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Termite infestation in historical buildings and residences in the semiarid region of Brazil

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Abstract

This study evaluated termite infestations in historical buildings (HB) and residences (RB) in five cities in the semiarid region of Brazil (A1: Fagundes; A2: Pocinhos; A3: Alagoa Grande; A4: Areia; A5: Bananeiras). Eighty-nine percent of infestation of historical buildings and 62% of residential buildings were caused by nine species of termites, belonging to six genera and three families (Kalotermitidae, Rhinotermitidae and Termitidae). We observed greater richness in A3, A4 and A5 (*Amitermes amifer*, *Heterotermes tenuis, H. sulcatus, H. longiceps*, *Neotermes* sp. and *Nasutitermes corniger*), relating to A1 and A2 (*Nasutitermes* sp.1, *Nasutitermes* sp.2, *N. corniger* and *Microcerotermes strunckii*). *N. corniger* and dry wood termite was responsible for 66.9% and 33.1% for infestations in HB and 29.7% and 72.3% in the RB, respectively. The economic impact for these infestations was estimated at 609,956.03 USD. No correlation between the quantity of infestations and the age of the buildings was found; nor was there a correlation between the humidity and the number of infestations. However, the infestations of the RB correlated with humidity. Possibly the absence of preventative mechanisms of infestation control, along with the loss of natural habitat of these insects caused by urban expansion, explain the high indicators of registered infestations.

Introduction

Termites are recognized as insects that interact with the urban ecosystem in the most complex way (Fontes, 1995). With approximately 3,105 described species in the world (Krishna et al., 2013), of the registered 534 species in Brazil, 18 are considered urban pests (Constantino, 2005). Meanwhile, the disorganized growth of urban areas has created an impact on natural ecosystems, changing the population dynamics and resulting in the adaptation of the new species to urban conditions, which has turned them into pest species (Milano & Fontes, 2002).

Termite infestations have become increasingly more frequent inside the urban perimeter. In tropical countries and coastal regions of continents, Harris (1971) reports infestations caused mainly by *Reticulitermes* spp. (Europe and United States), *Coptotermes* spp. (Australia, Asia and part of Africa) and *Cryptotermes* spp. (Colombia, and the vast majority of South American countries). In South America the infestations are caused mainly by *Coptotermes gestroi* (Wasmann) (Rhinotermitidae), *Heterotermes tenuis* (Hagen), *H. longiceps* (Snyder) (Rhinotermitidae), *Nasutitermes corniger* (Motschulsky) (Termitidae) and *Cryptotermes brevis* (Walker) (Kalotermitidae), the last of which is considered the main species pest termite in urban regions (Fontes, 1995; Torales et al., 1997; Bandeira et al., 1998; Eleotério & Berti-Filho, 2000; Constantino & Dianese, 2001; Vasconcellos et al., 2002; Oliveira et al., 2006).

The occurrence of termites in urban areas is seen as a complex that extrapolates the limit of economic damage to human populations. These insects can reach high levels of infestation in a short period of time, causing damage to the artistic, historic and cultural patrimony (Bandeira et al., 1989; Fontes, 1995). Currently, the annual cost in building repairs estimated in urban areas worldwide for treatment and replacements is in the order of the 40 billion USD (Rust & Su, 2012).

In Brazil, research has generated only limited discussion about the pest potential and distribution of these species in specific regions of the country, mainly the Southeast and

Center-West (Lelis, 1995; Fontes, 1999; Eleotério & Berti-Filho, 2000; Constantino & Dianese, 2001; Ferraz & Cancello, 2001; Fontes & Milano, 2002 and Costa et al., 2009). These studies revealed the potential of *N. corniger* and *C. brevis* as pest species. However, little is known about the urban fauna and termite control methods infestations in the Northeastern Region of Brazil (Bandeira et al., 1989; Bandeira et al., 1998; Matias et al., 2006; Albuquerque et al., 2012), especially in the state of Paraíba, with focus on the studies of Bandeira et al. (1998) and Vasconcellos et al. (2002).

The objective of this study was to survey the termite occurrences in historical and residential buildings in the semiarid region of the Northeastern Region, assessing the richness of species, examining the determining factors for infestation, as well as estimating the economic damage caused by infestations.

Materials and Methods

The study was developed in five cities in the State of Paraíba, in Brazil's Northeast semiarid region. The collecting occurred between 2010 and 2012 in the city of Fagundes - 11,405 inhabitants (A1) (7º20'45,56"S/35º47'51,13"W); Pocinhos - 17,032 inhabitants (A2) (7º04'36,26"S/36º03'40,22"W); Alagoa Grande - 28,479 inhabitants (A3) (07°05'20"S/35°38'36"W); Areia - 23,829 inhabitants (A4) (06º 57'46"S/35º41'31"W); and Bananeiras - 21,851 inhabitants (A5) (06º 45' 00"S/35º 37' 58"W) (IBGE, 2010).

The cities of Fagundes and Pocinhos present arid climatic characteristics, with an average temperature between 28ºC and 30ºC and an irregular precipitation pattern (Inmet, 2012), while the cities of Alagoa Grande, Areia and Bananeiras are located in the region of "Brejo de altitude", with milder climatic conditions (10ºC to 28ºC), the yearly precipitation between 900 and 1300 mm (Inmet, 2012). The municipalities contribute to the history of the state of Paraiba and of Brazil, and their houses are listed in the cultural patrimony of the cities, especially the city of Areia, which is listed in the national historical patrimony.

The general characteristics of the historical buildings present in the municipalities were analyzed, beyond 50 residences. These were chosen randomly through a raffle, placed within the 10 streets that border the central area, totaling a sample of 46 historical buildings and 250 residential buildings. The ages of the historical buildings vary from 40 to 150 years, and the residential buildings from four to 102 years.

In each building, the existence of key factors indicate interaction with the termites were analyzed, such as the presence of wooden furniture, the structural conditions of the building, coverage, beyond the existence of leaks and internal indicators the unit obtained from the thermo-hygrometer in each compartment of the buildings. The number of infestations per building was considered based on quantifying the number of pieces of wood that contained termites.

The termites were collected and conditioned in 80% alcohol, identified through specialized literature (Constantino, 1999) and confirmed by researchers Dr. Luiz Roberto Fontes and Dr. Alexandre Vasconcellos. In some cases, dry wood termites have not been identified in this study because they colonize the interior furniture and wooden structures which were not authorized to be broken down into pieces that made up the interior of the historic and residential buildings, making it difficult to collect soldiers. In these cases, we considered the presence of insect infestations (soldiers and workers) and the characteristic signs of their presence, as the existence of holes in the wooden parts for which they are expelled to be as fecal matter characteristic of dry wood termites.

The economic damage caused by infestation was calculated from an estimated market price for replacement and repair of parts and damaged structures. The samples found were deposited in the Entomological Collection of Termitology Laboratory in the Biology Department of State University of Paraíba.

Pearson correlation tests were performed using an array with information about the number of infestations by age and values of internal moisture in buildings. The frequency of infestations in wooden structures was associated with the presence of termites. The frequency of occurrence of the species in historical and residential buildings was counted according to the number of times a species was recorded. The chi-square test (χ^2) was used to check for differences in the frequencies of infestation observed and expected by age class and type of building.

Results

Infestations were diagnosed in 89% of the historical buildings and 62% of the residential buildings, caused by nine species of termites, belonging to six genera and three families (Kalotermitidae, Rhinotermitidae and Termitidae) (Table. 1).

Fagundes and Pocinhos present the least generic richness when compared with the municipalities' termite fauna in Alagoa Grande, Areia and Bananeiras (Table. 1). *N. corniger* and dry wood termites were present in real estate in the five inspected cities, with evidence such as damaged cabinets, wooden benches, tables, paintings, doors, windows and roofing (Table. 1).

The greater frequency of infestation by termites was registered in the roofing, followed by doors, windows and internal furniture in historical buildings (cabinets, secretaries, tables and painting frames) and in the residential (cabinets, tables and chairs) (Table. 2).

The economic damage caused by infestations was estimated in 609,956.02 USD, for repairs and/or replacements in damaged structures, being 555,149.59 USD for historical buildings and 54,806.43 USD for residential buildings.

Table 1 - Frequency the termite's species in historical and residential buildings in the municipalities of Fagundes (A1), Pocinhos (A2), Alagoa Grande (A3), Areia (A4) and Bananeiras (A5), located in the semiarid region of Brazil.

Family	Species	Municipalities					Frequency (%)
		A1	A2	A3	A4	A5	
Termitidae	*Amitermes* sp.1			x			5.64
	Nasutiternes sp.1	x					6.65
	Nasutitermes sp.2	x					1.4
	Nasutiternes corniger (Motschulsy)	x	x	x	x	x	39.4
Rhinotermidiae	*Microcerotermes strunckii* (Sörensen)		x				1.4
	Heterotermes longiceps (Snyder)				x		1.4
	Heterotermes tenuis (Hagen)			x			1.4
	Heterotermes sulcatus (Mathews)		x		x		1.4
Kalotermitidae	*Neotermes* sp.			x			1.4
	Dry wood termite *	x	x	x	x	x	40
Total	**09**	**04**	**04**	**04**	**04**	**02**	**100**

* Was not treated as a species.

Table 2 – Wooden parts and/or structures with termite's infestations in historical (HB) and residential (RB) buildings in the municipalities of de Fagundes (A1), Pocinhos (A2), Alagoa Grande (A3), Areia (A4) and Bananeiras (A5), located in the semiarid region of Brazil. (HB – historical buildings; RB – residential buildings).

Structures and/or parts	% Infestation	
	HB	RB
Cabinet	6.1	6.43
Chest	0.39	0.25
Wooden benches	6.84	-
Secretaries	3.33	2.23
Bed	0.59	0.74
Chair	1.18	9.65
Shelf	4.73	5.45
Stairs	0.59	6.68
Window	6.08	4.7
Table	5.1	15.1
Door	10.39	4.21
Roof lining	0.98	1.24
Framing	25.1	-
Roofing	28.6	43.32
Total	**100**	**100**

Problems related to humidity, which varied from 45% to 98%, and infiltrations in the walls and roofs were observed in 80% of the buildings and in 64.8% of the residences. Meanwhile, there was no correlation between the humidity and the number of infestations in historic buildings ($r = 0.23$, $p = 0.12$), while a correlation was found between these parameters for residences ($r = 0.16$, $p < 0.05$).

No correlation was found between the number of infestations and the age of the historic buildings ($r = -0.17$, $p = 0.26$) and residential buildings ($r = 0.12$, $p = 0.06$). No significant difference between the observed frequency and the expected frequency of infestation was observed, concentrated by age class in both types of buildings studied (historical: $\chi^2 = 0.13$, $p = 0.99$ and residential: $\chi^2 = 3.72$ $p = 0.81$). However, the historic buildings up to 40 years of age represent only about 15.22% of total observed and present the greatest amount of infestation (36.5%), while in residential buildings, with ages between 21 and 40 construction years, corresponding to 33.2% of total observed, present the largest quantities of infestation (46.2%).

Discussion

The richness of termite species found in the studied areas was considered low (nine), when compared to studies with similar objectives to this study that totaled the registration of 22 species (Vasconcellos et al., 2002; Eleotério & Berti-Filho, 2000; Constantino & Dianese, 2001). Nevertheless, there is a similarity in richness of the urban fauna of termites with the observations of Albuquerque et al. (2012) in the city of Recife in the Northeast of Brazil.

The absence of ventilation mechanisms and inside temperature control (be it artificial or natural) through adequate constructive techniques, combined with precarious preservation conditions, with countless infiltrations in the walls and the roof, all favor the increase in internal humidity of real estate. These conditions combine to create a favorable environment for the nesting of new colonies and can explain the elevated infestation rate (Lelis, 1999; Hedges, 1998).

Despite the impossibility of specific identification of dry wood termites, we believe that the high number of attacks by dry wood termites verified may be related to the fact that some species of the genus *Cryptotermes* submit acclimation capacity and high level of responses to orphans, especially

Cryptotermes brevis, considered a major pest of urban Brazil (McMahan, 1962; Steward, 1983; Edwards & Mill, 1986; Bacchus, 1987; Fontes, 1995). Moreover, the low durability and natural resistance of woods used in furniture may also be contributing to this frequency in the domestic environment (Spear, 1970; Silva et al., 2004).

The elevated frequency of *N. corniger* in the study corroborates the importance of the species as one of main urban pests in Brazil (Eleotério & Berti-Filho, 2000; Vasconcellos et al., 2002; Costa et al., 2009; Albuquerque et al., 2012). Some researchers theorize that this species' success in colonizing in urban space is due to its great biological plasticity, mainly related to its reproduction mechanisms (Thorne & Noirot, 1982), its feeding habits (Bustamante & Martius, 1998; Vasconcellos & Bandeira, 2000) and aspects related to its nesting (Levings & Adams, 1984; Vasconcellos, et al., 2002).

Irregular occurrences of *Amitermes* sp., *Heterotermes longiceps*, *H. sulcatus*, *H. tenuis*, *Microcerotermes strunckii* and *Neotermes* sp. were also observed by Constantino and Dianese (2001); Milano and Fontes (2002); Vasconcellos et al. (2002); Costa et al. (2009); Albuquerque et al. (2012). We believe that the low frequency of these species in the urban environment is a result of lack of planning and disordered growth of urbanization that stimulate adjustment factors and the occurrence of species that previously occurred only in natural areas, as well as the product from the competition with well-established species in this environment. In 1989, Bandeira et al. highlighted the importance of *Heterotermes* as a potential pest in Brazil. These termites have been reported for being responsible for attacks on books, journals, painting frames and wooden shelves in an urban area (Pizano & Fontes, 1986; Mill, 1991; Lelis, 1995).

The infestation indicators observed in the buildings' wooden roofing and the reported attacks on doors and windows are possibly related to their state of conservation and exposure of these parts during the termites' swarm. In general, the buildings present precarious structural conditions, with roof infiltrations, and in the case of historical buildings, without performing repairs and preventative restorations over time. According to Fontes (1998), wooden sections facing the external side of buildings that are not directly exposed to weatherproofing offer good conditions for termite establishment. The presence of infiltrations in the roof promotes the elevation of environmental humidity, facilitating the proliferation of biologic agents such as fungi, organisms that facilitate the installment of termite colonies (Bandeira, 1989; Torales, 1997). However, even though the buildings present different levels of infestation, it was observed that the existence of reforms in some of the historic buildings and homes older than 50 years showed a trend toward a decrease in the number the infestations, and thus influenced the lack of correlation between age of the property and the number of reported infestations.

Importantly, even with problems of infiltration and considerable internal moisture content are responsible in the buildings do not have protocols or specific control techniques to combat and prevent infestations, they used from the indiscriminate use of insecticides of different classes resulting in failed attempts to control. No reports were found in the literature on techniques for termite control for this type of construction in Paraíba. However, for some historic buildings, an attempt to control the termites may have interfered in our findings, even in the short term, resulting in the absence of correlation between the humidity and the number of infestations.

Even though resistance and natural durability tests were not performed on the woods used for the manufacturing of the observed structures that were infested with termites, it is possible that the termite attacks on the furniture in buildings is due to the weak durability of the wood used in the furniture, the precarious structural conditions of the real estate, and the absence of repair activities and prevention by the responsible parties. These factors associated to infiltration and humidity problems are determinant in the increase in likelihood of infestations (Bandeira, 1989; Torales, 1997; Silva et al., 2004; Milano & Fontes, 2002).

Attacks on historical and residential buildings in the arid zone of Paraíba, northeastern Brazil, were caused by nine species of termites, causing severe economic consequences and damaging the historical and cultural patrimony of the inspected cities. We found that the problems of infiltration and indoor humidity coupled with few or no repairs to the structure of the buildings as well as the absence of diagnosis and prevention of termite infestation accounted for a part of the high percentage of the attacks on the buildings. However, based on the findings of the frequency of occurrence and the types of damage caused, it was discovered that only dry wood termites and *N. corniger* were present as pest species in the cities we analyzed.

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