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Cryptotermes brevis - a silent earthquake for the wood structures in a World Heritage city in the Azores Islands

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ABSTRACT

In the Azores archipelago the exotic drywood termite *Cryptotermes brevis*, detected in early 2000's, is destroying the wood structures of the typical buildings and is already considered the main urban pest in these islands.
This work aims to show the spread evolution of this pest along the last six years in the first Portuguese city classified as world heritage by UNESCO, Angra do Heroísmo. For six years, several buildings were monitored, using traps with glue to catch the alates (flying individuals), during the swarm season that occurs, normally, from the late spring until the end of summer. The number of captured individuals was used to determine the density per building. This data was analysed with a GIS in order to build risk maps of the termite spread in space along time.
The results clearly indicate that the pest species is expanding. The city centre is no longer the only affected area. The percentage of buildings that are affected or in risk to be affected is very high in the entire city. Traditional construction, with timber load bearing structures, is being replaced by metal or other materials. There is still no Integrated Urban Pest Management implemented in the region or in the city. Therefore, with time, timber structures might become restricted to exist only in buildings like museums, churches or palaces.

Keywords: *Cryptotermes brevis*, world heritage, Azores Islands, Integrate Urban Pest Management

1. INTRODUCTION

Termites are social insects and important recyclers in the natural ecosystems (Black, H. I. J. and Okwakol, 1997; Roisin et al., 2006) . Although, with the increase urbanization and human commerce, some species became invasive in agriculture systems and, mainly, in urban centres all over the planet, being presently responsible, for huge economically impact (Black, H. I. J.; Okwakol, 1997; Evans, Forschler, & Grace, 2013). In the Azores islands four exotic species are already present: the subterranean species with restricted distribution, *R. grassei* occurring only in Horta (Faial Island; Nunes & Nobre, 2007) and *R. flavipes* in Terceira Island (restricted to a small site near the Lajes Air Force Base at Praia da Vitória; Austin et al., 2012). The drywood termites, with a more extended distribution, *Kalotermes flavicollis* occurs in most of the southeast coast of Terceira, Ponta Delgada (S. Miguel), and Horta (Faial; Myles et al. 2007) and *Cryptotermes brevis* is already present in S. Miguel, Terceira, Faial, Santa Maria, São Jorge, and Pico (Myles et al., 2007, Guerreiro, 2009, Borges et al., 2014).

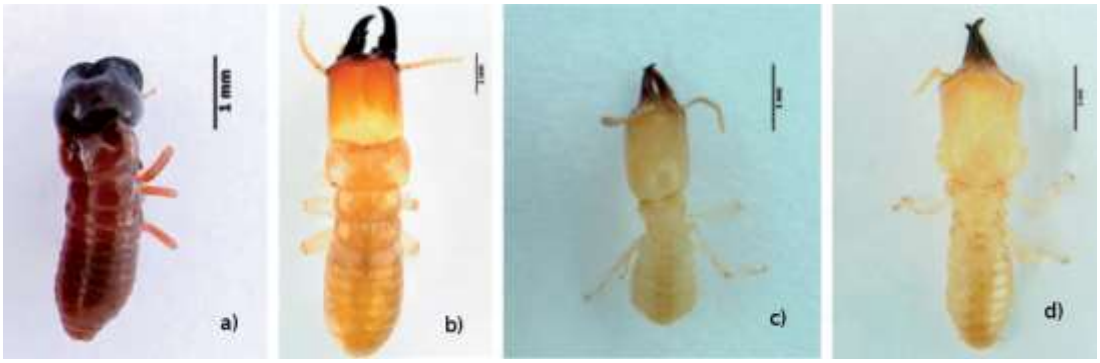

Figure 1: Soldiers from the different species occurring in the Azores: (a) *C. brevis*, (b) *K. flavicollis*; (c) *R. grassei*; and (d) *R. flavipes* (photos: Enésima Mendonça).

This drywood termite it is the most problematic in the Azores because it is present in the urban areas of the main cities, hence causing huge economic damages in the timber structures of buildings (Borges et al. 2006). It has a widespread distribution in the tropical and subtropical regions of the world, being the Azores the northern boundary where this species is established. The occurrence of *C. brevis* was also registered in continental Europe in cities such as Lisbon and Barcelona (Nunes et al., 2010). However, because of the more temperate climate of the Iberian Peninsula, this termite is not likely to flourish as it has in the Azores. Originally from the deserts of Peru and Chile (Scheffrahn et al. 2009), this species was first described in Jamaica (Walker 1853) and recorded in the Azores in 2000 (Borges, et al. 2004; Myles et al., 2007).

Figure 2: *Cryptotermes brevis* colony

Presently it is recognized that is most probably unrealistic to fully eradicate *C. brevis* in the most affected cities of Ponta Delgada and Angra do Heroísmo in the Azorean islands (Borges and Myles 2007). Although the possibility to eradicate this species from the other four least affected islands it is real. Also, once the eradication is unlikely, understand the spread of *C. brevis* in the major cities is necessary to implement an Integrated Urban Pest Management. Therefore, to understand the species spread and infestation patterns, a long-term approach monitorization program was implemented to monitor the species' dispersal flights in several private and public buildings in the world heritage city of Angra do Heroísmo.

2. METHODS

2.1 Study area

The Azorean Archipelago is located in the North Atlantic Ocean (36–40º N, 25–31º W), 1,584km west of southern Europe, and 2,150km east of the North American continent.

It is composed by nine Islands distributed in three groups (Fig. 2): the western group of Corvo and Flores; the central group of Faial, Pico, Graciosa, São Jorge, and Terceira; and the eastern group of São Miguel and Santa Maria. The monitored city, Angra do Heroísmo, is located in Terceira Island in the Central Group. The central zone of the Town of this city Angra do Heroismo in the Azores was the first Portuguese city classified by UNESCO as world heritage monument (UNESCO, 1983).

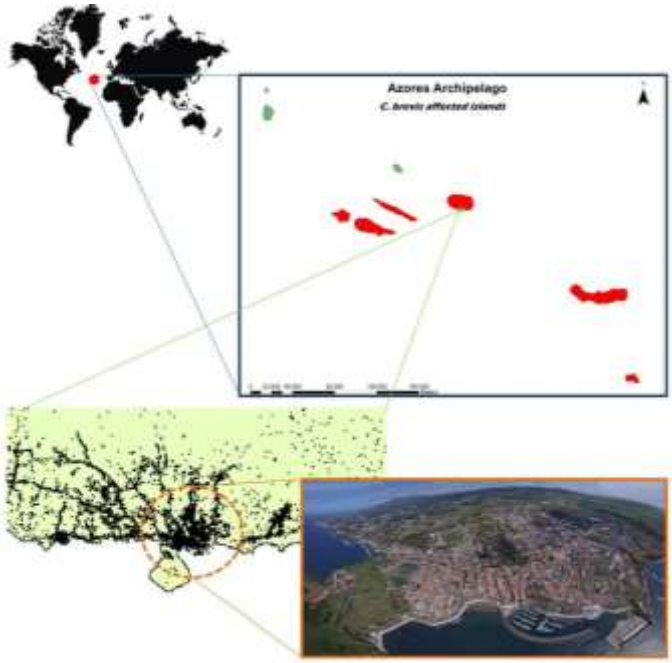

Figure 3: Locations of Angra do Heroísmo in Terceira Island and in the Azores. The islands colored in red are the ones that are already affected by *C. brevis*.

2.2 Monitoring

Several buildings were monitored from 2010 to 2015 doing a sampling of the swarming of *C. brevis*. For this purpose a yellow adhesive trap (45 by 24 cm) was set in buildings (mainly in the attics) from beginning of June to the end of September, which corresponds to *C. brevis*' flight season (swarming) (Figure 4). The traps were set under a natural light entrance (windows, skylights, glass tiles, etc.) or with a light bulb (either fluorescent or incandescent) when natural light was not at disposal.

Figure 4: Trap sample in beginning of the sampling period

In the end of September, traps were removed, taken to the laboratory and counted. For quantification two methods were used: 1) individual counting when the number of specimens in the traps was low; 2) overall estimated abundance using a transparent plastic sheet with three 5-by 5-cm squares randomly positioned, over traps that were heavily covered with alates.

Figure 5: Trap sample of a heavily infested building in end of the sampling period

Termite abundance was measured as mean number of termites per trap, because in some buildings, more than one trap was used. Afterward, the number of captured alates was used to estimate the number of colonies per building according to the average number of individuals per colony and percentage of nymphs alates present on a colony (Myles et al., 2007). On the basis of this, we estimated the existent number of colonies at each building site, dividing the number of alates in traps by the number of nymphs alates present in average on a colony. To obtain infestation levels, the abundance of alates were organized in a logarithmic scale using the following octave binning system: bin 1=number of houses with 1 colony or less, bin 2 = number of houses with 2–3 colonies, bin 3=4–7, bin 4=8–15, bin 5=16–31, etc. (Gray et al. 2006). The octave scale was transformed into an infestation index: Incipient (bin 1; 1 colony); Slight (bin 2; 2 or. 3 colonies); Moderate (bins 3 and 4; 4–15 colonies); Heavy (bins 5 and 6; 16–63 colonies); Very Heavy (bins 7 and 8; 64–255 colonies); and Destructive (bins 9 and higher; >255 colonies) (Borges et al., 2014). According to this scale, we mapped the buildings and applied an infestation probability on the surrounding area of 100m (according to the average flying capability of this species studied by (Guerreiro, 2009).

3. RESULTS AND DISCUSSION

During the 6 yr of monitoring, 955461 alates were captured in the city of Angra do Heroísmo (Table 1). We monitored an average of 80 buildings per year in Angra do Heroísmo with an 1982,2 average captures. There was a clear variation of captures along the years (2010 to 2015) in which 2011 and 2013 had the lower captures, with 1466,5 and 1279,5 respectively (average number of alates per trap). Also the year of 2012 had a small number of captures (1548,4). The years with higher numbers where 2014 and 2015. In these years the average number of captures increased.

Table 1: Number of total alates captured during the 6-yr of monitoring

Year	Number of Alates	Number of buildings	Average Captured/Building
2010	160067,8	77	2078,8
2011	112922,1	77	1466,5
2012	131614,7	85	1548,4
2013	102360,8	80	1279,5
2014	213086,6	69	3088,2
2015	235409,2	94	2504,3
Total	955461,2	482	1982,2

One possibility for the variation of captures might be related with the number of buildings that have a “Destructive” infestation level. In table 2 it is possible to see the number of buildings

accordingly with the infestation level. Also in this table the years of 2014 and 2015 have more Destructive buildings than the previous years.

Table 2: Number of infested buildings according the infestation level along the 6-yr of monitoring

Infestation level/Year	2010	2011	2012	2013	2014	2015
Destructive	20	13	22	13	26	35
Very Heavy	19	27	16	22	16	19
Heavy	11	9	15	18	9	14
Moderate	7	10	10	13	9	13
Slight	6	6	4	6	4	5
Incipient	14	12	18	8	5	8

The numbers previously presented are easily comprehended in the Fig. 6. In this we associate the infestation level to a colour and printed in Angra do Heroísmo map according with the geographic location of each building.

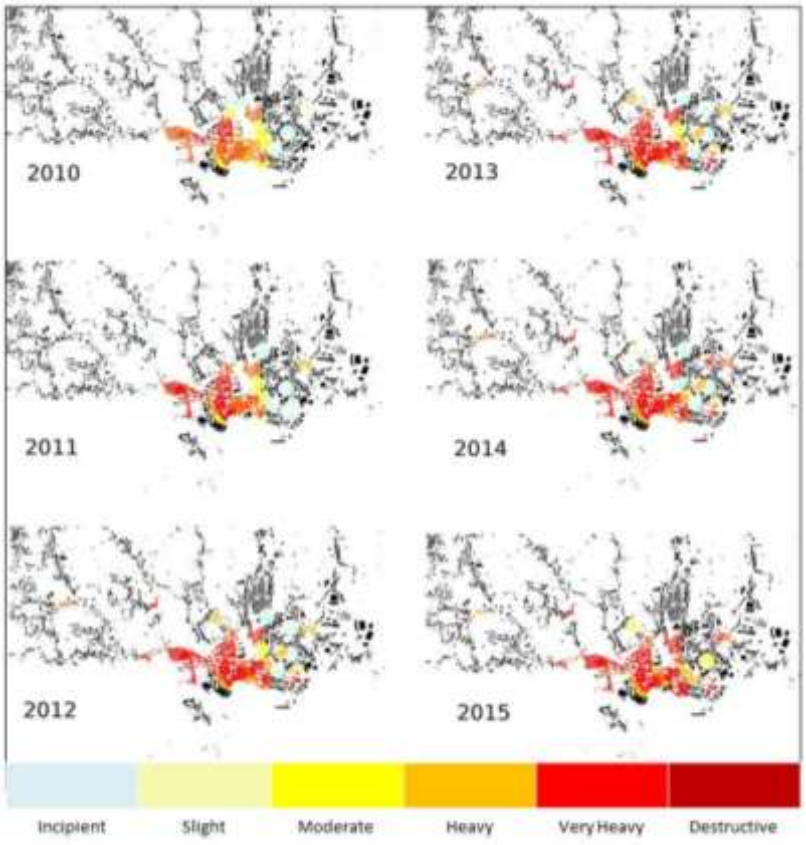

Figure 6: Evolution of the spread of *C. brevis* in Angra do Heroísmo from 2010 to 2015

The warmer colours are related with the high infestation level. Therefore it is easy to visualize the evolution along the 6-years of sampling and monitor. From 2010 until 2015 it is clear that the city historical centre evolve from a moderate- heavy infestation with some small parts destructive to a, almost, complete very heavy- destructive infestation. Also, the infestation area became quite larger and there are new infested spots that are isolated from the city centre. This isolated active sites may have been the result of human transport of infested goods from the already infested areas in the city center or from a foreign location. According to Ferreira (2011),

the *C. brevis* infestation in the Azores had more than one origin. Therefore, this infestation, which is distant from the center by more than 500 m, may have been established from a different source than the one in center of the city.

4. CONCLUSIONS

The heavy infestation observed in Angra do Heroísmo and the clear increase of infestation observed between 2010 and 2015 is a reason for concern. The current distribution of the species in the island should call attention for an urgent application of an IPM strategy to control this termite pest in Azores before all wood structures disappears.

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