The Journal of Animal & Plant Sciences, 29(6): 2019, Page: 1793-1799
ISSN: 1018-7081

MICROHABITAT USE, MORPHOLOGY, AND LIFE CYCLE OF BROWN WIDOW SPIDER *LATRODECTUS GEOMETRICUS* (ARANEAE: THERIDIIDAE) IN THAILAND: A CASE STUDY OF COMMUNITY HOUSING IN SAMUT SONGKHRAM PROVINCE

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ABSTRACT

The brown widow spider, *Latrodectus geometricus* Koch 1841, is a toxic spider that is widespread in Thailand, where it has recently been reported on by various media outlets, causing wide concern among the public. However, very little is currently known about the ecology of this species in this country. Therefore, the aim of this research was to investigate the microhabitat use, morphology, and life cycle under laboratory conditions of *L. geometricus* inhabiting community housing in Samut Songkhram Province. We collected 152 adult spiders between January and August 2017, the majority of which were female (85.53%) and were found on motorcycles (87.50%). Females were much larger than males, with a total body length from the top of the cephalothorax to the bottom of the abdomen of 6.92 ± 0.67 mm, compared with 3.27 ± 0.99 mm in males. In addition, the morphological differences between males and females were significant ($p<0.05$). Adult females also had a longer life span than males (56.40 ± 11.52 vs. 31.00 ± 2.45 days).The results of this study give us a greater understanding of the biology and morphology of *L. geometricus* and will be useful for the future monitoring of this species.

Key words. Morphology, microhabitat use, brown widow spider, *Latrodectus geometricus,* Thailand.

INTRODUCTION

Latrodectus geometricus Koch 1841 (the brown widow spider) is an invasive species (Yiğit *et al*., 2008) that was first discovered in Colombia, South America, in 1841(Lotz, 1994) but is believed to have originated in Africa due to its dense distribution there (Garb *et al*., 2004). The species is able to attach itself to ships and aircraft and consequently is now widespread, being found in tropical and sub-tropical regions around the world (Garb *et al.*, 2004), including India (Shukla and Broome, 2007), Japan (Hirotsugu, 1995), Southern California (Vetter *et al*., 2012), Hawaii (Brown *et al*.,2008), and Turkey (Bayram*et al*., 2008). This species is not aggressive and is not considered dangerous (Simó *et al.*, 2013), where its bites not usually causing severe symptoms in contrast with the closely related black widow spider (*L. mactans*) (Goddard*et al.,* 2008; Muller, 1993) However, *L. geometricus* is still dangerous for children, the elderly, and those with severe allergies to its venom (Cordeiro *et al*.,2015).

Latrodectus geometricus is not native from Thailand but it is currently found in many provinces, in very different environments from those of its original habitat. There have been many reports on the biological adaptations of animals, including arthropods, to changing environments, which can include changes in their behavior, life cycle, and morphology (Ružicka *et al*.,2011), and a recent study of Chilean spiders showed that their ecology is associated with their physiology and body size (Canals *et al*.,2015). However, although the morphology of *L. geometricus* has been studied in many countries, no research has been conducted in Thailand.

Therefore, the aim of this research was to investigate the microhabitat use, morphology, and life history of *L. geometricus* in Samut Songkhram Province, Thailand, which is a densely populated area in which the presence of this species has been reported on by various media outlets, such as television and newspapers. To do this, we investigated the morphology of adults collected from the study area, and monitored the growth and development of *L. geometricus* egg sacs under laboratory conditions. The results of this research will not only contribute to our understanding of the biology and ecology of this spider in Thailand but will also provide important information for medical interest and a baseline data for future monitoring of this species in the country.

MATERIALS AND METHODS

Study area: The study was performed in inhabiting community housing (13° 24′ 32.52″ N 100° 0′ 41.40

″ E) in Muang district of in Samut Songkhram Province, Thailand (Figure1).Samut Songkhram is a small province in the middle of Thailand that is relatively close to the capital city of Bangkok and has a total area of 413.39 square kilometers (Chaiphongpachara and Sumruayphol, 2017; Chaiphongpachara *et al.,* 2017).

Collection and identification: *Latrodectus geometricus* were collected from community housing in Samut Songkhram once every two weeks between January and August 2017. The captured spiders were recorded and labeled with information that included the microhabitat type, date, sex, and life stage (egg sac or adult). Egg sacs were kept individually in glass bottles for the duration of the study and adult spiders were preserved in 70% ethanol to investigate their morphology. All collected egg sacs and adults were transported to the laboratory at the College of Allied Health Science, Suan Sunandha Rajabhat University, Samut Songkhram, where they were identified to species and, in the case of adults, sex by microscopic examination of their morphology using the taxonomic keys of Levi (Levi, 1959**)**.

Morphology of adults: Each adult *L. geometricus* was photographed using a digital camera connected to a stereo microscope (Nikon Corp., Tokyo, Japan) and a size scale was included on the picture to allow the morphological characteristics to be measured. The program ImageJ (freely available at https://imagej.nih.gov/ij/) was then used to measure each of the external morphological characteristics of the spiders. We measured five parts of the body (carapace length, carapace width, abdomen length, abdomen width, and total body length) and seven segments of the legs (coxa, trochanter, femur, patella, tibia, metatarsus, and tarsus) in both males and females (Figure2).

Growth and development under laboratory conditions: Ten egg sacs of *L. geometricus* were cultured individually in glass bottles (6.3 × 6.3 × 8.6 cm) in the laboratory at a temperature of 25 to 28°C and a relative humidity of 50 to 60%. Individuals were tracked from the first day of emergence from the egg sac until they reached the adult stage. The total number of spiders that emerged from the egg sac, the reduction in the number of spiders in each bottle, and the number of molts were registered. Mealworms (*Tenebrio molitor*) were fed to the spiders twice per week. When the spiders became adults, they were mated and the period of egg production was recorded to complete our study of the life cycle of *L. geometricus* spider under laboratory conditions.

Data analysis: The percentage of adult *L. geometricus* collected from each microhabitat was calculated. Means and standard deviations were also calculated for each of the measurements made during the morphology and life cycle studies. A normality test was investigated before statistical analysis. An independent t-test was performed to compare morphological differences between males and females in each of the parameters measured using R statistical software.

RESULTS

A total of 152 adult spiders were collected between January and August 2017 from community housing in Samut Songkhram Province, Thailand, 130 (85.53%) of which were female and 22 (14.47%) of which were male. Photographs of male and female *L. geometricus* collected in Samut Songkhram are shown in Figure3.

Microhabitat use: The individuals of *L. geometricus* were collected from various microhabitats, including motorcycles (n = 133, 87.50%), cars (n = 10, 6.58%), small plants or bushes (n = 6, 3.95%), bicycles (n = 2, 1.31%), and car tires (n = 1, 0.66%) (Table 1).

Morphology of adults: The mean total body length was 6.92 ± 0.67 mm for females and 3.27 ± 0.99 mm for males. In terms of the separate components, the carapace length and width were 2.33 ± 0.31 and 2.21 ± 0.24 mm, respectively, in females and 1.19 ± 0.37 and 1.01 ± 0.30 mm, respectively, in males; and the abdomen length and width were 4.50 ± 0.75 and 3.62 ± 0.74 mm, respectively, for females and 2.02 ± 0.61 and 1.50 ± 0.41 mm, respectively, for males (Table 2). The adults exhibited three different color forms, including light gray, dark gray, and black (Figure4).

The mean total lengths of legs 1–4 were 16.94 ± 2.77, 9.87 ± 1.36, 7.27 ± 0.06, and 13.88 ± 1.07 mm, respectively, in females and 7.56 ± 1.46, 4.16 ± 0.62, 3.01 ± 0.64, and 5.94 ± 2.18 mm, respectively, in males, showing that leg 1 was the longest, followed by legs 4, 2, and 3 in both sexes. The measurements of the seven different sections of the legs in each sex are shown in Table 3. The statistically significant differences between males and females showed in all part external morphological characteristics ($p<0.05$) (Table 1 and 2).

Growth and development under laboratory conditions: Ten *L. geometricus* egg sacs were reared individually in the laboratory to study the life cycle of this species. The average length of time between laying and hatching was 18.70 ± 5.01 days. Female *L. geometricus* had a greater number of molts than males (maximum = 8 vs. 5) and so took a longer time to reach maturity than males, and adult females also had a longer life span than adult males (56.40 ± 11.52 vs. 31 ± 2.45 days).Females produced egg sacs an average of 3.6 ± 0.84 days after mating (Table 4).

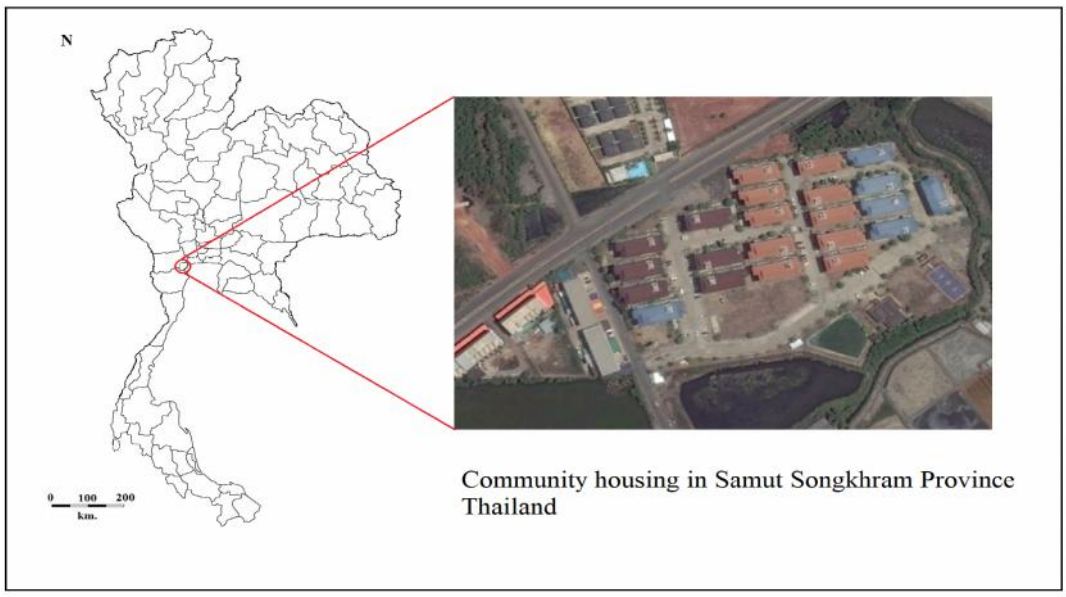

Figure 1. Location of study site.

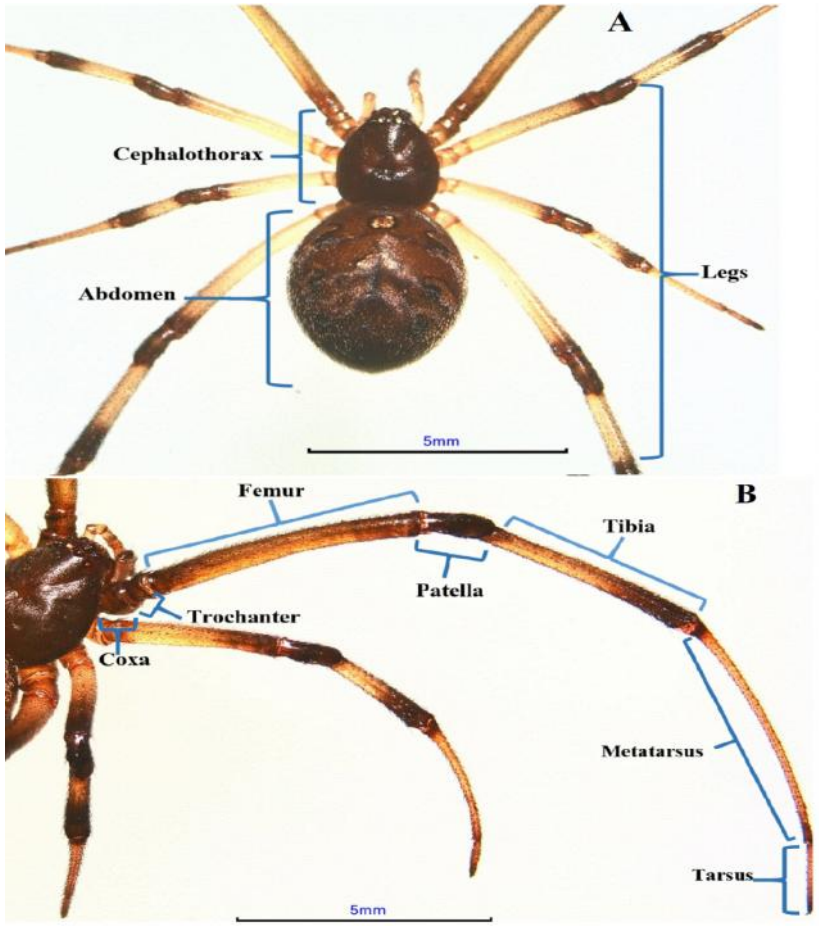

Figure 2. The different regions of *Latrodectus geometricus* that were measured in the morphological analysis. A: The three main components that were measured (the cephalothorax, abdomen, and legs). B: The parts of the legs that were measured (the coxa, trochanter, femur, patella, tibia, metatarsus, and tarsus). Scale bars = 5 mm.

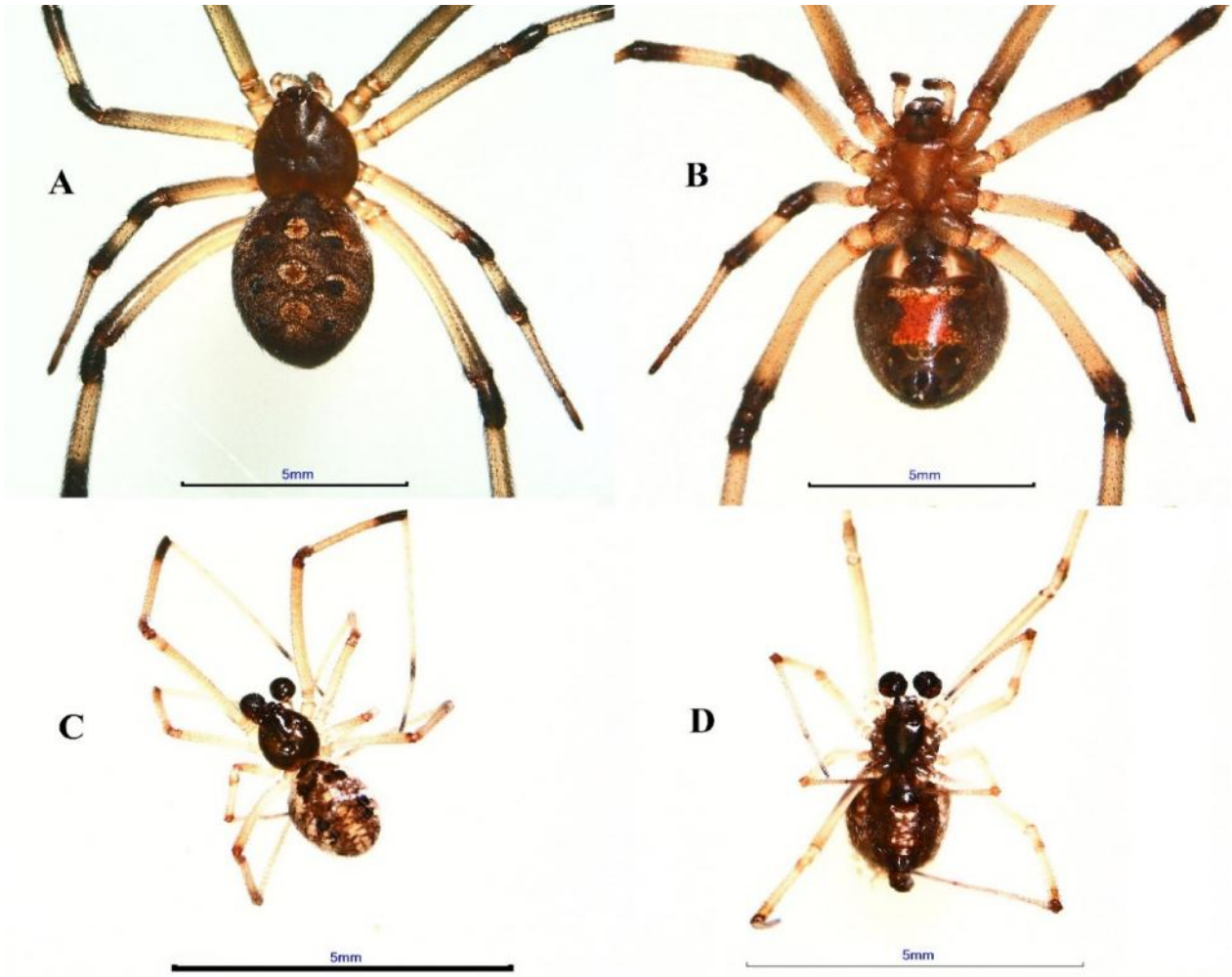

Figure 3. Photographs of male and female *Latrodectus geometricus* collected from Samut Songkhram Province, Thailand. A: Dorsal view of a female. B: Ventral view of a female. C: Dorsal view of a male. D: Ventral view of a male. Scale bars = 1 mm.

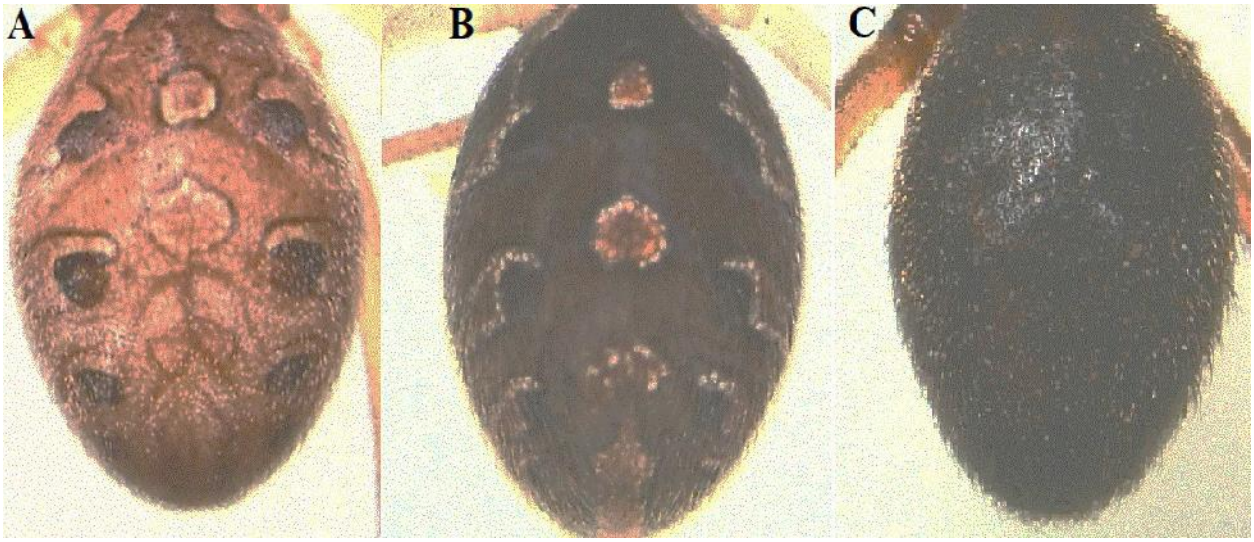

Figure 4. Photographs of the abdomens of *Latrodectus geometricus* showing the three color forms. A: Light gray color form. B: Dark gray color form. C: Black color form.

Table 1. Microhabitats in which *Latrodectus geometricus* were collected in community housing in Samut Songkhram Province, Thailand.

Microhabitat	No. (individual)	Percentage
Motorcycle	133	87.50
Car	10	6.58
Inside small plant or bush	6	3.95
Bicycle	2	1.31
Inside car tire	1	0.66

Table 2. Statistical analyses of mean body of *Latrodectus geometricus*.

Parts of body	Mean body of *L. geometricus* in mm				
	Male (Mean ± SD)	n	Female (Mean ± SD)	n	*p*-value
Cephalothorax length	1.19 ± 0.37[a]		2.33 ± 0.31[b]		< 0.05
Cephalothorax width	1.01 ± 0.30[a]		2.21 ± 0.24[b]		< 0.05
Abdomen length	2.02 ± 0.61[a]	22	4.50 ± 0.75[b]	130	< 0.05
Abdomen width	1.50 ± 0.41[a]		3.62 ± 0.74[b]		< 0.05
Total body length	3.27 ± 0.99[a]		6.92 ± 0.67[b]		< 0.05

The same letters in each row are not significantly different at $p < 0.05$.

Table 3. Statistical analyses of mean of length of the legs of *Latrodectus geometricus*.
The same letters in each column are not significantly different at $p < 0.05$.

Sex	Parts of leg	Mean length of the legs of *L. geometricus* in mm				
		n	Leg 1 (Mean ± SD)	Leg 2 (Mean ± SD)	Leg 3 (Mean ± SD)	Leg 4 (Mean ± SD)
Male	Coxa		0.23 ± 0.05	0.17 ± 0.03	0.18 ± 0.07	0.20 ± 0.05
	Trochanter		0.18 ± 0.04	0.14 ± 0.03	0.17 ± 0.24	0.17 ± 0.04
	Femur		1.91 ± 0.61	1.06 ± 0.30	0.63 ± 0.26	1.48 ± 0.71
	Patella		0.44 ± 0.11	0.38 ± 0.09	0.31 ± 0.09	0.47 ± 0.18
	Tibia		1.77 ± 0.44	0.89 ± 0.14	0.60 ± 0.11	1.36 ± 0.46
	Metatarsus		2.13 ± 0.49	0.99 ± 0.21	0.69 ± 0.28	1.53 ± 0.67
	Tarsus		0.90 ± 0.25	0.54 ± 0.13	0.42 ± 0.14	0.74 ± 0.27
	Total	22	7.56 ± 1.46[a]	4.16 ± 0.62[a]	3.01 ± 0.64[a]	5.94 ± 2.18[a]
Female	Coxa		0.34 ± 0.08	0.34 ± 0.10	0.31 ± 0.12	0.39 ± 0.11
	Trochanter		0.47 ± 0.06	0.31 ± 0.06	0.26 ± 0.08	0.37 ± 0.08
	Femur		4.57 ± 0.54	2.63 ± 0.53	1.86 ± 0.54	4.01 ± 0.45
	Patella		1.15 ± 0.16	1.00 ± 0.12	0.87 ± 0.13	1.24 ± 0.13
	Tibia		3.77 ± 0.35	2.02 ± 0.19	1.46 ± 0.21	3.11 ± 0.32
	Metatarsus		4.90 ± 0.49	2.58 ± 0.35	1.76 ± 0.36	3.63 ± 0.61
	Tarsus		1.79 ± 2.46	0.98 ± 0.81	0.74 ± 0.13	1.12 ± 0.16
	Total	130	16.94 ± 2.77[b]	9.87 ± 1.36[b]	7.27 ± 0.06[b]	13.88 ± 1.07[b]
	p-value		< 0.05	< 0.05	< 0.05	< 0.05

Table 4. Duration of each of the stages in the life cycle of *Latrodectus geometricus* under laboratory conditions.

Stages	Duration (days)					
	Mean ± SD				Range (minimum–maximum)	
	Males	n	Females	n	Males	Females
Hatching	18.7 ± 5.01			10	10–28	
First molt	15 ± 2	5	14.6 ± 5.41	5	13–17	11–24
Second molt	18.8 ± 0.84	5	21 ± 5.79	5	18–20	15–27
Third molt	25 ± 3.35	5	32.8 ± 13.52	5	21–29	17–50
Fourth molt	30 ± 1.22	5	40.8 ± 17.20	5	28–31	20–58
Fifth molt	32.5 ± 0.71	2	46.4 ± 15.27	5	32–33	25–64

Sixth molt	33.5 ± 0.71	2	52.6 ± 14.67	5	33–34	29–65
Seventh molt	-	-	52.8 ± 11.95	4	-	37–63
Eighth molt	-	-	55 ± 0	1	-	55–55
Adult	31 ± 2.45	5	56.4 ± 11.52	5	28–34	37–65
Egg production	-	-	3.6 ± 0.84	5	-	3–5

A total of 10 individuals were followed, which were separated into five males and five females during the molting stages. The n value of less than 5 indicates that some of the spiders had become adults.

DISCUSSION

In total, 152 adult *L. geometricus* were found during our survey of community housing in Samut Songkhram, Thailand, providing important evidence for the presence of this invasive species in Thailand. This spider has spread widely across the globe from its native habitat in Africa by attaching itself to imported materials (Garb *et al*., 2004) and has recently been reported in some countries in Southeast Asia, including Malaysia (Muslimin et al.,2015). Most of the spiders that were caught in Samut Songkhram were female (85.53%) due to the females of this species having a longer life span than males. After mating, the female will eat the male and store the sperm in a spermatheca, which serves a as sperm storage organ, to create the egg without mating with other males (Biaggio *et al*.,2016; Schneider, 2014).

We found the majority of brown widow spider on motorcycles (87.50%) followed by cars (6.58%), indicating that these modes of transport may be important for spreading this species to other parts of Thailand (Marie and Vetter, 2015). *L. geometricus* were also found in small plants or bushes, bicycles, and the inside of car tires, likely because these are common microhabitats in the study area and are close to the ground, making them suitable for nesting spiders(Barrantes and Eberhard, 2010).

Female *L. geometricus* had an average length of 6.92 ± 0.67 mm, which was twice that of males (3.27 ± 0.99 mm) and consistent with a previous report on the length of this spider in Northern Argentina(Pinter, 1967). Females were also twice as wide as males and had longer legs. Three color forms of the spider were found in the study area, including light gray, dark gray, and black. It is surprising that all three color forms were found in the same area, but Marie et al.,(Marie and Vetter, 2015) also reported many color forms of *L. geometricus* in the same area. Therefore, this is likely due to these spiders having adapted to different environments, as observed in other arthropods (Yin *et al.,* 2016). We found that females took longer to reach maturity than males due to their larger size and greater number of molts. These findings are similar to results from other areas (Simó *et al.,* 2013; Yiğit *et al.,* 2008), indicating that the physiology of *L. geometricus* has not undergone adaptation alongside the morphological changes in this area.

Conclusions: *L. geometricus* currently occurs in many countries in Southeast Asia, including Thailand. However, there is currently very little ecological information available for this invasive species in Thailand, with this being the first study on its microhabitat use, morphological characteristics, and life cycle in this country. In this study, we found that a large number of these spiders inhabit an area with community housing in Samut Songkhram and that they may be moved between sites by motorcycle. Several researchers have reported on the serious toxicity of this species and recent reports of it in many provinces have triggered panic among the public. However, this species is not considered dangerous because it is not aggressive and only active at night, and there have been no reports to date of people being seriously injured or killed by it. Nonetheless, this spider should be monitored throughout Thailand and accurate information on it should be provided to the public. Therefore, the results of this study will serve as a useful basis for future monitoring work and ecological studies on this species.

Acknowledgements: This work was supported by Suan Sunandha Rajabhat University, Thailand, where provided facilities throughout this work, and we would like to thank the College of Allied Health Science, Suan Sunandha Rajabhat University, Thailand, for their kind support of this research.

Conflicts of Interest: No conflict of interests

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