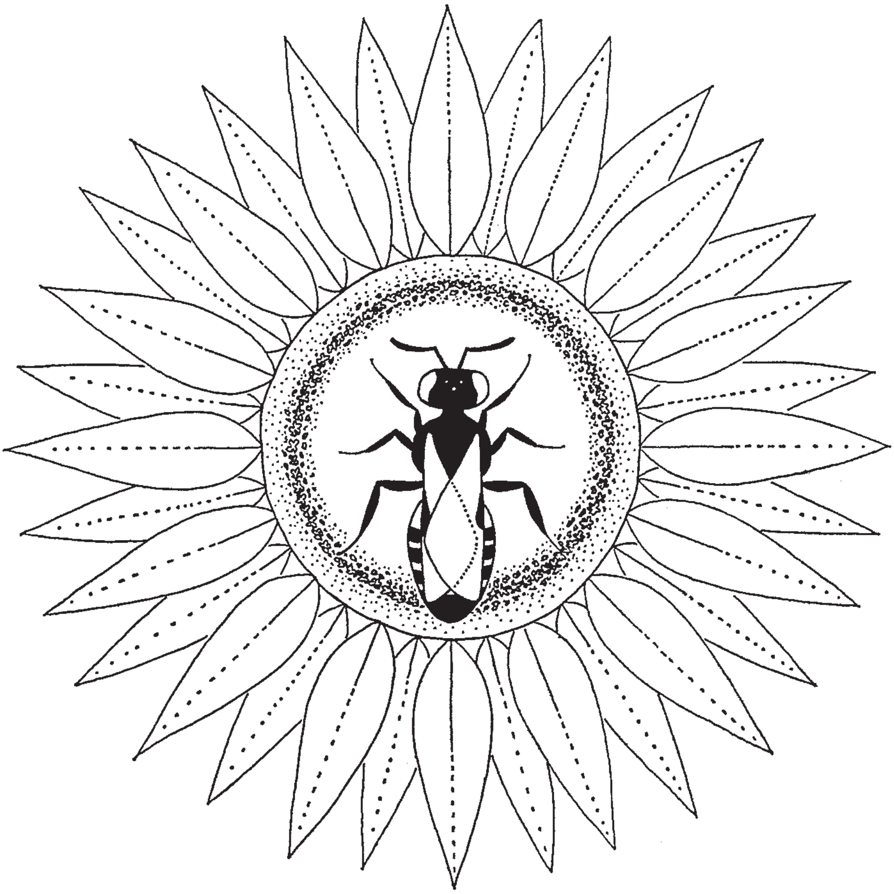
JKES

Journal of the Kansas Entomological Society
(Central States Entomological Society)



Periodicity of Molting and Resumption of Post-Molt Feeding in the Brown Recluse Spider *Loxosceles reclusa* (Araneae: Sicariidae)

Richard S. Vetter and Michael K. Rust
Department of Entomology, University of California, Riverside, CA 92521

JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY
83(4), 2010, pp. 306–312

Periodicity of Molting and Resumption of Post-Molt Feeding in the Brown Recluse Spider *Loxosceles reclusa* (Araneae: Sicariidae)

RICHARD S. VETTER AND MICHAEL K. RUST
Department of Entomology, University of California, Riverside, CA 92521

ABSTRACT: The periodicity of molting and resumption of feeding after molting was investigated in the brown recluse spider, *Loxosceles reclusa* Gertsch and Mulaik (Sicariidae). Spiders molted almost every hour of the day but there was a tendency to molt more frequently between 8 A.M. and 1 A.M. Spiderlings resumed feeding after 20 hrs post-molt with feeding occuring more frequently around the 43rd hour and well-established after 48 hrs.

KEY WORDS: Arachnida, ecdysis, life history, periodicity

The brown recluse spider, *Loxosceles reclusa* Gertsch and Mulaik (Sicariidae), is one of the best known spiders in North America, being familiar outside of the arachnological world due to its ability to cause necrotic skin lesions and the propensity of humans to exaggerate this capability. Even though the toxicological aspects of its venom and the medical consequences that ensue are well researched, there is comparatively little information regarding aspects of its life history.

Molting in arthropods is a period of extreme change. In spiders, a few days before molting, the legs darken as new setae become evident under the old cuticle (Peck and Whitcomb, 1970; Foelix, 1996) so the onset of molting is obvious. Feeding ceases and does not resume until some degree of exoskeletal hardening occurs. Molting can consume a significant amount of energy. In six spider species studied by Célérier (1986) (theraphosid, four lycosids, ctenid), exuvia production represented 5 to 16% of the growth production for the entire post-embryonic development .

Various developmental life history traits in *Loxosceles* spiders have been documented. The length of individual instars, time from egg to maturity, and overall longevity have been rigorously investigated for *L. reclusa* (Hite *et al.*, 1966; Horner and Stewart, 1967), *L. laeta* (Nicolet) (Galiano, 1967), *L. gaucho* Gertsch (Rinaldi *et al.*, 1997), *L. hirsuta* Mello-Leitão (Fischer and da Silva, 2001) and *L. intermedia* Mello-Leitão (Fischer and Vasconcellos-Neto, 2005). However, other aspects, such as molting periodicity and resumption of feeding post-molt in *Loxosceles* spiders, have not been researched to our knowledge and, hence, we present our research herein.

Materials and Methods

The colony of immature brown recluse spiders was started from egg sacs from females collected in Lenexa, Kansas and Russellville, Arkansas. During non-experimental periods, early-instar spiderlings were fed early-instar German cockroaches, *Blattella germanica* L., and western subterranean termites, *Reticulitermes hesperus* Banks. Cockroaches were fed water and chunks of dry dog food;

Accepted 11 August 2010; Revised 6 October 2010

termites were reared on damp brown paper towels in plastic boxes. During the 2nd and 3rd instars, spiderlings were communally maintained in a plastic 4-liter jar with crumpled paper towels, which provided a plethora of hiding places. Insect prey was added to the jar at sporadic intervals. As long as *Loxosceles* spiderlings have sufficient prey, siblings of disparately different sizes coexist peaceably with no noticeable cannibalism (Vetter and Rust, 2008).

Spiders were later separated and housed individually in clear plastic vials (12 to 40 dram), the size of which was chosen as appropriate to the size of the spider. A piece of paper toweling was placed such that it covered half of the inner circumference of the vial. This allowed each spider to deposit silk which trapped prey and also provided a purchase for molting. The spiders were maintained in the Level 3 area of the Quarantine facility on the University of California-Riverside campus, in a room with a west-facing window covered with unwaxed brown paper; the spiders were exposed to a natural light cycle. The quarantine facility is situated at 33°58′N latitude and receives a 15:9 L:D cycle at summer solstice. Temperature in the room ranged from 21° to 27°C, increasing during the afternoon. Spiders were maintained in subdued lighting portions of the room when not being fed or otherwise handled. Spiders were removed from this room for the experiments, which were conducted in August and September where sunrise and sunset were approximately 6 A.M. and 8 P.M., respectively, on August 1st and 6:45 A.M. and 6:35 P.M., respectively, on September 30th.

Periodicity of Molting

Spiders ($N = 73$) were checked daily. Those with blackened legs were checked for molting at least every 2 to 3 hrs throughout a 24-hour period for 5 wks. An hour or two prior to the active molting process, brown recluse spiders assume a characteristic splay-leg molting position (Fig. 1). When this was observed, splay-legged spiders were checked every hour at the top of each hour until the spider molted. Initial observation suggested that spiders molted almost exclusively between 6 A.M. and midnight. However, after a few were found molting during the night during random checks, they were checked visually every 90 min to 2 hrs throughout the 24-hour period on nights when observations were possible through an entire day. At night, spiders were checked with a flashlight with the lens covered with several layers of red cellophane and the light blocked by fingers such that only the minimum amount of light was used. On the few days in the 5-week observation period where 2-hour checks were not possible for 24 continuous hours, data were excluded for any spiders that molted, with the 24-hour period starting at 6 A.M. Because a brown recluse requires about 2 hrs between assuming the molting position and undergoing molting, it was possible to accurately determine which hour of the day or night molting took place by checking at least every 2 hrs on the hour. For 71 of 73 spiderlings, the hour of molting was either observed or could assuredly be determined. In one nocturnal instance, two spiders molted during a 3-hour period when the hour could not be definitively determined but an estimated guess could assign it to an hour of high probability of occurrence; these two were presented in Fig. 2 as "approximated". This experiment was run in the first author's home; spiders received subdued lighting throughout the day and darkness during the night.

The distribution of times when spiders molted was grouped in pairs of 12-hour duration, giving 12 separate pairs of comparisons. Each pair of 12-hour periods was

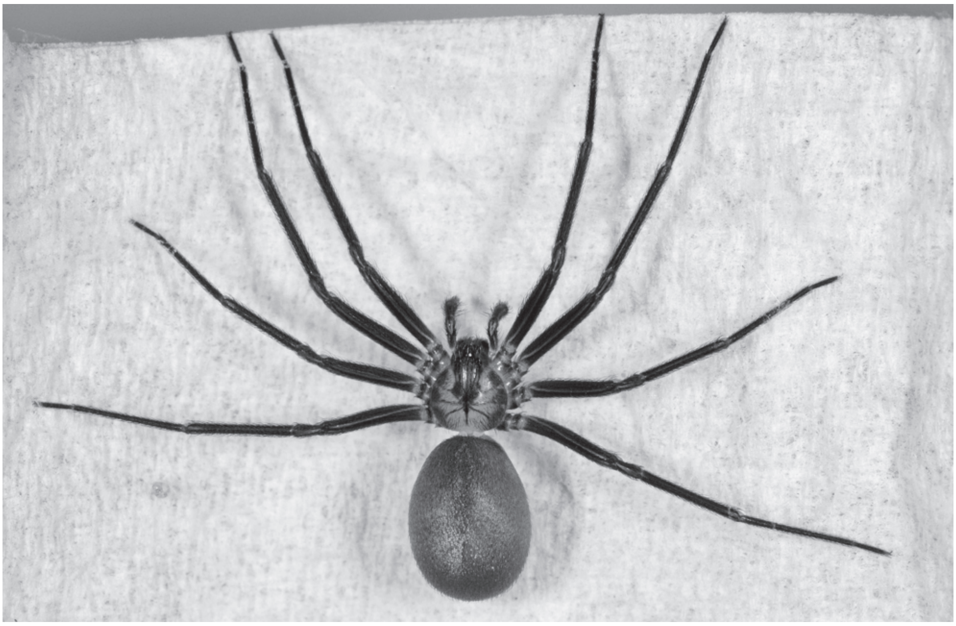


Fig. 1. Splay-leg position of a brown recluse spider, *Loxosceles reclusa*, 1 to 2 hrs prior to molting.

analyzed with a X^2 distribution test (Sokal and Rohlf, 1995). For example, numbers of moltings during the period of 8 A.M. to 7 P.M. were compared to 8 P.M. to 7 A.M. Then comparisons were made between 9 A.M. to 8 P.M. and 9 P.M. to 8 A.M. and so forth. After statistics were run on all 12 comparisons, those with significant differences would indicate if there was a periodicity.

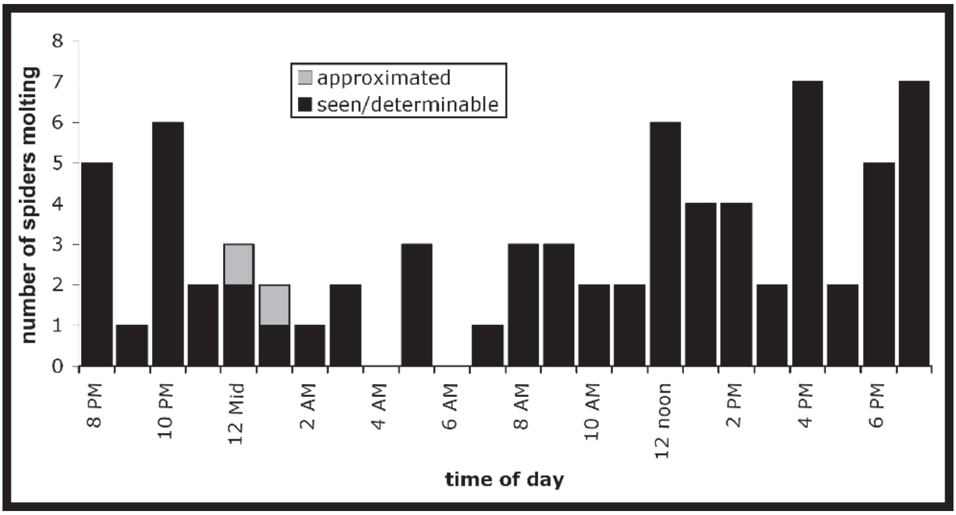


Fig. 2. The periodicity of molting for brown recluse spiders ($N = 73$).

Resumption of Feeding after Molting

Throughout this study, when a spider was seen in the act of molting, the hour of the day was recorded for each spider. Individual spiders ($N = 133$), from 12 to 60 hrs post-molt, were offered a small German cockroach about 50% to 75% of the spider's body length, placed on its back or forcibly thrown into the silk so that the roach struggled and could not escape. We tested one spider for each hour from 12 to 18 hrs post-molt and three spiders for each hour between 19 and 60 hrs. This time period was chosen because in preliminary tests, spiders fed at 44, 58, and 83 hrs post-molt; therefore, by 60 hrs, we felt feeding would have resumed in most of the spiderlings. After the post-molt cockroach offering, spiders were checked several times during the next 30 min to determine if they were feeding or to reposition the cockroach if it extracted itself from the silk. In normal behavior in the lab, feeding-capable brown recluse spiders typically attack and bite prey immediately and feed within minutes of contact. Recluses feed continuously for many hours after subduing a prey item so this behavior is not likely to be missed with 15 min checks.

All spiders were fed in the lab under normal day illumination from fluorescent lights, which did not appear to inhibit behavior. Temperature was maintained approximately at a consistent 25°C.

Voucher Specimens

Voucher specimens will be deposited at the University of California Riverside Entomology Research Museum.

Results

Periodicity of Molting

Brown recluse spiders molted almost every hour of the day (Fig. 2). Significantly more brown recluses molted during 12-hour periods starting at 8 A.M. ($X^2 = 6.04$), 9 A.M. ($X^2 = 8.56$), 10 A.M. ($X^2 = 6.04$), 11 A.M. ($X^2 = 11.52$), noon ($X^2 = 11.52$), 1 P.M. ($X^2 = 7.25$) and 2 P.M. ($X^2 = 4.95$) (d.f. = 1, $P < 0.05$ for all comparisons) than their complementary period. The remaining five comparisons were not significantly different.

Resumption of Feeding after Molting

When given 30 min to feed on a cockroach, spiders first resumed feeding after 22 hrs post-molt (Fig. 3) and fed more frequently than not after 43 hrs. In the earliest instance, a spider that was offered a cockroach 19 hrs after molting did not feed within the 30-min observation period but was observed feeding during the 20th hour. Although some of the spiders readily attacked the cockroach in typical fashion, often times, they sat passively while the prey struggled only a few millimeters away. The struggling prey in the silk caused involuntarily movements of the spider's legs so the spider could not have been unaware of the prey presence. Typically, cockroaches struggled at some point of the 30-minute observation period such that a spider that was capable of feeding should have responded. Occasionally spiders that ended up not feeding at the end of 30 min were observed during this period to approach and presumably bite prey, however, the spiders would then move away from the cockroaches and show no further apparent interest. Random observation hours later often showed that they relocated the prey and were feeding.

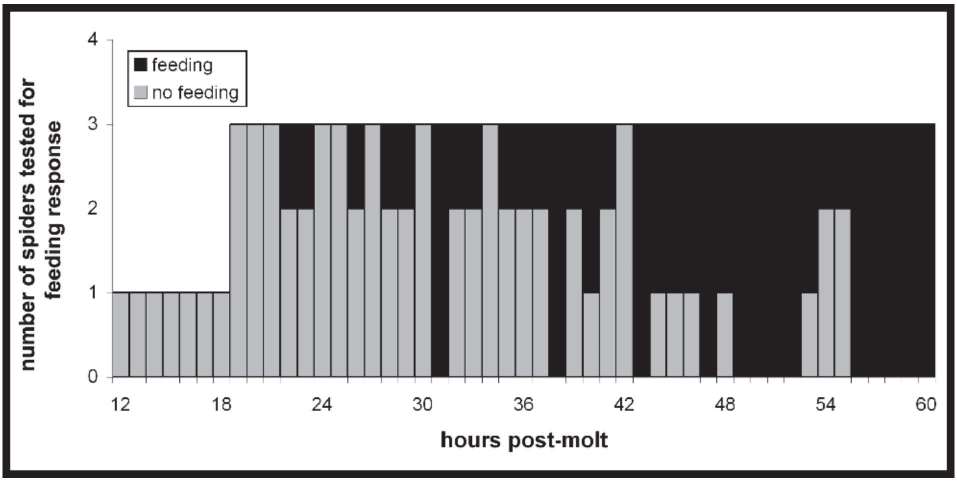


Fig. 3. The number of hours after molting when brown recluses started feeding during a 30-min observation period ($N = 133$).

General Comment

In our study, throughout the entire process of rearing the cohorts of 160+ brown recluses from egg sacs through multiple molts, only one spider died from having its legs trapped inside the exuvia and no legs were lost in spiders that successfully extracted themselves from the old exoskeleton.

Discussion

Hite *et al.* (1966) presented a detailed description of the active process of ecdysis in brown recluse spiders. Horner and Stewart (1967) remark that *L. reclusa* maintained at 15°C do not molt. In this study, we demonstrate that periodicity of *L. reclusa* molting in the lab is not restricted to a specific portion of the day and that some spiderlings start feeding again after 20 hrs although there is variation of feeding resumption. By the 48 hr period post-molt, most brown recluses are feeding again.

We were somewhat surprised by the lack of sharp periodicity in molting (Fig. 2). *Loxosceles* spiders are nocturnal so it was expected that they would molt predominately during the diurnal inactivity period. Instead, they had a tendency to molt more frequently between 8 A.M. and 1 A.M. than the remaining period of the night and early morning. Although spiders were kept in subdued light during the day, this should have closely mimicked light levels where they are found (under rocks, in garages, basement, and attics) rather than exposure to bright light.

The resumption of feeding did not occur uniformly for the spiders but became more likely after the 43rd hour mark (Fig. 3). Some brown recluses attacked vigorously and fed after 24 hrs post-molt but others tested after 40 hrs were quite indifferent to the struggling prey. We had expected to see a more distinct onset of feeding. However, the lack of feeding in the later hours could have been influenced by the degree of struggling of the entrapped cockroach as some stayed motionless for long periods.

Occasionally, a spider was seen attempting to bite a cockroach, however, the spider then moved away and showed little interest. Possibly the fangs were not yet

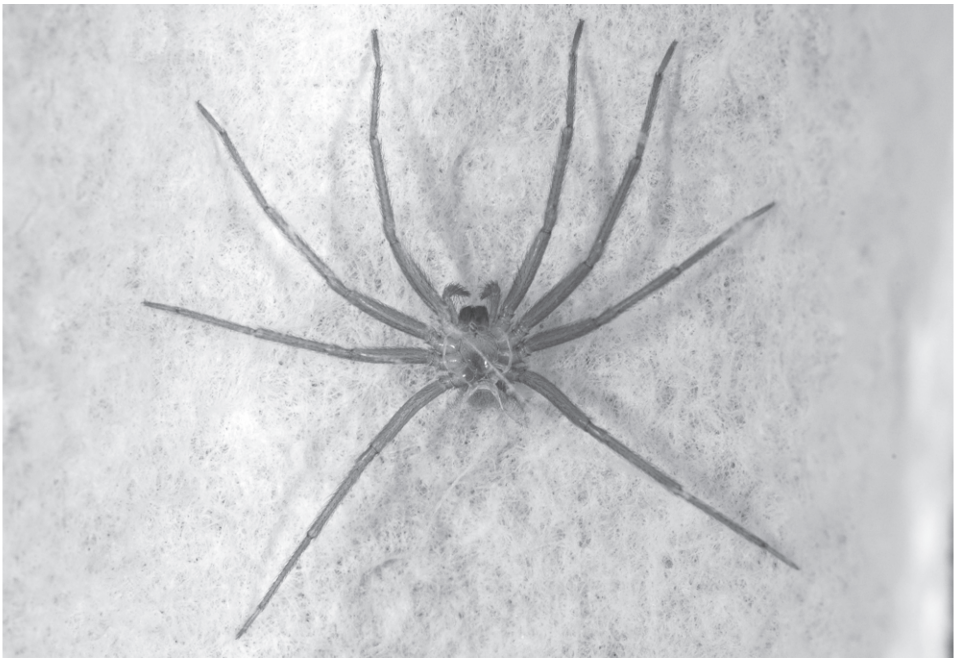


Fig. 4. Shed skin of the brown recluse spider with the exuvia left behind, showing that the legs retain their outstretched position. Not all shed skins are this symmetrical. This is a diagnostic remnant sign of *Loxosceles* presence and can be useful to determine a historical *Loxosceles* infestation even in the absence of actual spiders.

sufficiently sclerotized to effect a viable envenomation at which point, the spider retreated and waited for a later time when it was capable of feeding. However, there was a decided timidity on the part of recently molted brown recluse spiders in comparison to spiderlings that were further past molting; the latter exhibited the typical immediate biting and feeding behavior seen in routine feeding episodes.

The process of molting is considered to be an act with high source of mortality for the salticid *Phidippus johnsoni* (Jackson, 1978) and the uloborid *Octonoba octonarius* (=*O. sinensis* Simon 1890) (Peaslee and Peck, 1983). Likewise, when *L. reclusa* spiderlings were maintained at natural winter temperatures, most did not survive the first post-winter molt (Horner and Stewart, 1967). Deevey (1949) reports that of 166 *Latrodectus* spiderlings that died in the course of her experiment, about half died during the molting process. Half of these died from incomplete molting (mostly in the early instars) and the other half being eaten by mealworm prey in the vial when the spider was defenseless (mostly the later instars); this points out the risks involved in molting from both endogenous and exogenous sources. However, in a laboratory study involving *Loxosceles intermedia*, Fischer & Vasconcellos-Neto (2005) remark that mortality associated with molting was low, similar to this study.

Finally, the characteristic appearance of the leg-splayed exuvia (Fig. 4) that is left behind can be a diagnostic indication of a *Loxosceles* infestation within a structure in the absence of actual spiders. We are not aware of any other North American spider that molts against a flat surface and leaves a shed skin that does not shrivel from its molting posture after molting. This could be very useful evidence to determine the presence of *Loxosceles* spiders in a structure as well as an estimate of the size of the infestation. Although this aspect is well-known to people who have experience with *Loxosceles* spiders, for those outside endemic areas, this information could have significance in the pest control industry and in litigation cases in determining if *Loxosceles* spiders are or have been present in a building of interest.

Acknowledgements

We thank Diane and Brenna Barger for supplying the batch of brown recluse spiders from Kansas from which egg sacs were laid. We thank Imad Bayoun and Serguei Triapitsyn for permitting use of the quarantine facility at the University of California-Riverside for housing the spiders. Lucio Rodriguez assisted in data collection. The study was in part supported by a grant from Corky's Pest Control Company in San Diego.

Literature Cited

Célérier, M. L. 1986. Energy cost of exuviae production of spiders. Bulletin of the British Arachnological Society 7:77–82.

Deevey, G. B. 1949. The developmental history of *Latrodectus mactans* (Fabr.) at different rates of feeding. American Midland Naturalist 42:189–219.

Fischer, M. L., and E. M. da Silva. 2001. Oviposição e desenvolimento de *Loxosceles hirsuta* Mello-Leitão, 1931 (Araneae; Sicariidae). Estudos de Biologia Curitiba 47:15–20.

Fischer, M. L., and J. Vasconcellos-Neto. 2005. Development and life tables of *Loxosceles intermedia* Mello-Leitão 1934 (Araneae, Sicariidae). Journal of Arachnology 33:758–766.

Foelix, R. F. 1996. Biology of Spiders. 2nd ed. Oxford University Press, New York, New York. 330 pp.

Galiano, M. E. 1967. Ciclo biologico y desarrollo de *Loxosceles laeta* (Nicolet, 1849) (Araneae, Scytodidae). Acta Zoologica Lilloana 23:431–464.

Hite, J. M., W. J. Gladney, J. L. Lancaster, and W. H. Whitcomb. 1966. The biology of the brown recluse spider. University of Arkansas, Fayetteville. Agricultural Experiment Station Bulletin #711, 26 pp.

Horner, N. V., and K. W. Stewart. 1967. Life history of the brown spider, *Loxosceles reclusa* Gertsch and Mulaik. Texas Journal of Science 19:334–347.

Jackson, R. R. 1978. The life history of *Phidippus johnsoni* (Araneae: Salticidae). Journal of Arachnology 6:1–29.

Peaslee, J. E., and W. B. Peck. 1983. The biology of *Octonoba octonarius* (Muma) (Araneae, Uloboridae). Journal of Arachnology 11:51–67.

Peck, W. B., and W. H. Whitcomb. 1970. Studies on the biology of a spider, *Chiracanthium inclusum* (Hentz). University of Arkansas Agricultural Experiment Station Bulletin #753, 76 pp.

Rinaldi, I. M. P., L. C. Forti, and A. A. Stropa. 1997. On the development of the brown spider *Loxosceles gaucho* Gertsch (Araneae, Sicariidae): the nympho-imaginal period. Revista Brasileira de Zoologia 14:697–706.

Sokal, R. R., and F. J. Rohlf. 1995. Biometry. 3rd ed. W. H. Freeman and Co., New York, New York. xix + 887 pp.

Vetter, R. S., and M. K. Rust. 2008. Refugia preferences by the spiders *Loxosceles reclusa* and *Loxosceles laeta* (Araneae: Sicariidae). Journal of Medical Entomology 45:36–41.