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ABSTRACT

The detection in 2002 of drywood termites in the islands of Azores has became an urgent issue to be coped with given the fast degradation that structural elements can show after a short period of installation of a colony. A recent study indicates drywood termite presence in about half of the buildings of the historic centre of Angra do Heroísmo (a World Heritage site) in Terceira Island and timber structures surveys conducted so far points to strong levels of degradation of timber elements and structures.

A strong effort should be put on the rehabilitation of structures already affected, implementation of control procedures for restraining the spread of new colonies into so far sound buildings and alteration of traditional practices (namely choice of wood species and protection treatments) regarding timber utilization in construction.

This document presents some of the most relevant facts regarding drywood termites' presence in the Azores, degradation problems already detected, research efforts in place and preliminary proposals already made to deal with this problem.

Keywords: drywood termites, Azores, world heritage, impact

1 Introduction

Drywood termites are social insects, but unlike subterranean termites, they live inside the wood they infest (Pearce 1997). This characteristic facilitates their dispersion, thus being easily transported with infested materials and, once introduced in suitable environments, colonies can survive and establish. *Cryptotermes brevis* (Walker) (Isoptera: Kalotermitidae) is considered to be the termite species that has suffered more introductions and the most important drywood termite with pest status (Scheffrahn *et al.,* 2009).

C. brevis has a lifecycle with caste division as all social insects. In this species, the colonization of the building structure begins when the male and female mate and originate eggs. The nymphs, which develop from those eggs, have the capability to become any caste (pseudergates, soldiers and/or reproductive). Pseudergates (false workers) are responsible for obtaining food, feeding the others castes, eliminating the dead or sick individuals and taking care of the eggs. Only pseudergates can digest cellulose due to symbiotic protozoa (Pearce, 1997). Soldiers are responsible for the defence of the colony.

Every year, usually starting in June (Guerreiro *et al.,* 2006), the primary reproductives or alates emerge and are responsible for the colonization of new areas. However, if the queen dies, supplementary reproductives may replace the queen. A typical *Cryptotermes* colony has about 300 individuals (though it may reach 3000 individuals per colony) and so several independent colonies may exist in a determinate area. Due to their feeding habits on drywood, all timbers not subjected to treatment can become a potential food source and suffer consequent destruction.

2 Wood in the Azores building tradition

The Azores is an archipelago with volcanic origin, with nine major islands (S. Miguel, Pico, Terceira, S. Jorge, Faial, Flores, Santa Maria, Graciosa and Corvo) and eight small islands (Formigas) in the Atlantic Ocean between Europe and North America. It lies on the Lisbon parallel, on latitudes 39º 43'/36º 55' N.

Buildings in the Azorean cities historical centres are usually three and four stories high masonry buildings with timber floor and roof structures (figure 1). Each building shares, with the adjacent buildings, its lateral two walls, and several buildings in these conditions form a city block acting in the urban panorama as a unitary building structure.

Fig. 1: Typical building in Ponta Delgada, Azores.

This kind of construction is common in buildings constructed after the XIX century, where we can find timber beams supporting the floor planks. Due to the roof inclinations and spans, the roof structures are formed with timber trusses where timber beams and sheathing planks, supported by the trusses, can receive ceramic tiles.

Nowadays, timber is less used in the buildings construction, namely in floor structures, but in roofs it still has an important role, since one of the best ways to reach the good behaviour of a building under earthquake actions (very common in the Azores), is to reduce the building mass, specially in the higher levels (Fragoso *et al.*, 2005).

Several technical inspections carried out in old buildings in the cities of Angra do Heroísmo and Ponta Delgada, showed that the most common timber applied in load-bearing structures, such as floor and roof beams and, also, roof trusses, are wattle and eucalyptus, while in the non-resistant elements is cryptomeria (sugi) wood. These timbers were very popular in Azorean buildings because the climate and the local forest could provide good trees leading to long and straight resistant elements.

The building inspections also showed that most structural timber elements are not protected by any treatment for long term protection against insects.

More recently, due to significant changes in agricultural practices, wattle and eucalyptus are difficult to find, and the building construction industry uses tropical timbers such as iroko, mahogany and agba, as alternatives. Also, the well-known damages in wood structural elements of old buildings produced by *Cryptotermes brevis*, are operating a new construction philosophy, which consists in the preventive protection of the wood applied in buildings, and a more careful inspection and maintenance of this protection during building's life.

3 *Cryptotermes brevis* introduction in the Azores

An extensive taxonomic and biogeographic history of *C. brevis* has been recently presented by Scheffranhn and co-workers (2009) including the finding for the first time of this species in outdoor woodland environments, in Chile and Peru. Nevertheless, a vast majority of *C. brevis* current distribution range remains of introduced origin. A last account of this species distribution (Scheffranhn, 2005) indicates about 70 countries in all continents except for Antarctica.

In Europe, several references can be found of the presence of live isolated infestation episodes mainly related to the transport of wooden artefacts from central and south America, namely in England where the presence of *C. brevis* was referenced twice (Gay, 1969) and in Berlin, Germany (Becker and Kny, 1977). Recently, two other apparently confine but severe introductions were described in Genova (Raineri *et al*., 2001) and Padova (Fontana and Buzzetti, 2003) in northern Italy.

Well established populations of *C. brevis* have been referenced for several years in the Mediterranean Islands of Italy (Liotta, 2005), in the Spanish Canary Islands (Martinez, 1957) and in the Portuguese Madeira and Porto Santo Islands (Mateus and Goes, 1953).

In 2002, *C. brevis* was identified for the first time in the Portuguese Islands of Azores though alates and wings had been noted by a number of people in the previous years without clear recognition of their origin. An assessment of the situation on the several islands of the Azorean archipelago has already been done and so far well established populations of this pest termite were found in the Islands of S. Miguel, Terceira, Faial and Santa Maria (Myles *et al*., 2007; Nunes, 2008)

In Angra do Heroísmo, Borges and co workers (2004) refer a progressive degradation, which is often alarming to the architectural heritage, showing the impact of this termite species as a pest of buildings. The data available indicates that 43 % of the buildings in Angra do Heroísmo were infested and 50% of the infested cases presented severe infestation and destruction.

The most infested parts of the buildings are usually the roof structures. Drywood termites may enter through attic ventilations or other entries that might exist (figure 2). Once installed inside the wood for instance using the holes already made by wood borers like *Anobium* spp. (Coleoptera: Anobiidae) or drilling their own holes (personal observation in ongoing trials), these holes to the exterior are sealed and the identification of their presence becomes even more difficult.

Figure 2: Example of a possible point of entry of *C. brevis* alates

The origin of the termites in the Islands of Azores is still undetermined, though their distribution in Angra do Heroísmo (heavy infestation extending from the harbour) suggests an entry in the port area at least several decades ago, possibly at the time of the last major earthquake (in 1980) and associated with the extensive rebuilding that took place at that time (Nunes *et al.*, 2005). Infested furniture is traditionally one of the most important means of introducing the pest and should also be considered as a possibility in this case.

The following figures 3 to 8 show several examples of degradation by C. brevis found in the cities of Ponta Delgada (São Miguel Island) and Angra do Heroísmo (Terceira Island).

Fig. 3: Example of an heavy infested structure close to rupture

Fig. 4: Example of an infested structure where rehabilitation is still possible

Fig. 5: Detail of the degradation found in a beam of a building in Ponta Delgada

Fig.6: Detail of the degradation found in a roof beam of a building in Angra do Heroísmo (Photo: PestKill Lda.)

Fig. 7: Aspect of the fecal pellets on the floor

Fig. 8: Detail of the degraded wood with C. brevis attack

4 Strategy of the intervention

The patterns of infestation that were observed imply great costs to the owners of the buildings, especially in the highly infested areas. Drywood termite control costs in the United States are estimated to exceed $300 million annually with greatest losses occurring in southern California, peninsular Florida, and Hawaii. *Cryptotermes brevis* accounts for about $120 million in the US and untold amounts worldwide (Scheffrahn and Su, 1999). These costs are for treatment only and do not include labour, equipment and materials needed for repair or replacement of structures. Liability risks and actual health and environmental risk are also not included in the estimates.

Eradication of *C. brevis* was tried in the past in several regions of the world but no records were found of success in dealing with a well-established invasion like the one found in São Miguel and Terceira Islands. The reasons for the quick and strong establishment of *C. brevis* in some specific areas of the world, mostly islands, and particularly in the case of the Azorean Archipelago, is not yet clearly understood and further research is ongoing.

The most effective way to act against an infestation by drywood termites is to prevent their installation and thus to slow down the process of introduction of the invasive species.

Imports of sawn timber or timber products from areas that are known to be infested should be done with great care namely by using treatment with gas at their entrance/destination port, unless they had been preservative treated or when the natural durability of the species has been proven. This applies to timber, furniture of wood handicraft items that are introduced into Azores, or transported between islands or sent outside the Archipelago.

In already infested areas, installation of dry wood termites in new or existing, but yet unspoiled, timber structures can be prevented by avoiding the access of alates. Windows, doors and ventilations holes, particularly at the roof or attic level, should be protected with small mesh screening. This is particularly important during summer, when infestation by dissemination of alates takes place.

Termite alates are weak fliers and flights are slow with wings shed within minutes of landing (Guerreiro *et al.*, 2006). Nevertheless complete blockage of alates is extremely difficult to be achieved. Any possible means to intercept and destroy the insects at this stage should be implemented. This can be done for instance with an UV light electric trap, like the ones frequently used in restaurants to catch domestic flies. Desiccating or toxic dusts such borate dust seem also be effective in preventing installation of the reproductives (Lewis, 2003).

Unlike most other wood destroying organisms, *C. brevis* has been reported to be able to attack most timber species, to some degree. This presents a major problem, not only because most existing structures will in general be susceptible, but also because at present no record could be found of a 100% durable timber species. This is an important topic and a research program on the evaluation of natural durability of alternative timber species or wood-based products has been ongoing. Initial results have demonstrated the amazing ability of this species to rapidly colonized susceptible timbers and interesting (and promising) results were reached with wood based materials (Amaral, 2008).

At the present knowledge only treated timber with deep impregnation is known to be durable to *C. brevis*. This has been recommended for new construction and for partial replacement of infested structures (Fragoso *et al.*, 2005). Surface treatment of timbers with low impregnability and high natural durability can also at this stage of knowledge be considered as a possible alternative.

Meanwhile, if there is already an infestation, control measures need to be applied after careful evaluation of the damages and extension of the infestation. The results of the inspection will be determinant in the choice of the best treatment options as no single control method is best for all situations. Drywood termite treatments are divided into three general categories: (a) whole structure; (b) compartmental and (c) local or “spot” applications.

The combat against *C. brevis* infestations is particularly difficult. Unlike subterranean termites, which only establish in moist wood and will not infest building’s structures unless there are accidental water leakage problems and will leave if those defects are solved, *Cryptotermes brevis* colonises “healthy” buildings and moisture control cannot be used as a remedial treatment. Besides, unlike beetles, drywood termite colonies may live indefinitely inside the timber member and surface treatment is unable to deal with this kind of problem.

In the USA and other infested areas, *C. brevis* infestations to buildings are generally controlled by the use of fumigation, the only method known to be able to claim complete eradication of termites from an infested structure (though without any residual effect). This method requires the isolation of the structure to be treated and is suitable to treat uni-familiar isolated houses. The use of such method in the urban structure of Azorean cities is extremely difficult, due to the presence of common walls in adjacent buildings and the hazardness of the most common gases used (methyl bromide and more recently, sulfuryl fluoride) that lead to the suggestion of an exclusion zone for bystanders of 10 meters around buildings under treatment (Anon, 2007).

Thermal and microwave treatments are also methods that have proved their efficacy to deal with drywood termites in parts of houses such as an attic or a bedroom. Full scale building treatments should be tested to overcome all the technical challenges of implementing them but also to study ways to reduce the possible risk of fire.

In the case of the Azorean buildings, and having in mind the present knowledge, chemical treatments (compartmental and “spot”) represent the most suitable and safe methods to control termite infestation and avoid the complete destruction of infested structures. These include the treatment of infested and adjacent timbers with preservative products with recognised termiticide action, either by brushing or aspersion (figure 10).

Infested timbers should also be treated by wood injection. The amount of drilling required and the effectiveness of the treatment depend on the chemical used and most chemicals will remain active in the wood after treatment.

Figure 10: Details of the application of a chemical treatment by aspersion (Photo: PestKill Lda.)

Regulatory concerns over the indoor use and the environmental hazards of several traditional wood preservatives and, particularly, the recent legislation applicable to the use of chromated copper arsenate (CCA) have triggered the research on alternatives with improved characteristics namely focusing in the target control of the pest species.

The development and testing of these and other new products is an important area of future work, where the better understanding of the particular conditions of establishment of *C. brevis* in Azores may take an important role. Research is also needed on the improvement of detection and monitoring techniques that will contribute to the development of a long term integrated approach strategy for the control of this important timber pest.

In the case of Azores, where seismic hazard is very high, as was unfortunately proven often in the past, drywood termite damage may have a strong impact in the structural safety and should be taken into account in the effective risk assessment of buildings.

5 References

Amaral, C. 2008. Avaliação e reabilitação de estruturas de Madeira degradadas por térmitas de madeira seca. Relatório de progressão de 2008. Relatório 54/2008. LREC, Ponta Delgada. 29pp.

Anon. 2007. Sulfuryl fluoride (PT18). Document I. Evaluation Report. European Union. Accessed online 2009.03.11. http://circa.europa.eu/Public/irc/env/bio_reports/library?l=/review_programme/ca_reports/pt18_insecticides/sf-18_publicpdf/_EN_1.0_&a=d.

Becker, G. and U. Kny. 1977. Survival and development of the drywood termite *Cryptotermes brevis* (Walker) in Berlin. Anz. Schadl. Pflanz. Umwelts., 50(12):177-179.

Borges, P., Lopes, D. H., Simões, A.M., Rodrigues, A. and S.E. Bettencourt. 2004. Determinação da distribuição e abundância de Térmitas (Isoptera) nas habitações do concelho de Angra do Heroismo. Project Report. Universidade dos Açores, Angra do Heroísmo. 55 pp.

Fontana, P and F. M. Buzzetti. 2003. Nuova segnalazione di *Cryptotermes brevis* (Walker, 1853) in Italia settentrionale (Insecta, Isoptera, Kalotermitidae). Boll. Mus. Civ. Stor. Nat. Venezia 54: 35-44.

Fragoso, M.R., Cruz, H., Nunes, L., Amaral, C. Regras gerais para intervenções em estruturas de madeira danificadas por térmitas de madeira seca (Documento de Trabalho – Versão 3.00). LREC. Ponta Delgada. April 2005, 39 pp.

Gay, F. J. 1969. Species introduced by man. In Krishna K. and F.M. Weesner (eds) Biology of termites - volume I. Academic Press, New York, London. pp 459-494.

Guerreiro, O., Myles, T., Ferreira, M., Borges, A., Borges, P.A.V. 2006. Flight and colony foundation of Azorean termites with emphasis on Cryptotermes brevis (in Portuguese). In: P A V Borges and T Myles (eds.), Workshop "Medidas para gestão e combate das térmitas nos Açores". Livro de resumos, Universidade dos Açores, Angra do Heroísmo: 17 – 33.

Lewis, V.R. 2003. IPM for drywood termites (Isoptera: Kalotermitidae). J. Entomol. Sci., 38(2), pp. 181-199.

Liotta, G. 2005. Le termiti agenti di degrado delle strutture lignee dei beni culturali. Gennaro Tampone Ed. Proceedings of the International Conference “Conservation of Historic Wooden Structures”. Florence, 22-27 February, Vol.1, pp.3-10.

Martinez, JB. 1957. El termes de Madera seca (*Cryptotermes brevis*) en las isles Canarie. Montes, 13 : 147-161.

Mateus, T., Goes, E.R. 1953. Sobre uma térmite das madeiras secas, *Cryptotermes brevis* Walker. Lab. Nac. de Eng. Civil, Lisboa. Memória nº 44, 1953, 56 pp.

Myles, T. G., Borges P.A.V. and M. Ferreira. 2007. Phylogeny, biogeography and ecology of Azorean termites (in portuguese). In Térmitas dos Açores. Resultados do Workshop "Medidas para gestão e combate das térmitas nos Açores". Coordination: P A V Borges e T Myles. Princípia, São João do Estoril. pp. 15-28.

Nunes, L. 2008. Termite infestation risk in Portuguese historic buildings. Proceedings of the COST Action IE0601 International Conference “Wood science for preservation of cultural heritage: mechanical and biological factors”. Braga, November 2008. 6pp.

Nunes, L., Cruz, H., Fragoso, M., Nobre, T., Saporiti, J.M. and A. Soares. 2005. Impact of drywood termites in the Islands of Azores. In IABSE Symposium on Structures and Extreme Events. Lisboa, Portugal. 7 pp.

Pearce, M. J., Termites: Biology and Pest management., CAB International. 1997, 293 pp.

Raineri, V., Rey, A., Marini, M. and V. Zaffagnini. 2001. A new discovery of *Cryptotermes brevis* in Genoa, Italy (Isoptera). Boll. Soc. Entomol. Italiana, 133(2):99-102.

Scheffrahn, R.H. 2005. *Cryptotermes brevis* – Full Datasheet. Cabi Forestry Compendium on-line. http://www.cabi.org/compendia/cpc/.

Scheffrahn, R.H.; Su, N.-Y. 1999. West Indian Powderpost drywood termite, Cryptotermes brevis (Walker). Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Doc. nº EENY-079. On-line http://creatures.ifas.ufl.edu.

Scheffrahn, R H., Kracek, J., Ripa, R., Luppichini, P. 2009. Endemic origin and vast anthropogenic dispersal of the West Indian drywood termite. Biological Invasions DOI 10.1007/s10530-008-9293-3. 13 pp.