2022. Journal of Arachnology 50:23–26

SHORT COMMUNICATION

Observations of dispersal in the brown recluse spider, *Loxosceles reclusa* (Araneae: Sicariidae)

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Abstract. We studied dispersal of brown recluse spiders, *Loxosceles reclusa* (Gertsch & Mulaik, 1940), around an infested urban garage using pitfall traps. Over a four-month period, 23 were captured from a source population that averaged 100 individuals observed in nocturnal censuses. *Loxosceles reclusa* were captured in far lower proportions compared to their potential source population size than were other spiders such as theridiids and agelenids that also resided in the garage, albeit in far lower numbers. Dispersal was weakly positively correlated with the source population size. We compare our findings to anecdotal reports from prior studies and the general consensus that brown recluse spiders are poor dispersers to argue for more detailed examination of the movement and specific habitat requirements of this medically important spider. Habitat specificity and high mortality during dispersal may help explain the highly clustered spatial distribution of brown recluse spiders, not only a lack of attempted emigration.

Keywords: Movement, emigration, habitat preference, pitfall traps

https://doi.org/10.1636/JoA-S-21-003

The brown recluse spider (*Loxosceles reclusa*, Gertsch & Mulaik, 1940) (Sicariidae) is well-known as a medically important spider of North America. The potential for serious necrotic skin lesions (i.e., loxoscelism) and, rarely, systemic complications from its bite, has led to its notoriety as well as much misinformation and misdiagnoses of skin lesions (Vetter & Bush 2002; Vetter et al. 2003, 2004; Bennett & Vetter 2004; Frithsen et al. 2007). Perhaps as a result, since the seminal study of basic biology by Hite et al. (1966), most research on this species has focused on its venom, the pathology and etiology of bites, potential treatments, and distribution (reviewed in Vetter 2015). An increased interest in its basic ecology and behavior has led to recent work on population biology (Cramer & Hileman 2018), foraging behavior (Sandidge 2003; Parks et al. 2006; Cramer 2008, 2015; Vetter 2011) and temperature tolerance (Cramer & Maywright 2008; Cramer & Zagar 2016).

One aspect of the spider's biology of particular interest in preventing human exposure is its dispersal ability. As infestations of buildings can be significant, containing up to thousands of individuals (e.g., Vetter & Barger 2002), spread to adjacent structures is a rational concern. However, as a haplogyne spider, brown recluse spiders are presumed to not balloon so any dispersal should be cursorial. Preliminary evidence from arachnologists summarized by Vetter (2015) suggests that brown recluses are very poor dispersers. Anecdotally, of two adjacent buildings within meters of each other, one may be heavily infested with brown recluses while the other contains none. Cramer (2015) found that brown recluses are very sedentary, limiting any movement to the immediate vicinity of their web for more than 95% of their daily activity budget. Nonetheless, rare but long-distance movements could provide the opportunity for colonizing new habitats. However, to our knowledge no published studies have specifically examined dispersal in brown recluse spiders. To shed more light on the potential for dispersal in this species in a natural setting, we investigated movements of brown recluse spiders compared to other spiders around an infested urban garage.

We placed twenty pitfall traps and a drift fence around three sides of a large (20 × 10 m), urban garage in Monmouth, IL, USA (40.19° N, 90.64° W; described in Cramer 2015). A two-story house with attic and basement is located about 3 m northwest of the garage. We were unable to place traps on the west entrance to the garage due to heavy use. We placed a line of traps one meter away from each of the three other exterior garage walls beginning each line one meter from the end of the wall and spacing traps two meters apart, resulting in eight traps by each of the north and south walls and four by the east wall. The north-facing wall had decorative river rock and landscaping plants such as hostas immediately exterior to the garage. Closely mowed lawn surrounded the east and south-facing garage walls. Due to this heterogeneity, we labeled traps into five zones of four traps each: two zones each on the longer (20m) south (zones A and B) and north (zones D and E) walls and one on the east-facing wall (zone C). We constructed the drift fence of 15 cm high clear plastic Mylar sheeting (1 ml thickness) with vertical metal wire (1.5 mm diameter) supports woven through the sheeting at 50 cm intervals. The drift fence was continuous on each of the three sides of the garage and continued flush to the edge of the pitfall traps. Pitfall traps were 10.5 cm in diameter, 7.5 cm deep and divided by a fine mesh screen to distinguish between movement toward (immigration) or away from (emigration) the garage. We covered each pitfall trap with a sturdy plastic plate to protect it from rainfall. Traps were filled to a depth of 2 cm with propylene glycol (commercially available marine anti-freeze).

We sampled continuously from 14 June through 11 October 2017, collecting samples every 8–11 days (13 sampling dates) and preserving specimens in 70% ethanol. Brown recluses at this site are typically active from early May through mid-October (Cramer 2015), so our study did exclude some early season activity in May. We identified all arthropods captured in the pitfall traps to phylum and order and spiders to family. Spiders not identifiable to family due to poor preservation or damage were lumped into an "unidentified" group.

We also monitored the population of spiders in the garage by taking a census after dark on the same day that we collected from pitfall traps. We recorded all visible spiders using red light headlamps while walking an established route through the garage for 30 min. For brown recluse spiders, we recorded the sex of adults and three stages of immatures: early instar (< 3mm body length), late instar (3 – 6mm), and subadults (6 – 9mm).

The number of individuals captured in pitfalls may reflect relative abundance, activity or some combination of both ("activity-abundance" as defined by Woodcock [2005]). Here we use the term activity to focus on movement of brown recluse spiders outside of the structure. Because resident populations of recluse spiders are not

Table 1.—Arthropods sampled by taxonomic group. Percentages of total < 1 not listed.

Class	Order	Family	Totals	%
Arachnida				
	Acarina		53	
	Araneae		630	4.2
		Agelenidae	3	
		Araneidae	4	
		Corrinidae	14	
		Dysderidae	34	
		Gnaphosidae	6	
		Linyphiidae	193	
		Lycosidae	146	
		Oxyopidae	1	
		Salticidae	111	
		Sicariidae	23	
		Theridiidae	26	
		Thomisidae	40	
		Unidentified	29	
	Phalangida		28	
	Pseudoscorpionida		7	
Chilopoda			7	
Diplopoda			738	4.9
Hexapoda				
	Coleoptera		4430	29.3
	Collembola		554	3.7
	Dermaptera		65	
	Diptera		787	5.2
	Ephemeroptera		9	
	Heteroptera		1852	12.3
	Hymenoptera		1493	9.9
	Lepidoptera		50	
	Orthoptera		494	3.3
	Thysanura		1	
Isopoda			3909	25.9
Total Arthropods			*15107*	

observed outside of the structure, we assume any pitfall captures reflect emigration rather than localized activity. Given the highly skewed nature of the data (many zeros and a few very active-abundant taxa), assumptions of normal distributions and equal variance were violated and not correctable by transformation. We used nonparametric Kruskal-Wallis adjusted for ties (K-W), Spearman rank correlation and chi-square analysis of independence.

Because total arthropods, total spiders, and individual spider families were caught in equal numbers on both sides of the traps (immigration/emigration), it became evident that the drift fence was ineffective in distinguishing directional movement, so we pooled the data for all subsequent tests. Beetles (Coleoptera) and isopods were the most numerous arthropod taxa, followed by Heteroptera and Hymenoptera (97% Formicidae) (Table 1). Spiders (Araneae) accounted for 4% of all arthropods. Overall arthropod activity peaked in early summer and dropped off significantly in early August and again in early September until mid-October (K-W, H = 25, $P = 0.016$, $n = 15107$).

Spiders, like arthropods in general, also peaked in early summer (K-W, H = 92, $P < 0.001$, $n = 630$; Fig. 1). Brown recluse spiders ($n = 23$) comprised 3.6% of all spiders encountered in pitfalls and were the third least abundant family (Table 1). Although slightly more brown recluse spiders were captured early in the season the trend was not significant, likely due to small sample size (K-W, H = 13, $P = 0.39$; Fig. 1). Four were adult males and the remainder immatures. The immatures were dominated by the earliest instar ($n = 11$) with four each in the late instar and subadult classes.

Arthropods showed no variation in activity across zones (K-W, H = 7.3, $P = 0.12$) nor did spiders (H = 4.6, $P = 0.33$). Spiders were slightly more active-abundant in the north-facing wall zone that contained a border of landscaped plants and river rock. In contrast, brown recluse spiders were only captured in the three zones of the south and east-facing walls by open lawn; none were encountered on the north-facing wall that was nearest to an adjacent structure also inhabited by brown recluse spiders (K-W, H = 15, $P = 0.005$).

The most abundant spiders in pitfalls (Linyphiidae, Lycosidae and Salticidae) were virtually never encountered in the garage; only three lycosids were found during nightly censuses (Table 1). Of the three families we consider to be permanent residents of the garage, Theridiidae, Agelenidae and Pholcidae, 26 theridiids, three agelenids and no pholcids were captured in pitfalls. In garage censuses, these three families were found at far lower numbers than brown recluse spiders, with a median of 10 (Theridiidae), 4.6 (Agelenidae), and 1.8 (Pholcidae). In stark contrast, *L. reclusa* was overwhelmingly the most abundant spider in the garage (median = 96, mean = 100) with two-thirds of those immatures. To estimate relative dispersal rates of these garage residents, we compared the number of spiders captured

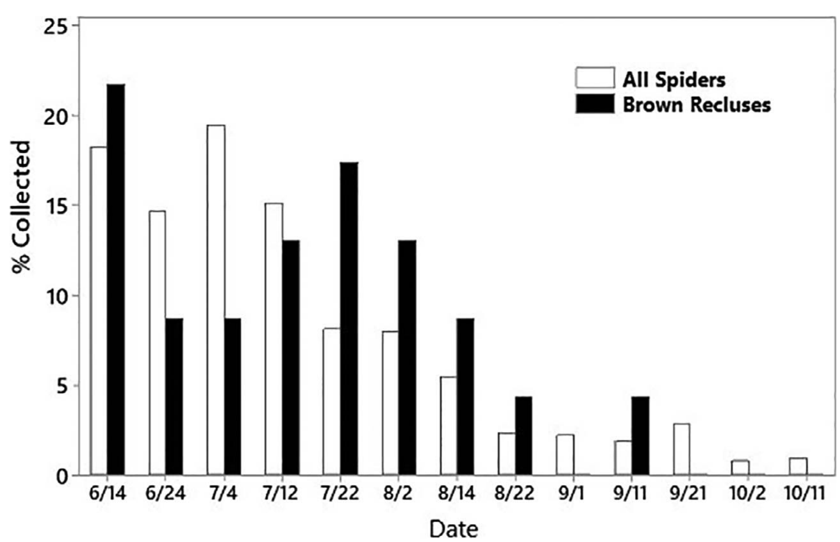

Figure 1.—Seasonal trends in proportions of spiders and brown recluse spiders captured.

in pitfalls to the censuses for each taxon in the garage. An average of 16.5 resident non-recluse spiders (Agelenidae, Theridiidae, and Pholcidae) was recorded, and a mean of 2.23 were captured in pitfalls (14.6%). In contrast, a mean of 1.79 brown recluse spiders was found in pitfalls with a mean census of 100 in the garage (1.8%). A lower percentage of brown recluse spiders than other garage residents were found in pitfalls ($X^2 = 46$, $P < 0.001$, $df = 1$).

The number of brown recluse spiders found in pitfalls was weakly positively correlated (Spearman rank) with their numbers in the garage at the time of their capture ($r = 0.58$, $P = 0.05$, $n = 13$). However, there was no correlation between dispersing immatures and the population in the garage ($r = 0.13$, $P = 0.69$), or immatures in the garage ($r = 0.05$; $P = 0.89$).

Our study shows that brown recluse spiders do disperse from preferred habitat into unsuitable habitat, presumably, in a search of new areas to colonize. The preponderance of immature brown recluse spiders and the correlation of emigrants with higher populations in the garage offers some support for this conclusion (though see Chiara et al. 2019). The fact that all adults captured were male is consistent with the generally higher activity and longer movements of males recorded in many species, including brown recluse spiders (Cramer & Hileman 2018).

Whether brown recluse spider dispersal is greater or less than other wandering spiders is a difficult question to address given the diverse methods of estimating dispersal and inherent difficulties in distinguishing it from local movements unrelated to dispersal. In our study, it is safe to assume that brown recluse spiders encountered outside of the garage were dispersing because adults are not resident outside the garage. However, comparing movement of other garage-inhabiting spiders to brown recluse spiders is confounded by the fact that these families are also fairly common residents outside of human structures. Thus, we would expect to find more of them in pitfall traps merely due to local activity, not just dispersal from the garage. Our finding that the proportion of brown recluses dispersing from the garage source population was significantly less than movements of other resident garage spiders is confounded by the lesser habitat specificity of the other spider families.

Curiously, we found all dispersing brown recluse spiders exiting away from the nearby house. No recluse spiders exited toward the house, although a prior study noted that on at least two occasions marked, adult recluse spiders (both males) moved from the garage to the house (Cramer & Hileman 2018). It is possible that, at least in zone E (closest to the house), traps placed amidst decorative river rock were less effective at capturing moving spiders. However, this explanation is unlikely given that many other species of spiders of similar size were abundant in the same traps.

Sandidge (2005) conducted a similar study around nine homes in Kansas known to have brown recluse spiders. Ten pitfalls (without drift fences) placed within three meters around each house captured 26 brown recluses in a 3-month period. The majority of specimens were immatures or spiderlings, consistent with our findings, though he did capture two adult females whereas we encountered none. It's notable that he captured no recluse spiders around 1/3 of the houses, though these houses also had some of the lowest numbers captured inside on sticky traps. Using his raw data, we ran a Spearman correlation of the spiders on sticky traps vs. pitfalls and found a positive, but not significant, relationship ($r = 0.48$, $P = 0.19$). Cutler (2001) found no specimens of brown recluses in cardboard traps placed 5 – 30 m outside a home in a residential setting where brown recluse spiders are common, but he had only observed two brown recluses in the house (Cutler, pers. comm). Likewise, the observations that a persistent, but highly localized population of brown recluse spiders in a rotting log were not able to colonize a building more than 300m away (Gorham et al. 1969) may not be surprising given the long distance to suitable habitat.

In sum, brown recluse spiders seem to disperse, particularly in the immature stages, but the success of such dispersal is unknown. While many in the literature have assumed brown recluses are poor dispersers, alternative hypotheses may explain why infested structures may exist adjacent to uninhabited ones. Dispersal is inherently risky, especially at earlier stages when predation, starvation, and desiccation are probable. Negotiating these risks over even a few meters may eliminate substantial numbers of emigrants. Finally, adjacent structures may not provide the same microhabitats, and little is known about the abiotic and biotic conditions necessary for brown recluses to successfully colonize and occupy a structure. We hope our study will spur others to quantify the movement of brown recluse spiders around buildings they occupy, as well as their specific habitat requirements. Such further studies will be necessary to gain a fuller understanding of brown recluse spider dispersal and colonization, and perhaps lead to greater control in urban settings.

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Manuscript received 17 January 2021, revised 21 February 2021, accepted 14 March 2021.