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Brown recluse spiders: A review of biology, life history and pest management

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Members of the spider genus *Loxosceles* (Araneae: Sicariidae) are found throughout the world. Their venom can cause severe open necrotic lesions in humans that can take several months to heal. Bite victims may also develop systemic reactions that can be life-threatening if medical attention is delayed or unavailable. Many *Loxosceles* species establish large populations in human habitats, creating a threat to human health and safety. *Loxosceles reclusa*, the brown recluse spider, is by far the most abundant spider species in many homes throughout the south-central United States. There has been an increase in awareness of brown recluse spiders, primarily due to negative media coverage of disfiguring bites and immense, slow-healing wounds. Although the bite of *L. reclusa* has been identified as a cause of necrotic lesions for nearly five decades, surprisingly few studies examine the biology of these spiders, and none have examined their association with humans. Few data have been published on the killing efficacy of pesticides on *L. reclusa*. Although millions of dollars are spent each year to control populations of *L. reclusa* in homes, no studies have been conducted to test newly developed chemicals or examine the benefits of integrated pest management practices. Here, we review historical accounts of pest management for *L. reclusa* populations and previous laboratory studies of biology and behavior. We then discuss how current studies of urban ecology, biological control, and urban pest management contribute to the management of *L. reclusa* populations in human habitats.

Keywords: Loxosceles, pesticide, spider, pest management.

INTRODUCTION

Spiders are among the most readily recognizable, publicly feared, and often misunderstood groups of arthropods. However, of the 35,000+ described species, only 50–60 have established human toxicity (Russell and Gertsch 1983) and only 20–30 (0.057–0.086%) are considered significant risks to human health (Foelix 1996). Spiders in the genus *Loxosceles* (Araneae: Sicariidae) are one of the most abundant and widespread groups of spiders considered a threat to human health. *Loxosceles reclusa*, the brown recluse spider, is a common pest in homes and other human-made habitats throughout south-central North America (fig. 1). The venom of *L. reclusa* is responsible for painful necrotic wounds that can take days, weeks, and even several months to heal, often leaving behind severe skin disfiguration and scarring (Atkins et al. 1958; Gorham 1968a, b; Anderson 1982a, b; Anderson 1990; Anderson 1998). In many cases, bite victims accumulate expensive medical bills due to experimental procedures, latency of diagnosis and treatment, severity of bite symptoms, or adverse reactions to treatments (Sandidge, unpub. data). Bite victims may suffer from allergic or other systemic reactions. Symptoms include nausea, chills, fever, myalgias and arthralgias, body rash, and

Figure 1. Closeup photograph of the brown recluse spider, *Loxosceles reclusa*.

blood abnormalities (see review in Sams and King 1999; Sams et al. 2001). Severe clinical manifestations that may be mild in adults but severe and potentially life threatening in young children include hemolytic anemia and hemolysis, hematuria, seizure, renal failure, and coma (Brady, Debehnke and Crosby 1994).

Historically, few deaths have been attributed to presumptive or suspected brown recluse spiders bites (Lesseden and Zimmer 1960; Nance 1961; Nicholson and Nicholson 1962; Riley et al. 1964; Taylor and Denny 1966; Rose 1970; Vorse et al. 1972; Williams et al. 1995; Wasserman et al. 1999). However, it is possible that additional deaths have occurred, but are either listed in obscure publications, or are not recorded in the literature (G. Wasserman, pers. com.). Although death is an unlikely consequence of envenomation, hundreds of potentially life-threatening complications and abnormal reactions have been documented. Many of these serious complications are documented from verified bites where the patient presented the spider upon treatment (Vukusic 1962; Minton and Olson 1964; Gorham 1968b; Delozier et al. 1988; Eichner 1984; Rees et al. 1987; Ingber et al. 1991; Michaud and Gibler 1991; Wendell 2003).

Reactions to brown recluse spider bites range from non-eventful, whereby patients do not develop lesions or medical symptoms, to relatively mild with small lesions that heal rapidly, to dramatic symptoms with intense pain and large necrotic lesions that require long periods of time to heal, and may require skin grafts, hospital stays, and months of rehabilitation (Brady, Debehnke and Crosby 1994). Reactions depend on the amount of venom injected (Dillaha, Jansen and Honeycutt 1964), the victim's immune system and the location of the bite on the body (Brady, Debehnke and Crosby 1994). The

extreme variation in symptoms following envenomation helps fuel the fear and paranoia that has contributed to many myths, urban legends, and inaccurate information about brown recluse spiders that extend beyond the general public into the medical profession (Vetter and Bush 2002a, b) and the pest industry (Sandidge, unpub. data).

Species range

Loxosceles reclusa is found primarily in the south-central United States (Gertsch 1958; Hite 1964; Gorham 1968a; Gertsch and Ennik 1983), yet debate exists on their natural distribution. Verified specimens have been collected from locations 100s of km outside of this theoretical endemic region, from locations in Maine, Florida, California and Canada (Gertsch and Ennik 1983; U.S. Department of Agriculture 1966). However, specimens collected from many of these locations were labeled as transient spiders transported to urban areas by commerce from endemic regions (Gertsch and Ennik 1983). In this review, the definition of urban environment follows McIntyre (2000) as "*…a heterogeneous mosaic of residential dwellings, commercial properties, parks, and other land-use types that provides an array of habitat types that can be used by arthropods.*" This definition does not restrict the use of the term "urban" to heavily populated metropolitan areas.

Loxosceles reclusa is abundant in Oklahoma, Texas, Arkansas, Kansas, and Missouri, and found commonly in Alabama, Mississippi, Kentucky, Tennessee, and Illinois. In the southern portion of its distribution, *L. reclusa* is found in nature under rocks, behind the bark of trees and in other natural cracks and crevices (Hite 1964). However, brown recluse spiders have adapted so well to humans that in more northern regions of their distribution they exhibit a marked preference for human-made habitats and are difficult and often impossible to find in natural areas (Gorham 1968a; Sandidge, pers. obs.). This increases the possibilities for human/spider contact, thereby increasing the number of accidental envenomations and the resulting medical complications.

Brown recluse spider populations can be rather large in nature (Hite 1966; Hite et al. 1966). However, populations in urban habitats are considerably larger, with up to 2055 spiders recorded from a 270-m^2 home in Kansas in six months (Vetter and Barger 2002). One of the authors (J.S.) hand collected >80 spiders in less than one hour, collected 63 spiders on sticky insect traps in 14 days, as well as capturing 526, 240, 226, 184, and 150 brown recluse spiders on sticky insect traps in two months from houses in Kansas (Sandidge, unpub. data). These spiders have proven to be a challenge to pesticide professionals, pesticide manufacturers, and homeowners (Hall and Anderson 1981). Although several attempts have been made to control and eradicate populations in homes, hospitals, warehouses and other human dwellings and workplaces, most efforts have proven futile and many think that eradication is an unlikely, if not an impossible task (Gorham 1968b; Hall and Anderson 1981). There is a need for control methods in existing urban populations and methods to deter additional populations. However, both depend on knowledge of past pest control efforts and current information on the biology, behavior, and ecology of *L. reclusa* in human habitats.

History

On November 5, 1928, Dr. Lyle Schmaus, a physician from Halstead, Kansas recorded the first account of medical symptomology following a brown spider bite (Schmaus 1929). The spider recovered by the bite victim was first identified as *Loxosceles rufescens*. The identification was changed to *L. reclusus* in 1940 after a new species was described by Gertsch and Mulaik (1940). The species is currently known as *L. reclusa*

(Gertsch 1958). Macchiavello (1937) described necrotic reactions following a bite from *Loxosceles laeta*, which occurs in South America. Twenty-nine years later Dr. Schmaus's account of brown spider bite was revisited when Atkins et al. (1958) showed definitively that *L. reclusa* was indeed the culprit of many previously, unidentified necrotic wounds.

Hundreds of research articles and medical case reports have been written to describe the destructiveness and chemical composition of brown recluse venom and the many medical outcomes following envenomation. However, questions remain about the biology, behavior, and geographic distribution of this species. This lack of information may be the primary reason that reports of brown recluse bites are much more widespread than the spider's actual distribution (Vetter et al. 2003).

BIOLOGY, LIFE HISTORY AND ASSOCIATIONS WITH HUMANS

Brown recluse spiders are principally nocturnal, yet are often observed during daylight hours in bright areas. They are found most often at night in corners, under furniture, under piles of clothing on the floor, in attics and basements, under or in boxes, and in pantries or cellars. However, the location of brown recluse spiders differs in each home with variations in home construction, temperature, brown recluse population sizes, and many other variables (Sandidge, unpub. data).

Known as brown recluse spiders, fiddleback spiders, brown back spiders, recluse spiders, brown spiders, violin spiders, and violin backs, *L. reclusa* typically has a light brown or tan body with somewhat darker legs and a dark brown inverted violin shape located on its cephalothorax. However, this fiddle-like shape should not be the primary distinguishing character separating brown recluse spiders from other spider species, as many other species have similar fiddle-like shapes on various body parts (see Vetter 1999 for descriptions and a list of species). In addition, this feature may be absent in juveniles and adult spiders that have recently molted or have especially dark or light coloration. A more accurate way to identify the brown recluse spider is by their eye pattern in conjunction with more traditional ways. While most spiders have eight eyes arranged in two rows, members of *Loxosceles* have only six eyes arranged in a triangular pattern of three pairs, called dyads. Misidentifications of other spiders that have similar markings, colors, or patterns help propagate the myth that the spider has a cosmopolitan distribution (Vetter 1999; Sandidge, unpub. data).

The webs of *L. reclusa* are sparse and irregular, and usually constructed low to the ground out-of-doors. In houses, spiders build webs in areas that are rarely disturbed and out of direct sight. Brown recluse spiders also build webs on the exterior of homes in areas such as between wood siding, behind shutters, underneath wooden shingles, etc. Unless recently spun, the webs of brown recluse spiders do not seem to retain prey, but may detain prey long enough for the spider to become aware of its presence and attack (Sandidge, unpub. data). Hite (1966) reported that prey capture behaviors using webs that were observed in the laboratory were not witnessed in natural settings.

Unlike most wandering spiders, which use stealth, strength and excellent vision to capture prey, *L. reclusa* quickly attacks prey, retreats, and returns to consume prey at its convenience. Brown recluse spiders eat a wide variety of insect and arthropod prey. Sandidge (2003) revealed that *L. reclusa* exhibits a clear preference for dead prey over live prey. These spiders actively fed on fresh killed prey, prey killed several months prior, prey killed with insecticides, and prey killed days before by other *L. reclusa*.

Brown recluse spiders have poor eyesight and quite fragile morphology. Many spiders are injured, often resulting in the loss of a leg, or killed during prey capture. This is of importance because *L. reclusa* is unable to regenerate limbs during subsequent molts. Though fragile, brown recluse spiders are incredibly hardy and can survive long periods without food or water. It is common for brown recluse spiders captured on sticky insect traps to live several months. In addition, specimens housed in 12x17x6 cm plastic boxes have lived up to ten months without food or water and in 8 oz airtight plastic containers six months without food, water, or air (Sandidge, unpub. data).

In laboratory observations by Hite et al. (1966), the average lifespan for male spiders was 543 days, and female spiders 627 days. One female spider survived for 894 days, and a single male survived 796 days (Hite et al. 1966). Longevity studies by Elzinga (1977) were performed in a more controlled, temperature-regulated environment than Hite (1966) in order to simulate stable temperature conditions in homes. Elzinga (1977) showed that under lower and more stable temperatures spiders survived significantly longer than conditions described in Hite (1966). The average lifespan for male spiders in Elzinga (1977) was 646 days and females 794 days. One male spider survived for 897 days, and 25% of females lasted more than 1000 days. One female lived 1755 days and another 1434 days.

Pest management

The ability of brown recluse spiders to survive long periods without food or water, their reclusive nature, their large population numbers, their extended lifespan in temperature-regulated environments, their opportunistic predatory behaviors, and their preference for scavenging help explain why these spiders can endure harsh conditions for extended periods of time in urban habitats. These characteristics of brown recluse spiders make pest management and eradication from human habitats difficult. Few studies have been conducted to test the killing efficacy of chemicals on brown recluse spiders. In the past, pest management professionals have used various fumigants and aerosol sprays to combat these spiders. Wingo (1964) reported that a mixture of 2% DDT and 2% chlordane was used to combat brown recluse spiders with decent success in the late 1950's and early 1960's. Wingo also found that an application of 0.06% lindane, which was found to have an LD_{50} of 85 µg/g (typo in original paper), applied to infested areas of the home and outbuildings gave adequate control of brown recluse spiders (Wingo 1964).

Hite et al. (1966) examined the killing efficacy of topical applications of 13 chemicals. General chemical 3707 (LD_{50} = 3.9 µg/g) was the most toxic of these chemicals, followed by lindane (LD_{50} = 13.2 µg/g), trithion (LD_{50} = 19.0 µg/g), diazinon (LD_{50} = 34.0 µg/g), entex (LD_{50} = 64.0 µg/g), heptachlor (LD_{50} = 74.0 µg/g), chlordane (LD_{50} = 93.0 µg/g), pyrethrum (LD_{50} = 104.0 µg/g), malathion (LD_{50} = 109.0 µg/g), bayer 39007 (LD_{50} = 128.0 µg/g), tedion (LD_{50} = 403.0 µg/g), DDT (LD_{50} = 2716.0 µg/g) and sevin (LD_{50} = 6192.0 µg/g). Hite et al. (1966) indicated that lindane was the chemical of choice.

Studies by Norment and Pate (1968) examined the residual activity of diazinon and lindane for control of brown recluse spiders. Their studies showed that lindane gave effective control up to one week at a 1% concentration and was more effective than diazinon at killing these spiders. As new pesticides became available, Gladney and Dawkins (1972) performed toxicity trials applying aqueous solutions of resmethrin, dichlorvos, methoxychlor and ronnel to the cephalothorax of spiders. Resmethrin had an LD_{50} of 14.2 µg/g that was comparable to lindane at 13.2 µg/g. However, dichlorvos

was comparatively ineffective. Methoxychlor and ronnel did not cause mortality even at extremely high dosages. Gladney and Dawkins (1972) also tested the toxicity of resmethrin by spraying a 0.25% aqueous solution directly on spiders and the toxicity of dichlorvos by placing 20% dichlorvos impregnated plastic strips (No-Pest Strips®) into exposure cells. The aqueous resmethrin solution killed 100% of male spiders (N=15) and 73.3% of females (N=11). Dichlorvos strips had no effect on the spiders. In this study, it was deemed necessary to apply chemicals directly to the exoskeleton to kill spiders.

Conclusions of available pesticide trials and the actual records of chemicals used in routine pesticide applications are extremely contradictive. Although Wingo (1964) stated that a 2% DDT and 2% chlordane mix was quite effective, it should be noted that the LD_{50} of DDT in tests by Hite et al. (1966) was 2716 µg/g and that of chlordane was 93 µg/g. Trials by Hite et al. (1966) showed that during the mass eradication efforts in the 1960's, DDT (which the EPA lists as oncogenic) was undoubtedly an ineffective control agent due to the extremely high lethal dosage necessary for killing efficacy. In addition, comments by Dr. Howell from Oklahoma State University listed in a technical release from the National Pest Control Association states that DDVP sprays (dichlorvos, Vapona Vaponite®) are "*very effective for the control of the brown recluse spider*" (Anonymous, 1964). However, Gladney and Dawkins (1972) stated that dichlorvos was ineffective in topical applications and in impregnated plastic strips. The EPA also lists dichlorvos as a probable human carcinogen.

Many of the chemicals used in studies during the 1960's and 1970's involved chemicals that are currently restricted, severely restricted, or banned in the United States. In the past, brown recluse spider management has included the haphazard use of chemicals without prior knowledge that these chemicals would actually kill spiders effectively or efficiently. Many of the common chemicals used in the 1950's–1980's were not effective, but were used routinely and often excessively.

Future of integrated pest management (IPM)

Currently, there are no general or standard treatments found to be effective against brown recluse spiders. An effective plan should involve five steps.

1. A preliminary search for spiders that should be conducted between 8:00 p.m. and 9:00 a.m. This search should be a thorough and comprehensive look at the spider's behavior and favorite hiding places in the house. It should also include a search for eggsacs, webbing and hiding spiders. One major problem with brown recluse management is finding where spiders reside and where they retreat when pest applications are performed. A second problem is how to access and treat many of these areas.

2. Sticky insect monitoring traps should be placed during the preliminary search to detect spider travel routes, invasion points into the house and access areas into and out of different rooms. Traps should be placed every 2.8-3.7 m^2 (30–40 ft^2) in potential hotspots.

3. Revisit the home after several days to examine the contents of all traps. One author (J.S.) suggests revisiting the home after 5–7 days, but no less than 4 days. If spiders are not found, reposition traps and revisit the home in one week. Determine the sex of each spider and count the number of spiders captured to estimate population size. Next, look at the age structure of the captured spiders—older adults, juveniles, or spiderlings. Pay close attention to the direction of travel, including the position and orientation of the spider on the traps. Next, look at the

other insects and arthropods on the traps to determine if they are primarily indoor pests (silverfish, termites, flies, cockroaches, etc.) or primarily outdoor prey (crickets, moths, grasshoppers, leafhoppers, etc.) that have somehow found their way inside the home. If prey can enter houses, spiders can also enter and leave freely and structural changes (mechanical exclusion) may be necessary to correct the problem.

4. Devise an approach to control each specific population. The age, size, sex, and condition of spiders will be a guide in later pesticide application.

5. Because males travel more frequently and are more aggressive, areas with a large number of males put the homeowner at a greater risk of spider bite (Sandidge, unpub. data). Treat these areas for traversing spiders using sticky insect monitoring traps and low toxicity chemicals with high residuals and/or products that cause mechanical injury. Males are highly active throughout the summer and are more likely to contact and therefore be killed by aqueous applications, dusts, or crack and crevice products. Areas containing a large number of females are more likely to provide the optimal environmental conditions and low disturbance necessary for egg and spiderling development. Treat these areas with aqueous sprays for a fast knockdown, and consider fumigation or fogging for heavy infestations.

Many chemicals may not kill the spider, but will disrupt the nervous system and other bodily functions, causing the spiders to be extremely agitated and aggressive. Spiderlings (newly hatched spiders) stay close to their mother for the first few weeks of life (Hite 1966). Spiderlings are extremely susceptible to aqueous chemicals, but sprays must directly contact the spiders. Aqueous sprays at a normal concentration can be used to kill spiderlings in these areas. However, spraying the spiderlings with water lacking chemicals will kill them, so there is no need for heavy chemical applications. Compounds with mechanical killing action or granules will have little or no effect on these small spiders, since the particles are simply too large. Spiderlings are not present year-round. If applications are performed June–August, eggsacs may be present. Eggs and eggsacs are not susceptible to pesticide treatments, so they must be located and removed. Juvenile spiders are found in large numbers throughout the house at certain times of the year. If a large concentration of juveniles is found, continue to use sticky traps in the area, and treat with dusts or powders. Dusts are highly effective in high traffic areas. Although these general tips should help develop population management strategies, each plan must be as unique as the house in which it will be implemented.

Each management plan must involve several control methods such as sticky insect traps that take advantage of the spider's natural behavior of walking along walls and moldings, as well as powder-like pesticides or dusts placed in access areas and in all accessible cracks and crevices. These compounds must be applied in such a way that chemicals touch vulnerable parts of the spider's anatomy such as the cephalothorax or the abdomen. Chemicals should also be limited to access and habitation areas to reduce the chances of human/pesticide interactions. Brown recluse spiders usually have one to two main areas of the house where eggsacs are deposited and spiderlings develop. These areas must be located and treated for current problems while developing a more long-term plan that uses methods such as physical barriers to prevent re-invasion, long-lasting pest products using chemical or mechanical killing properties, and changes in human behavior to make environments less hospitable to brown recluse spiders.

Biological control

Sandidge (2004) investigated the potential biological control of *L. reclusa* using the natural arachnid fauna of most homes. Three common web-building cosmopolitan spiders, *Achaearanea tepidariorum* (C.I. Koch 1841), *Steatoda triangulosa* (Walckenaer 1802) (Theridiidae) and *Pholcus phalangioides* (Fuesslin 1775)(Pholcidae) all readily feed on brown recluse spiders and are deemed beneficial in the control of populations. These spiders are also relatively harmless to humans. Therefore, management plans should effectively kill brown recluse spiders while leaving the existing spider communities intact (Sandidge 2004).

Conclusions

Brown recluse spider population control has proven challenging, and pest management strategies are often contradictive. Pest treatments for brown recluse spiders must be thorough and directed specifically to this pest. The killing efficacy of pesticides should be evaluated before use to reduce human exposure to toxins and increase the chances of adequate population control. In addition to chemical control methods, the search for an effective management plan for brown recluse spider population control should include aspects of biology and behavior, and incorporate the preferences and the requirements of these spiders in homes.

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