RELATÓRIO PROJECTO

COMBATE E GESTÃO DAS TÉRMITAS (ISOPTERA) EM HABITAÇÕES DOS AÇORES COM ENFASE NA ILHA TERCEIRA

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Wood consumption and pellet production by Azorean Kalotermitidae, *Kalotermes flavicollis* and *Cryptotermes brevis*

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Abstract: Two termite species of the family Kalotermitidae occur in the Azores. *Kalotermes flavicollis* is a dampwood termite and minor house pest. *Cryptotermes brevis* is a drywood termite and a major pest of furniture and structures. Records of wood species consumed by each species in the Azores are reviewed. Differences in the color, size, shape, disposal of fecal pellets of each species are described. Rates of wood consumption, pellet production were experimentally studied for *Cryptotermes brevis* on 49 different wood species. Two wood species that are locally produced and widely utilized for construction, *Cryptomeria japonica* and *Eucalyptus* sp., were found to be among the most preferred woods for termite consumption indicating an important need for the development of an effective local pressure treatment system for preserving these woods. Least preferred (most resistant woods) included tropical hardwood species such as *Jatoba* and *Massundumba.* Fecal pellets expelled from galleries by termites are the most conspicuous evidence of *Cryptotermes brevis* infestations and provide a potential means of monitoring termite location, colony size and activity. Pellet expulsion was found to be discontinuous. However some bouts of pellet dumping were observed to be continuous for at least several days with rates of pellet expulsion of up to 274 pellets per hour, with pellet accumulations of as much as 7.8 grams over a two-week period.

Resumo: Duas espécies de térmitas da família Kalotermitidae existem nos Açores. *Kalotermes flavicollis* é uma térmita de madeira verde e é uma praga urbana menor. *Cryptotermes brevis* é uma térmita de madeira seca e é uma importante praga para mobiliário e estruturas. As espécies de madeira consumidas por cada espécie nos Açores é revista. Diferenças na cor, tamanho, forma, e modo de despejo das partículas fecais é descrito . A taxa de consumo de madeira e a produção de partículas fecais para a espécie *Cryptotermes brevis* foram estudadas em 49 tipos diferentes de madeiras. Verificou-se que duas espécies de madeira que são produzidas localmente e muito usadas na construção, *Cryptomeria japonica* e *Eucalyptus* sp., foram das mais consumidas, indicando a importância do desenvolvimento de um sistema local para tratamento por pressão em auto-clave das madeiras. Entre as madeiras menos consumidas (mais resistentes) encontram-se espécies tropicais como *Jatoba* e *Massundumba.* As partículas fecais que são expulsas das galerias pelas térmitas são a forma mais conspícua de detectar infestações por *Cryptotermes brevis,* dando bons meios para monitorizar a localização de térmitas, o tamanho da colónia e a sua actividade. Foi verificado que a expulsão de partículas fecais é descontinua. Contudo alguns períodos de expulsão de partículas fecais são contínuos por alguns dias com taxas de expulsões de 274 partículas fecais por hora com acumulações de até 7.8 gramas num período de duas semanas.

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1. Introduction

We can find two termite species of the Kalotermitidae family in the Azores (Borges et al. 2004). The two species of Azorean Kalotermitidae (*Cryptotermes brevis* and *Kalotermes flavicollis*) are ecologically similar in that their excavations are entirely in wood and not in the ground and therefore their colony development is usually limited to a single item of wood above ground (Lind 1997). Because of this limitation, these colonies are normally rather small, only a few dozens or few hundreds of termites (Nutting 1970). This is in contrast to the subterranean termite (*Reticulitermes grassei*) that is able to access many different wood items by tunnelling through the ground, and which may have colony sizes in the order of millions. However, these two Kalotermitidae species represent very divergent phylogenetic branches within this family. *K. flavicollis* is a classic "dampwood termite" and is representative of the more primitive ecological condition which is more dependent on higher moisture content in the wood. *C. brevis*, on the other hand, is the ultimate example of a "drywood termite" and can only survive in wood that is sheltered from precipitation not needing a high degree of moisture (Borror et al. 1992). The ability to retrieve water from wood is a very important feature in this species. Another difference between theses two species is the form of the pellets produced as well as the part of wood consumed.

Both species are polyphagous being able to consume a wide variety of wood species. We have collection records of *K. flavicollis* from Terceira in grape vines, and various hardwood trees including olive, citrus, salt cedar, *Metrosideos* and *Pitosporum undulatum.* It usually excavates galleries in the heartwood of dead branches adjacent to live tissue thus deriving moisture from the living tree. When it attacks structural wood it is usually only where that wood is exposed to leaks or condensation. *C. brevis,* in contrast, has not been collected outdoors but only inside structures in both structural wood and in furniture. For this reason it is a very important structural pest to consider. It attacks a wide variety of both hardwoods and softwoods although with clearly different preferences. Minnick et al. among others have done some preliminary research on the subject of wood preference for *C. brevis*, using 10 types of wood. In our studies we used up to 49 different types of wood and compared the different consumptions whether by pellets produced as by weight loss of the different types of wood used, with the purpose of finding evidences of which types of wood are preferred by *C. brevis*. Both locally produced and foreign types of wood were used for this purpose.

An understanding of the preferences and rates of consumption of wood by *C. brevis* as well as a clearer differentiation between some characteristics of the two Kalotermitidae species were studied with the purpose to provide some knowledge about these termites in order to implement more efficient plans of control. Also some treated woods were tested for efficacy against the consumption of *C. brevis*.

2. Methods

For the wood feeding experiments, pieces of different types of wood were cut into small blocks (Fig. 1) which were oven dried and weighted. These were then placed in Petri dishes with 10 termites each and were checked weekly. For the weekly check, dead termites were removed and pellets were counted. The woods used in the first wood consumption experiment were *Cryptomeria*, *Eucalyptus*, Jatoba, Sapel, Takula, Roseira, Pine, Acacia and Massarundumba. For all of these woods a total of three replicates were setup. By the end of three months the wood was again oven dried and re-weighted.

For the second wood consumption experiment, some of the same woods were used, but mostly foreign woods brought from Canada were used. In this case, the woods were divided into blocks and sheets. The blocks were placed in plastic cups, while the sheets were placed in Petri dishes. Three replicates for each wood were mounted and 50 termites were used for each replicate. The pellet production and termite mortality was also checked weekly.

For the experiment of termite mortality with treated wood blocks of treated wood were also placed in plastic cups with 50 termites each with 3 replicates. The woods used were two varieties of Pine, Marine and Resinous treated with Xylophene by emersion

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and vacuum and also treated with vacuum with salts like copper and borate (Appendix I).

Figure 1. Termites in a *Cryptomeria* block.

The pellets from *Kalotermes flavicollis* and *Criptotermes brevis* were observed under the microscope to analyze the differences between them (Fig. 2).

Figure 2. Pellets from *Criptotermes brevis* (5 rows from the left) and *Kalotermes flavicollis* (last 3 rows).

The pellet production was also analyzed by the collecting of pellets dropped from an infested ceiling at different time periods, from 30 min to 2 months in several different places in the field laboratory.

Statistical analysis: Both the EXCEL and STATISTICA 6.0 were used for the statistical analysis. A paired t-test was used in comparing the different woods for both the feeding experiments.

3. Results and Discussion

Observations of sectioned boards of various infested species indicate that this species always prefers to eat sapwood and has a lower preference for heartwood, this is especially true with *Cryptotermia japonica* in which the sapwood can be almost hollowed out while the heartwood in the same board is little tunnelled (Fig. 3).
Rates of wood consumption vary from 0.8 (Jatoba) to 12.6 (Eucalyptus) mg per month. This can also be expressed in terms of volume of wood excavated suggesting maximal rates of volume excavation of 0.004 cc per termite per month in *Cryptomeria*, suggesting that it would take 50 termites 40 days to excavate 1 cubic centimeter of wood.

Figure 3. Consumption of sapwood by *Cryptotermes brevis*.

Wood preference could also be expressed by pellet production. Rates of pellet production on the different woods varied from 0.9 to 4.3 pellets per termite per week. The colour, consistency, size and shape of pellets are varied between wood species consumed. Lignin is not substantially degraded in wood feeding termites, so the pellets produced by these are rich in lignin (Bignell 2006). Observations of resinous pellets generated in abundance when *Cryptotermes brevis* feeds on resinous wood such as *Pinus* were made. We believe that this ability to sequester resin during digestion is an important adaptation in this species allowing it to attack resinous softwoods. The manner in which faecal pellets are disposed also differs between the two species. In both species the pellets have a characteristic appearance with six strongly impressed lateral surfaces giving them a hexagonal cross section. In *K. flavicollis* the ends of the fecal pellets are usually flatter, and the color is brown or black, never light tan, whitish, or resinous. In *Cryptotermes brevis* the pellets are a little smaller and often more pointed at the posterior end. *Kalotermes* pellets are packed together in large clumps forming plugs between their large galleries. Large loose piles of expelled pellets are not found. In *Cryptotermes brevis* the pellets are never glued together but remain loose and sand-like, many (perhaps 50% or more?) are expelled by the termites from "kick holes". The rate of pellet dumping from kick holes in some cases may be as rapid as one pellet every 20 second and such dumping may be continuous for many days. We measure sustained rates of faecal pellets accumulations of up to about 10 grams over periods of two months.

The time between the drops of pellets is very variable. In 30 minutes time a total of 138 pellets were dropped. Most of the pellets took 0 to15 seconds between drops although sometimes the time between a pellet dropping would be more than a minute (Table 1).

Table 1. Time between pellets dropped during a period of 30 minutes.

time (seconds)	**number of pellets**
0 a 5	48
6 a 10	38
11 a15	17
16 a 20	6
21 a 25	12
26 a 30	7
31 a 35	2
36 a 40	3
41 a 45	1
46 a 50	1
51 a 55	1
56 a 60	0
Over 60 seconds	3

Also we observed that the pellet production in terms of weight varies greatly, from a maximum of 9.1224g collected in 2 months time to 1.1756g. While in a 2 week period we could collect from 7.8035g to 0.2147 (Fig. 9).

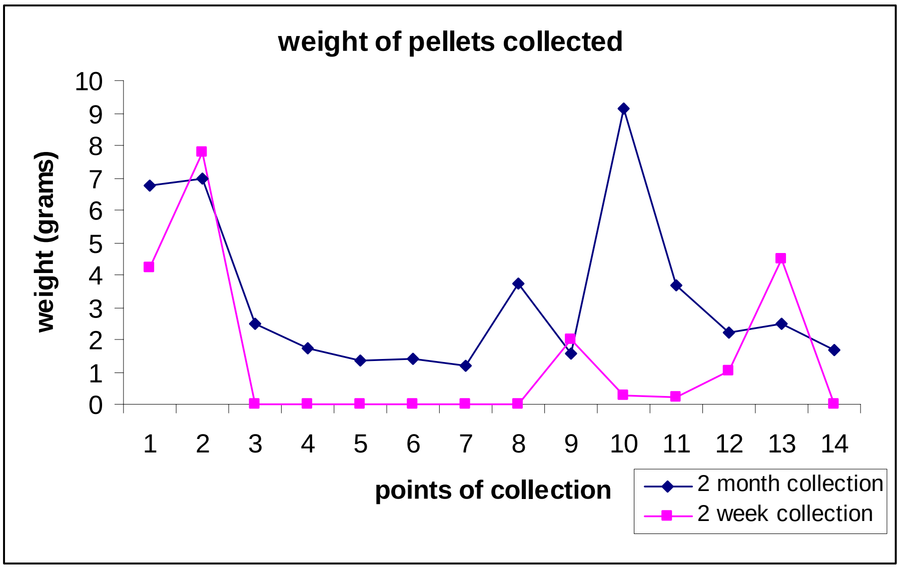

Figure 4. Pellets collected over two time frames at 14 different collection points.

We can also observe in Fig. 4 that for instance in point 2, there was a very similar value of pellet production even thought the time frame was different. This suggests that pellet dropping from termites is a rather variable event, not constant in time and quantity. This can suggest that in order to survey a house for termite presence, there is a need to inspect a house at different times because one time may not be enough to detect the presence of termites if you miss the pellet dropping time frame.

The first series of wood consumption experiments produced the following results:

In terms of weight loss *Eucalyptus* was the wood that lost the more weight due to termite consumption along with Roseira (Fig. 5). All the other wood types had a similar weight loss. This could indicate that *Eucalyptus* and Roseira are a preferred wood for termites, but on the other hand in terms of pellet production *Cryptomeria* as well as *Eucaliptus* were the woods that created more pellets per termite as can been seen in Fig. 6. This can happen for several reasons. Either the values of weight loss are so different between replicates that it is difficult to have accurate results, or there is no real relation between the weight loss of wood by consumption and the production of pellets. Also another reason is that these woods have very different densities so a bigger loss of weight does not mean a real increase in consumption, because the same amount of volume loss from two different types of wood can correspond to two completely different weight differences.

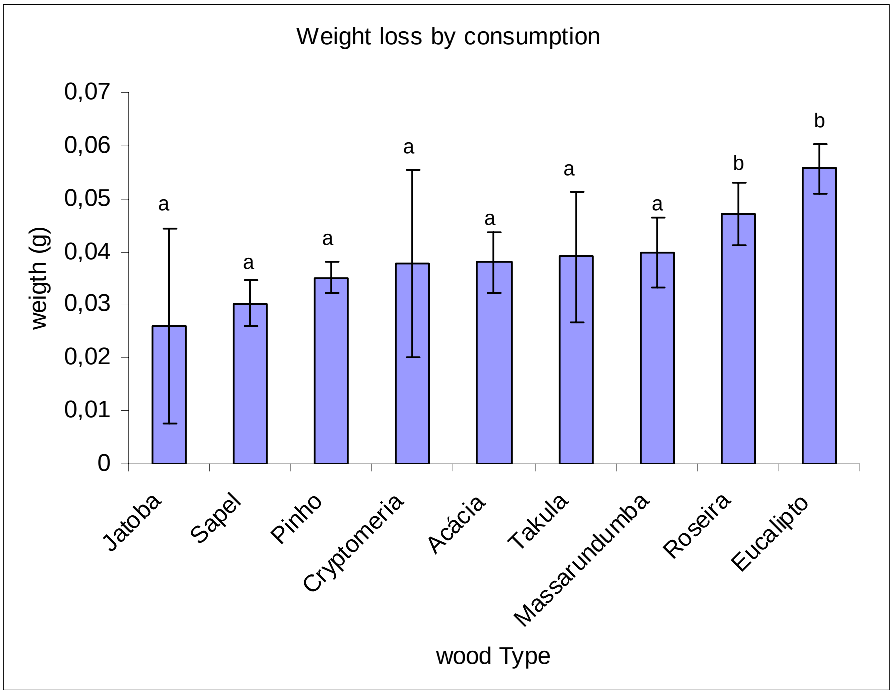

Figure 5. Weight loss due to termite consumption in the wood blocks. Bars with the same letter are not significantly different (p <0.05).

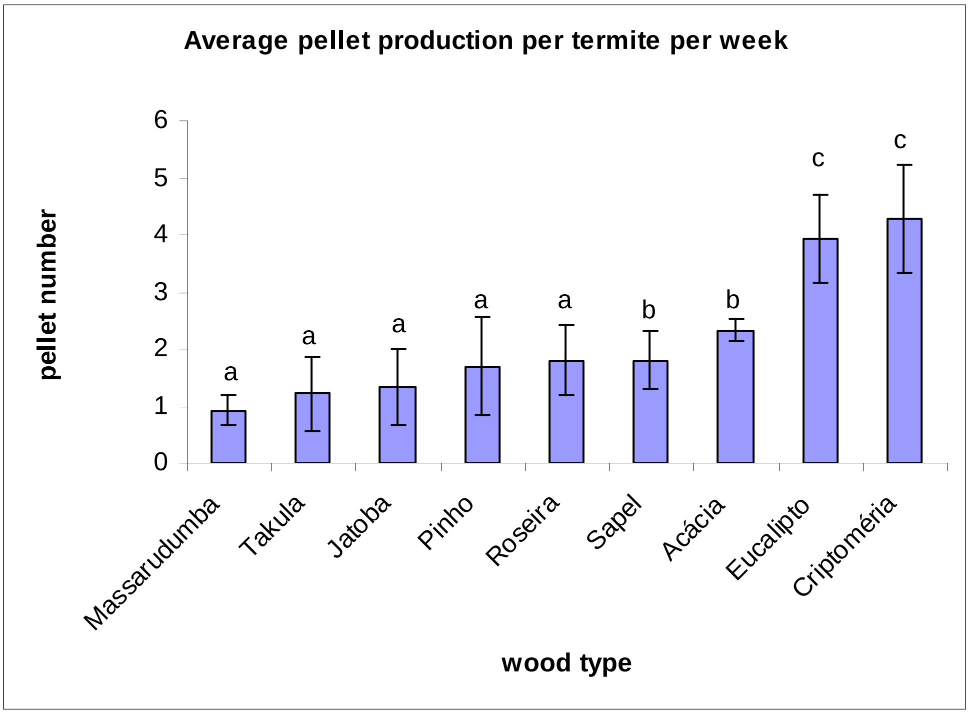

Figure 6. Pellet production per termite per week Bars with the same letter are not significantly different (p <0.05).

In the second wood consumption experiment, the woods that loss more weight were , Swiss Pear(*Prunus* sp.), Oak (*Quercus* sp.), Yellow Birch (*Betula alleghaniensis*), White Oak (*Quercus alba*) and Red Alder (*Alnus rubra)*. Although here are not represented the blocks weighted because these actually reported an increase in weight (Appendix II). For that reason they weren't considered for the weight loss results. This could have happened because on all the blocks weighted there were several plugs made by the termites, but further investigation on to this matter is necessary. We can also see in Fig. 7 that the woods that lost less weight were among others Liriodendron, *Eucalyptus* and Jatoba. This seems to show that compared to other woods *Eucalyptus* is not as consumed as it indicated the results of the first wood consumption experiment. However, other works have demonstrated that *Eucalyptus* is highly susceptible to attack by *C. brevis* (Silva et al. 2004).

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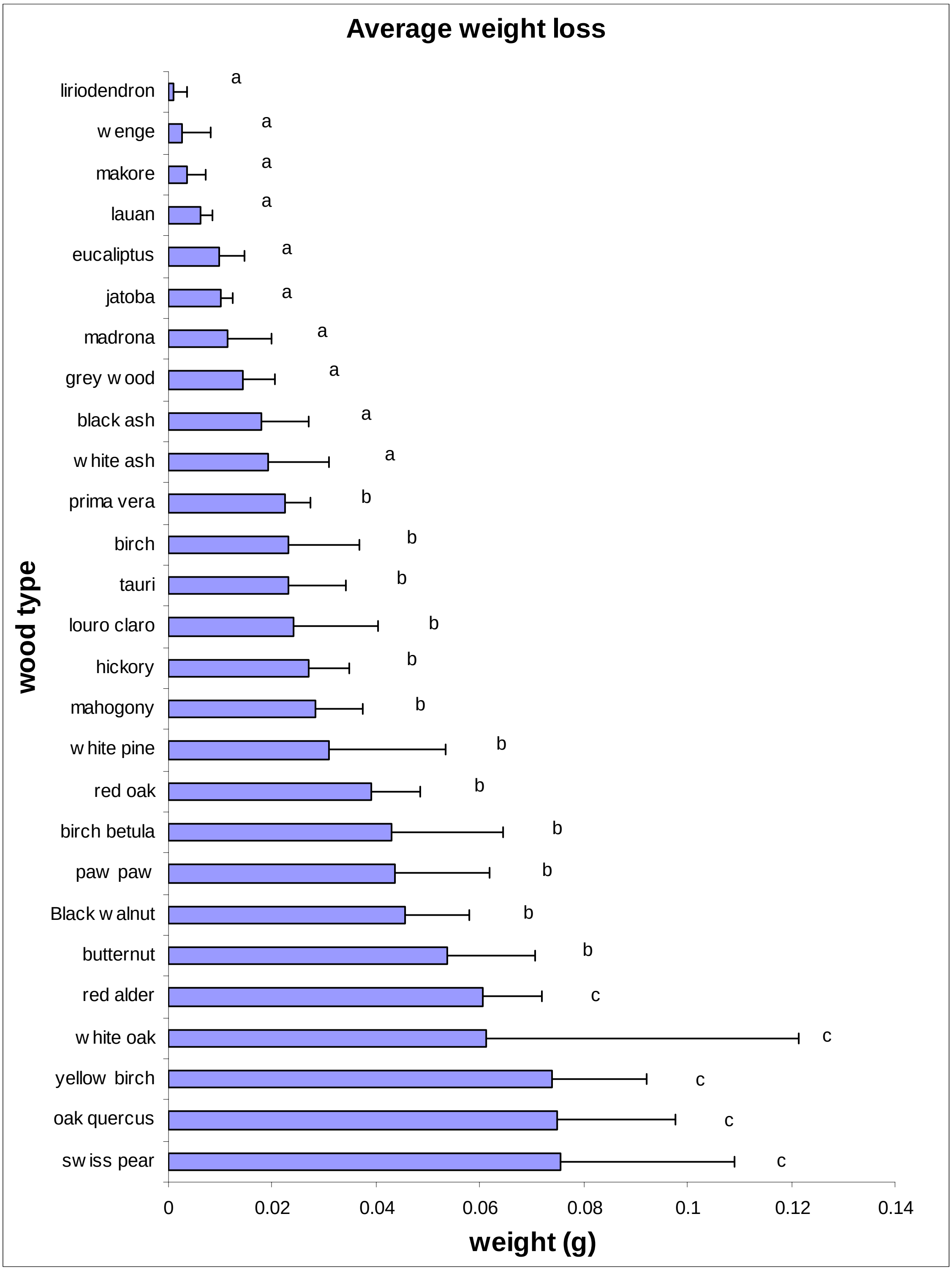

Figure 7. Average weight loss of several wood types in 2 months. Bars with the same letter are not significantly different ($p < 0.05$).

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As for the pellet production per termite we can see that all the woods referred previously as the ones that have lost more weight are also between the woods that produced more pellets per termite, being Red Alder the highest (Fig 8). We can also see that once again *Eucalyptus* shows as one of the woods that produces fewer pellets per termite. We can say that compared with a broader range of woods *Eucayiptus* is not one of the most consumed woods, although on a local scale as seen in the first experiment is not a very good choice for structural wood, as well as *Cryptomeria*. Also we can see that more exotic woods like Massarundumba or Makore are more resistant to attack by *C. brevis*, which should be taken into consideration when choosing wood for the home. This resistance of exotic woods have also been observed for other exotic woods like Cupiuba (Gonçalves & Oliveira 2006).

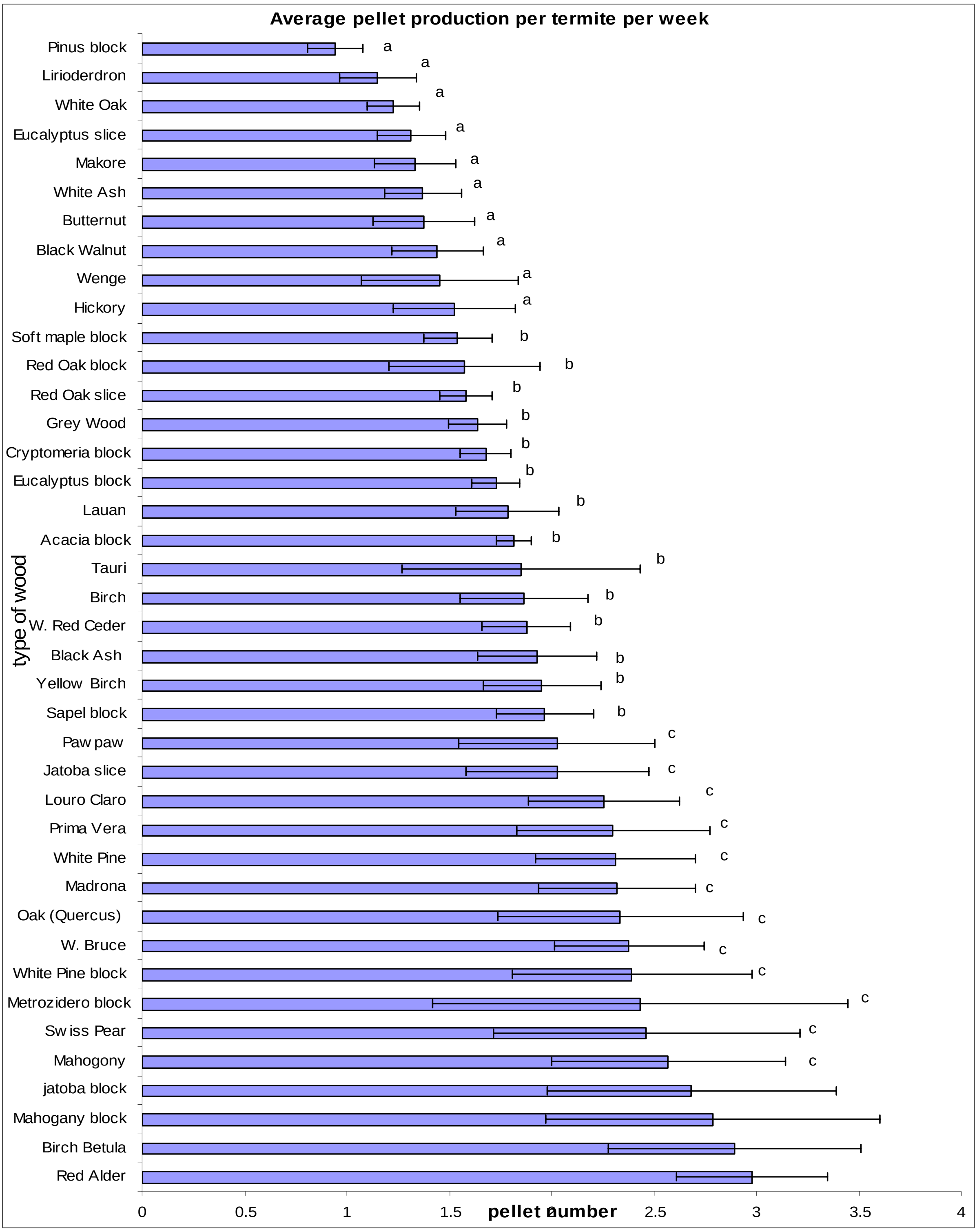


Figure 8. Production of pellets per termite per week in a 2 months period. Bars with the same letter are not significantly different ($p < 0.05$).

As for the results in treated woods we could see that there was a high percentage of mortality, 100% after 2 weeks in almost all the woods. Being the only one that did not have an 100% mortality was the *Pinus* treated with double vacuum of mineral salts (copper and borate), but achieving however a 92% mortality. This seems to indicate that treated woods from lumberyards are a good choice for use in the house with al the due precautions. Although there are several studies testing treated wood and its resistance to termites as for example Maistrello et al. (2002) and Wong and Grace (2004), this is still a subject that requires more studies.

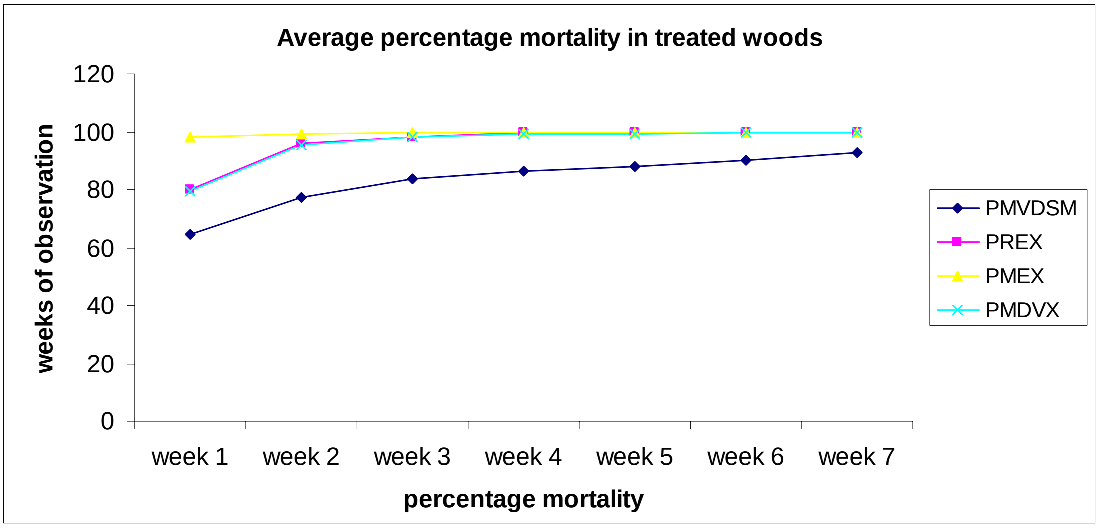


Figure 9. Percentage of mortality on 4 different treated woods.

4. Conclusions

From this study several conclusions can be drawn. First of all it is possible to distinguish an infestation from *Kallotermes flavicollis* and *Cryptotermes brevis* because they present different types of pellets as well as consume different areas of wood. This is an important notion to have when inspecting houses. Secondly, also an important aspect to note, is the variance of the pellet drops by *C. brevis* along a period of time.

As for the wood consumption preferences *C. brevis* showed a preference for woods like Swiss Pear (*Prunus sp*.), Oak (*Quercus sp.*), Yellow Birch (*Betula alleghaniensis*), White Oak (*Quercus alba*) and Red Alder (*Alnus rubra)* and not consume as much in exotic woods like Massarundumba and Makore. As for the locally produced woods *Eucaliptus* and *Cryptomeria* they are highly consumed, but not as much as the other woods already referred. This is a very important notion to have when deciding what wood to use when building new structures. Also another conclusion that is very important to have in mind is the use of treated woods in new construction seen that this and other studies seem to indicate that these are much more resistant to termite attack.

5. References:

Bignell, D.E. (2006). Termites as soil Engineers and Soil Processors. In: König, H., Varma, A., editors. *Soil Biology: Intestinal Microorganisms of soil Invertebrates and Termites.* Volume 6 p 183-220.

Borges, P.A.V., Lopes, D.H., Simões, A.M.A., Rodrigues, A.C., Bettencourt, S.C.X. (2004). *Relatório do Projecto – Determinação da Distribuição e Abundância de Térmitas (Isoptera) nas Habitações do Concelho de Angra do Heroísmo*. Unpublished.

Borror, D.J., Triplehorn, C.A., Johnson, N.F., (1992). *An Introduction to the Study of Insects*. 6th Edition, Saunders College Publishers, U.S.A.

Gonçalves, F.G., Oliveira, J.T.S. (2006). Resistência ao ataque de cupim-de-madeira seca (*Cryptotermes brevis*) em seis espécies florestais. *Cerne Lavras*, 12: 80-83.

Lind, P. (1997). Drywood Termites. *Journal of Pesticide Reform,* 17: 22-23.

Nutting, W.L. (1970). Composition and size of some termite colonies in Arizona and Mexico. *Annals of the Entomological Society of America,* 63:1105-1110.

Maistrello, L., Henderson, G., Laine, R.A. (2002). Comparative effects of vetiver oil, nootkatone and disodium octaborate tetrahydrate on Coptotermes formosanus and its symbiotic fauna. *Pest Management Science,* 59: 58-68.

Minnig, D.R., Wilkinson, R.C., Kerr S.H., (1972). Feeding preferences of the Drywood termite *Criptotermes brevis*. *Environmental Entomology,* 2: 481-484.

Silva, J.C., Lopez, A.G.C., Oliveira, J.T.S. (2004). Influência da idade na resistência natural da madeira de *Eucalyptus grandis* W. Hill ex. Maiden ao ataque de cupim de madeira seca (*Cryptotermes brevis)*. *Revista Árvore – Viçosa MG,* 28: 583-587.

Wong, A.H.H., Grace, J.K. (2004). Laboratory Evaluation of the Formosan Subterranean Termite Resistance of Borate-treated Rubberwood Chipboard. *Communication for the International Research Group on Wood Preservation*, Slovenia

Appendix I

List of used woods:

Wenge (*Millettia Laurentii*)

Madrona (*Arbutus menziesii)*

Jatoba (*Hymenaea courbaril*

Mahogany (*Swietenia sp)*

Primavera *(Cybistax donnell-smithii)*

Tauri (*Couratari sp*)

Makore*(Mimusops heckelii)*

Eucalyptus (Eucalyptus sp)

Lauan (*Shorea sp*)

Grey Wood (*Diospyrus sp*)

White Pine (*Pinus strobes)*

Eastern white spruce (*Picea glauca)*

Western red cedar (*Thuja plicata*)

Red Alder (*Alnus rubra)*

Birch Betula *(Betula papyrifera)*

White Ash (*Fraxinus Americana)*

Yellow Birch (*Betula alleghaniensis*)

Pawpaw *(Asimina triloba)*

Swiss Pear (*Prunus sp*)

Lirioderdron (*Liriodendron tulipifera*)

Oak (*Quercus sp*)

Louro Claro (*Roupala montana*)

Birch (*Betulla sp*)

White Pine *(Pinus strobus)*

Makore (*Mimusops Heckelii*)

Black Ash (*Fraxinus nigra*)

Hickory *(Carya sp)*

W. Bruce

Sapel (*Salix pentandra*)

Soft maple (*Acer rubrum*)

Pinho (*Pinus sp)*

White Oak (*Quercus alba*)

Red Oak (*Quercus rubra*)

Black Walnut (*Juglans nigra*)

Butternut (*Juglans cinerea*)

Cryptomeria (*Cryptomeria japonica*)

Metrozidero (*Metrozidero sp*)

Acacia (*Acacia sp*)

Treated woods:

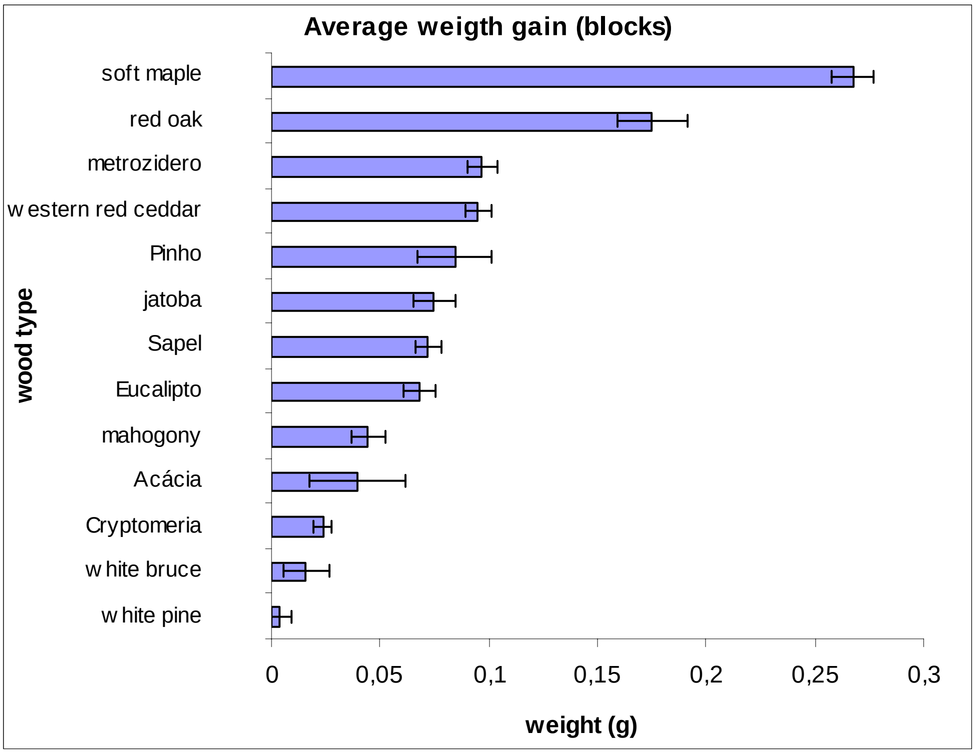
PMVDSM – "Pinho Marítimo com Vácuo Duplo de Sais Minerias de Cobre e Borato" - Marine Pine treated with double vacuum of Copper and Borate.

PREX – "Pinho Resinoso com Emersão em Xylophene" - Xylophene emersed Resinous Pine

PMEX – "Pinho Marítimo emerso em Xylophene" - Xylophene emersed Marine Pine

PMDVX – Pinho Marítimo com duplo vácuo em Xylophene" – Marine Pine treated with double vacuum of Xylophene.

Appendix II



Average weight gain in the blocks of wood from the second feeding experiment.