

RESEARCH

Open Access

First report of brown widow spider sightings in Peninsular Malaysia and notes on its global distribution

Mustakiza Muslimin¹, John-James Wilson^{2,3}, Amir-Ridhwan M Ghazali¹, Kamil A Braima¹, John Jeffery¹, Fitri Wan-Nor⁴, Mohamed E Alaa-Eldin⁵, Siti-Waheeda Mohd-Zin¹, Wan S Wan-Yusoff¹, Yusoff Norma-Rashid², Yee L Lau¹, Mahmud Rohela¹ and Noraishah M Abdul-Aziz^{1*}

Abstract

Background: The brown widow spider (*Latrodectus geometricus* Koch, 1841) has colonised many parts of the world from its continent of origin, Africa. By at least 1841, the species had successfully established populations in South America and has more recently expanded its range to the southern states of North America. This highly adaptable spider has been far more successful in finding its niche around the world than its famous cousins, the black widow, *Latrodectus mactans*, found in the south-eastern states of North America, and the red-back, *Latrodectus hasselti*, found mostly in Australia, New Zealand and Japan.

Methods: We performed an extensive web search of brown widow sightings and mapped the location of each sighting using ArcGIS. Specimens reputedly of the species *L. geometricus* were collected at three localities in Peninsular Malaysia. The spiders were identified and documented based on an examination of morphological characteristics and DNA barcoding.

Results: The spiders found in Peninsular Malaysia were confirmed to be *Latrodectus geometricus* based on their morphological characteristics and DNA barcodes. We recorded 354 sightings of the brown widow in 58 countries, including Peninsular Malaysia.

Conclusion: Reports from the Americas and the Far East suggest a global-wide invasion of the brown widow spider. Herein we report the arrival of the brown widow spider in Peninsular Malaysia and provide notes on the identification of the species and its recently expanded range.

Keywords: *Latrodectus geometricus*, Brown widow spider, Colonization, DNA barcoding, Envenomation, Global invasion, Invasive species, Medically important arthropods, Synanthropy

Background

The widow spiders comprise 30 species in the genus *Latrodectus* Walckenaer, 1805 [1]. They earned the name “widow” because the female eats the male after mating. However, this behavior has been only conclusively documented for one species, the red-back spider (*L. hasselti* Thorell, 1870) [2]. Black widow [*L. mactans*, (Fabricius 1775)] envenomation can cause death in humans; however, lethality is less than 1% [3,4]. Human mortality

caused by the red-back spider, native to Australia and New Zealand, has never been reported, perhaps in part because these two countries have an extensive supply of antivenom [5,6]. Human death resulting from envenomation by the lesser-known brown widow (*L. geometricus* Koch, 1841) was reported in Madagascar in 1991. However, the identity of the spider, consequences of delayed medical intervention and the exact details of the case, whose report is in French, remain in question [7]. Furthermore, medical conditions associated with spider bites are often over-diagnosed and misdiagnosed [8]. The brown widow is known by many arachnologists to be nonaggressive and usually bites only when threatened. Like most

* Correspondence: noisha@ummc.edu.my

¹Department of Parasitology, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

Full list of author information is available at the end of the article

widow spiders, it avoids people and prefers the shelter of its protective retreat. If the retreat is disturbed, the spider often jumps from its web to the ground, retracts its legs and plays dead, in a behavior known as thanatosis [9].

Reports from the Americas to the Far East suggest a recent global-wide invasion of the brown widow spider and numerous sightings of brown widows have been reported in Central Asia and the Middle East [10-16]. The Department of Parasitology at the University of Malaya Faculty of Medicine, Kuala Lumpur, is monitoring this invasion and is contacted periodically by concerned local citizens reporting unusual spiders in their homes. These concerns are likely unwarranted since only one single case of a venomous spider (*Lampropelma violaceopedes* Abraham, 1924) biting a human has been reported in Southeast Asia [17]. However, rapid urbanization in East Asia and the region's bustling economic trade and growing population may promote colonization by synanthropic widow spiders as specimens "hitchhike" in containers to densely populated areas [1,18,19]. This paper reports the arrival of the brown widow spider in Peninsular Malaysia and provides notes on the identification of the species and its global distribution.

Methods

Global distribution of *Latrodectus geometricus*

Global records of *L. geometricus* were compiled from the scientific literature and popular media through web searches, together with GPS coordinates obtained directly from the records or inferred as precisely as possible from the stated locations. These records were then mapped using ArcGIS 9.2 [20].

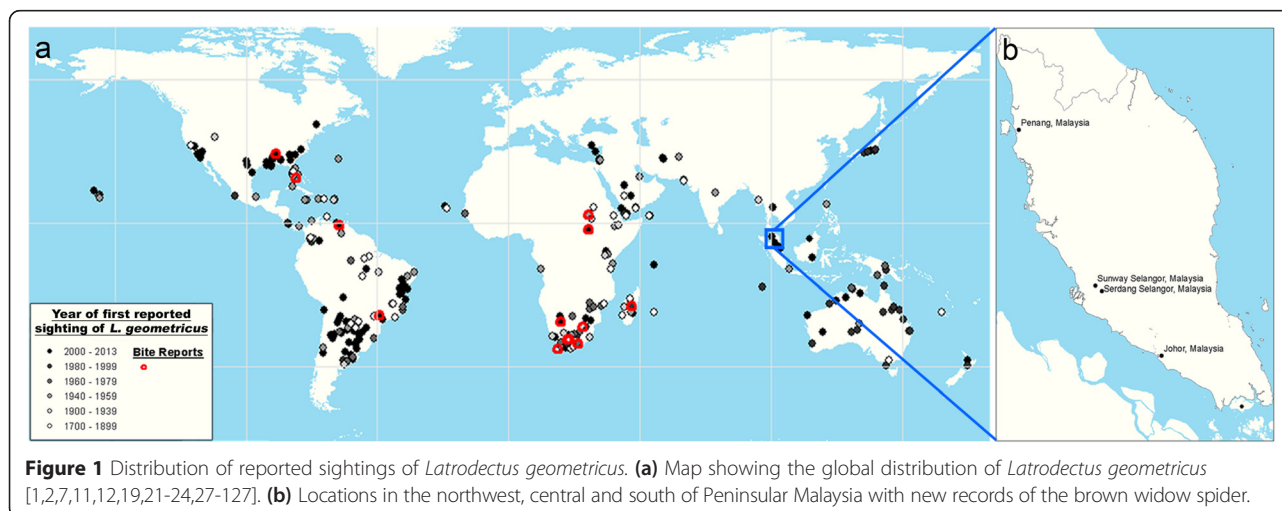
Latrodectus geometricus in Peninsular Malaysia

Acting on calls from the general public, spider specimens reputedly of the species *L. geometricus* were collected at

three localities in Peninsular Malaysia: Penang (5°24'00"N, 100°14'20"E), at a private residence after obtaining permission from the owners; on the roadside, near food stalls in a residential area in Selangor (3°20'N, 101°30'E); and in a private vehicle in Johor (1°29'14"N, 103°46'52"E) after obtaining the permission of the vehicle owner. Permission to collect spiders in Peninsular Malaysia was approved by the Department of Wildlife and National Parks of Peninsular Malaysia, commonly known as PERHILITAN (application number: JPHL&TN(IP): 80-4/2 Jld16).

Spiders were provisionally identified by examining the palps, epigynum, geometrical markings on the underside of the abdomen and spherical spikey off-white egg sacs [21]. As a member of the family Theridiidae, *L. geometricus* has four pairs of eyes positioned in two parallel rows, a comb feet arranged in a comb-like row of bristles on the tarsi of the hind legs, and distinctive paired spermathecae with coiled copulatory ducts [21-24]. Similarly to some other widow spiders, brown widows have a characteristic hourglass-shaped streak on the underside of the abdomen which varies from a pale to dark orange as the spider matures. Females are significantly larger than males (leg length 30-40 mm compared with 16-20 mm in males).

DNA was extracted from whole spiders using a NucleoSpin tissue kit (Macherey-Nagel) following the procedures recommended by the manufacturer. We PCR-amplified the "DNA barcode" fragment of the mitochondrial cytochrome c oxidase subunit I (*COI*) gene (mtDNA) using the primer combination LepF1/LepR1 and standard thermocycling conditions [25]. The PCR product was sequenced in both directions using the PCR primers by a local company (MyTACG Bioscience, Kuala Lumpur). The resulting sequences were edited and combined with all *COI* sequences from *Latrodectus* available on the GenBank and analyzed using the neighbor-joining method and MEGA 6 software [26]. The DNA sequences and



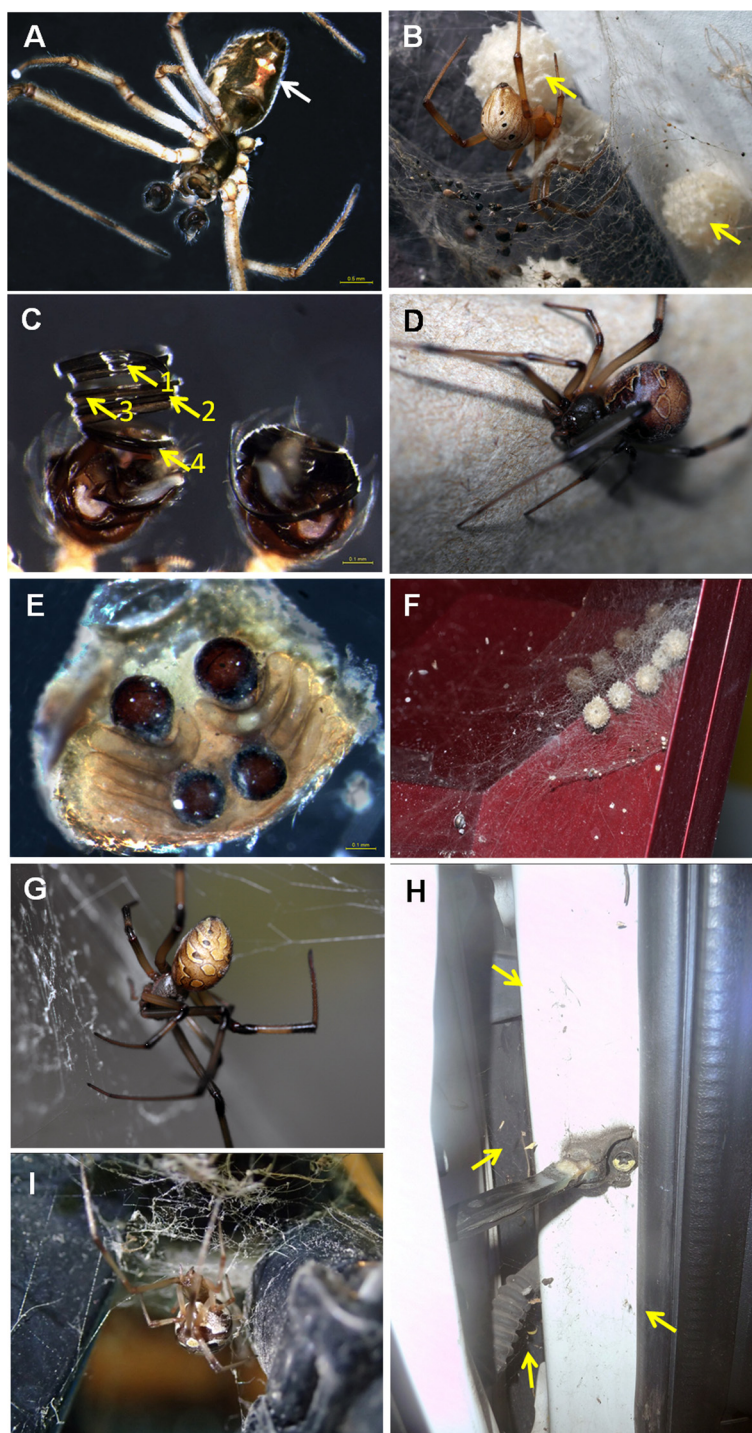


Figure 2 Common morphological characteristics of *Latrodectus geometricus* according to Koch (1841). **(A)** The hourglass-shaped streak on the underside of the abdomen (male, Johor, Malaysia). **(B)** Dome-shaped abdomen typical of a juvenile Theridiidae and the spiky spherical egg sacs (Penang, Malaysia). **(C)** Embolus inside the palp of the male spider showing four coils. **(D)** A brown widow caught in central Peninsular Malaysia bearing darker and more spherical features on its abdomen. **(E)** The epigynum, characteristic of females, with two pairs of spermathecae located on the underside of the abdomen. **(F)** Spiky spherical egg sacs lined in a row on a window sill of a house (Penang, Malaysia). **(G)** The dome-shaped abdomen of a female brown widow from the northwest of Peninsular Malaysia bearing lighter features on its abdomen. **(H)** Egg sacs, moulted skin and live and dead juvenile/adult *L. geometricus* (yellow arrows) being surrounded by its cobweb. **(I)** Dorsal aspect of abdomen with distinct pattern surrounded by cobweb, found in and around bicycle compartment.

associated information about the specimens (photographs, collection date and locality) can be found in the public dataset DS-LATRO on the Barcode of Life Datasystems' (BOLD) website (<http://www.boldsystems.org>), and also on GenBank (<http://www.ncbi.nlm.nih.gov/genbank>; accession numbers: KF227386-KF227396).

Results

We compiled 354 records of *L. geometricus* sightings from 117 sources (Figure 1) and plotted the locations onto a world map (Figure 1). The spiders collected in Penang, Selangor and Johor were confirmed as *L. geometricus* based on an examination of morphological characteristics

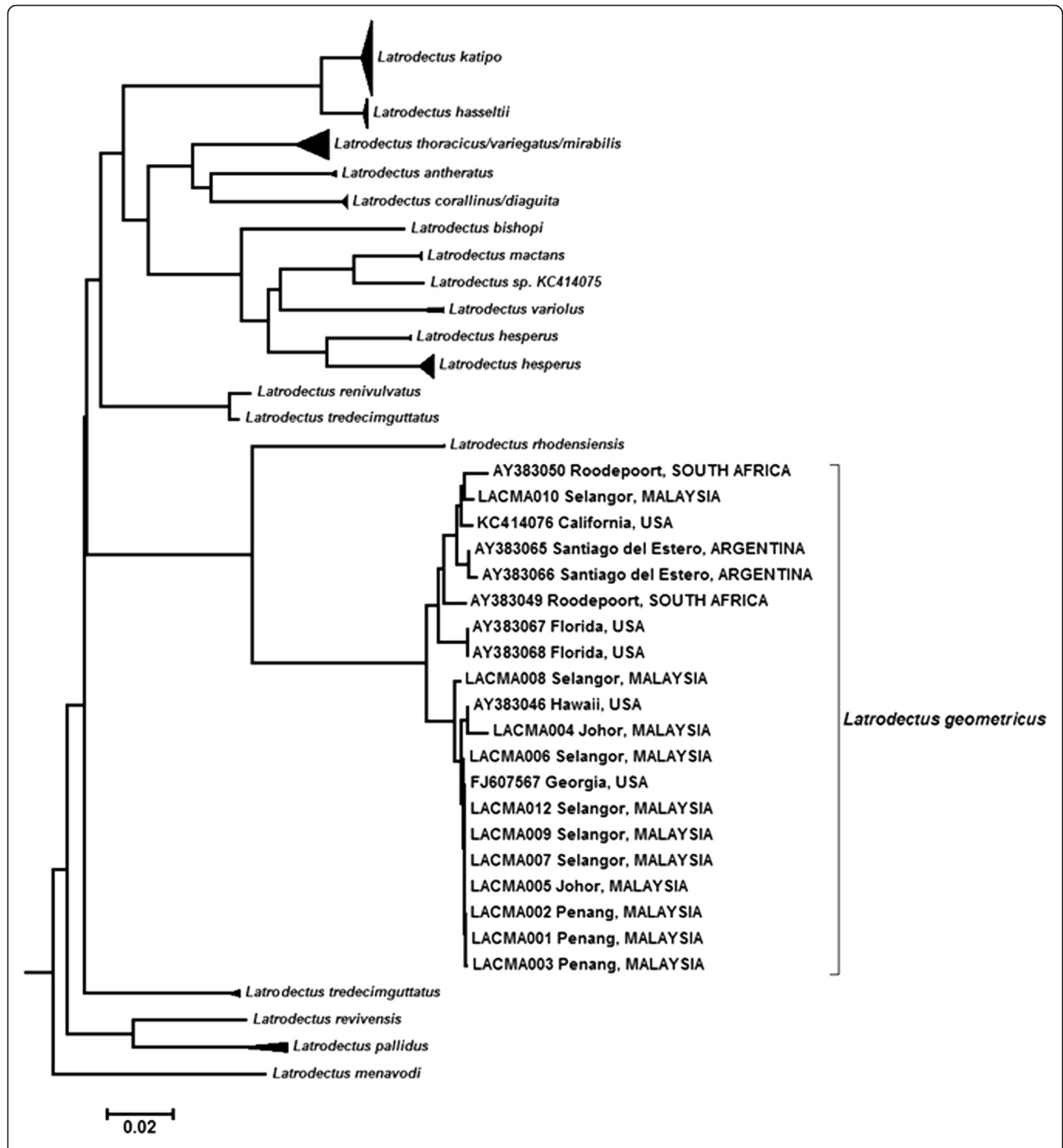


Figure 3 Neighbor-joining tree showing K2P distances between newly sequenced DNA barcodes from spiders collected in Peninsular Malaysia (codes: LACMA00XX) and publicly available sequence data for *Latrodectus geometricus* collected worldwide (GenBank accession numbers by locality).

(Figure 2) and DNA barcoding (Figure 3) and therefore added to the world map.

Discussion

Although the description of this species is based on a specimen collected in Colombia, South America in 1841, *Latrodectus geometricus* is thought to be native to southern Africa and to have gradually expanded its range since the 1800s to cover both tropical and temperate regions of the world (Figure 1) [29]. Sightings of brown widows had already been reported in South America, North America, and the Middle East (Yemen in 1890) before 1900 [28,32,88]. Since then, sightings were reported in Saudi Arabia in 1959, Israel in 1983, Central Asia (Afghanistan in 2008 and Turkey in 2008), Southeast Asia (Indonesia in 1950, the Philippines in 1950 and Singapore in 2006), Japan in 1995, and Australia in 1987 [15,51,52,73,75,80,86,95,107]. Although the presence of the brown widow has yet to be reported in Europe, with the exception of Turkey, the species is extending its range into temperate North America with recent reports from southern US states such as Texas, North Carolina and Mississippi [128].

Although the *L. geometricus* specimens found in Peninsular Malaysia were easily identifiable due to their morphological characteristics, the findings were confirmed using DNA barcoding. The brown widows collected in the northwest (Penang) and south (Johor) of Peninsular Malaysia seemed to be morphologically similar to those reported in port cities in Japan, suggesting that Japan is the source of the infestation [127]. This would not be surprising, given the amount of trade between Japan and these two ports [129]. Penang is an international port, popularly known as the Pearl of the Orient, and therefore we suspect that *L. geometricus* was accidentally imported.

Upon arrival, *L. geometricus* is known to colonize urban areas especially in and around homes and gardens, which is consistent with our observations of brown widow webs and eggs in both well-lit and dark areas around windows, ceilings and car door hinges [1,48,78,130]. Since *Latrodectus geometricus* was reported in Singapore, the proximity of Singapore and Johor suggests that the brown widow collected in Johor may have come from the former, whose population is likely to have originated in Japan [107]. The *L. geometricus* colony from Selangor (central Peninsular Malaysia) appeared to have two different morphotypes. However, no genetic differentiation was found in their DNA barcodes. The first was similar to those found in Penang and Johor, while the second had a spherical abdomen and was more similar to the brown widow reported in India and Brazil [103]. Phylogeographic studies of different gene regions together with searches for *L. geometricus* in other localities may shed some light on these findings. Following recent reports from South and North

America, Peninsular Malaysia is the latest region to be occupied by the global invasion of the brown widow.

Conclusions

The brown widow spider remains a potential concern and should be monitored. Reports from the Americas and the Far East suggest a global-wide invasion of the brown widow spider due to its far-reaching adaptability. The arrival of the brown widow spider in Peninsular Malaysia including identification of the species using both taxonomic and molecular methods was reported. Furthermore, its recently expanded range and its phylogeographic distribution were discussed in view of its impact on humans.

Ethics committee approval

Permission to collect samples was granted by the Department of Wildlife and National Parks, Peninsular Malaysia (PERHILITAN): application number JPHL&TN(IP): 80-4/2 Jld16(24). This consent prohibits the collection of endangered or protected species.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MM and JJW performed the systematic literature review. MM, JJW and NMAA conceived the project and wrote the manuscript with assistance from KAB, JJ, SMZ, WSW, YN, YLL and RM. MM, MGA, FW, KAB performed the fieldwork. MEA, KAB performed the GIS analysis and plotted the coordinates. All authors read and approved the final version of this manuscript.

Acknowledgements

Authors were awarded University of Malaya Research Grants (RG301/11HTM to WSW, and RG509-13HTM to NMAA) and Fundamental Research Grants from the Malaysian Ministry of Higher Education (FP013/2010A to WSW, and FP036/2010A to RM). KAB was supported by the University of Malaya Postgraduate Research Fund (PV052/2012A) and research assistantship High Impact Research Grant (UM.C/625/1/HIR/148/2). JJ was awarded a research assistantship (RG509-13HTM). The funders played no part study design, data collection and analysis, decision to publish, or preparation of the manuscript. The corresponding author, Noraishah Mydin Abdul-Aziz, had full access to all study data and had final responsibility for the decision to submit for publication.

Author details

¹Department of Parasitology, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia. ²Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia. ³Museum of Zoology, Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia. ⁴Faculty of Veterinary Medicine, University Putra Malaysia, Serdang, Selangor, Malaysia. ⁵Department of Civil Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia.

Received: 11 August 2014 Accepted: 27 April 2015

Published online: 09 May 2015

References

- Garb JE, González A, Gillespie RG. The black widow spider genus *Latrodectus* (Araneae: Theridiidae): phylogeny, biogeography, and invasion history. *Mol Phylogenet Evol.* 2004;31(3):1127–42.
- Segoli M, Arieli R, Sierwald P, Harari AR, Lubin Y. Sexual cannibalism in the brown widow spider (*Latrodectus geometricus*). *Ethology.* 2008;114(3):279–86.

3. Gaisford K, Kautz DD. Black widow spider bite: a case study. *Dimens Crit Care Nurs*. 2011;30(2):79–86.
4. Clark RF, Wethern-Kestner S, Vance MV, Gerkin R. Clinical presentation and treatment of black widow spider envenomation: a review of 163 cases. *Ann Emerg Med*. 1992;21(7):782–7.
5. Sutherland SK, Trinca JC. Survey of 2144 cases of red-back spider bites: Australia and New Zealand, 1963–1976. *Med J Aust*. 1978;2(14):620–3.
6. Bonnet MS. The toxicology of the *Latrodectus hasselti* spider—the Australian red back spider. *Br Homoeopath J*. 1999;88(1):2–6.
7. Ramialiharisoa A, de Haro L, Jouglard J, Goffyon M. Latrodectism in Madagascar. *Med Trop (Mars)*. 1994;54(2):127–30.
8. Diaz JH. The global epidemiology, syndromic classification, management, and prevention of spider bites. *Am J Trop Med Hyg*. 2004;71(2):239–50.
9. Vetter RS. Spiders of the genus *Loxosceles* (Araneae, Sicariidae): a review of biological, medical and psychological aspects regarding envenomations. *J Arachnol*. 2008;36(1):150–63.
10. Yoshida T. Distribution of *Latrodectus geometricus* in Japan. *Med Entomol Zool*. 2003;53 Suppl:62. (in Japanese).
11. Vetter RS, Vincent LS, Danielsen DW, Reinker KI, Clarke DE, Itynry AA, et al. The prevalence of brown widow and black widow spiders (Araneae: Theridiidae) in urban southern California. *J Med Entomol*. 2012;49(4):947–51.
12. Simó M, Dias MFR, Jorge C, Castro M, Dias MA, Lorborda A. Habitat, redescription and distribution of *Latrodectus geometricus* in Uruguay (Araneae: Theridiidae). *Biota Neotropica*. 2013;13(1):371–5.
13. Borkan J, Gross E, Lubin Y, Oryan I. An outbreak of venomous spider bites in a citrus grove. *Am J Trop Med Hyg*. 1995;52(3):228–30.
14. Jiang L, Peng L, Chen J, Zhang Y, Xiong X, Liang S. Molecular diversification based on analysis of expressed sequence tags from the venom glands of the Chinese bird spider *Ornithoctonus huwena*. *Toxicon*. 2008;51(8):1479–89.
15. Lamb L, Ross D, Lalloo DG, Green A, Morgan E, Warrell DA. Management of venomous bites and stings in British Military Personnel deployed in Iraq, Afghanistan and Cyprus. *J R Army Med Corps*. 2008;154(Suppl 4):2–40.
16. Schäfer CN, Nissen LR, Kofoed LT, Hansen FØ. A suspected case of systemic envenomation syndrome in a soldier returning from Iraq: implications for Special Forces Operations. *Mil Med*. 2010;175(5):375–8.
17. Lim B, Davie C. The bite of a bird-eating spider *Lempopelma violaceopedes*. *Med J Malaya*. 1970;24(4):311.
18. Luniak M. Symburization - adaptation of animal wildlife to urban development. In: Shaw W, Harris L, Van Druff L, editors. *Proceedings of the 4th International Symposium on Urban Wildlife Conservation*. Tucson, AZ: College of Agriculture and Life Sciences, University of Arizona; 2004. p. 50–5.
19. Brown KS, Necaize JS, Goddard J. Additions to the known US distribution of *Latrodectus geometricus* (Araneae: Theridiidae). *J Med Entomol*. 2008;45(5):959–62.
20. ESR. ArcGIS 9.2. Environmental Systems Research Institute Inc Redlands, California; 2006.
21. Center for Invasive Species Research (CISR): How to identify Brown Widow Spiders. Riverside: University of California. 2013 http://cizr.ucr.edu/identifying_brown_widow_spiders.html.
22. Knoflach B, Pfaller K. Kugelspinnen – eine Einführung (Araneae, Theridiidae). *Denisia*. 2004;14:111–60.
23. Koh JKH, Ming LT. Biodiversity in the Heart of Borneo - Spiders of Brunei Darussalam. Kinabalu: Natural History Publications (Borneo); 2013.
24. Levi HW. Cosmopolitan and pantropical species of theridiid spiders (Araneae: Theridiidae). *Pac Insects*. 1967;9(2):175–86.
25. Wilson JJ. DNA barcodes for insects. *Methods Mol Biol*. 2012;858:17–46.
26. Tamura K, Stecher G, Peterson D, Filipitski A, Kumar S. MEGA6: molecular evolutionary genetics analysis version 6.0. *Mol Biol Evol*. 2013;30(12):2725–9.
27. Shukla S, Broome VG. First report of the brown widow spider, *Latrodectus geometricus* CL Koch (Araneae: Theridiidae) from India. *Curr Sci*. 2007;93(6):775–7.
28. Koch CL. Die Arachniden getreu nach der Natur abgebildet und beschrieben. Nürnberg: C H Zeh'schen Buchhandlung; 1831. p. 1–129.
29. Thorell T. On some spiders from New-Caledonia, Madagascar, and Réunion. *Proc Zool Soc Lond*. 1875:146–8.
30. Keyserling E. Die Insekten. Konchuaikokai. 1884;26:14–8.
31. Karsch FAF, Übereinige von Herr JM. Hildebrandt im Zanzibargebiet erbeutete Arachniden. *Zeitschrift für Ges Naturschft*. 1878;51(3):311–22.
32. Marx G. Catalogue of the described Araneae of temperate North America. *Proc US Nat Mus*. 1890;12(782):497–594.
33. Simon E. Études arachnologiques. 22e Mémoire. XXXV. Etude sur les arachnides recueillis par M. L. von Höhnel, officier de la marine autrichienne, pendant l'expédition de M. le comte Teleki dans l'Afrique orientale équatoriale en 1887–1888. *Ann Soc Entomol Fr*. 1890:125–130. <http://biostor.org/cache/pdf/9f/9b/49/9f9b49419eb2d3d752fb86ba1f8b93ed.pdf>.
34. Pocock RI. The fauna of British India, Arachnida. London: Taylor and Francis; 1900.
35. Cambridge FP. On the spiders of the genus *Latrodectus* Walckenaer. *Proc Zool Soc Lond*. 1902;1:247–61.
36. Cambridge OP. Descriptions of some new species, and characters of three new genera, of Araneidea from South Africa. *Ann S Afr Mus*. 1904;5(3):143–66.
37. Strand E. Arachniden aus Madagaskar, gesammelt von Herrn Walter Kaudern. (Pseudoscorpiones by Edv. Ellingsen). *Zool Jahrb Abt Anat Ontog Tiere*. 1908;26:453–88.
38. Pocock R. Arthropoda. Arachnida. Scorpions and spiders. In: Forbes HO, editor. *The natural history of Sokotra and Abd-el-Kur*. Bull Liverpool Mus (Special Bulletin). 1903. p. 209–32.
39. Berland L. Araignées. In: Voyage de M. le Baron de Rothschild en Ethiopie et en Afrique orientale anglaise (1904-1905). Résultats scientifiques. Animeux Articulés. Paris. 1922;1:43–90.
40. Carbonell J. Algunos datos sobre las arañas del género *Latrodectus* que se hallan en la Argentina. *Physis*. 1923;6:350–3.
41. Reimoser E. Einheimische Spinnen 1 & 2. *Die Natur (Wien)*. 1928;4(5):103–8.
42. Chamberlin RV, Woodbury AM. Notes on the spiders of Washington County. *Utah Proc Biol Soc Wash*. 1929;42:131–42.
43. Petrunkevitch A. The spiders of Porto Rico, part 1. *Trans Conn Acad Arts Sci*. 1929;30:1–158.
44. Petrunkevitch A. The spiders of Porto Rico, part 2. *Trans Conn Acad Arts Sci*. 1930;30:159–356.
45. Pearson JF. *Latrodectus geometricus* Koch in southern Florida. *Science*. 1936;83:522–3.
46. Vellard J. Le venin des araignées. Paris: Masson et Cie; 1936.
47. Roewer CF. Katalog der Araneae von 1758 bis 1940, vol. 1. *Natura: Bremen, Bruxelles*; 1942.
48. Smithers RH. Contributions to our knowledge of the genus *Latrodectus* (Araneae) in south Africa. *Ann S Afr Mus*. 1944;36:263–312.
49. Bianchi FA. Notes on the abundance of the spiders *Latrodectus mactans*, *L. geometricus* and *Argiope avara*, and of their parasites on the Island of Hawaii. *Proc Hawaiian Entomol Soc*. 1945;12(2):245–7.
50. Caporiacco DL. Aracnidi della Colonia del Kenya raccolti da Toschi e Meneghetti negli anni 1944-1946. *Commentat Pontif Acad Scient*. 1949;13(6):309–17.
51. Keegan HL, Blauw AS, Anderson RI. *Latrodectus geométricus* Koch on Luzon. *Am J Trop Med Hyg*. 1950;30(6):901–7.
52. Roza M, Soedibio R. *Latrodectus hasselti* Thorell. *Hemera Zoa*. 1950;58:169–70.
53. Baerg WJ. The brown widow and the black widow spiders in Jamaica (Araneae, Theridiidae). *Ann Entomol Soc Am*. 1954;47(1):52–60.
54. Bouillon A. La fécondité chez l'araignée *Latrodectus geometricus* C. Koch. *Leopoldville: Éditions de l'Université*; 1957.
55. Levi HW. The spider genus *Latrodectus* (Araneae, Theridiidae). *Trans Am Microsc Soc*. 1959;78(1):7–43.
56. Abalos JW, Baez EC. On spermatid transmission in spiders. *Psyche*. 1963;70(4):197–207.
57. Chrysanthus P. Spiders from south New Guinea V. *Nova Guinea (NS, Zool)*. 1963;24:727–50.
58. Bucherl W. Distribuição geográfica dos aracnoides peçonhentos temíveis. *Mem Inst Butantan*. 1964;31:55–66.
59. Gerschman BS, Schiapelli RD. El genero *Latrodectus* Walckenaer 1805 en la Argentina. *Rev Soc Ent Arg*. 1965;27:51–9.
60. McCrone JD, Stone KJ. The widow spiders of Florida, vol. 2. Florida: Division of Plant Industry; 1965 [Series: Arthropods of Florida and neighboring land areas].
61. Abalos JW, Baez EC. Las arañas del genero *Latrodectus* en Santiago del Estero. *Cordoba: Universidad Nacional de Cordoba*; 1967 [Serie Ciencias Naturales N. 55].
62. Abalos JW, Baez EC. The spider genus *Latrodectus* in Santiago del Estero, Argentina. *Animal Toxins*. Oxford: Pergamon Press; 1967. p. 59–74.
63. Pinter LJ. Species of widow spiders in northern Argentina (*Latrodectus*: Theridiidae). *Psyche*. 1967;74(4):290–8.

64. Abalos JW. La transferencia espermática en los arácnidos. *Rev Univ Nac Córdoba*. 1968;9(1-2):251–78.
65. Lamoral BH. On the nest and web structure of *Latrodectus* in South Africa, and some observations on body colouration of *L. geometricus* (Araneae: Theridiidae). *Ann Natal Mus*. 1968;20(1):1–14.
66. Levi HW, Levi LR. A guide to spiders and their kin. New York: Golden Press; 1968.
67. Zumpt F. Latrodectism in south Africa. *S Afr Med J*. 1968;42(16):385–90.
68. Kaston BJ. Comparative biology of American black widow spiders. *Trans San Diego Soc Nat Hist*. 1970;16(3):33–82.
69. Mackay IR. A new species of widow spider (genus *Latrodectus*) from Southern Africa (Araneae: Theridiidae). *Psyche*. 1972;79(3):236–42.
70. Anderson MP. Notes on the brown widow spider, *Latrodectus geometricus* (Araneae: Theridiidae) in Brazil. *Great Lakes Entomol*. 1972;5(4):115–8.
71. Abalos JW. Las arañas del género *Latrodectus* en la Argentina. *Rev Cent Museo de La Plata*. 1980;4(1):29–51.
72. Pinter LW. The widow spiders of Hawai'i. In: Smith CW, editor. *Proceedings of the Third Conference in Natural Sciences Hawaii Volcanoes National Park*; 1980 June 4-6; Honolulu. Honolulu (HI): University of Hawaii at Manoa, Department of Botany; 1980. p. 265.
73. Levy G, Amitai P. Revision of the widow-spider genus *Latrodectus* (Araneae: Theridiidae) in Israel. *Zool J Linn Soc*. 1983;77:39–63.
74. Müller HG. Abgebrochene Emboli in der Vulva der 'Schwarzen Witwe'*Latrodectus geometricus* C. L. Koch 1841 (Arachnida: Araneae: Theridiidae). *Entomol Z, Frankf*. 1985;95:27–30.
75. Raven R, Gallon J. The redback spider. In: Covacevich J, Davie P, Pearn J, editors. *Toxic plants and animals: A guide for Australia*. Brisbane: Queensland Museum; 1987. p. 307–11.
76. Dippenaar-Schoeman AS. Annotated check list of the spiders (Araneae) of the Mountain Zebra National Park. *Koedoe*. 1988;31(1):151–60.
77. Heeres A. Natural history observations of the brown widow spider *Latrodectus geometricus* (Araneae: Theridiidae). *Naturalist*. 1991;35(1):31–4.
78. Müller G. Black and brown widow spider bites in south Africa. A series of 45 cases. *S Afr Med J*. 1993;83(6):399–405.
79. Lotz LN. Revision of the genus *Latrodectus* (Araneae, Theridiidae) in Africa. *Navorsing van die Nasionale Museum, Bloemfontein*. 1994;10:1–60.
80. Ono H. Records of *Latrodectus geometricus* (Araneae: Theridiidae) from Japan. *Acta Arachnol*. 1995;44(2):167–70.
81. Levy G. Fauna Palaestina, Arachnida III: Araneae: Theridiidae. Jerusalem, Israel: Acad Sci Human; 1998.
82. Dippenaar-Schoeman AS, Leroy A, de Jager M, van den Berg A. A check list of the spider fauna of the Karoo National Park, South Africa (Arachnida: Araneae). *Koedoe*. 1999;42(1):31–42.
83. Forster R, Forster L. *Spiders of New Zealand and their worldwide kin*. New Zealand: University of Otago Press; 1999.
84. Rafiinejad J, Tirgari S, Balali M. Dispersion of poisonous species genus *Latrodectus* sp. in north of Khorasan and their medical importance (Araneae: Theridiidae). *Scientific Res Q Shahed Univ*. 2000;27:31–8.
85. Foord S, Dippenaar-Schoeman AS, Van der Merwe M. A check list of the spider fauna of the western Soutpansberg, south Africa (Arachnida: Araneae). *Koedoe*. 2002;45(2):35–43.
86. Knoflach B, van Harten A. The genus *Latrodectus* (Araneae: Theridiidae) from mainland Yemen, the Socotra Archipelago and adjacent countries. *Fauna of Arabia*. 2002;19:321–62.
87. Cardoso JLC, Brescovit AD, Haddad Jr V. Clinical aspects of human envenoming caused by *Latrodectus geometricus* (Theridiidae). *J Vemon Anim Toxins incl Trop Dis*. 2003;9(2):418. http://www.jvat.org.br/full/i-2003/volume_9/number_2/symposium_2002/posters_051-100/p63-sbtx-2002.htm.
88. Dippenaar-Schoeman AS, Leroy A. A check list of the spiders of the Kruger National Park, South Africa (Arachnida: Araneae). *Koedoe*. 2003;46(1):91–100.
89. Dippenaar-Schoeman AS, van der Walt AE, de Jager M, le Roux E, van der Berg A. The spiders of the Swartberg Nature Reserve in South Africa (Arachnida: Araneae). *Koedoe*. 2005;48(1):77–86.
90. Garb JE, Hayashi CY. Modular evolution of egg case silk genes across orb-weaving spider superfamilies. *Proc Natl Acad Sci U S A*. 2005;102(32):11379–84.
91. Craemer C. Spiders a problem on export grapes. *Plant Prot News*. 2006;67:10.
92. Dippenaar-Schoeman AS. New records of 43 spider species from the Mountain Zebra National Park, South Africa (Arachnida: Araneae). *Koedoe*. 2006;49(2):23–8.
93. Sahra G. Renew checklist of spiders (Aranei) of Iran. *Pakistan J Biol Sci*. 2006;9(10):1839–51.
94. Miller J. *Latrodectus geometricus*. Version 08 January. 2007. http://tolweb.org/Latrodectus_geometricus/93770/2007.01.08.
95. Bayram A, Danisman T, Yigit N, Kunt KB, Sancak Z. A brown widow spider new for the Turkish araneo-fauna: *Latrodectus geometricus* C. L. Koch, 1841 (Araneae, Theridiidae). *Turk J Arachnol*. 2008;1(1):98–103.
96. Bowles LCDE, Swaby CJA. Field guide to venomous and medically important invertebrates affecting military operations: identification, biology, symptoms, treatment. Version 2.0, 31 July 2006. San Antonio: USAF Institute for Operational Health; 2008.
97. Dippenaar SM, Dippenaar-Schoeman AS, Modiba MA, Khoza TT. A checklist of the spiders (Arachnida, Araneae) of the Polokwane Nature Reserve, Limpopo Province. *South Africa Koedoe*. 2008;50(1):10–7.
98. Eberhard WG, Barrantes G, Madrigal-Brenes R. Vestiges of an orb-weaving ancestor? The "biogenetic law" and ontogenetic changes in the webs and building behavior of the black widow spider *Latrodectus geometricus* (Araneae Theridiidae). *Ethol Ecol Evol*. 2008;20(3):211–44.
99. Goddard J, Upshaw S, Held D, Johnson K. Severe reaction from envenomation by the brown widow spider, *Latrodectus geometricus* (Araneae: Theridiidae). *South Med J*. 2008;101(12):1269–70.
100. Kiriakos D, Núñez P, Parababire Y, García M, Medina J, Sousa LD. First case of human latrodectism in Venezuela. *Rev Soc Bras Med Trop*. 2008;41(2):202–4.
101. Kobelt M, Nentwig W. Alien spider introductions to Europe supported by global trade. *Divers Distrib*. 2008;14(2):273–80.
102. Vincent LS, Vetter RS, Wrenn WJ, Kempf JK, Berrian JE. The brown widow spider *Latrodectus geometricus* C. L. Koch, 1841, in southern California. *Pan-Pac Entomol*. 2008;84(4):344–9.
103. Almeida RAMB, Ferreira Junior RS, Chaves CR, Barraviera B. Envenomation caused by *Latrodectus geometricus* in São Paulo state, Brazil: a case report. *J Venom Anim Toxins incl Trop Dis*. 2009;15(3):562–571. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1678-91992009000300016.
104. Brazil TK, Pinto-Leite CM, Almeida-Silva LM, Lira-da-Silva RM, Brescovit AD. Aaranhas de importância médica do Estado da Bahia, Brasil. *Gaz Méd Bahia*. 2009;79 Suppl 1:32–7.
105. Reyes-Lugo M, Sánchez T, Finol HJ, Sánchez EE, Suárez JA, Guerreiro B, et al. Neurotoxic activity and ultrastructural changes in muscles caused by the brown widow spider *Latrodectus geometricus* venom. *Rev Inst Med Trop Sao Paulo*. 2009;51(2):95–101.
106. Gerlach J, Marusik Y, editors. *Arachnida and Myriapoda of the Seychelles islands*. United Kingdom: Siri Scientific Press; 2010.
107. Ng PKL, Corlett R, Tan HTW, editors. *Singapore biodiversity: an encyclopedia of the natural environment and sustainable development*. 1st ed. Singapore: Editions Didier Millet; 2011.
108. Offerman SR, Daubert GP, Clark RF. The treatment of black widow spider envenomation with antivenin *Latrodectus mactans*: a case series. *Perm J*. 2011;15(3):76–81.
109. Taucare-Ríos A. Primer registro de la viuda marrón, *Latrodectus geometricus* Koch, 1841 (Araneae: Theridiidae) en el Norte de Chile. *Rev Chil Entomol*. 2011;36:39–42.
110. Vetter RS, Vincent LS, Itnyre AA, Clarke DE, Reinker KI, Danielsen DWR, et al. Predators and parasitoids of egg sacs of the widow spiders, *Latrodectus geometricus* and *Latrodectus hesperus* (Araneae: Theridiidae) in southern California. *J Arachnol*. 2012;40(2):209–14.
111. Muller GJ, Wium CA, Marks CJ, Du Plessis CE, Veale DJ. Spider bite in southern Africa: diagnosis and management. New Haven: Continuing Med Educ (CME). 2012;30(10):382.
112. Raven RJ, Seeman O. *Latrodectus geometricus* C.L. Koch, 1841 - Brown Widow Spider. Brisbane: Queensland Museum provider for OZCAM. 2013. <http://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:6909553a-1336-4db1-9c7f-436b72099c1d>.
113. Cnaranaraneae. Portal UNIBIO, Instituto de Biología, Universidad Nacional Autónoma de México. 2013. <http://www.gbif.org/occurrence/126884996>.
114. Museum of Comparative Zoology. *Latrodectus geometricus* C. L. Koch, 1841. Cambridge: Harvard University; 2013.
115. Naturhistorisches Museum der Burgergemeinde Bern, Suíça. *Latrodectus geometricus* C. L. Koch, 1841. 2013. http://www.wsc.nmbe.ch/species/39047/Latrodectus_geometricus.
116. iNaturalist.org. iNaturalist research-grade observations. 2013. <http://www.gbif.org/dataset/50c9509d-22c7-4a22-a47d-8c48425ef4a7>.
117. Instituto Nacional de Biodiversidad (INBio), Costa Rica. Especímenes INBio. 2013. <http://www.gbif.org/dataset/4220d19f-f919-4f36-8251-41fe1a36b1da>.

118. Museo Argentino de Ciencias Naturales. Colección Nacional de Aracnología - Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia'. 2013. <http://www.gbif.org/dataset/34e892b0-d9c7-11de-b793-b8a03c50a862>.
119. Nearctic Spider Database. *Latrodectus geometricus* C. L. Koch, 1841. 2013. <http://www.biologybrowser.org/node/1194423>.
120. Royal Museum for Central Africa. Arachnomorphae Collection & Systematics. *Latrodectus geometricus* Koch C.L., 1841. 2013. http://www.africamuseum.be/collections/browsecollections/naturalsciences/biology/arachnomorphae/browse_systematics?orderBy=Full%20name&b_start:int=29700.
121. Senckenberg. Collection Arachnology SMF. *Latrodectus geometricus* C. L. Koch, 1841. 2013. <http://www.gbif.org/occurrence/207865986>.
122. Srinivasulu C, Srinivasulu B, Javed SMM, Seetharamaraju M, Jyothi SA, Srinivasulu CA, et al. Additions to the araneofauna of Andhra Pradesh, India-part II. Records of interesting species of the comb-footed genera *Latrodectus*, *Rhomphaea* and *Coleosoma* (Araneae: Theridiidae). *J Threat Taxa*. 2013;5(10):4483–91.
123. SysTax: SysTax - Zoological Collections. 2013. <http://www.gbif.org/dataset/7d8ed137-1d30-42f1-8b78-12a4957e4690>.
124. Vetter RS. Spider envenomation in north America. *Crit Care Nurs Clin North Am*. 2013;25(2):205–23.
125. Western Australian Museum. Western Australian Museum provider for OZCAM. *Latrodectus geometricus* C. L. Koch, 1841. 2013. http://www.gbif.org/occurrence/search?taxon_key=2157944&dataset_key=7c93d290-6c8b-11de-8226-b8a03c50a862.
126. Platnick NI. The World Spider Catalog. Version 14.5. New York: American Museum of Natural History; 2014.
127. Ori M, Shinkai E, Ikeda H. Introduction of widow spiders into Japan. *Med Entomol Zool*. 1996;47(2):111–9.
128. Vetter RS. The distribution of brown recluse spiders in the southeastern quadrant of the United States in relation to loxoscelism diagnoses. *South Med J*. 2009;102(5):518–22.
129. Kratoska PH, editor. Southeast Asian minorities in the wartime Japanese empire. United Kingdom: Routledge Curzon; 2002.
130. Hunter P. The human impact on biological diversity. How species adapt to urban challenges sheds light on evolution and provides clues about conservation. *EMBO Rep*. 2007;8(4):316.

Submit your next manuscript to BioMed Central and take full advantage of:

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

