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Field study of prey attraction by a bird-dropping masquerading crab spider *Phrynarachne ceylonica* (Araneae: Thomisidae)

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Abstract: *Phrynarachne ceylonica*(O. Pickard-Cambridge, 1884), a sit-and-wait crab spider (Thomisidae), not only visually resembles a typical bird dropping, but also prefers bird droppings as the substrate to sit on it, and even smells like bird droppings. It is hypothesized that *P. ceylonica* resembles bird droppings to avoid predation by being misidentified as inedible objects by predators or gain access to prey by being mistaken for innocuous objects by its prey. However, no studies have been conducted to test these two alternative hypotheses. In this study, using field observations of prey types and prey-capture rate, we investigated whether *P. ceylonica* resembles bird droppings to gain access to prey by being mistaken for innocuous objects by its prey in nature in the Xishuangbanna Tropical Botanic Garden(XTBG), Yunnan, China. Results showed that similar to bird droppings, *P. ceylonica* attracted and captured mainly dipterans, hymenopterans, lepidopterans and spiders, and about 89% of prey captured by bird-dropping crab spiders were dipterans, of which about 69% were flies from the family Agromyzidae. In terms of prey-capture rate, field surveys showed that a mean of 23 flies per hour per spider was captured by spiders during about 1-h daily survey for five days. This study suggests that bird-dropping masquerading may increase foraging success of this ambushing predator by being mistaken for bird droppings by its prey, particularly by flies.

Keywords: masquerade; bird dropping; *Phrynarachne ceylonica*; prey; flies

Introduction

Cryposis (avoiding detection as an entity), aposematism (the signaling of defensive properties), mimicry (resembling a noxious model), and masquerade have been described as textbook examples of natural selection since Darwin(Ruxton *et al.* 2004). The adaptive significance of crypsis, mimicry and aposematism is extensively studied (Speed 1993; Ruxton *et al.* 2004; Mappes *et al.* 2005; Vereeken & Schiestl 2008; Stevens & Merilaita 2009), but the function of masquerade has been much less explored. A masquerading animal evolves to closely resemble inedible and generally inanimate objects such as twigs, leaves, stones, and bird droppings to avoid predation by being misidentified as inedible objects by its predators or gain access to prey by being mistaken for innocuous objects by its prey (Endler 1981; Allen & Cooper 1985; Skelhorn & Ruxton 2010, 2011a, b, 2013, 2014; Skelhorn *et al.* 2010a, b, c; 2011; Liu *et al.* 2014; Zhang *et al.* 2015). The use of masquerade is widespread across a wide array of animals such as insects, cuttlefish, spiders, fish, sea anemones and birds (Ruxton *et al.* 2004; Skelhorn *et al.* 2010a, b; Brooker *et al.* 2011; Buresch *et al.* 2011; Hoeksema &

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Crowther 2011).

While strikingly resembling sticks and leaves is the most common masquerades(Ruxton *et al.* 2004), bird-dropping masquerading is also well known in several groups of spiders (Cott 1940; Edmunds 1974). *Phrynarachne* is a genus of sit-and-wait predators in crab spiders(Araneae:Thomisidae). Their appearance, size and colour look like bird droppings, and *Phrynarachne*(formerly *Ornithoscatoides*) *ceylonica* is often cited as a classical example of bird dropping masquerade (Ruxton *et al.* 2004; Skelhorn *et al.* 2010a,b; 2011). It has long been assumed that *P. ceylonica* visually resembling bird droppings avoid predation, or gain access to prey(Zhu & Song 2006; Skelhorn *et al.* 2011a). These two alternative hypotheses have never been empirically tested yet they continues to permeate literature and are often assumed to be an established fact(e.g., Ruxton *et al.* 2004; Skelhorn *et al.* 2010a,b; 2011). In addition, *P. ceylonica* often sit on bird droppings; furthermore, they also smell like bird droppings. Thus, it is conceivable that their volatile odour may be used to attract many flies as prey that are similar to those being attracted to bird droppings (Ono 1988). Yet this hypothesis remains untested. In this study, using *P. ceylonica* we conducted a field study to investigate whether the bird dropping crab spiders gain access to prey by attracting insects, particularly flies by being mistaken for bird droppings by comparing the types and abundance of prey attracted and captured by *P. ceylonica* with the prey attracted by bird droppings in the same habitats. Specifically, in this field study we determined the main prey types and estimated prey-capture rate to provide baseline data for further studies of functioning of bird-dropping masquerading in *P. ceylonica*. This study, to our knowledge, is the most extensive data set available on the ecology of bird dropping crab spiders.

Materials and Methods

Figure 1. A female juvenile bird dropping crab spider *Phrynarachne ceylonica* on a leaf of the elephant ear taro *Alocasia macrorrhizain* (Araceae) in the XTBG (Taken by YU Long).

Phrynarachne ceylonica is elusive animals that are rarely encountered in nature. As such it has not been possible to collect large data sets on their biology, particularly in their natural habitats. *P. ceylonica*

were found on leaves of giant taro or elephant ear taro *Alocasia macrorrhizain* (Araceae)(Figure 1) in the tropical rainforest areas of the Xishuangbanna Tropical Botanic Garden (XTBG), Menglun, Yunnan Province, China. All field observations on *P. ceylonica* and bird droppings were performed in the forested areas at XTBG in April 2014. First, we located a total of 27 *P. ceylonica* juvenile spiders (body length: range = 0.40-0.60 mm, mean± SE = 0.44±0.01 mm) and seven fresh bird droppings each near (within 1 m) some located spiders. We marked them with a unique number for each spider and each bird dropping. We then used video cameras(HDR-PJ600E) to record the responses of prey to the spiders, and the recordings were made 1 hour a day for each spider (from 1000 h to 1600 h) for five successive days. For confirming the types of prey, using small vials(inner diameter 5.4 cm, height 7.4 cm), we collected by hands potential prey attracted to, passing by and/or landed on the bird droppings in 1 hour a day for each bird dropping for five successive days. Video cameras were placed 1-2 m away from the spiders. After the completion of field observation, we viewed video footage noting events of prey capture and the type of prey that were identified to orders and some of which to families. Among all the captured prey, we considered most common types of prey for your data analysis. For each individual spider and bird dropping used, the number of different types of prey was totaled and divided by the number of monitoring hours to estimate the prey capture rate(number of prey captured per hour per day monitoring).

Results

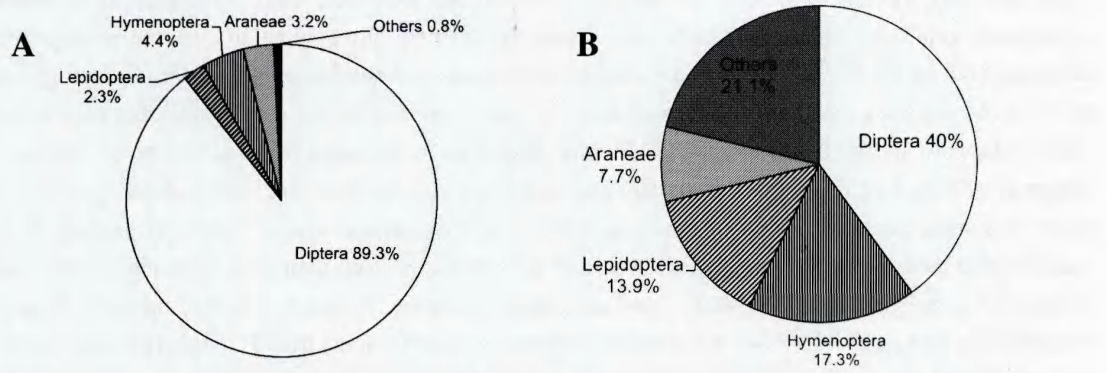

Figure 2. Types of prey and their composition obtained from a 5-day field survey of bird droppings and bird dropping crab spiders (*P. ceylonica*) in April, 2014 in the tropical rainforested areas of the Xishuangbanna Tropical Botanic Garden (XTBG), Yunnan Province, China. (A) Percentages of prey types that were attracted to, passing by, landed on the bird droppings. (B) Percentages of prey types that were attracted to and captured by *P. ceylonica* (N = 27) in an hour a day for five days.

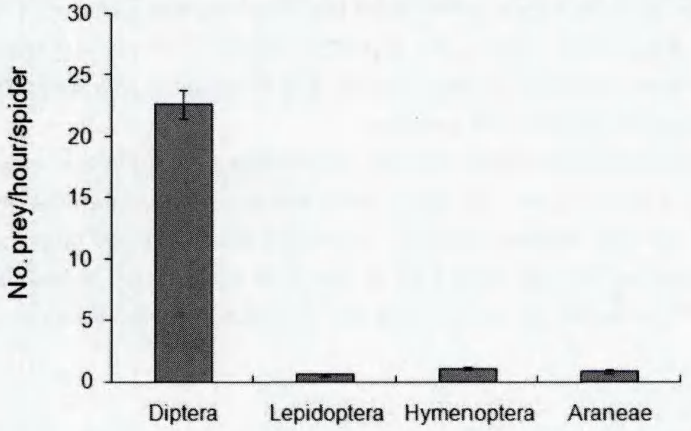

Figure 3. Mean(±SE) number of prey captured by each spider per hour per day in 5-day surveys in April 2014. A total of 27 *P. ceylonica* juveniles were surveyed and 1,676 prey items were captured.

A total of 260 prey items were collected from seven bird droppings in the 5-day survey, of which dipterans (40%), coleopterans (18.9%), hymenopterans (17.3%), lepidopterans (13.9%) and spiders (7.7%) were the four main prey types (Figure 2A). Hemipterans (0.8%), mantodeas (0.4%), odonatans (0.8%) and orthopterans (0.4%) were also found.

In five days, 27 *P. ceylonica* spiders caught a total of 1,676 prey items, of which the majorities were dipterans (89.3%), lepidopterans (2.3%), hymenopterans (4.4%), other spiders (3.2%) and other insects (0.8%) were also attracted to and caught by crab spiders (Figure 2B). Of dipterans, 69%(1029 out 1,496) flies were from the family Agromyzidae. In terms of per-hour prey-capture rate, on average each spider caught 23 dipterans per hour a day, but captured about only 0.6 lepidoperans, 1.1 hymenopterans and 0.8 other spider per hour a day (Figure 3).

Discussion

Almost all studies on functioning of masquerading have focused on whether masquerading animals gain protection from their predators by causing predators to misclassify them as the inedible objects that they appear to resemble (Skelhorn & Ruxton 2010, 2011a,b, 2013, 2014; Skelhorn *et al.* 2010a, b, c; 2011; Liu *et al.*, 2014). An alternative explanation for masquerading is that masquerading functions to gain access to prey by being misidentified as innocuous objects such as bird droppings prey by their prey(Skelhorn & Ruxton 2010, 2011a,b). Yet this hypothesis has rarely been tested. Our study here was not designed as a manipulated experiment to test this hypothesis. Rather we conducted the field observations to examine whether the bird dropping crab spider *P. ceylonica* would attract similar types and number of prey as bird dropping would in the wild. As expected, our results provide evidence that the types and number of prey attracted and captured by crab spiders are similar to those attracted by bird droppings in the same habitats. The most common prey attracted by both bird dropping crab spiders and bird droppings are dipterans with a majority of agromyzid flies. This suggests that *P. ceylonica* may resemble bird droppings to access to prey by causing their prey misclassified them as bird droppings. However, how *P. ceylonica* cause their prey to misidentify them as bird droppings is unclear. Since their shape, size and colour resemble, at least to a human observer, typical bird droppings in their natural habitats, the visual cues (shape, size and colour) from *P. ceylonica* may allow them to visually deceive and ambush prey. However, this possibility should be tested using colour modeling to compare *P. ceylonica* and bird dropping colouration from perspective of a prey such as fly, or by manipulating *P. ceylonica* spiders appearance(shape, colour and/or size) to compare their attractiveness to prey with bird droppings in the field and/or in the laboratory. Perhaps *P. ceylonica* may chemically resemble bird droppings to attract prey since these spiders smell like bird droppings and sometimes sit on bird droppings (Ono 1988; Zhu & Song 2006). Again, this hypothesis should be tested experimentally in the future. Furthermore, future studies are needed to test whether the bird dropping crab spider *P. ceylonica* resemble bird droppings to gain protection from their predators.

In conclusion, our field study suggests that the bird dropping crab spider *P. ceylonica* may from bird dropping masquerade to access to prey by causing their prey misclassified them as bird droppings. The fact that many agromyzid flies were attracted by both *P. ceylonica* spiders and bird droppings in the same habitats indicates that these flies may form the main natural prey of *P. ceylonica*. The bird dropping crab spider *P. ceylonica* provides to our knowledge the first evidence for potential masquerading as a predatory strategy in the animal kingdom.

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锡兰瘤蟹蛛(蜘蛛目:蟹蛛科)鸟粪伪装在猎物吸引上的野外研究

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摘 要:锡兰瘤蟹蛛(*O. Pickard-Cambridge*, 1884)是一种狩猎型蜘蛛,不仅看起来类似鸟粪,并且也喜欢呆在鸟粪上面,甚至闻起来也与鸟粪相似。本文通过在中国云南省勐仑中国科学院西双版纳热带植物园热带雨林中野外猎物的调查发现该类蜘蛛的主要捕食对象有双翅目类 (89%)、膜翅目类 (4.4%)、鳞翅目类 (2.3%) 昆虫以及蜘蛛 (3.2%),其中双翅目潜蝇科蝇类昆虫 (69%) 为最常见捕食对象,并与在同一生境中鸟粪所吸引到的昆虫和蜘蛛类群及数量很相似。从而说明锡兰瘤蟹蛛这种鸟粪伪装或许能能够帮助他们吸引猎物,特别是蝇类昆虫。

关键词:鸟粪伪装;锡兰瘤蟹蛛;猎物;蝇