, 1963; Bobrovskykh and Uzenbaev, 1987); they also actively fed on these invertebrates during field experiments as well (Volkov and Fedulova, 1972; Volkov and Popov, 1982).

Ticks are known to be quite common parasites of reptiles (Kudryavtsev et al., 1995; Stanyukovich and Iohanssen, 2005). Among the temporary or permanent reptile parasites, there are 15 families of Acari, belonging to three orders: Mesostigmata, Metastigmata, and Prostigmata (Fajfer, 2012). Gamasina are the most numerous of reptile parasites among Mesostigmata. Three families of this group are associated with reptiles: Entonyyssidae are endoparasites inhabiting the lungs of snakes, while Ixodorhynchidae and Omentolaelapidae are ectoparasites of snakes (Balashov, 2009). High rate of infestation with the reptile mite *Ophionyssus natricis* (Gervais, 1844) was recorded in the Siberian pitviper *Gloydius halys* (Pallas, 1776) by specialists from Novosibirsk, Russia. From 10 snakes caught for the experiment, all were infected, with a rate from 4 to 20 mites (Simonov and Zinchenko, 2010). As many as 100 species of ixodid ticks that parasitize reptiles are known in the world (Balashov, 2009). At least six tick species of the family Ixodidae have been registered as parasites of snakes occurring in the Volga River basin (Bakiev, 2007). Infestation of reptiles from Siberia by gamasid mites and ixodid ticks was recorded by several authors more (Belova and Grigorjev, 1981; Kuranova et al., 2011).

Up to now, this problem has not been investigated for the Russian Far East. Far-Eastern mixed coniferous-broad-leaved forests are known for their high biological productivity (Mil'kov, 1977), and large areas of nature reserves in this region support original focuses of infections due to relative stability of multiple wild mammal populations and considerable numbers of sanguinivorous insects, ticks and mites that carry infections (Olsufyev et al., 1970). The general stability of biocoenoses in the virgin forests of Sikhote-Alin' Mountains determines a constantly high number of gamasid mites and ixodid ticks in original Korean pine-broad-leaved forest (Sagdieva, 1984).

The described area is situated on the southern spurs of Sikhote-Alin' Mountains (Przhevalsky Mountains) and is characterized by a pronounced monsoon climate (Abramov et al., 1996). The location of Kaimanovka Village near the Ussuri Nature Reserve area, within protected forests, specified the presence of minimally disturbed forests around the village. This area is described as one of the largest focuses of tick-borne encephalitis (Bolotin, 2000). The characteristic feature of the gamasid mites' fauna of Primorye (139 species) is that an average number of species is 9.3 per a family, which is one of the highest species richness index for families in the southern Russian Far East (Volonikhina, 1994).

Both *G. ussuriensis* and *C. granulatus* are common local species. They are eurytopic, but prefer swampy valleys. Both are far from avoiding human settlements, and are often found in the countryside: on vegetable gardens, near utility structures, etc. (Korotkov, 1985; Lafer, 1989; Maslova, 2003; Sundukov, 2013; authors' observations). Therefore, ground beetles may easily meet reptiles, as well as find completely or half-satisfied ticks and mites, attractive food for them, on snakes' bodies.

It should also be pointed out that numerous parasites may cause a negative effect on snakes' health and provoke various diseases, as studies show (Fajfer, 2012). Snakes, moreover, often scratch the sites of tick's bites, rubbing them against hard objects. The reptiles bit by ticks or mites become extremely irritable (Wozniac and DeNardo, 2000), and extermination of acarids brings them visible relief.

To summarize, we suppose that on July 18, 2011 we observed a case of protocooperation between the pitviper *G. ussuriensis* and the ground beetle *C. granulatus*. The ground beetle was looking for food, and the pitviper was getting rid of parasites causing skin irritation, various diseases and anemia, which could decrease the snake's immunity.

Fig. 2. A ground beetle *Carabus granulatus* is eating ectoparasites on body surface of pitviper *Gloydius ussuriensis*.

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