

## Prey capture by the purse-web spider *Calommata signata* (Araneae: Atypidae)

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**Abstract** — Prey capture and subsequent behaviors of *Calommata signata* (Araneae: Atypidae) were observed and video-documented in the laboratory. Our observations indicated that the spider captures various soil animals by using only its chelicerae. Furthermore, when closing the entrance of the burrow, the spider made a provisional cover of the entrance by hooking and drawing the inner surface of the burrow before covering the entrance with silk webbing from its spinnerets.

**Key words** — purse-web spider, Atypidae, *Calommata*, prey capture, potential prey

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### Introduction

Purse-web spiders (family Atypidae) have attracted considerable attentions because of their specialized strategy of capturing prey (Coyle & Shear 1981; Edwards & Edwards 1990; Gertsch & Platnick 1990; Cutler et al. 2004). Most atypid spiders of the genera *Atypus* and *Sphorodos* construct unique silk-lined burrows with the aerial portion extending above the ground. When prey walks over or lands on the surface of the aerial portion, the spider captures the prey from the inside of the burrow by impaling its long fangs, and then pulls the prey into the burrow. Thus, the aerial portion of the purse-web is considered to expand the prey sensing area and increase the number of potential prey such as aerial insects (Coyle 1986). In addition to their unique prey capture behavior, the natural history, habitat requirement, and distribution of these atypids are also beginning to draw attention from a conservation viewpoint (Řezáč & Heneberg 2014).

*Calommata* Lucas 1837 is a small but widespread genus in Asia and Africa (Fourie et al. 2011). The burrows of *Calommata* differ from those of other atypids in having no large aerial portion, and the burrow structures of two *Calommata* species have been reported (van Dam & Roberts 1917; Fourie et al. 2011). In *C. tibialis* burrows, the top part forms a crater-like chamber that is covered with silk webbing. The spider lies on its back in the chamber and ambushes wandering prey. In *C. transvaalica* burrows,

however, the top part is raised slightly above the ground, and no lid is attached to the burrow entrance. Structural differences of the burrows may lead to differences in capturing prey strategies among atypid species. However, little is known about prey capture behavior of *Calommata*.

*C. signata* Karsch 1879 is a species found in Japan, which constructs the burrow without lid (Fig. 1). The spider waits at the entrance of the burrow and catches passing or nearby prey by using its long fangs, and then pulls the prey into the burrow (Chikuni 1989). After feeding, the entrance of the burrow is closed with silk webbing (Yoshikura 1987). The spider's exuvia and fragmented prey exoskeletons are packed into the bottom end of the burrow (Katsura & Okuno 1991; Kaneno 1994). Although prey capture behavior of this species has been adumbrated above, details of this behavior have not yet been reported. In order to understand the natural history of this species, it is important to examine the overall predatory sequence. Therefore, in our laboratory observations, we attempted to record the behavioral sequence from capturing of prey to closing of the entrance. In addition, our study includes examinations of prey exoskeletons packed into the burrow and feeding trials by using various prey items to examine the potential prey of the spider.

### Materials and methods

Adults of *C. signata* were collected by excavating their burrow in grass verges at Funabashi, Chiba, from 2005 to 2008. For observations of prey capture behavior in the

laboratory, the collected spiders were allowed to reconstruct their burrows in soil maintained in plastic containers with a diameter of 7.5 cm and a height of 13.5 cm. Spiderlings collected in the field or born in captivity were also used for observation of prey capture behavior. The excavated burrows were dissected to examine fragmented prey exoskeletons packed into the burrows.

Crickets and various soil animals (Table 1) were offered as prey to *C. signata*. Prey capture and subsequent behaviors of the spiders were observed at room temperature and video-documented using digital cameras at 30 frames per second. Prey captures were also recorded using a high-speed camera (EX-F1, Casio, Japan) at 600 frames per second. The movie data of this study are available at the Movie Archives of Animal Behavior (<http://www.momo-p.com/>).



**Fig. 1.** The burrow entrance of *Calommata signata*. Scale=5 mm.

## Results

### Prey capture behavior

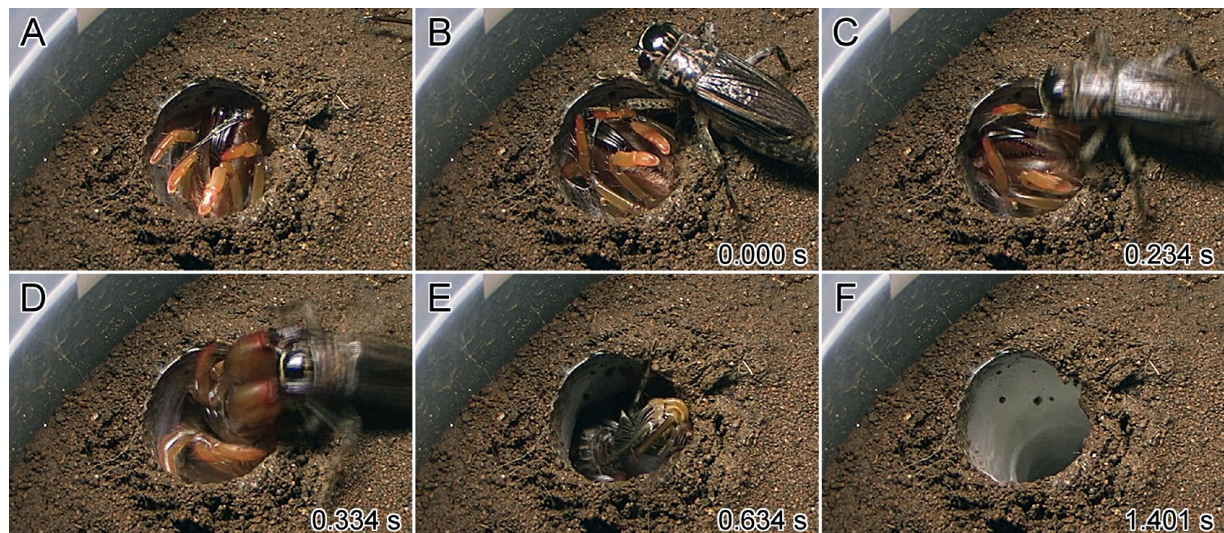
In this study, 32 prey capture events of 10 individuals of *C. signata* were recorded (Kuwada 2008; Kuwada-Kusunose 2016a). The spiders captured both approaching prey at the entrance and the prey that wandered into the burrow. After analysis of the recorded videos, the sequence of prey capture behavior can be summarized as follows (Fig. 2). When waiting at the entrance of the burrow, the spider reared up and placed its pedipalps and legs I on the lip of the entrance or slightly out the entrance (Fig. 2A). The spider, upon sensing a prey, raised its pedipalps and legs I, facing the prey (Fig. 2B). When the prey touched it, the spider extended its fangs wide and spread its chelicerae laterally (Fig. 2C). And the spider quickly leaned out of the burrow

**Table 1.** Prey offered to *Calommata signata* during the experimental feeding trials.

Arachnida	Araneae	Agelenidae Theridiidae
Chilopoda	Lithobiomorpha	
Malacostraca	Isopoda	Armadillidiidae Porcellionidae
Insecta	Blattodea	
	Collembola	
	Coleoptera	Staphylinidae
	Dermaptera	Anisolabididae
	Lepidoptera	Limacodidae (larva)* <sup>1</sup>
		Zygaenidae (larva)* <sup>1</sup>
	Orthoptera	Acrididae
		Gryllidae
		Pyrgomorphidae
Gastropoda	Stylommatophora	Limacidae* <sup>2</sup>
Oligochaeta	Haplotaxida	

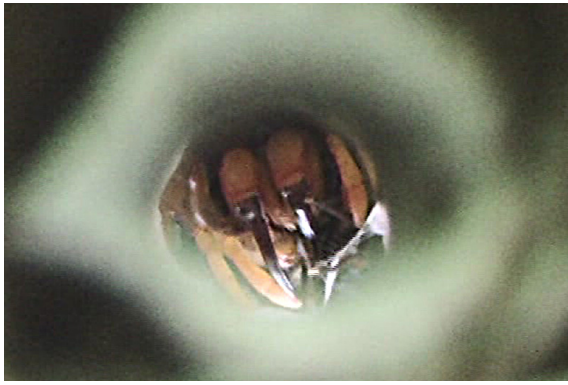
\*<sup>1</sup> Hairy caterpillars were captured but discarded by *C. signata*.

\*<sup>2</sup> Slugs were not attacked by *C. signata*.



**Fig. 2.** Frames of prey capture behavior of *Calommata signata*. The elapsed time from sensing prey (B) is shown in each figure. The related movie is available at the Movie Archives of Animal Behavior (<http://www.momo-p.com/>; Kuwada 2008).





**Fig. 3.** *Calommata signata* in its burrow eating a cricket. The related movie is available at the Movie Archives of Animal Behavior (<http://www.momo-p.com/>; Kuwada-Kusunose 2016b).

and captured the prey by using the chelicerae (Fig. 2D). The spider then grabbed the prey by closing its fangs and chelicerae; the pedipalps and legs did not contribute to holding the prey. Legs II–IV remained within the burrow during the capture response. After capture, the spider immediately retreated into the burrow with the prey (Fig. 2E–F). Prey capture duration (the time from extending fangs until retreating into the burrow after catching prey) was less than 1 s in 21 of the 30 observed cases, although the duration sometimes increased due to prey resistance.

### Feeding behavior

It was difficult to observe the inside of the burrows following prey capture, and therefore, feeding behavior of *C. signata* in the burrow could be observed only once (Kuwada-Kusunose 2016b). As shown in Fig. 3, the spider faced toward the burrow entrance and consumed the prey at the bottom of the burrow. During feeding, the spider

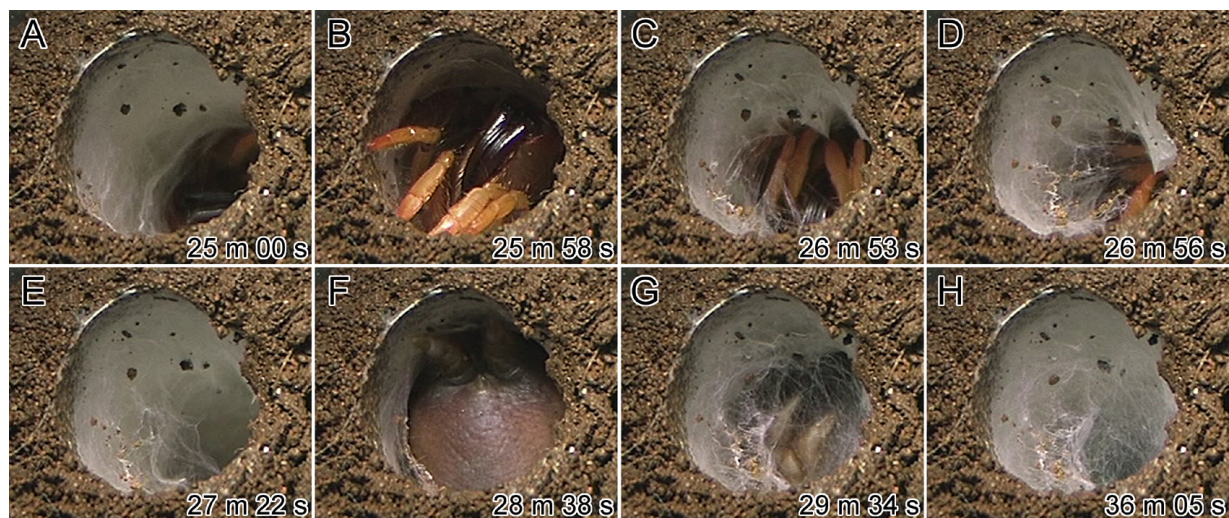
chewed the prey repeatedly by its chelicerae. In the middle of feeding, the spider pressed the prey into the inner surface of the burrow and climbed up to close the entrance. When large prey clogged the entrance, the spider began feeding on the prey at entrance, and after the size of the prey reduced after feeding, it was drew into the bottom of the burrow.

### Behaviors after prey capture

Twenty behavioral events after prey capture of 8 individual spiders were recorded (Kuwada-Kusunose 2016c) and summarized as follows. After prey capture, the spider climbed in the burrow, pushing aside and sometimes repairing the frayed inner surface (Fig. 4A–B). The time lapse after prey capture (Fig. 2) and before climbing to close the entrance (Fig. 4A) ranged from 12 to 120 min. And then behavior like drawing a curtain was observed immediately below entrance; the spider hooked and drew the inner surface of the burrow by using pedipalps and legs I–II (Fig. 4C–D). This behavior was confirmed in 17 records of 8 individuals. Lastly, the spider retreated to the bottom of the burrow (Fig. 4E), then backed up in the burrow and covered the entrance by silk webbing from its spinnerets (Fig. 4F–H). We also confirmed the same behavior sequence after prey capture in 4th instar spiderlings (Kuwada-Kusunose 2016d).

### Actual and potential prey of *C. signata*

Five excavated burrows were used to examine trash deposits packed into the bottom end. In these trash deposits, ground beetles (Carabidae) were the most common prey, and ants (Formicidae) and isopods (Armadillidiidae) were next common. And fragmented exoskeletons of a click beetle (Elateridae) and an earwig forcep (Anisolabididae) were also found. Evidently the primary prey of *C. signata* are arthropods found on the ground surface frequently.



**Fig. 4.** Frames of behavior after prey capture by *Calommata signata*. The frames are continuations from Fig. 2, and the elapsed time from sensing the prey (Fig. 2B) is shown in each figure. The related movie is available at the Movie Archives of Animal Behavior (<http://www.momo-p.com/>; Kuwada-Kusunose 2016c).

In addition, various soil animals were offered as prey to *C. signata* to infer the potential prey (Table 1). Our laboratory observations show that the spider can prey upon many land arthropods (insects, isopods, centipedes, and other spiders) and earthworms (Kuwada 2008). Conversely, some animals might be ruled out as potential prey. For example, hairy caterpillars were captured but discarded, and land slugs were not recognized as prey, because the spider hardly reacted to slugs walking on the spider (Kuwada-Kusunose 2016e).

## Discussions

In this study, we described the sequence of prey capture behavior by *C. signata* in detail (Fig. 2). Although it has been suggested that this species captures prey by using its fangs (Chikuni 1989), our observations confirmed that the spider grabs prey only by using its chelicerae and not with its pedipalps or legs. This prey capture behavior is unique, unlike that of other mygalomorph spiders that use their legs and/or pedipalps to capture prey (Coyle 1971; Coyle & Icenogle 1994; Bond & Coyle 1995; Hils & Hembree 2015). Raven (1985) considered *Calommata* as the sister group of *Atypus* and *Sphodros*. From this, we infer that in the evolutionary history of atypids, prey capture by using only the chelicerae was acquired after development of the large atypid fangs and before expansion of their burrows above ground. However, although it is well known that other atypids can capture prey through their web by using their long fangs (Coyle 1986; Yoshikura 1987), to our knowledge, no study has clarified the actual motions of prey capture by these spiders. Our observations in *C. signata* may provide a useful cue for understanding the behavior of other atypids in their web.

After prey capture, two events were observed for closing of the entrance of the burrow; a curtain drawing behavior and covering by silk webbing by using the spinnerets (Fig. 4). In particular, the curtain drawing behavior, although initially considered an accidental behavior, was observed not only in adults but also in spiderlings, suggesting that this behavior is common in *C. signata*. The curtain, made using the inner surface, seemed inadequate in preventing invaders. Thus, the curtain might be a provisional cover of the entrance and act as anchor points during covering by silk webbing.

From observation of the exoskeleton packed into the burrow, a few studies showed that *C. signata* primarily captured beetles and ants as prey (Katsura & Okuno 1991; Kaneno 1994; Ooti 2015). Our observations also indicated that the deposits in the burrow contain many exoskeletons of beetles and ants. However, it is probable that the prey list obtained from the deposits is biased in favor of hard-bodied taxa, because the hard exoskeletons were easier to locate and identify than the softer ones (Coyle & Icenogle 1994). In this study, the feeding trials by using various prey indicated that various soil animals are suitable prey for *C. signata*. Another study by Ooti (2015) clarified that aerial

insects are also potential prey. This wide array of prey might be advantageous for the expansion of their habitat range. Some atypid species are considered as endangered and red-listed in Central Europe and South Africa (Fourie et al. 2011; Řezáč & Heneberg 2014); *C. signata* is also considered in danger of extinction and is listed as Near Threatened in the Japanese Red List in 2006 (Shinkai 2006; Sato et al. 2007). Our study provides information about not only the actual prey but also potential prey, which might be available to promote the conservation of the spider.

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