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EVALUATION OF THE EFFICACY OF VACUUM CLEANERS FOR THE INTEGRATED CONTROL OF BROWN SPIDER *Loxosceles intermedia*

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ABSTRACT: Some venomous spiders of the genus *Loxosceles* can reach high population densities inside and around houses. In Brazil, most spider accidents are related to *Loxosceles intermedia*. Control of loxoscelism should utilize integrated pest management tools, such as vacuum cleaners, to eliminate egg sacs, webs and spiders. The present study tested the efficacy of one type of vacuum cleaner (for professional and domestic use) in the control of *L. intermedia* populations. Cockroaches (*Pycnoscelus surinamensis*) were used in some tests for comparison. Vacuuming using standard accessories or a paper tube resulted in the death of all female (n=60), male (n=60), young (n=60) and just-hatched (n=60) *L. intermedia*, and all egg sacs (n=5) were destroyed. The removal of the plastic plate present at the bottom of the vacuuming tube inside the machine allowed some spiders to survive the vacuuming process. When kept inside a vacuum bag full of dust and debris, adult females (n=10) survived for 10 days; however, significant mortality was observed among male (n=10) and young individuals (n=10). Addition of cornstarch to the vacuum bag did not affect the spiders (n=20). Vacuum cleaners, such as the one used in the present investigation, are promising tools for integrated management of *L. intermedia* and other spiders in domestic environments.

KEY WORDS: Loxoscelism, *Loxosceles intermedia*, vacuum cleaners, venomous animals, spiders.

CONFLICTS OF INTEREST: There is no conflict.

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INTRODUCTION

Spiders of the genus *Loxosceles* are commonly known as brown spiders. Adult individuals present 1–2cm body length and 3–4cm leg span. Several *Loxosceles* species became typical representatives of the urban fauna, occupying dark and quiet places inside houses. They can reach high population densities inside and around houses (19). Their bite leads to dermonecrosis and systemic effects which characterize loxoscelism (8).

Eight *Loxosceles* species occur in Brazil, among which *L. hirsuta*, *L. laeta*, *L. gaucho*, and *L. intermedia* are found in Paraná State (12). The latter species is responsible for most of the accidents caused by *Loxosceles* spiders in that country. It occurs mainly indoors (4); therefore, approximately 80% of the accidents are inside houses (15).

Control of loxoscelism should utilize integrated pest management tools. Natural predators of *L. intermedia*, such as geckos, can be used inside houses (14). Vacuum cleaners can also be employed to remove egg sacs, webs and spiders (9, 10, 18, 22). Such devices are commonly used by the population and by pest control companies for loxoscelism management in Curitiba. However, evaluation of the survival of *Loxosceles* species subjected to suction or discussions about different aspects of spiders control related to the use of vacuum cleaners have not been reported.

The aim of the present investigation was to test the efficacy of a vacuum cleaner used to collect solids and liquids as a method for integrated control of *L. intermedia* populations. The vacuum cleaners of this type available in the Brazilian market have similar design and capacity, and their use is entirely viable in domestic environments; they have been regularly used by cleaning and/or pest control companies. Vacuum cleaners designed exclusively for domestic use were not tested because of the wide diversity of suction capacities and models available on the market.

MATERIALS AND METHODS

A wet/dry vacuum cleaner recommended for professional and domestic use (1100 Watts; Black&Decker™; model “Super 1100”) was used in the experiments. Its standard accessories were: corrugated flexible tube (2.23m length, 3cm smallest

internal diameter, 3.7cm external diameter); rigid plastic tube (50cm length, 3cm internal diameter), which could be connected to a crevice tool (1cmX3.5cm opening) at end of the vacuuming intake. A transparent acrylic plate was attached to an opening (10cmX5cm) made in one side of the vacuum cleaner to allow visual inspection of its contents when necessary. A flashlight was also used for this purpose.

Spiders were supplied by the Center for the Production and Research on Imunobiologicals (CPPI), an agency of the Paraná State Secretariat of Health. They were adult females and males, young (third and fourth instars) and just-hatched (up to a week after hatching), which were kept at room temperature in the laboratory and weekly fed with larvae of *Tenebrio molitor* (Coleoptera: Tenebrionidae). Cockroaches, *Pycnoscelus surinamensis* (Dictyoptera, Blaberidae), raised in the laboratory and also supplied by CPPI, were included in some experimental stages to allow comparison with the arachnids.

At least 10 male and 10 female *L. intermedia* were used in each experimental stage. Young and/or just-hatched individuals were only used in some stages. Mortality was assessed one minute after all spiders were vacuumed. During that one-minute period, the device kept functioning; then, it was switched off, opened, and the animals were observed. When damage to the animal was not evident, the criterion used for inferring mortality was lack of motion in response to touch on its body using tweezers. Normally, the vacuum cleaner was used with a standard vacuum bag.

The spiders were individually vacuumed from their maintenance pots in most stages, avoiding prior contact between the suction intake and the animal. The crevice tool or just the 50cm plastic tube described above were used. Animals without discernible lethal body damage after the procedures were kept in their maintenance pots for possible recovery.

Experimental Stages

Stage 1 – vacuuming without the vacuum bag: during vacuuming, the interior of the device was observed through the acrylic window made; after the procedures, the animals found inside the machine were observed. The vacuum cleaner was used with and without the crevice tool attachment for each group of 10 spiders vacuumed. Young and just-hatched individuals of *L. intermedia* were used.

Stage 2 – vacuuming with the vacuum bag: after vacuuming, the vacuum bag (no prior use) was removed and opened, and the animals were observed inside it. The number of individuals and the accessories – with and without the crevice tool attachment – used were the same as those used in Stage 1.

Stage 3 – vacuuming with soft tube: the standard corrugated flexible tube was removed and a cardboard tube (1.42m length and 5cm internal diameter) with a soft interior was attached to the device. Only the crevice tool attachment was used and the vacuum bag was removed. The interior of the machine was observed through the acrylic window. Young and just-hatched individuals were used.

Stage 4 – vacuuming from the floor: spiders were placed at an arena delimited by a plastic wall on a smooth cement floor and vacuumed using the crevice tool attachment. Young and just-hatched individuals were used.

Stage 5 – survival inside the vacuum bag: before vacuuming, the animals were placed inside the vacuum bag (no prior use). The device was kept functioning for five minutes; then, the animals were observed. Young and just-hatched individuals were used.

Stage 6 – vacuuming of egg sacs: five egg sacs from *L. intermedia* spiders were individually vacuumed from the pots using the crevice tool attachment. The vacuum bag was then removed and the state of the egg sacs was evaluated.

Stage 7 – vacuuming of *Pycnoscelus surinamensis* cockroaches: 10 cockroaches of different body sizes were vacuumed from a maintenance box using the crevice tool attachment.

Stage 8 – survival of spiders exposed to dust: an area of about $2m^2$ was vacuumed in the attic of an old building (approximately 100 years old), containing accumulated dust and little debris, which were enough to significantly reduce the suction capacity of the vacuum cleaner. Then, the vacuum bag was taken from the device and its top was removed. Containers made of 1mm metal mesh (external dimensions: 2cm

length and 1cm diameter) where animals (10 male, 10 female and 10 young spiders) were individually introduced were placed inside the bag. Then, an acrylic dish was placed above the metallic containers and the edges of the vacuum bag were glued to the dish and sealed. The spiders were daily observed through the acrylic dishes, and the vacuum bags were shaken after observation in order to expose the animals to the bag contents. Animals were kept in the bag for ten days.

Stage 9 – survival of cockroaches exposed to dust: the same experimental procedure and the same vacuum bag used in Stage 8 were used for the evaluation of *Pycnoscelus surinamensis* cockroaches.

Stage 10 – vacuuming without the plastic plate: after the plastic plate located inside the vacuum cleaner and connected to the vacuuming tube (Figure 1A) was removed, the animals were vacuumed and observed in the interior of the vacuum bag (no prior use). Only the rigid plastic tube was employed. Young and just-hatched *L. intermedia* individuals were used.

Stage 11 – vacuuming without the plastic plate and with the soft tube. The standard corrugated flexible tube was removed from the machine and replaced by the same cardboard tube used in Stage 3. The animals were then vacuumed as in Stage 10. Young and just-hatched individuals were used.

Stage 12 – addition of cornstarch to the vacuum bag: 50g of cornstarch (Maizena®) were vacuumed from a pot. *Loxosceles intermedia* individuals were then introduced into the vacuum bag using tweezers. The vacuum cleaner was switched on 3 times at 30-minute intervals and operated for two minutes each time. Two hours later, the vacuum bag was removed and the surviving spiders were individually introduced into pots to which a spoon of cornstarch was added. The pots were daily inverted.

RESULTS

A total of 60 male, 60 female, 60 young and 60 just-hatched *L. intermedia* were vacuumed from Stages 1 to 4, in which all individuals were dead at the end of the vacuuming process (Figure 1B). Most spiders showed leg loss and many of them

presented either abdomen damage or had the cephalothorax severed from the abdomen. Even those few individuals without discernible body damage did not resist vacuuming (there was no subsequent recovery of individuals replaced in the pots). In Stages 1 and 3, in which the vacuum bag was removed and the interior of the vacuum cleaner was visually examined, body damage was already evident when spiders entered the device and no passive motion was observed inside the vacuum cleaner, which might be due to the airflow inside the machine. Spiders also collided against the plastic plate that is positioned at 90° to the end of the vacuuming duct in the main part of the machine and protects the vacuum bag against perforations (Figure 1A).

All individuals (male, female, just-hatched and young spiders) used in Stage 5 (survival inside the vacuum bag) were alive at the end of the experiment; they showed no observable damage and none of them died during the week following the experiment.

The egg sacs vacuumed in Stage 6 were all destroyed and the eggs were separated and mostly damaged.

All cockroaches (of various body sizes) vacuumed in Stage 7 were alive when the vacuum bag was opened and some showed evident body damage (damaged elytra, loss of one or more legs). Those kept in the laboratory were all alive a week after the experiment.

In Stage 8, among 10 *L. intermedia* females initially placed inside the vacuum bag with accumulated debris, only one died due to mechanical damage while trying to escape from the retention mesh and was excluded from the sample (Table 1). The surviving animals displayed normal locomotion patterns at the end of the experiment (Figure 1D) and none of them died the week after. Two males died 48 hours after being introduced into the vacuum bag and others died in the subsequent days. At the end of 10 days, only one male was alive and displayed normal locomotion pattern upon removal from the vacuum bag; it still kept alive in the maintenance pot a week after the conclusion of the experiment. A young individual died 48 hours after the beginning of the experiment (Figure 1C). At the end of 10 days, two young spiders were alive and displayed normal locomotion patterns; they were still alive in the maintenance pots a week after the conclusion of the experiment. Among 10 young animals, one died during ecdysis and another fell prey to other *L. intermedia*

after escaping from the retention mesh and were both excluded from the sample. Among the *Pycnoscelus surinamensis* introduced into the vacuum bag (Stage 9), three died after 48 hours and none of them was alive on the seventh day of the experiment.

In stages in which the plastic plate was removed and the spiders were vacuumed using the standard accessories (Stage 10) or the cardboard flexible tube (Stage 11), several spiders survived the vacuuming process and were removed alive from the bag (Table 1). Mortality was higher when spiders were vacuumed using the standard corrugated tube (collective mortality for males, females and young spiders: Pearson Chi-square with Yate's Correction, $\chi^2 = 5.69$; DF=1, $p<0.05$, 2-tailed value). Among the animals removed alive at the end of the vacuuming process, none of those vacuumed with the standard accessory survived after 24 hours.

The spiders (n=20) introduced into the vacuum bag with cornstarch (Stage 12) survived the experiment and were kept alive in individual pots containing cornstarch.

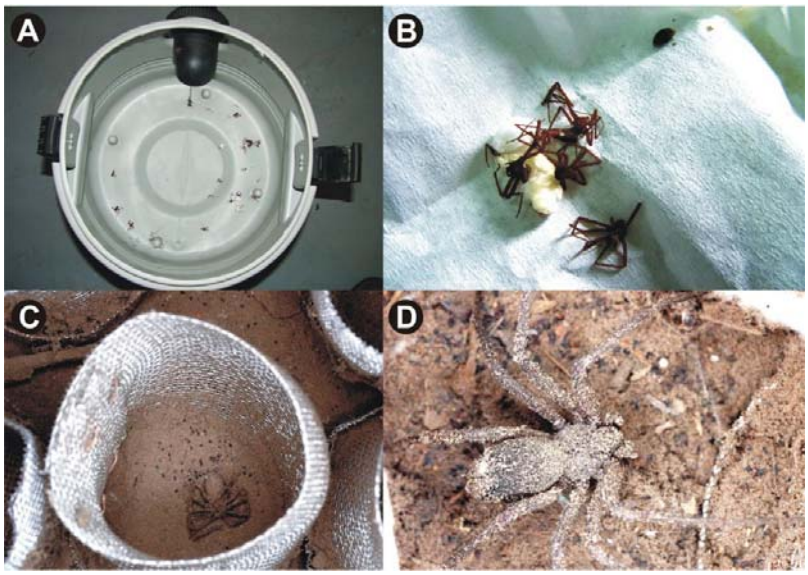

Figure 1. (A) Top view of the vacuum cleaner containing vacuumed *Loxosceles intermedia*. Note the plastic plate at the top of the photograph. (B) Vacuumed *L. intermedia* inside an open vacuum bag. (C) Dead young *L. intermedia* in the retention mesh inside the vacuum bag containing debris. (D) Female *L. intermedia*, at the end of Stage 8, inside the vacuum bag with debris.

Table 1. Number of live *Loxosceles intermedia* at the end of experimental stages 8, 10 and 11. Total number of individuals included in each sample is shown in parentheses.

	Female	**Male**	**Young (3^{rd}–4^{th} instars)**
Stage 8			
End of the test	9 (9)	1 (10)	2 (8)
One week later	9 (9)	1 (10)	2 (8)
Stage 10			
End of the test	5 (10)	5 (10)	2 (10)
24h later	4 (10)	3 (10)	1 (10)
Stage 11			
End of the test	1 (10)	1 (10)	1 (10)
24h later	0 (10)	0 (10)	0 (10)

DISCUSSION

All animals died when vacuumed in the following situations: using the plastic plate inside the main part of the vacuum cleaner; using the vacuum bag or not; using the crevice tool attachment; using the plastic tube only; or using the corrugated or soft vacuuming tube.

Removal of the plastic plate allowed the survival of part of the vacuumed spiders (Stages 10 and 11). Body damage might have occurred when standard accessories (corrugated tube) were used, leading to multiple impacts against the transverse grooves inside the vacuuming tube and against the plate that protects the vacuum bag. In Stages 3 and 11, an adapted tube of soft interior was used to reduce the possibility of lesions to the animals; however, all vacuumed spiders died and discernible body damage could be observed when they entered the device. The corrugated tube caused higher mortality than the soft tube when the plastic plate was not present; the mechanical impact against the plate might have caused death to all spiders vacuumed with little debris inside the vacuum bag.

Pycnoscelus surinamensis survived vacuuming using standard accessories. Spiders are more susceptible than insects to mechanical damage. Loss of body fluid in spiders hinders their locomotion which depends on hydraulic mechanisms (6).

The present investigation did not include different *Loxosceles* species but as body size and morphology are very similar within this genus (3, 7), significantly different results are not expected for other species.

Vetter *et al*. (20) stated that “vacuuming spiders can be an effective control technique because their soft bodies usually do not survive this process”; however, those authors did not cite other experiments. In the present study, adult female *L. intermedia* resisted exposure to the contents of the vacuum bag full of debris for ten days with no apparent damage, whereas significant mortality was observed among male and young *L. intermedia* as well as *Pycnoscelus surinamensis*.

Some reports in literature have recommended that vacuuming should be used for the management of domestic cockroaches and “vacuumed cockroaches and debris should be destroyed” (11, 16). “Because bits of cuticles and droppings may be allergenic, it is recommended that the vacuum cleaner have HEPA (high efficiency particulate absorber) or triple filters” (16). There are not records of similar allergy induced by vacuuming *Loxosceles* or other spiders nor reports about the survival of other Blaberidae in vacuum cleaners to allow comparison with data obtained using *Pycnoscelus surinamensis*.

Some authors have stated that dust in the vacuum bag will usually clog the roaches breathing apparatus and suffocate them; therefore, they recommend vacuuming up “a tablespoon of cornstarch to be sure they die” (2, 21). Such recommendation, however, has not been made for the use of vacuum cleaner in controlling spiders and, as demonstrated in Stage 12, that procedure had no effect on *L. intermedia*.

No hypotheses were raised in the present paper regarding the different mortality rates of *Loxosceles* males and females exposed to the contents of the vacuum bag. Reports about other species of spiders were not found in literature to allow comparison. Akre and Catts (1) reported that spiders collected by vacuuming “will die rapidly in the dry, enclosed bag”, but no experimental data are shown. In literature, there are no articles about dehydration of spiders by mere exposure to room-temperature airflow, and the results obtained in Stage 5 did not support such hypothesis.

For integrated pest management, a vacuum cleaner with a “crevice tool” type attachment should be used to vacuum spiders in hard-to-reach places. Situations in which the suction capacity is significantly reduced when vacuuming *Loxosceles* (e.g. vacuum bags with excessive debris) should be avoided. If the individuals do not die during the vacuuming process, they may survive inside the vacuum bag for variable periods depending on their genus, developmental stage (Stages 5 and 8) and, obviously, on the amount and type of debris inside the vacuum bag.

We observed that *L. intermedia, L. laeta and L. gaucho* can easily climb the walls of the vacuum bag and leave the vacuum cleaner. Akre and Catts (1) stated that “depending on the type of vacuum used, it might be better to dispose of the vacuum bag immediately after capture so the spider will not escape”, but they do not mention the type and model of vacuum cleaner that should be used. A simple precaution is recommended, therefore, when vacuum bags are not disposed of after vacuuming spiders of *Loxosceles* genus or others. A mesh consisting of a piece of thin fabric should be placed on the vacuuming intake or on the opening of the vacuum body in case the vacuuming tube is removed. The fabric can be fixed using elastic or other material to avoid animals escaping from the vacuum as well as risk of accidents. To avoid accidents when reusing, the vacuum cleaner should be briefly switched on before removing the fabric from the intake. The use of mesh made of fabric, plastic or other material with large pores is preferred, since it allows operating the device without the cover on the intake blocking the suction; therefore, animals near the top of the device can be seen through the mesh.

Discarded vacuum bags should have their openings sealed and, if possible, mechanical pressure should be applied along the bags external surface to kill the spiders or other invertebrates contained in it (step on the bag with appropriate footwear or use a broom or other utensils), thus avoiding their possible dispersion to other locations and the risk of manipulation by garbage collection personnel.

On the basis of accumulated knowledge about the biology of *Loxosceles intermedia*, lengthier and more careful vacuuming is recommended in cold seasons, when the number of reported accidents is reduced because the spiders are much less active (13) and there is a greater possibility of vacuuming young spiders and egg sacs originated in warmer months when reproduction is more intense (5). *Loxosceles* prefer substrates such as wood, cardboard and construction material (4); such

locations merit special attention. The attic in houses should be vacuumed, avoiding accumulation of material in such places.

In Curitiba city, Brazil, there are several pest control companies that use vacuum cleaners, similar to that used in the present investigation, for integrated management of *Loxosceles*. Normally, the attic of houses and other places can be vacuumed before the use of contact pesticides or others. Vacuum cleaners have not been cited as integrated pest management tools for the control of *L. reclusa* populations (17).

Vacuum cleaners capable of collecting solids and liquids and recommended for professional and domestic use, as the one used in the present investigation, have been considered a promising tool for integrated management of *L. intermedia* and other spiders in household environments and others.

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