

Determination of the maximum and minimum lethal temperatures (LT₅₀) for *Loxosceles intermedia* Mello-Leitão, 1934 and *L. laeta* (Nicolet, 1849) (Araneae, Sicariidae)

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Abstract

In this study, the maximum and minimum lethal temperatures (LT₅₀) of *L. intermedia* and *L. laeta* were determined in two treatments: gradual heating (25–50°C) and cooling (25°C to –5°C), and 1 h at a constant temperature. In gradual temperatures change, *L. intermedia* mortality started at 40°C and the LT₅₀ was 42°C; for *L. laeta*, mortality began at 35°C and the LT₅₀ was 40°C. At low temperatures, mortality was registered only at –5°C for both species. In the constant temperature *L. intermedia* showed a maximum LT₅₀ at 35°C and *L. laeta* at 32°C; the minimum LT for both species was –7°C.

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1. Introduction

Although spiders can perceive changes in their body temperature and in the temperature of their surroundings (Foelix, 1996), spider thermal ecology is still poorly understood, with thermoregulation, tolerance and preference studies having examined less than 0.1% of the species (Schmalhofer, 1999). A favorable thermal environment which provides greater ecological efficiency may be more important for some species than an abundance of prey (Riechert and Tracy, 1975). Thus, the availability of an adequate thermal environment represents a trade-off in the natural history of many species. Nevertheless, in most cases, the optimal temperature range is very small when compared to the range of

temperatures in the environment. According to Seva-cherian and Lowrie (1972), the optimal individual limits and their various physiological processes determine the conditions in which an organism can survive and its success in adapting to a particular environment. Animals may select individual or species temperature limits. Faced with unfavorable conditions, ectothermic animals can tolerate temperature changes of only a few degrees, and often have to adapt in order to survive in extreme environments (Riechert and Tracy, 1975). This adaptation involves thermoregulation (with physiological, morphological and behavioral mechanisms), micro-habitat selection, limits to the periods of activity, movement from one place to another, water absorption from the substrate, a reduction in metabolic rate and the adoption of adequate postures (Riechert and Tracy, 1975). According to Foelix (1996), high temperatures increase the transpiration rate of spiders, which can be lethal when the individual loses more than 20% of body mass.

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Temperature studies of spiders have included thermal tolerance in dune spiders (Almquist, 1970, 1971), activity in winter (Aitchison, 1981, 1984; Gunnarsson, 1988; Martyniuk and Wise, 1985) and in diurnal orbweb spiders (Krakauer, 1972; Tolbert, 1979); the influence of foraging activity (Lubin and Henschel, 1990; Schmalhofer and Cassey, 1999) and community species abundance (Uetz, 1979), reproductive success (Riechert and Tracy, 1975; Downes, 1988), sex ratios (Gunnarsson, 1987), copulatory behavior (Costa and Sotelo, 1984, 1994; Humphreys, 1992), diapauses and egg resistance (Schaefer, 1976), and temperature preference (Sevacherian and Lowrie, 1972), as well as thermal relationships, water loss and oxygen consumption (Seymour and Vinegar, 1973).

Spiders of the genus *Loxosceles* show great tolerance to temperature extremes, and are found in cold regions and deserts (Gerstch, 1967). Nevertheless, few studies had assessed the critical temperatures for this genus. Huhta (1972) studied *L. laeta* at 2°C, 3°C and 4°C in order to assess the possibility of this species being introduced into Finland through apple boxes exported from Argentina and stored at -2°C. Hite et al. (1966) concluded that *L. reclusa* survive at temperatures from 4.5°C to 43.5°C. Gorham (1968) examined the relationship between the temperature range (23–27°C) of different American regions and the range of *L. reclusa* inside and/or outside houses. Eskafi et al. (1977) examined the weight loss, longevity and quantity of water present in the body of *L. reclusa* at the moment of death in relation to nutrition, water, sex, air relative humidity, vapor and water pressure, and deficit of pressure and temperature.

Four species of *Loxosceles* (*L. intermedia*, *L. laeta*, *L. hirsuta* and *L. gaucho*) occur in the Brazilian State of Paraná. The geographical distribution of these species is probably related to environmental characteristics, of which temperature and relative humidity seem to be the most significant. *L. intermedia* has the greatest distribution in the State whereas the other species have a more punctuated occurrence: *L. gaucho* occurs in the north, *L. laeta* in the south and *L. hirsuta* in the southeast (Marques-da-Silva and Fischer, 2000). Based on the Koeppen system of climate classification, the annual average temperature in Curitiba is 16.5°C and the climate is classified as Cbf, always humid, warm pluvial, with the hottest monthly average temperature less than 22°C (Maack, 1981). In these climatic conditions, *L. intermedia* accounts for most of the spiders (90%) with the remaining (10%) being *L. laeta* (Fischer, 1994); the latter predominates in the southern countries of South America (Gerstch, 1967). Information on the thermal tolerances of *Loxosceles* is important for understanding the mechanisms involved in the distribution of this genus. In this study, the maximum and minimum lethal temperatures

(LT₅₀) of *L. intermedia* and *L. laeta* were determined in the laboratory in order to understand the pattern of occurrence these species in Curitiba.

2. Materials and methods

The experiments were done in the Section of Venomous Arthropods in the CPPI (Center of immunobiologic production and research) during July–November 2000. Three hundred and sixty *L. intermedia* and 360 *L. laeta* (40 juveniles, 160 females and 160 males all captive-reared) were housed for at least 1 month at 25±3°C (sensitivity of 0.1°C) and a relative humidity of 77±7%. One *Tenebrio molitor* (Insecta; Coleoptera) larva or *Pycnoscellus surinamensis* (Insecta; Blattariae) nymph was offered to each spider every week. A hothouse was used for the high temperature tests and a freezer for the low temperatures (≤10°C). The temperatures of 15°C and 20°C were obtained through standard air-conditioning. The temperatures were verified with a manual thermometer (scale from -20°C to 100°C) with sensitivity of 0.1°C. The variations in relative humidity were not evaluated. Immediately before and after each treatment, the spiders were weighed on to the nearest 0.1 mg an analytical electronic balance, with the water loss rates assumed to be equal to the weight loss rate (Seymour and Vinegar, 1973). After the experiment, the spiders were housed at 25±3°C and monitored daily inspected for survival. No spiders were reused in consecutive experiments. Three treatments were done in which the spiders were simultaneously submitted to the tests and housed in their original recipients.

2.1. Treatment I: gradual heating

Male, female and juvenile *L. intermedia* and *L. laeta* (20 specimens of each class) were placed in a hothouse in which the temperature was increased by 5°C every 10 min (0.5°C/min) in a gradient from 25°C to 50°C. After every 5°C increase, the temperature remained constant for 10 min. In this interval in that the temperature stayed constant the activity of the spiders was registered. These activities were classified as surface resting (body in contact with the surface), stationary suspended (suspended body sustained by the substrate or web), suspended body in weak movement (suspended with slow, uncoordinated movements). The spider showed none of these activities, the recipient was shaken slightly to stimulate the spider. Spiders that did not respond to this intervention were placed in the "no response" category, which included dead spider.

2.2. Treatment II: gradual cooling

Male, female and juvenile *L. intermedia* and *L. laeta* (20 specimens of each class) were placed in a freezer in which the temperature was decreased by 5°C every 10 min (0.5°C/min) in a gradient from 10°C to –5°C. After every 5°C decrease, the temperature remained constant for 10 min, after which the spiders were examined and classified as described above. Because of the failure to determine the LT_{50} in the first sets of tests, 10 further tests were done for each class using different spiders and gradually reducing the temperature from 25°C to –10°C, as already described.

2.3. Treatment III: exposure to a constant temperature for 1 h

Groups of males ($n = 20$) and females ($n = 20$) of *L. intermedia* and *L. laeta* were held for 1 h at 40°C, 35°C, 30°C, 0°C, –5°C and –10°C. For each temperature, a spiders lot ($n = 40$) was used. The spiders were not reused in other tests. At the end of each period, the number of survivals was registered.

2.4. Statistical procedure

The chi-square test was used to compare the intra- and interspecific differences in the proportion of live and dead spiders and the frequencies of activities at each temperature and between species. Yates' correlation was used when the expected proportion in one of the classes was lower than 5 (values indicated by *). Body weight loss data were square root arcsine transformed. In cases

in which the transformed data still did not have a normal distribution and homogeneous variances, the Kruskal-Wallis (H) and Mann-Whitney (U) non-parametric tests were used, especially to compare weight loss between classes and species.

3. Results

3.1. Tolerance to high temperatures: gradual heating

Mortality in *L. intermedia* was observed from 40°C onwards, and corresponded to 40% ($n = 24$) of the individuals, the LT_{50} was calculated to be 42°C (Fig. 1). Two males and three females survived at 50°C. For *L. laeta*, mortality occurred from 35°C onwards, and corresponded to 6.6% ($n = 4$) of the spiders. The LT_{50} for this species was 40°C (Fig. 1) and none of the spiders survived at 50°C.

3.2. Tolerance to low temperatures: gradual cooling

For both species, mortality was observed only at –5°C, and affected 28% ($n = 17$) of *L. intermedia* and 8.3% ($n = 5$) of *L. laeta* (Fig. 1). Of the 30 additional spiders tested up to –10°C, six deaths (20%) were registered for *L. intermedia* and none for *L. laeta*.

For *L. intermedia*, the mortality of juveniles was higher than for females at 40°C and 45°C ($\chi^2 = 6.7, P < 0.01, df = 1$ and $\chi^2 = 5.7, P < 0.01, df = 1$) and with tendency to increase at 50°C ($\chi^2 = 3.2, P = 0.07, df = 1$); juveniles also had a higher mortality than males at –5°C ($\chi^2 = 6.1, P$

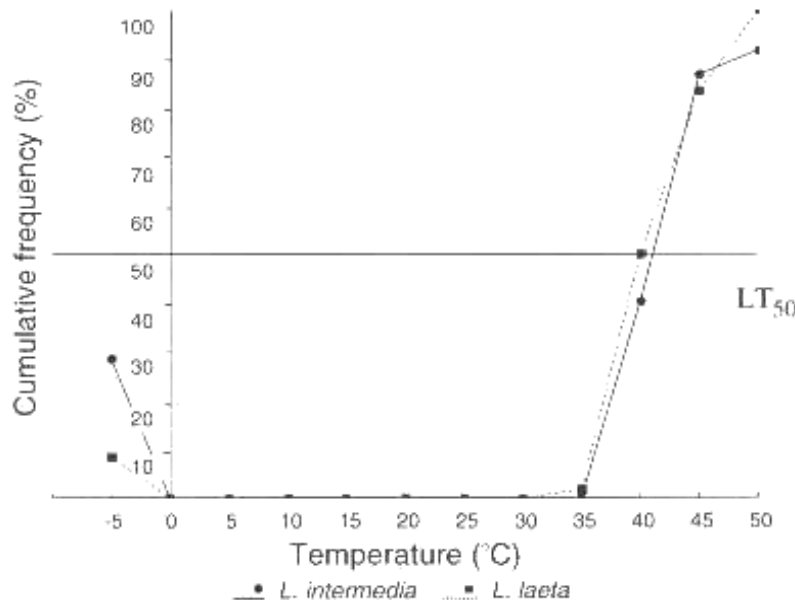


Fig. 1. Relative frequency of dead individuals and maximum LT_{50} for *L. intermedia* and *L. laeta* during gradual cooling (20°C to –5°C) and heating (25–50°C).

$<0.01, df = 1$), with a similar tendency to 45°C ($\chi^2 = 3.2, P = 0.07, df = 1$). For *L. laeta*, only females died at 35°C and the juvenile mortality tended to be higher than that of male at -5°C ($\chi^2 = 3.2, P = 0.07, df = 1$). Interspecific comparison in the proportion of living and dead spiders indicated greater *L. laeta* mortality at 35° and 50°C ($\chi^2 = 4.1, P < 0.01, df = 1$ and $\chi^2 = 5.2, P < 0.01, df = 1$) and greater *L. intermedia* mortality at -5°C ($\chi^2 = 8.01, P < 0.01, df = 1$) and -10°C ($\chi^2 = 6.6, P < 0.01, df = 1$).

3.3. Exposure to a constant temperature for 1h

L. intermedia had an $\text{LT}_{50(\text{Max})}$ at 35°C and *L. laeta* at 32°C , and an $\text{LT}_{50(\text{Min})}$ of -7°C for both species (Fig. 2). The frequencies of dead male and female spiders differed only for *L. intermedia* at 35°C ($\chi^2 = 4.3, P < 0.01, df = 1$), with a higher mortality for males. *L. laeta* had a greater overall mortality at 35°C ($\chi^2 = 5.3, P < 0.01, df = 1$).

3.4. Activities displayed at high temperatures

The activities displayed by *L. laeta* differed from *L. intermedia* only at 35°C ($\chi^2 = 41.2, P < 0.001, df = 4$), with fewer spiders showing an elevated body in movement ($\chi^2 = 4.9, P < 0.01, df = 1$) and more stationary suspended spiders, as well as more spiders with no response ($\chi^2 = 9, P < 0.01, df = 1$ and $\chi^2 = 20.2, P < 0.01, df = 1$). However, for both species, there were intraspecific differences in the frequencies of five

activities at all temperatures. At 25°C in both species, all spiders showed the stationary suspended posture. For *L. intermedia* at 30°C , this posture was the most frequent ($\chi^2 = 20, P < 0.001, df = 1$) while at 35°C the suspended body in movement was more common ($\chi^2 = 96.3, P < 0.001, df = 1$). For *L. laeta* at 30°C , there was no differences in the frequencies of the various activities whereas at 35°C the suspended body in movement was the most frequent activities ($\chi^2 = 17, P < 0.001, df = 1$). The suspended body in movement at 30°C was observed in 28.3% of *L. intermedia* and in 36.7% of *L. laeta*. An increase in temperature also increases the number of spiders showing this behavior. Thus, at 35°C , 76.7% of *L. intermedia* and in 50.8% of *L. laeta* showed this behavior, but the difference was significant only for *L. intermedia* ($\chi^2 = 13.3, P < 0.001, df = 1$). At 40°C , the number of spiders with suspended body in movement decreased significantly (*L. intermedia*: $\chi^2 = 8, P < 0.01, df = 1$ and *L. laeta*: $\chi^2 = 13.1, P < 0.001, df = 1$), and this activity was not seen at other temperatures. From 40°C onwards there were few responses (*L. intermedia* -40°C : $\chi^2 = 5.4, P < 0.05, df = 1$; 45°C : $\chi^2 = 57.8, P < 0.0001, df = 1$; 50°C : $\chi^2 = 20.8, P < 0.0001, df = 1$ and *L. laeta* -40°C : $\chi^2 = 5, P < 0.05, df = 1$; 45°C : $\chi^2 = 45, P < 0.0001, df = 1$; 50°C : $\chi^2 = 26.1, P < 0.0001, df = 1$).

3.5. Activities displayed at low temperatures

At low temperatures, the activities displayed by *L. laeta* did not differ from those of *L. intermedia*, only at -10°C (20°C : $\chi^2 = 634.7, P < 0.0001, df = 2$; 15°C :

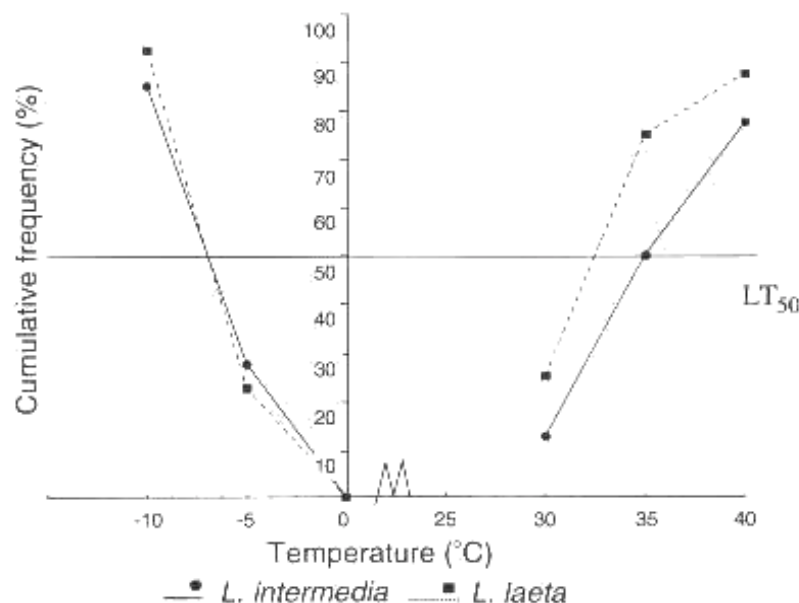


Fig. 2. Frequency of dead *L. intermedia* and *L. laeta*. $\text{LT}_{50(\text{Max})}$ and $\text{LT}_{50(\text{Min})}$ after exposure to -10°C , -5°C , 0°C , 30°C , 35°C or 40°C for 1h.

$\chi^2 = 94.8$, $P < 0.0001$, $df = 2$; 10°C : $\chi^2 = 113.1$, $P < 0.001$, $df = 2$; 5°C : $\chi^2 = 71$, $P < 0.01$, $df = 2$; 0°C : $\chi^2 = 705$, $P < 0.0001$, $df = 4$; -5°C : $\chi^2 = 16.8$, $P < 0.0001$, $df = 3$). *L. laeta* differed from *L. intermedia* at 20°C , by showing less resting and by having the body more frequently suspended in movement. At 20°C , 15°C , 5°C and 0°C , *L. laeta* was more frequently stationary suspended, and at -5°C had no spiders in the resting position. Intraspecific differences were observed at all temperatures. For *L. intermedia*, resting was more frequent from 20°C to 0°C (20°C : $\chi^2 = 33.8$, $P < 0.0001$, $df = 1$; 15°C : $\chi^2 = 9.8$, $P < 0.01$, $df = 1$; 10°C : $\chi^2 = 5$, $P < 0.05$, $df = 1$; 5°C : $\chi^2 = 7.2$, $P < 0.01$, $df = 1$; 0°C : $\chi^2 = 56.3$, $P < 0.0001$, $df = 1$). For *L. laeta*, the most frequent activity at 20°C , 15°C , 5°C and 0°C was stationary suspended behavior (20°C : $\chi^2 = 5$, $P < 0.05$, $df = 1$; 15°C : $\chi^2 = 6$, $P < 0.01$, $df = 1$; 5°C : $\chi^2 = 22$, $P < 0.01$, $df = 1$; 0°C : $\chi^2 = 18.7$, $P < 0.0001$, $df = 1$), whereas the suspended body in movement was more common at 10°C ($\chi^2 = 4$, $P < 0.05$, $df = 1$). At -5°C , a lack of responses prevailed for both species (*L. intermedia*: $\chi^2 = 56$, $P < 0.0001$, $df = 1$ and *L. laeta*: $\chi^2 = 4.2$, $P < 0.05$, $df = 1$).

3.6. Weight loss at high temperatures

A gradual increase in temperature produced differences in the weight loss amongst female, male and juvenile *L. intermedia* ($H = 8.1$, $P < 0.05$), with juveniles losing less weight than females ($U = 117$, $P < 0.05$) and males ($U = 102$, $P < 0.01$); males and females did not differ in their weight loss. For *L. laeta*, there were no differences among the classes ($H = 1.17$, $P > 0.05$). The overall weight loss of *L. intermedia* (females, males and juveniles) ($H = 17.5$, $P < 0.01$) differ from that of *L. laeta*. This difference reflected the fact that *L. intermedia* juveniles lost less weight than female ($U = 69$, $P < 0.001$), male ($U = 86$, $P < 0.01$) and juvenile ($U = 96$, $P < 0.01$) *L. laeta*, and *L. intermedia* males lost less weight than *L. laeta* females ($U = 119$, $P < 0.05$).

In the 1 h exposure to a constant temperature, there were no differences in weight loss between *L. intermedia* males and females ($U = 204$, $P > 0.05$) at 30°C ($U = 192$, $P > 0.05$) and at 35°C however at 40°C , females lost more weight than males ($U = 124$, $P < 0.05$). For *L. laeta*, there were no differences between males and females at the three temperatures.

In the interspecific comparison at 30°C , there were not significant differences in weight loss between *L. intermedia* and *L. laeta*, whereas at 35°C ($H = 8.14$, $P < 0.05$) and at 40°C ($H = 11.5$, $P < 0.01$) *L. intermedia* males lost less weight than *L. laeta* males ($U = 94$, $P < 0.01$ and $U = 127$, $P < 0.05$, respectively) and at 40°C *L. intermedia* females lost more than *L. laeta* males ($U = 81$, $P < 0.01$).

The weight loss with increasing temperature (gradual heating and one 1 h at a constant temperature) differed in *L. intermedia* ($H = 57.3$, $P < 0.0001$) and *L. laeta* ($H = 36.03$, $P < 0.001$), and between both species ($H = 102.99$, $P < 0.0001$).

Comparing both treatments, weight loss in *L. intermedia* with gradual heating up to 50°C (I) was greater than in the 1 h treatment (III) at 30°C ($U = 346$, $P < 0.0001$) and smaller than at 40°C ($U = 864$, $P < 0.05$). The loss at 30°C was smaller than at 35°C ($U = 332$, $P < 0.0001$) and 40°C ($U = 84$, $P < 0.0001$), and the loss at 35°C was smaller than at 40°C ($U = 603$, $P < 0.05$). For *L. laeta*, the weight loss with gradual heating up to 50°C differed only from the treatment at 30°C ($U = 460$, $P < 0.0001$), the former being greater. The loss at 30°C was smaller than at 35°C ($U = 363$, $P < 0.0001$) and 40°C ($U = 290$, $P < 0.0001$).

4. Discussion

The maximum and minimum LT_{50} and the displayed activities associated with the treatments indicated a greater sensitivity of *L. laeta* to high temperatures and a greater sensitivity of *L. intermedia* to low temperatures. Whereas the mortality of *L. intermedia* with gradual heating began at 40°C and the LT_{50} was 42°C , for *L. laeta* deaths began at 35°C and the LT_{50} was 40°C . Similarly, the LT_{50} for *L. intermedia* after 1 h at constant temperature was 35°C , while that for *L. laeta* was 32°C . Although *L. intermedia* had a slightly greater tolerance to high temperatures than *L. laeta* and managed to survive at 50°C , a significant difference in mortality between the species was seen only at 35°C , indicating that both had little resistance to high temperatures. With gradual cooling, it was not possible to obtain an LT_{50} for either of the species, whereas at constant temperature the LT_{50} was -7°C for both, although the mortality of *L. intermedia* was greater than that of *L. laeta* at -5°C and -10°C (gradual cooling). Thus, although *L. laeta* showed greater survival at low temperatures, both species were resistant to cold.

Although the tolerances differed only by a few degrees Celsius, this difference may be fundamental for the success of occupation of specific habitats. This observation agrees with the species' distribution, in which *L. laeta* occurs where low temperatures predominate, such as in southern countries of South America, and both species are absent from central and northeastern Brazil (Gerstch, 1967). Huhta (1972) concluded that 2°C was a critical temperature for *L. laeta* juveniles kept at low temperatures (2°C , 3°C , and 4°C) for more than 2 days. The ability to survive adverse conditions, such as cold and little food, is often related to the colonization of a specific microhabitat and reduction in metabolic rate (Foelix, 1996). Although it is not clear how some spiders

resist extreme cold, it is known that the hemolymph contains glycerol that can act as an anti-freeze. Spiders that are well adapted to winter have a low mortality and seek shelter in specific environments. In this regard, building can favor successful occupation by *Loxosceles* by offering protection against adverse environmental conditions, as suggested for *L. intermedia* (Fischer, 1996), *L. rufipes* (Delgado, 1966) and *L. reclusa* (Gorham, 1968; Schenone and Lentoja, 1975).

In the treatment with gradual temperature variation and a constant temperature, the survival limits were, respectively, -10°C to 50°C and -10°C to 40°C for *L. intermedia*, and -10°C to 45°C and -10°C to 40°C for *L. laeta*. For *L. reclusa*, Hite et al. (1966) recorded survivors from 4.5°C to 43.5°C after a 20 min exposure to different temperatures.

Even considering the size variation among females, males and juveniles, the only difference in *L. intermedia* mortality was with juveniles which were more sensitive to 40°C , 45°C and -5°C . These results indicated that the sensitivity and resistance to high and low temperatures might be much more related to the species than to the size of individuals. In a study of the relation between size and spider survival in winter, Gunnarsson (1988) also concluded that a large size did not increase the spiders survival rate. On the other hand, juvenile and female dune spiders are more sensitive to high temperatures (Almquist, 1970), whereas juvenile and male Lycosidae prefer lower temperatures than females (Sevacherian and Lowrie, 1972). Thus, tolerances appear to vary from species to species. Hulita (1972) suggested that *L. laeta* females and eggs were present more resistant to cold than juveniles, while, Almquist (1970) observed that only the oldest stages of dune spiders were more resistant to these conditions.

The activities displayed at high temperatures showed interspecific variations only at 35°C , with a higher frequency of no response and stationary suspended behavior in *L. laeta*, thus indicating that the responses to thermal stress were similar. Nonetheless, the suspended in movement behavior appeared to indicate thermal discomfort, since stationary suspended body, which dominated at 25°C and 30°C , was substituted by movement as the temperature increased. However, this was only significant for *L. intermedia*, and could indicate a predisposition to escape from hot places. This finding agrees with the hypothesis that *L. intermedia* has a greater locomotor pattern outside of the web than *L. laeta* (Fischer, 2002). According to Lubin and Henschel (1990), vigorous spider movements indicate thermal discomfort and an attempt to abandon the environment once the maximum critical temperature is reached. Seymour and Vinegar (1973) observed trembling body behavior in a tarantula *Aphanopelma* exposed to high temperatures, with the spiders surviving when the thermal stress ceased. The peak of suspended in move-

ment behavior occurred at 35°C . Beyond this temperature, the spider started to show slow, uncoordinated movements or no response at all. This behavior reflected thermal stress and water loss through evaporation, which coincided with the LT_{50} before the lethal temperature, culminated in death. Schmalhofer (1999) determined the highest and lowest temperatures at which the Thomisidae were able to maintain coordinated locomotor behavior when unable to escape from unfavorable temperatures. Thermal tolerance was delimited by critical temperatures that resulted in a state of stupor with heat and torpor with cold, which could result in deaths following prolonged exposure to extreme temperatures.

At low temperatures, *L. intermedia* did not show the same signs of thermal stress seen at high temperatures, but remained at rest at temperatures $<0^{\circ}\text{C}$. When movements were initiated at 0°C , they were slow and uncoordinated. On the other hand, *L. laeta* showed moving and stationary suspended behavior which indicated a greater adaptation to cold in which only low temperatures (-5°C and -10°C) make them show uncoordinated movements and a lack of response. According to Foelix (1996), a rigid posture, with the legs close to the body, is used to reduce the amount of surface area exposed to the environment, and is effective during winter and in protecting against desiccation.

The low weight loss in *L. intermedia* juveniles, compared to the conspecific adults and heterospecific juveniles, raises the question of whether this is evidence of an adaptation or resistance to high temperatures that is related to a better control of water loss through evaporation. This difference in weight loss was only seen at temperatures that preceded the LT_{50} (35°C and 40°C). For *L. intermedia*, gradual heating were equivalent to 1 h at 35°C , while for *L. laeta* it was equivalent to 1 h at 35°C and at 40°C , with less time required to reach the maximum of body water loss that could lead to death. The average percentage of weight loss in all treatments was less than 15%, which was below the 20% estimated by Foelix (1996) as being lethal to spiders. The highest value was shown by a *L. laeta* female with a 40% loss of the initial weight. Eskafi et al. (1977), noted that body water loss in *L. reclusa* up to death was independent of environmental factors, with losses from 28.8% to 42.7% of the original weight. Longevity was related to the proportion of weight loss per day and was influenced primarily by temperature and a water vapor pressure deficit. These authors attributed the increased deaths in the first 48 h to an inability of spiders to control the lung stigma and spiracles.

Eskafi et al. (1977) also observed that *L. reclusa* had the smallest water loss rates among the spiders studied and the third smallest among the Arthropoda. This finding probably applies to other species of the genus.

The mechanisms for retaining water in the body and hemolymph are unknown but seem to be related to the low metabolic rate. *L. reclusa* is unable to actively absorb water from sub-saturated air, and the proportion of water loss per day is maintained within the limits of survival. These authors suggested that the presence of well-developed lungs and a moderate size trachea, together with nocturnal habits, an ability to store food and to drink water from the sub-saturated ground, and a cuticular transition temperature of 42–44°C were protective mechanisms in hot summers. The use of microhabitats in small spaces in the summer and within houses in the winter was also a way of responding to extremes temperatures.

Variation in the tolerance of *Loxosceles* species to high and low temperatures, to desiccation, and to long periods of inanition contribute significantly to their adaptation to different environments. A close association with the environment favors colonization since the thermal properties of different substrata can modulate external temperature variations. Gorham (1968) noted a direct relationship between the surrounding temperature and *L. reclusa* habitats, such that in hot places, the spiders came outside of buildings, while in cold places they sought shelter within buildings. This data agree with those observed for Curitiba, where both species are preferentially associated with buildings (Fischer, 2002). Whereas temperatures of 32–42°C are easily reached in the summer months in many parts of Brazil, Curitiba has an average annual temperature of 16.5°C (Maack, 1981). Since this average temperature favors colonization by both species, the predominance of *L. intermedia* in Curitiba must be related to other factors. Nevertheless, as is shown here, there are intraspecific variations reflected in different behaviors towards certain temperatures, and these may be related to the distribution of the genus in the state of Paraná and throughout Brazil.

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