
MONITORING THE SUSCEPTIBILITY OF *Triatoma sordida*: STÅL, 1859 (HEMIPTERA: REDUVIIDAE) POPULATIONS TO THE INSECTICIDE DELTAMETHRIN, IN THE STATE OF SÃO PAULO, BRAZIL

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ABSTRACT

Triatoma sordida is the most abundant triatomine species in the State of São Paulo, with wide distribution and recurrent control activities. This study aimed to analyze the susceptibility of insects to the insecticide used for control. Dilutions of deltamethrin were prepared and applied to the backs of biologically synchronized first-instar nymphs derived from 100 populations (240 insects × population) from 40 municipalities. The control group received only pure acetone. Mortality was assessed after 72 hours. The susceptibility profile observed for these populations yielded RR50 values ranging from 0.74 to 3.50. The mortality rate in response to the diagnostic dose ranged from 93.3 to 100%. The populations demonstrated susceptibility to deltamethrin, confirming the effectiveness of the insecticide for vector control activities. Continuous monitoring is recommended to promptly identify possible changes in susceptibility that may compromise control actions.

KEY WORDS: Triatomines; vectorial control; bioassays; Chagas disease.

INTRODUCTION

Triatomines are paurometabolous insects whose development cycle goes from egg to adulthood, passing through five nymphal instars, where adults of both sexes and nymphs feed on blood and can become infected with *Trypanosoma cruzi* (Lent & Wygodzinsky, 1979). The subfamily Triatominae, which includes these vectors, is currently composed of 156 species and 18 genera distributed

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Received for publication: 25/6/2025. Reviewed: 5/9/2025. Accepted: 21/1/2026.

in five tribes (Zhao et al. 2021). Most triatomine species are found in South and Central America, with Brazil having the greatest diversity of triatomines, with 68 species recorded (Costa & Lorenzo, 2009). In the State of São Paulo, 13 species have been detected, including *Triatoma sordida* Stål, 1859, the most collected, which is present mainly in the northwest region of the state (Silva & Villela, 2023).

The species *T. sordida* is native to the Cerrado biome. Its general coloration varies from light to dark brown, and it is 14 to 19 mm long in males and 15 to 20 mm in females. It is considered ubiquitous, with high ecological potential, an eclectic diet, the ability to withstand major environmental changes, and a long life expectancy (Pelli et al., 2007).

This species is of secondary epidemiological importance in the State but deserves attention in surveillance programs. Although it inhabits chicken coops, warehouses, livestock enclosures, and animal shelters, which reduces its frequency within homes, it maintains close contact with human populations (Forattini et al., 1983). Natural infection rates are low compared to other species present in the State; however, it poses a risk due to its abundance and widespread distribution, especially in rural areas. Its constant presence in peridomestic areas creates opportunities for eventual colonization of the home, thereby increasing the risk of vector-borne transmission of Chagas disease (Silva & Villela, 2023). Recent studies in the State of São Paulo report the presence and colonization of this species also in urban environments, inside homes, and in peridomiciles (Silva et al., 2024).

The control of these insects, in addition to environmental management, is carried out using pyrethroid insecticides (Coelho et al., 2017). In the State of São Paulo, insecticides have been used continuously to control Chagas disease vectors since the early 1950s, with the use of hexachlorobenzene (BHC), used in field control strategies, and replaced by pyrethroids in the 1980s to the present day (Rocha e Silva & Rodrigues, 2000; Rocha e Silva et al., 2011). Triatomine resistance to insecticides has been reported involving several chemical actives in different parts of the American continent (Pessoa et al., 2015a).

A study of susceptibility to pyrethroid insecticides carried out with populations of *T. sordida* from the Central-West region of Brazil demonstrated a high level of susceptibility in most groups of insects evaluated. However, in groups from five regions, a greater probability of evolution of resistance and tolerance to insecticide treatment was observed, which indicates the need for constant monitoring of changes in susceptibility, so that triatomine control actions are always adequate and up to date (Obara et al., 2011). On the other hand, a study conducted in the State of Minas Gerais with this species, from areas with persistent infestations, demonstrated low resistance to insecticides (Pessoa et al., 2015b).

With the persistence of infestation observed for *T. sordida* in the State of São Paulo and the recurrent use of insecticides for its control, it becomes opportune to evaluate the susceptibility of insects to verify their effectiveness, allowing the direction of the actions undertaken by the teams involved in this action.

MATERIAL AND METHODS

Triatomines for evaluation

The samples came from municipalities in the northern and northwestern regions of the State of São Paulo, with field collections conducted between 2018 and 2024 (Figure). These regions are influenced by the subtropical highland climate, with average temperatures that may vary between 19.5 °C and 27.6 °C (INMET, 2025). Insects were manually collected by State field teams during active searches in areas with previous infestations or records of pyrethroid applications.

The insecticide used in control actions was alpha-cypermethrin. Surveillance has been conducted exclusively through resident notification since 2004, with comprehensive home entomological surveys targeting food sources. Chemical control is employed when new specimens are detected during this survey, with the application being made at the site of their discovery (Silva & Villela, 2023).

The active search consisted of an entomological survey of the home, considering the intra-household and peridomicile areas of the properties, aiming at the feeding sources of the triatomines, and occurred between the years 2018 and 2024. The collected insects were placed in jars for transport and sent to the Triatomine Laboratory of Mogi Guaçu, linked to the Disease Control Coordination of the State Department of Health of São Paulo, where they were identified using a triatomine dichotomous key and classified according to their development stage (Lent & Wygodzinsky, 1979). The triatomines in the immature instar were identified with the aid of a stereoscopic microscope and a specific dichotomous key for this purpose that characterizes the nymphal instars.

In the laboratory, they were kept in rearing conditions at 25 ± 3 °C, a constant relative humidity of $75 \pm 3\%$, and a 12-hour photoperiod. They remained in crystallizers measuring 10 cm in height by 23.5 cm in diameter, lined with filter paper to absorb feces and moisture, with a support made of 0.2 mm pressed cardboard in the shape of a beehive and covered with thick cotton cloth to protect them from light. The triatomines were fed artificially using chicken blood as a food source.

Each year, municipalities and their respective locations were selected for active vector searches in rural properties. Once these insects are received in the laboratory, after a 15-day quarantine period, the colonies are inspected daily to separate eggs. Testing begins when these eggs hatch.

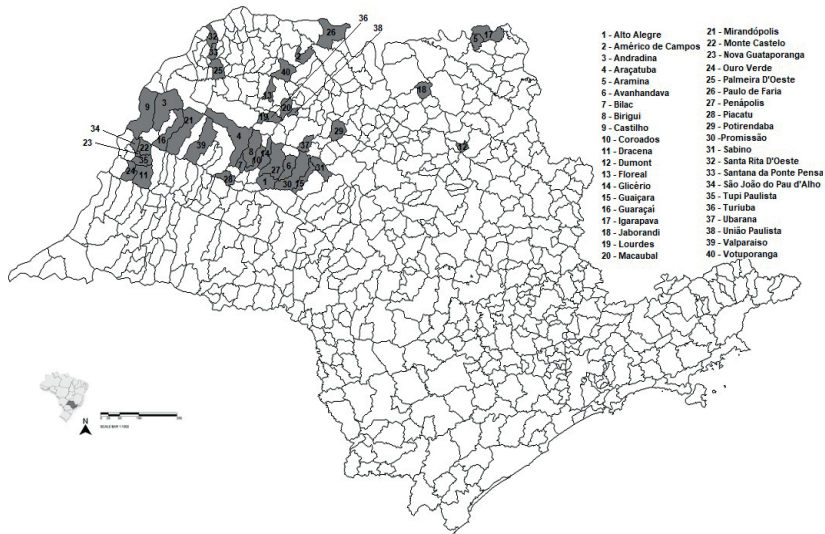


Figure. Municipalities with collections of Triatomines of the species *Triatoma sordida* used in susceptibility testing. State of São Paulo, collection period, 2018 to 2024.

Insecticide susceptibility test

The reference population of *T. sordida* was selected, from the municipality of Uberaba/MG, whose diagnostic dose in which 50% mortality of the population was observed (LD_{50}) was defined as 0.065 (95% CI 0.0520 - 0.0810) and the diagnostic dose in which 99% mortality of the population was observed (LD_{99}) was defined as 0.437 (95% CI 0.2460 - 1.6490), slope 2.766 ± 0.410 (Pessoa et al., 2016). The methodology used to monitor insecticide resistance in the laboratory was standardized by Pessoa et al. (2016) with definitions regarding insect generation, nymph age, and insecticide application site. The insects collected in the investigation were kept in quarantine upon arrival at the laboratory. At the end of the quarantine, the eggs laid were removed, and the birth of the first-instar nymphs was synchronized for the experiment.

The quarantine room, as well as the breeding, experiment, and application rooms, have controlled temperatures and humidity. These are independent rooms where insects are available for evaluation after the product is applied. After the quarantine period, the insects were separated to begin testing, which took place from 2018 to 2024, depending on the sample collection date.

The insecticide used was the pyrethroid deltamethrin, with a purity level of 99.1%, granted by Bayer®. A total volume of 0.2 μ L was applied to the

back of the nymph on the fifth day after birth, always by the same technician, aiming at reliability in the distribution of the insecticide. Control groups were selected, which received only acetone P.A. on the back. Readings were taken 72 hours after application, considering normal, intoxicated, and dead nymphs. Thirty-first-instar insects were used for each dilution, with at least eight doses required to determine a mortality curve, resulting in 10 to 90% mortality. Three groups of 10 insects each were formed, and the tests were conducted on different days.

Mortality data were analyzed using the Basic Probit Analysis program to estimate LD in nanograms of active ingredient per treated nymph. Susceptibility classification was performed as described by the Pan American Health Organization (PAHO, 2005).

The resistance ratio (RR_{50}) was obtained by dividing the LD_{50} of the field population by the LD_{50} of the susceptible line. The 95% confidence interval (95% CI) of each population was calculated and compared with the reference population using the Polo PC[®] program.

The RR_{50} values were considered significantly different when there was no overlap of the limits of the confidence intervals, at the 95% level of the reference population with the field samples.

Using the susceptibility baseline of the reference species *T. sordida*, 30 nymphs from each field population were subjected to a diagnostic dose of $1 \times LD_{99}$. The survival of at least two insects in three replicates was interpreted as an indicator of resistance.

RESULTS

Populations of *T. sordida* from 40 municipalities representing 100 localities were evaluated. The susceptibility to deltamethrin of the field populations varied between 0.74 and 3.50 ng/insect, with a median of 1.95 (Table). The values obtained for RR_{50} of the field populations demonstrated significant differences from the reference population, with no overlap of the limits of the confidence intervals at the 95% level. A variation between 93.3 and 100.0% of mortality was observed in the populations in response to the diagnostic dose.

Table. Lethal dose, resistance ratio, and mortality under the diagnostic dose applied under laboratory conditions to 240 first-instar nymphs of *Tritatoma sordida* populations, in each studied location, according to municipality. State of São Paulo, Brazil, 2018 to 2024.

| Municipality | Location | LD ₅₀ (IC95%)* | RR ₅₀ ** | Slope | % Diagnostic dose n = 30 |
|-------------------|----------------------|---------------------------|---------------------|----------------|-----------------------------|
| Alto Alegre | Serrinha | 0.407 (0.337 - 0.498) | 1.25 | 2.109 +/-0.307 | 96.7 |
| | Jatobá | 0.967 (0.718 - 1.834) | 2.98 | 1.910 +/-0.348 | 96.7 |
| | Santana | 0.633 (0.473 - 0.931) | 2.04 | 2.562 +/-0.315 | 96.7 |
| | Córrego Coroados | 0.536 (0.471 - 0.595) | 1.65 | 4.332 +/-0.530 | 100.0 |
| | Padre Claro | 0.495 (0.436 - 0.548) | 1.52 | 4.959 +/-0.584 | 100.0 |
| Américo de Campos | Dois Bracinhos | 0.781 (0.688 - 0.890) | 2.40 | 4.914 +/-0.557 | 100.0 |
| | Córrego Coqueiral II | 0.567 (0.519 - 0.612) | 1.74 | 6.551 +/-0.826 | 100.0 |
| | Água Branca | 0.883 (0.813 - 0.963) | 2.72 | 5.139 +/-0.619 | 96.7 |
| | Barro Preto | 0.838 (0.774 - 0.909) | 2.58 | 5.431 +/-0.631 | 96.7 |
| | Mista | 0.567 (0.478 - 0.646) | 1.74 | 5.789 +/-0.891 | 100.0 |
| Araçatuba | Prata I | 0.253 (0.225 - 0.284) | 0.78 | 3.889 +/-0.439 | 96.7 |
| | Pratinha | 0.696 (0.652 - 0.740) | 2.14 | 7.265 +/-0.856 | 100.0 |
| | Água Limpa I | 0.648 (0.602 - 0.693) | 1.99 | 6.572 +/-0.786 | 100.0 |
| | Córrego da Divisa | 0.731 (0.662 - 0.810) | 2.25 | 4.480 +/-0.627 | 100.0 |
| | Sítio Água Funda | 0.632 (0.591 - 0.671) | 1.94 | 7.619 +/-0.914 | 100.0 |

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|-------------|--------------------------|-----------------------|------|----------------|-------|
| Aramina | Água Funda | 0.623 (0.570 - 0.676) | 1.92 | 5.633 +/-0.745 | 100.0 |
| | Água Limpa III | 0.529 (0.468 - 0.580) | 1.63 | 5.038 +/-0.772 | 100.0 |
| | Traitu I | 0.642 (0.588 - 0.697) | 1.97 | 5.474 +/-0.663 | 100.0 |
| | Tamanduazinho | 0.579(0.543 - 0.614) | 1.78 | 8.747 +/-1.089 | 100.0 |
| | Tamandua | 0.579 (0.518 - 0.636) | 1.78 | 4.779 +/-0.708 | 100.0 |
| Avanhandava | Fazenda Santa Maria | 0.805 (0.724 - 0.901) | 2.47 | 5.317 +/-0.582 | 100.0 |
| Bilac | Lagoa | 0.509 (0.371 - 0.631) | 1.57 | 3.737 +/-0.506 | 96.7 |
| | Imbé | 0.492 (0.352 - 0.611) | 1.15 | 3.882 +/-0.512 | 100.0 |
| | Fazenda Conceição | 0.487 (0.354 - 0.601) | 1.50 | 3.883 +/-0.512 | 100.0 |
| Birigui | Goulart I | 0.389 (0.258 - 0.534) | 1.20 | 3.101 +/-0.409 | 93.3 |
| Castilho | Assentamento Rio Paraná | 0.591 (0.478 - 0.806) | 1.82 | 3.176 +/-0.426 | 93.3 |
| | Projeto Beira Rio | 0.596 (0.388 - 0.947) | 1.83 | 1.763+/-0.263 | 100.0 |
| Coroados | Barro Preto | 0.541 (0.446 - 0.627) | 1.66 | 6.359 +/-0.794 | 100.0 |
| Dracena | Cabeceira da Marrequinha | 0.891 (0.821 - 0.977) | 2.74 | 5.484 +/-0.764 | 100.0 |
| | Marrequinha | 0.608 (0.461 - 0.717) | 1.87 | 5.150 +/-0.737 | 100.0 |
| | Fazenda Floresta | 0.682 (0.588 - 0.768) | 2.10 | 5.084 +/-0.729 | 93.3 |
| | Palmeira I | 0.669 (0.576 - 0.752) | 2.06 | 5.221 +/-0.742 | 93.3 |
| | Java Paulista | 0.653 (0.613 - 0.696) | 2.00 | 8.170 +/-1.022 | 100.0 |
| Dumont | Fazenda Albertina | 0.474 (0.382 - 0.614) | 1.46 | 2.845 +/-0.353 | 96.7 |
| Floreal | Córrego Gabiroba I | 0.638 (0.514 - 0.812) | 1.96 | 3.758 +/-0.481 | 100.0 |
| | Barra Grande | 0.487 (0.435 - 0.549) | 1.50 | 4.216 +/-0.478 | 100.0 |

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|---------------|-----------------------|-----------------------|------|----------------|-------|
| Glicério | Arribada | 0.295 (0.243 - 0.338) | 0.91 | 4.216 +/-0.478 | 93.3 |
| | Fazenda Retirinho | 0.689 (0.608 - 0.786) | 2.12 | 3.640 +/-0.477 | 93.3 |
| | Fazenda São José | 0.685 (0.544 - 0.846) | 2.11 | 2.778 +/-0.389 | 93.3 |
| | Fazenda Bela Vista II | 0.490 (0.437 - 0.545) | 1.51 | 4.230 +/-0.467 | 96.7 |
| Guaicara | Benedito Santos | 0.454 (0.405 - 0.504) | 1.40 | 4.495 +/-0.491 | 96.7 |
| | Sítio Boa Esperança | 0.842 (0.778 - 0.912) | 2.59 | 6.528 +/-0.711 | 100.0 |
| | Estancia Aret | 0.832 (0.694 - 1.047) | 2.56 | 4.097 +/-0.595 | 96.7 |
| | Chylton | 0.835 (0.762 - 0.922) | 2.56 | 4.936 +/-0.646 | 100.0 |
| Guaraçai | Aurora | 0.466 (0.260 - 0.673) | 1.43 | 3.706 +/-0.484 | 100.0 |
| | Fazenda Palmares | 0.935 (0.828 - 1.089) | 2.88 | 3.569 +/-0.505 | 100.0 |
| | Mista | 0.534 (0.439 - 0.630) | 1.64 | 3.799 +/-0.437 | 100.0 |
| | Sertãozinho | 0.695 (0.617 - 0.774) | 2.14 | 5.654 +/-0.640 | 100.0 |
| Igarapava | Fazenda Aliança | 0.647 (0.594 - 0.703) | 1.99 | 5.570 +/-0.748 | 100.0 |
| | Fazenda Santa Rita | 0.565 (0.498 - 0.625) | 1.74 | 4.474 +/-0.666 | 100.0 |
| | Fazenda Jaborandi | 0.671 (0.630 - 0.717) | 2.06 | 7.861 +/-0.985 | 100.0 |
| | Pereirão | 0.606 (0.591 - 0.651) | 1.86 | 6.735 +/-0.881 | 100.0 |
| Macaubal | Córrego Cascavel I | 0.515 (0.413 - 0.610) | 2.06 | 4.825 +/-0.581 | 100.0 |
| | Aliança | 0.580 (0.536 - 0.621) | 1.78 | 7.268 +/-0.942 | 100.0 |
| | Córrego do Boi | 0.638 (0.592 - 0.685) | 1.96 | 6.796 +/-0.870 | 100.0 |
| Monte Castelo | Vila Nova | 0.610 (0.568 - 0.653) | 1.88 | 7.086 +/-0.947 | 100.0 |
| | Santa Marta I | 0.242 (0.155 - 0.390) | 0.74 | 3.101 +/-0.442 | 96.7 |
| | Gleba Seca | 0.538 (0.492 - 0.579) | 1.69 | 6.685 +/-0.929 | 100.0 |

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|-------------------|------------------------|-----------------------|------|----------------|-------|
| Nova Guataporanga | Mista | 1.137 (0.888 - 1.804) | 3.50 | 2.133 +/-0.416 | 100.0 |
| Ouro Verde | Caic | 0.827 (0.698 - 1.009) | 2.54 | 4.897 +/-0.648 | 100.0 |
| | Caic I | 0.845 (0.772 - 0.935) | 2.60 | 4.922 +/-0.649 | 100.0 |
| | Caic II | 1.077 (0.986 - 1.197) | 3.31 | 5.316 +/-0.718 | 100.0 |
| | Paraná | 0.876 (0.828 - 0.927) | 2.69 | 8.571 +/-0.955 | 100.0 |
| Palmeira D'Oeste | Barreirinho | 0.843 (0.749 - 0.946) | 2.59 | 4.137 +/-0.563 | 100.0 |
| | Chácara Felício B | 0.823 (0.711 - 0.982) | 2.53 | 2.797 +/-0.386 | 100.0 |
| | Sítio São José | 0.491 (0.328 - 0.616) | 1.15 | 5.772 +/-0.656 | 100.0 |
| | Rancho Alegre I | 0.636 (0.559 - 0.723) | 1.96 | 3.259 +/-0.441 | 100.0 |
| Paulo de Faria | Localidade 28 | 0.905 (0.786 - 1.054) | 2.78 | 3.197 +/-0.451 | 100.0 |
| | Fazenda Santa Tereza | 0.912 (0.757 - 1.099) | 2.81 | 3.603 +/-0.466 | 100.0 |
| | Água Quente + Coração | 0.894 (0.807 - 1.012) | 2.75 | 5.853 +/-0.793 | 96.7 |
| Penápolis | Baia III | 0.422 (0.376 - 0.479) | 1.30 | 3.684 +/-0.461 | 100.0 |
| | Centro Rural | 0.572 (0.532 - 0.609) | 1.76 | 7.908 +/-1.023 | 100.0 |
| Piaccatu | Mista | 0.293 (0.249 - 0.338) | 0.91 | 3.349 +/-0.404 | 100.0 |
| Potirendaba | Mista | 0.733 (0.548 - 1.266) | 2.26 | 2.690 +/-0.383 | 100.0 |
| | Localidade 30 | 0.804 (0.596 - 1.492) | 2.47 | 2.974 +/-0.423 | 100.0 |
| | Localidade 40 | 0.608 (0.509 - 0.767) | 1.87 | 2.435 +/-0.342 | 100.0 |
| Promissão | Agrovia José Bonifácio | 0.727 (0.617 - 0.899) | 2.24 | 2.504 +/-0.391 | 100.0 |
| | Agrovia Campinas | 0.766 (0.630 - 0.949) | 2.36 | 2.713 +/-0.381 | 100.0 |
| | Agrovia 44 | 1.064 (0.942 - 1.249) | 3.27 | 3.549 +/-0.573 | 100.0 |
| | Agrovia Central | 0.503 (0.425 - 0.582) | 1.55 | 2.975 +/-0.418 | 100.0 |
| | Agrovia Penápolis | 0.393 (0.326 - 0.451) | 1.20 | 3.279 +/-0.445 | 100.0 |

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|------------------------|------------------------|-----------------------|------|----------------|-------|
| Sabino | Córrego Seco | 0.600 (0.517 - 0.676) | 1.84 | 3.441 +/-0.504 | 100.0 |
| Santa Rita D'Oeste | Sítio João Molina | 0.664 (0.609 - 0.721) | 2.04 | 5.464 +/-0.651 | 100.0 |
| Santana da Ponte Pensa | Sítio Agido Divicêncio | 0.781 (0.710 - 0.864) | 2.40 | 6.372 +/-0.696 | 100.0 |
| São João Pau D'Alho | Sítio Abel Henrique I | 0.637 (0.596 - 0.679) | 1.96 | 7.846 +/-0.998 | 100.0 |
| | Mataouero | 0.604 (0.451 - 0.747) | 1.86 | 4.236 +/-0.461 | 100.0 |
| | Sítio São Martins | 0.644 (0.535 - 0.745) | 1.98 | 5.240 +/-0.577 | 100.0 |
| | Taquara Branca | 0.865 (0.617 - 1.235) | 2.66 | 3.154 +/-0.412 | 100.0 |
| Tupi Paulista | Iandara | 0.276 (0.224 - 0.332) | 0.85 | 2.282 +/-0.364 | 100.0 |
| | Tabajarinha | 0.579 (0.488 - 0.661) | 1.78 | 4.612 +/-0.562 | 100.0 |
| | Grotão | 0.520 (0.459 - 0.570) | 1.60 | 5.192 +/-0.790 | 100.0 |
| | Galante | 0.664(0.587 - 0.743) | 2.04 | 5.155 +/-0.615 | 100.0 |
| Turtuba | Sapezinho | 0.614 (0.570 - 0.659) | 1.89 | 6.918 +/-0.899 | 100.0 |
| Ubarana | Localidade 4 | 0.609 (0.444 - 0.810) | 1.87 | 4.236 +/-0.558 | 100.0 |
| | Localidade 5 | 0.591 (0.532 - 0.646) | 1.82 | 5.192 +/-0.696 | 100.0 |
| | Localidade 2 | 0.691 (0.566 - 0.860) | 2.13 | 3.226 +/-0.441 | 100.0 |
| | Localidade 6 | 0.683 (0.626 - 0.742) | 2.10 | 5.601 +/-0.680 | 100.0 |
| União Paulista | Laranjal | 0.583 (0.508 - 0.650) | 1.79 | 5.847 +/-0.736 | 100.0 |
| Valparaíso | Fazenda Bom Jesus | 0.541 (0.456 - 0.622) | 1.66 | 5.015 +/-0.609 | 100.0 |
| Votuporanga | Centro Rural | 0.565 (0.526 - 0.602) | 1.74 | 7.866 +/-0.927 | 100.0 |

*LD₅₀: 50% lethal dose ng a.i./ treated nymph (nanogram of active ingredient/treated nymph); 95% CI: 95% confidence interval;

** Resistance ratio

DISCUSSION

In the State of São Paulo, *T. sordida* is the most collected species, with colonization observed in rural and urban environments (Silva & Villela, 2023; Silva et al., 2024). In the rural environment, this species coexisted with *T. infestans*, whose control actions were undertaken continuously since the beginning of the 1950s, with the use of hexachlorobenzene, culminating in its elimination in the State of São Paulo in the 1970s (Wanderley, 1993).

When evaluating the susceptibility data, the São Paulo populations had a variation in RR_{50} , in most cases lower than those observed for Brazil, which were 1.15 to 3.50. It is worth noting that the mortality observed at the diagnostic dose, in all São Paulo populations, was higher than 93.3%, indicating that control actions in the State of São Paulo may continue with the same insecticide that has been used.

Currently, for chemical vector control, the Brazilian Ministry of Health provides states and municipalities with alphacypermethrin, a pyrethroid insecticide that has a low residual effect, does not remain on treated surfaces for long periods, and is subject to climate changes, which can impair its useful life (Oliveira-Filho et al., 2000).

There are different studies that have demonstrated cases of triatomine populations resistant to several active substances in different regions of America (Yon et al, 2004; Santos et al., 2007; Pessoa et al., 2015a). In Venezuela, the use of pyrethroids is associated with field treatments with *Rhodnius prolixus*, and in Brazil, Argentina, and Bolivia, with *T. infestans* found resistance to the insecticide (Depickère et al., 2012).

Studies aimed at verifying the susceptibility of *T. infestans*, *T. sordida*, and *T. brasiliensis* in Brazilian populations were carried out and found, in some situations, resistance to the pyrethroid insecticide deltamethrin (Obara et al., 2011; Pessoa et al., 2015b; Pessoa et al., 2015c). Pessoa et al. (2015b), in a study carried out with the species *T. sordida*, in the State of Minas Gerais, found populations with incipient levels of resistance to deltamethrin.

Using the criteria proposed by the World Health Organization, populations with mortality rates below 96.7% should be considered resistant (WHO, 1994). The comparison of the LD_{50} results obtained in this study with the results of the diagnostic dose revealed a lack of correspondence for the populations of Birigui - Goulart I, Castilho - Assentamento Rio Paraná, Dracena - Fazenda Floresta, Palmeira I, Floreal - Arribada, and Glicério - Fazenda Retirinho and Fazenda São José.

For these results, the possible resistance detected in the diagnostic dose was not confirmed by the RR_{50} value, which could be explained by the reduced number of samples used in the tests, which may not represent the characteristics of the population. It is worth noting that sugarcane monoculture is present in this

region, where small planes spray the cultivated area with insecticides containing a different active ingredient than that used for triatomines (Leite et al., 2012).

The observed slopes were equal to or greater than the slope of the reference population, suggesting a small degree of heterogeneity among the populations. Furthermore, populations from different locations within the same municipality, although geographically close, showed different RR₅₀ values. A possible explanation for these findings may be related to reduced gene flow, i.e., a population in each location may undergo an insecticide selection process, regardless of what happens to triatomines in neighboring locations (Picollo et al., 2005).

Molecular studies indicate less genetic diversity in areas where there is chemical treatment, and genetic variation should also be considered as a factor that can directly interfere with test results (Espinoza-Echeverria et al., 2018). Furthermore, the populations may have been exposed to different frequencies of chemical treatment, or the area may have suffered reinfestations and therefore received more insecticide applications, promoting greater selective pressure. It should also be considered that, even if they are close, populations may have distinct genetic origins, leading to different responses to insecticides (Panzer et al., 2015).

The high slope observed in several populations tested is indicative of a more homogeneous population, i.e., deaths are observed at similar concentrations. Although the population requires a higher dose of insecticide to obtain 50% mortality, the response is more uniform, indicating less variability among individuals. Many tested populations presented RR₅₀ values higher than the reference population, which may be an early warning of the onset of resistance development.

It is concluded that monitoring the insecticide susceptibility of native populations of *T. sordida* did not detect changes that could indicate resistance in these insects. The World Health Organization recommends that laboratory bioassays be used as an initial test to indicate possibly resistant populations, being subjected to field bioassays to confirm or refute insecticide resistance (WHO, 1994). Tests to verify the susceptibility of triatomine populations should be conducted continuously to identify factors that interfere with vector control and to evaluate and adjust intervention practices.

ACKNOWLEDGMENTS

To the Health Surveillance Coordination and the Fiocruz Reference Laboratory, linked to the Brazilian Ministry of Health, for their logistical and financial support for the study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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