RELATÓRIO PROJECTO

COMBATE E GESTÃO DAS TÉRMITAS (ISOPTERA) EM HABITAÇÕES DOS AÇORES COM ENFASE NA ILHA TERCEIRA
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Flight and colony foundation of Azorean termites with emphasis on *Cryptotermes brevis*

Voo e fundação de colónias nas térmitas dos Açores com ênfase em *Cryptotermes brevis*

Orlando Guerreiro, Timothy G. Myles, Maria Ferreira, Annabella Borges & Paulo A. V. Borges

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Flight and colony foundation of Azorean termites with emphasis on *Cryptotermes brevis*

Voo e fundação de colónias nas térmitas dos Açores com ênfase em *Cryptotermes brevis*

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Abstract: Each of the three Azorean termite species flies during a different season and different time of the day. *Cryptotermes brevis* flies from June to August at dusk, *Kalotermes flavicollis* flies from the September to October in the afternoon, and *Reticulitermes grassei* flies during the spring, probably during morning hours. Of these, *C. brevis* is the most important pest and the only one that flies at night, therefore light trapping is possible. Experiments were conducted with fluorescent and incandescent lights, different colours of sticky traps and different kinds of glue or tape. Following the dispersal flight the termite exhibits a sequence of behaviours which were observed and analysed. The timing of the follow behavioural events was studied: de-alation, searching behaviour, tandem running, sealing the copulation, de-antennation, commencement of oviposition and time to first hatch. Hole size preference and wood species preference for colony establishment were also investigated. In addition, egg production and colony survival rates on different woods were studied.

Resumo: Cada uma das três espécies de térmitas existentes no arquipélago Açoriano apresenta um comportamento de voo em momentos distintos ao longo do dia e ao longo do ano. A *Cryptotermes brevis* tem o seu período de dispersão (de voo) entre os meses de Junho e Agosto no crepúsculo vespertino, a *Kalotermes flavicollis* de Setembro a Outubro durante a tarde, e a *Reticulitermes grassei* tem o seu período de enxameamento durante a primavera durante a manhã. Das espécies referidas a que apresenta maior importância, por constituir uma praga de dimensões consideráveis em algumas das Ilhas, é a *C. brevis*, sendo também a única que tem um comportamento de voo nocturno tornando assim possível o uso de armadilhas luminosas. As experiências aqui apresentadas contêm vários testes com diferentes tipos de luzes, fluorescentes e incandescentes, diferentes cores de armadilhas pegajosas bem como diferentes tipos de colas e fitas colantes. Após o período de voo as térmitas exibem uma sequência de comportamentos que foram observados e analisados. O tempo para cada um dos seguintes padrões de comportamento foi estudado: libertação das asas, comportamento de procura (de um parceiro), formação de pares, selagem da câmara de reprodução (ou ninho), amputação das antenas, início da deposição de ovos e tempo até à primeira eclosão. A preferência para buracos de diferentes diâmetros e diferentes espécies de madeira foi também estudada. Foi ainda também estudado a produção de ovos e as taxas de sobrevivência e de produção de ovos.

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1. Introduction

Three different species of the order Isoptera are now known in the Azorean Islands (Borges *et al.*, 2004) and as exotic species are the cause of serious problems and damage in buildings and living trees in some of these islands. The three species of termites found in the Azores are *Cryptotermes brevis*, a dry-wood termite; *Kalotermes flavicollis*, a live-wood or damp-wood termite; and the *Reticulitermes* sp. (presumed to be *R. grassei*), a subterranean termite. This investigation records their flight periods and tries to understand more about the reproductive behaviour and spread of reproductive adults, in particular of *Cryptotermes brevis,* since this is the most problematic and damaging termite in the islands. According to the literature the swarming of *Cryptotermes brevis* is a crepuscular phenomenon, with peaks 30 minutes after sunrise and 80 minutes after sunset (Gray & Watson, 1982; Scheffrahn *et al*., 1998; Milano & Fontes, 2002) (see Fig. 1). The seasonal swarming is usually related with the rainfall, however there was no convincing evidence of daily swarming with wind or tides. Usually there is a relation between the daily swarming with daily fluctuations of temperature, humidity, and barometric pressure. Therefore several complementary experiments were carried out in order to understand which factors influence the establishment of the young couples during the swarming period. These factors were: the attraction to fluorescent and incandescent light and different colours of sticky traps and different kinds of glue or tape; observation of the sequential behaviour of: Dealation, searching behaviour, tandem running, sealing the copularian, de-antenation, egg production period and time to first hatch; wood preference were investigated as well as egg production and colony survival rate on different wood species.

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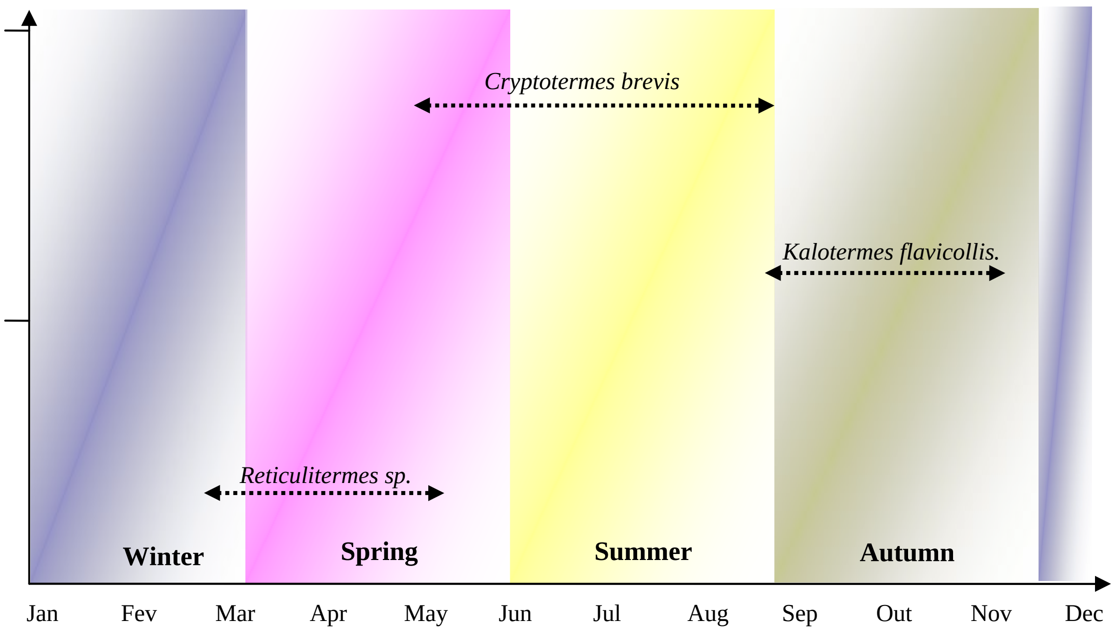

Figure 1. Seasonal and diurnal flight times of the different termite species in the Azores.

2. Materials and Methods

The first experiments sequence had the objective to understand which were the most attractive lights and colours. The objective was to find a new, easy and unexpensive trap for use by the general public.

Experiment 1: Light and color preferences.

Fluorescent and incandescent lights were used, as well as different colors of sticky traps (yellow, blue and brown) and different kinds of glue or tape (normal brown and transparent tape and mouse trap glue).

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Figure 2. Fluorescent light and blue and yellow sticky traps.

Experiment 2: Hole diameter and wood preferences for colony foundation.

This experiment aimed to understand which hole diameter is preferred by the newly flown alates to establish new colonies. Eighteen (18) wood blocks (15 x 4 x 2 cm) were used of both *Cryptomeria* and *Eucalyptus* each with 10 drilled holes 1 cm deep of diameters: 0, 2, 3, 4, 5, or 6 mm. The block with no holes was used to see if the termites might make their own hole to start a new colony. The blocks were placed in an open plastic box and exposed under a light previously scheduled with a timer to be on during the evening swarming period (20:00 to 24:00) (Fig. 3).

In a follow up tests we used six different types of wood: *Eucalyptus, Cryptomeria, Sapel, Játoba, Pinus,* and *Acácia* and seven different diameters (1, 1.5, 2, 3, 4, 5, 6 mm).

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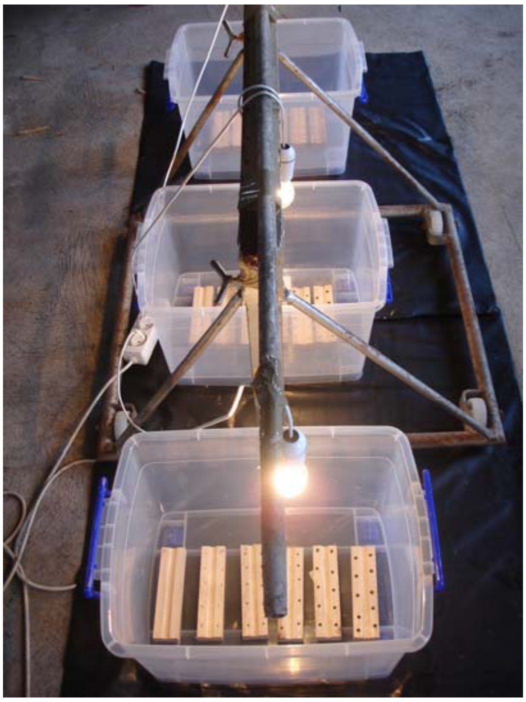

Figure 3. Experiments on hole preference.

Experiment 3: Dealation and Courtship behaviours

The alates leave the parental colony to start a new colony. Observation of the sequential behaviours following the flight period allowed us to record details of how the termites break off their wings (dealation) and form tandem pairs. The tandem pairing and running behaviour apparently constitutes the courtship behaviour in termites. These observations were recorded with digital photography and camcorder during the previous experiment on hole diameter preference.

Experiment 4: Copularium Closure and Oviposition

The crucial and perhaps the most important experiment is the one we call “suites test” which is a test to understand the colony foundation. In a first stage we use 20 blocks of *Eucalyptus* and *Cryptomeria* (10 of each) with 5 chambers (ø 24mm) with a 3 mm ø hole in the top of it. A piece of acrylic plexiglass, held in place with a rubber band, was used to close the chambers and provide a window through which we could observe copularium closure, de-antennation, oviposition and larvae as they developed, and count the number of pellets. A second stage includes other types of wood beside the first two: Sapel, Játoba, Pine, and Acácia. The strategy to attract the alates was the same used in the experiment 2. The monitoring of this experiment had the objective to understand some behaviour aspects investigated as well as egg production and colony survival rate in different wood species.

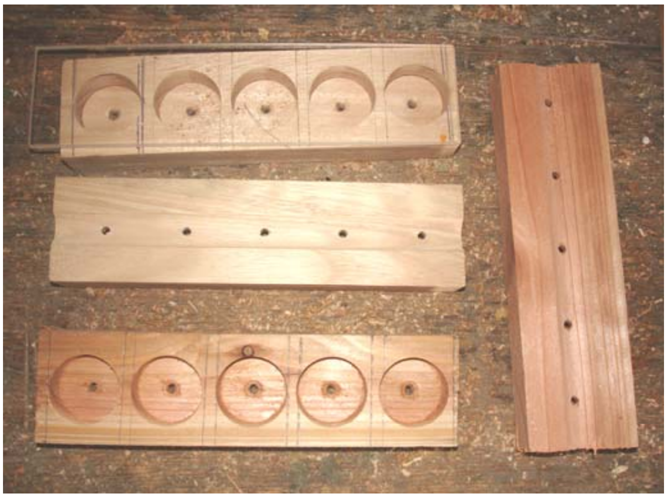

Figure 4: Copularium chambers to monitor colony development (suite test).

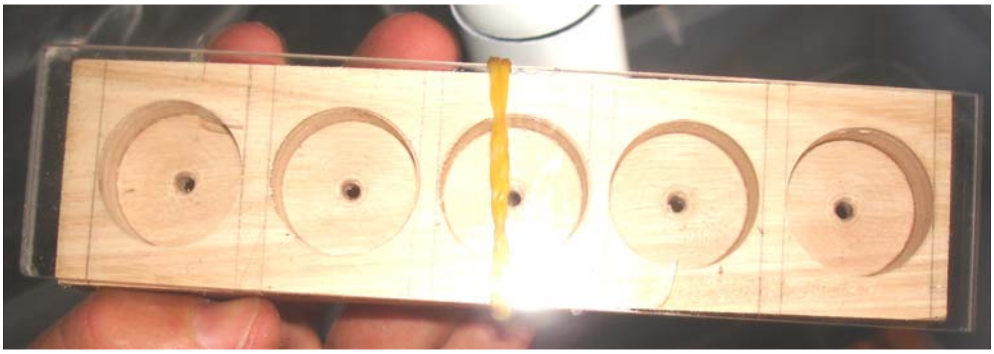

Figure 5. A block already set to be colonized.

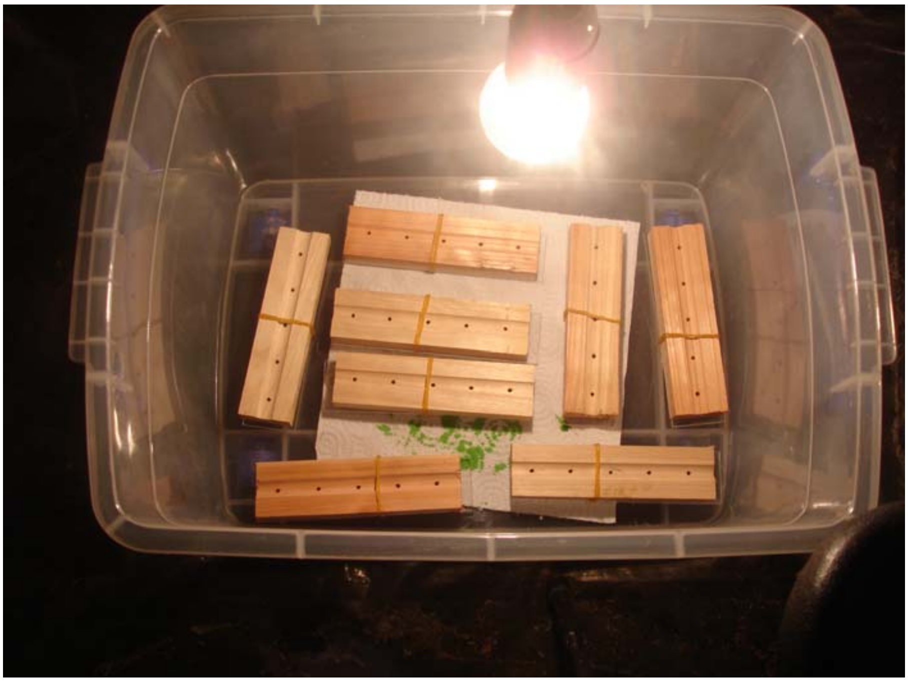

Figure 6. The system used in the Exp. 2 was also used to attract the alates. A plastic box with suites placed below a bulb light.

3. Results and Discussion

The results of each experiment were important to the development of further experiments.

Experiment 1

The light trap with sticky paper had success in the trap of young alates, with better results in the yellow color as seen in Figure 7.

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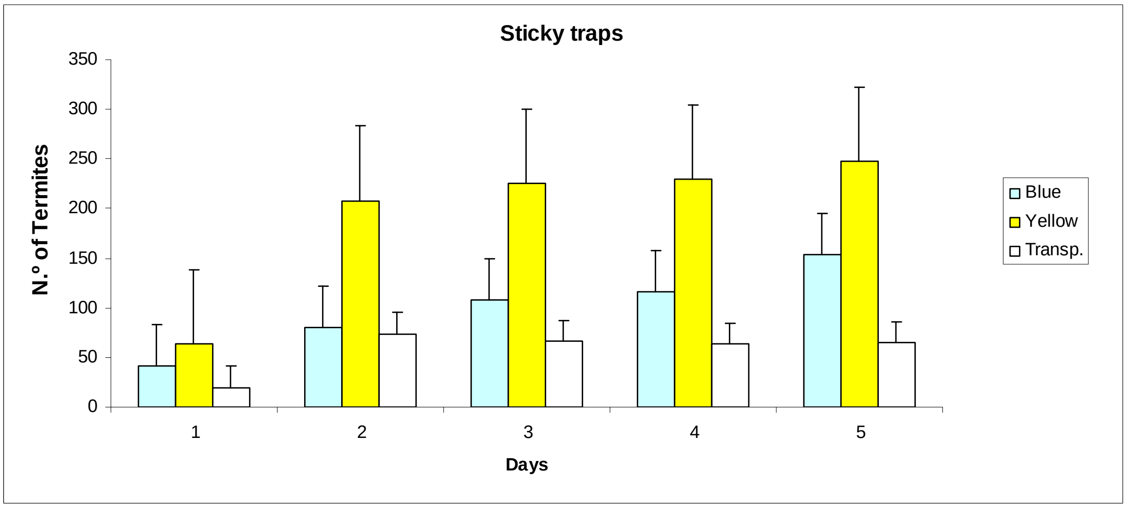

Figure 7. Cumulative number of alates trapped on the different coloured sticky traps.

The yellow sticky tape it was more efficient than the other tapes. We also found that all types of sticky traps, glues, and tape surfaces including the sticky surface of packaging tape were sufficiently tacky to trap alates which are rather weak insects. Both fluorescent and incandescent light traps were attractive to the termites. However the ªyellow" street lights that are present in the City of Angra do Heroísmo are not attractive which evidently comprises a different light spectrum compared to the yellow sticky traps. Another type of inexpensive trap can be made by suspending a light about 20 to 30 cm above a wide plastic bucket partly filled with engine coolant. Somewhat more expensive, but highly effective commercial ultraviolet "zap traps" are available that electrocute the alates. To ensure that the trapping is done every night, the light traps should be attached to a timer which is set to come on between 20:00 and 24:00. We recommend that all infested houses should run such a light traps from mid June through the end of August. All types of alate trapping are strongly recommended as an important remedial measure to be taken to reduce the rate of re-colonization and thereby prolonging the service life of infested wood structures. As this paper has shown, it is the multiplication of colonies by alates forming new colonies within a structure (re-colonization) which is a much greater threat to the structure than the actual growth rate of individual colonies, which is quite slow.

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Experiment 2

Experiment 2 shows the preferences of the alates for each wood type and the preferred hole diameter. The results reflect the number of holes that were colonized and completely sealed.

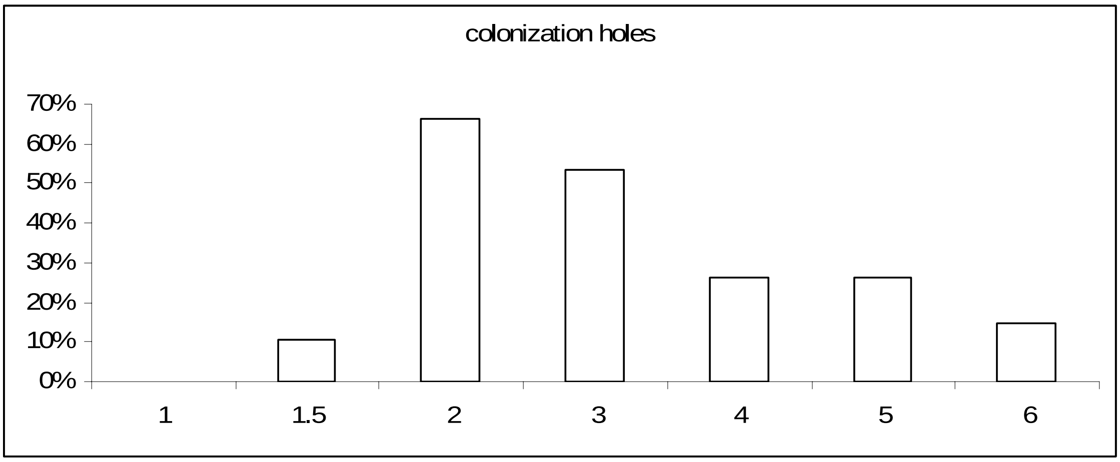

Figura 8. Percent of holes where colonization was started.

The results show that the 1.0 mm holes are too small for *C. brevis* to utilize (Fig. 8). However all hole sizes from 1.5 up to 6 mm were sometimes selected and used. When larger holes (4 to 6mm) were used they were often occupied by more than one pair of termites and this led to fighting and death of excess individuals. Also the larger holes took longer to seal and at 4 mm and above closure was often incomplete. Overall, the 2 and 3 mm holes appear to be are the ones that provide more success for colonization (Fig. 8).

Experiment 3

The results of the behavioural observation allow us to identify distinct patterns in a logical sequential. This sequence is composed of four distinct periods: dealation (Fig. 9), searching behaviour, tandem running and sealing the copularian chamber (Fig. 11).

Figure 9. Pair of wings and dealate couple. After dealation the male follows the female (Photo Rudolf H. Scheffrahn).

Figure 10. Tandem running, a male follows a female in the search for a new copularium chamber (Photo Rudolf H. Scheffrahn).

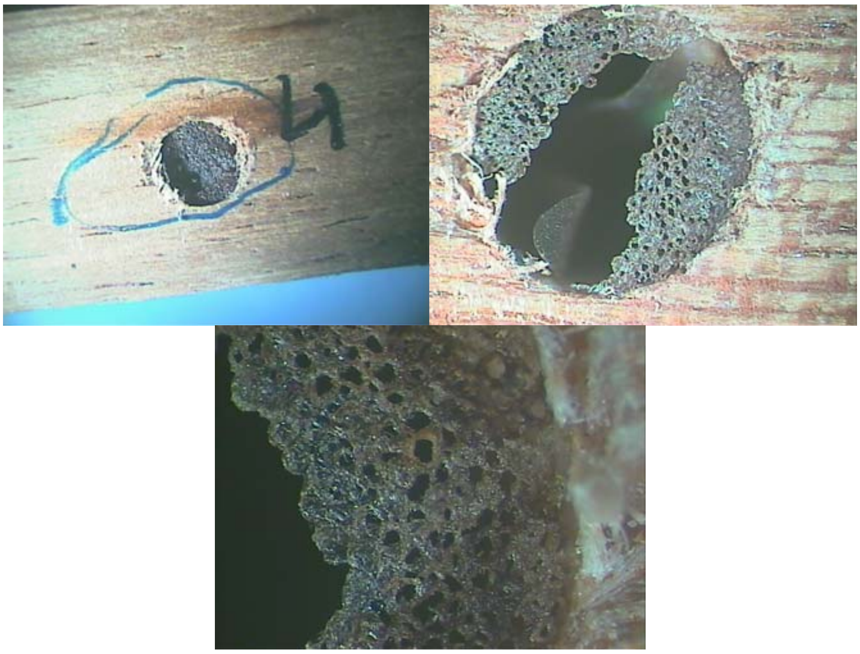

Figure 11. Copularium closure plugs; one on left is fully sealed, two on right and down are partially sealed.

The Figures above (Fig. 11) illustrate how the copularium closure plug is made nearly level with the exterior surface of the wood. Initially the plug is a more or less uniformly porous membrane. At a later stage these pores are pasted over and fully closed. It may be that the pores which appear to be of nearly uniform size are made by the styli which are tiny abdominal appendages near the anus. In alates only the male retains the styli, they are regressed under the 8th abdominal sternum of the female alate. If

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true, this suggests that the male is primarily or even exclusively involved in building the initial copularium plug.

Experiment 4

This last experiment is the perhaps the most important in clarifying the impact of *C. brevis* by providing data from which we may estimate the rate of colony development.

The first result (first stage) is the one that only includes *Eucalyptus* and *Cryptomeria* therefore including the results of these two species first (Figs. 12 and13).

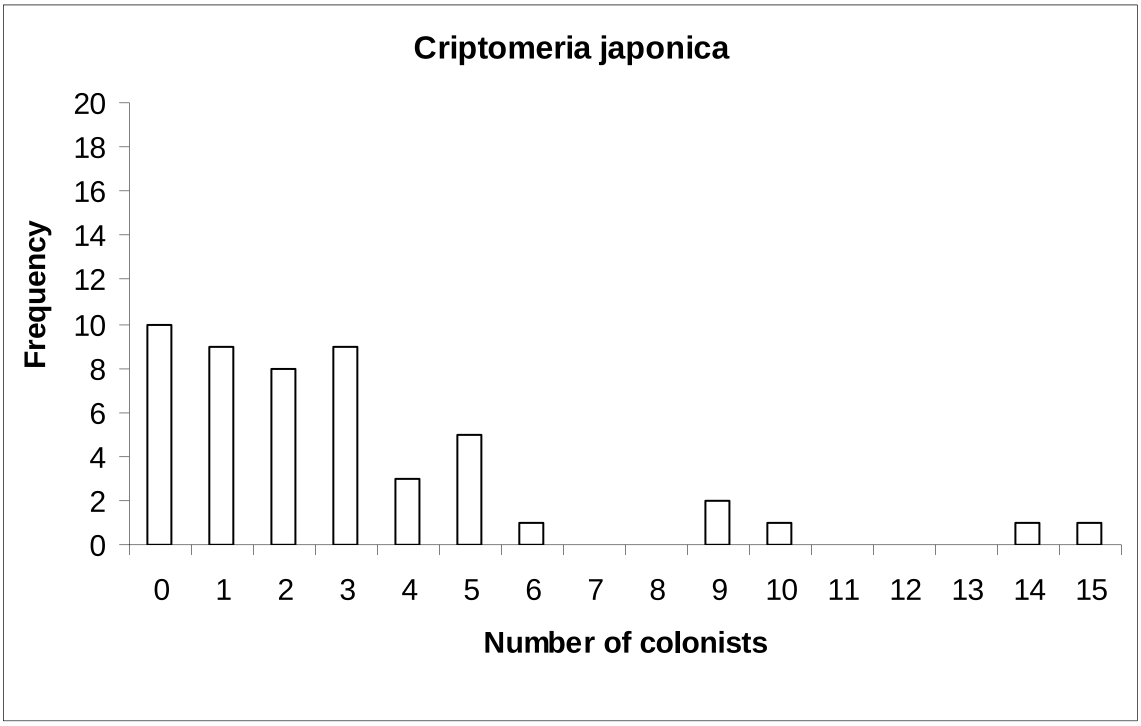

Figure 12. Alates frequency per hole in *Cryptomeria japonica.*

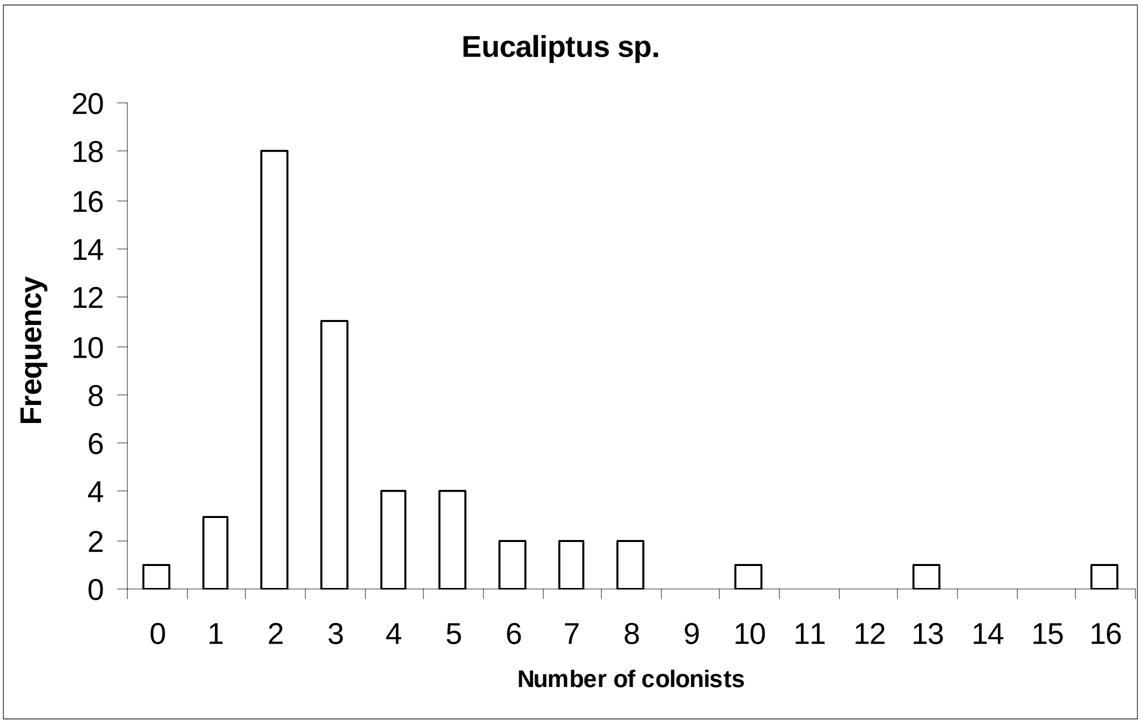

Figure 13. Frequency distribution of the number of alates per suite in *Eucalyptus* sp..

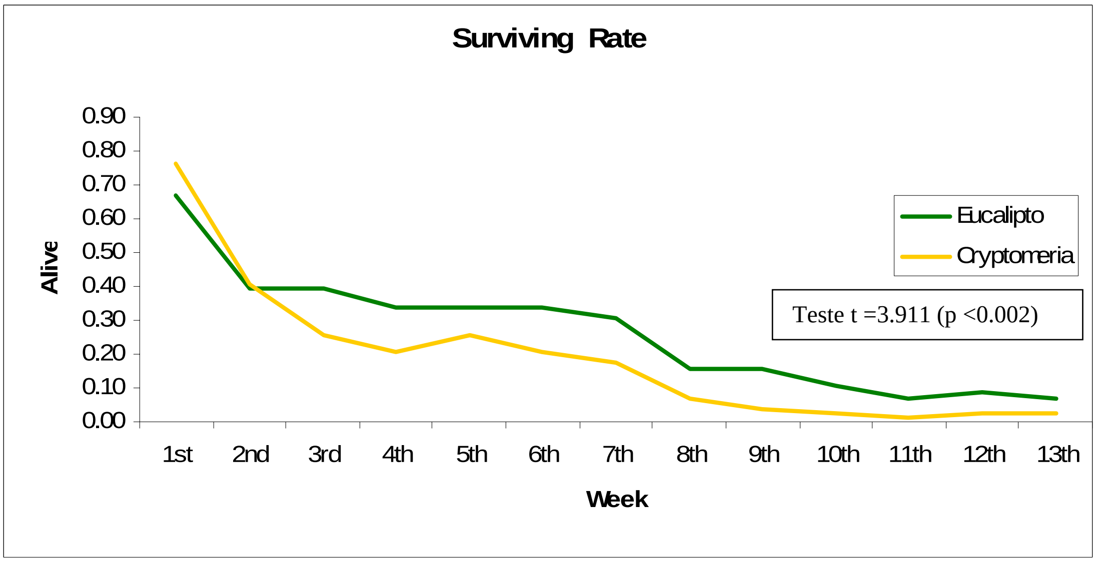

Figure 14. Comparison of colony survival rates on *Eucalyptus sp.* and *Cryptomeria japonica*.

Figure 12 shows that we observed a large number of suites occupied by variable numbers of alates, not just a pair (2). In many cases there was only a solitary termite, which of course could not successfully establish a colony without a mate! In other cases there were up to 15 termites present. In these cases of excessive numbers, there was always a high mortality apparently resulting from fighting among the termites, and leg and body scars from this fighting were observed. Figure 14 shows that survival rate in both woods declined at about the same rate over time suggesting that incipient colonies have a fairly high and steady death rate regardless of host wood species. Figures 15, 16 and 17 show that pellet production was higher, and egg and larvae production sooner on *Eucalyptus* compared to *Cryptomeria*, indicating that *Eucalyptus* may be a more favourable wood nutritionally.

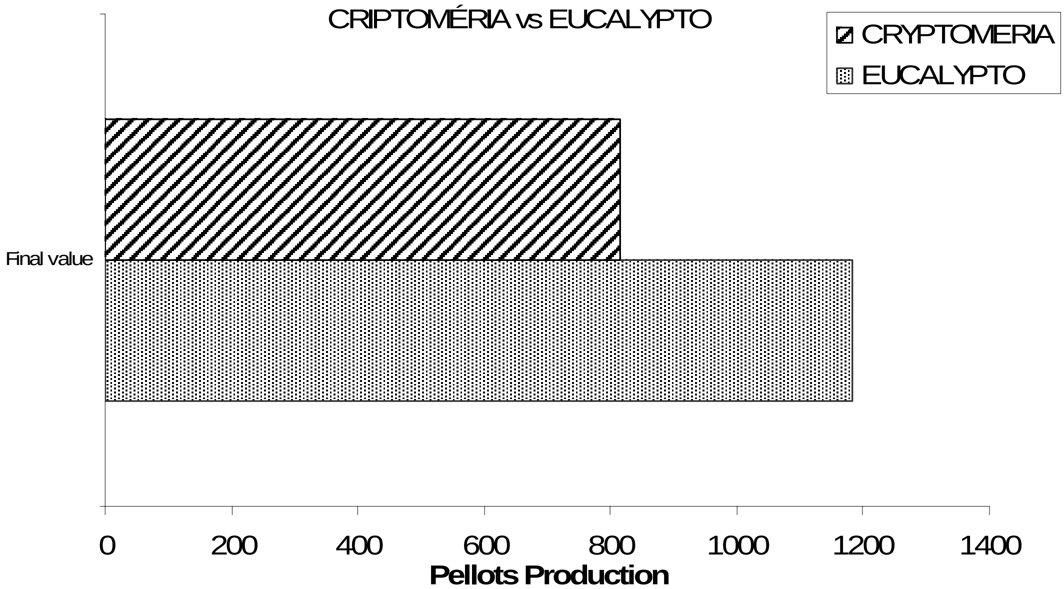

Figure 15. Comparison of pellet production on *Cryptomeria japonica* and *Eucalyptus* sp..

The *Eucalyptus* had a higher pellet production then the *Cryptomeria*, however this in part is due to the higher mortality rate on *Cryptomeria* (see Figure 14).

The next results show us how important is the feeding process to the colony success.

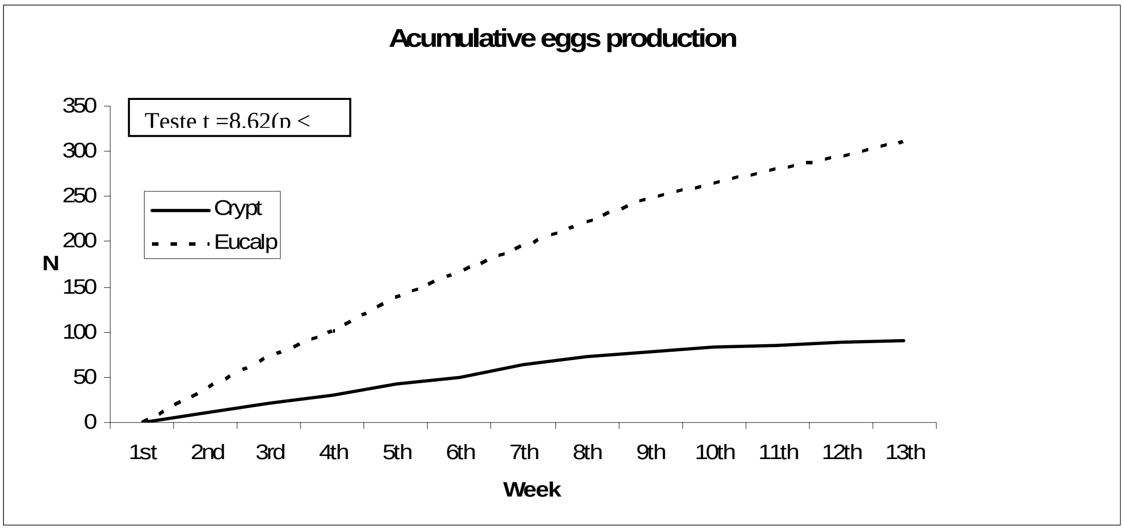

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Figure 16. Cumulative egg production during the monitoring period.

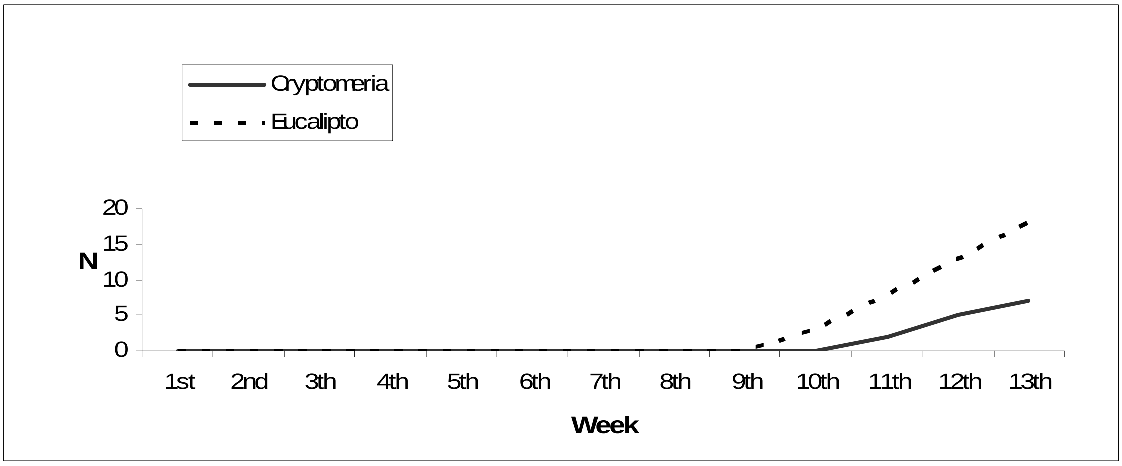

Figure 17. Cumulative larva production during the monitoring period.

The *Eucalyptus* compared with the *Cryptomeria* allow better conditions to the development of the *C. brevis* colonies, as we see above both graph show us that the development starts earlier and increases more rapidly on the *Eucalyptus* than on *Cryptomeria* (Figs. 16 and 17).

The second stage of this experiment occurred a few weeks latter and includes *Acacia, Jatoba, Pinus* and *Eucalyptus*. When this series was set up, fewer alates were flying most suites remained unoccupied (Figure 18). Of the occupied suites, most were occupied by a pair of alates but there were still a surprising number of suites with solitary alates that entered suites without a mate. The cumulative numbers for each wood species suggest that there was little difference in preference when alates had a choice between *Acacia, Pinus* and *Eucalyptus*. However all of these seemed to be significantly preferred over *Jatoba*. Figure 19 shows difference in colony survival rates among these wood species, with lowest mortality on *Acacia*.

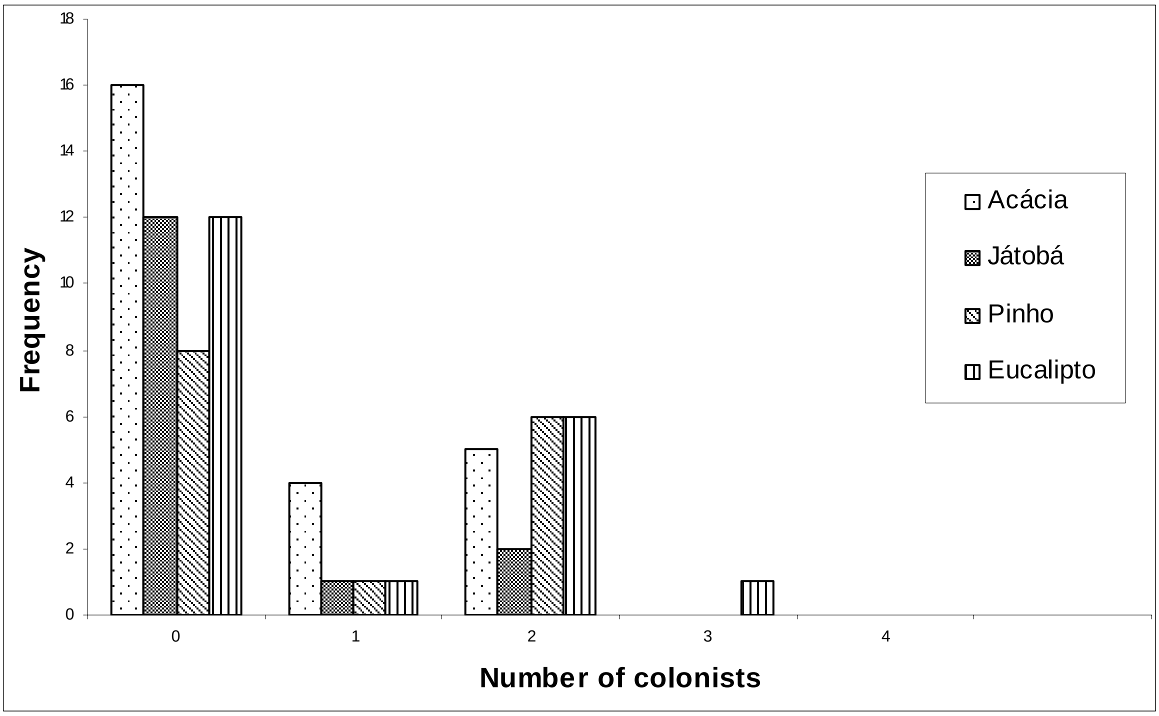

Figure 18. Frequency of colonization in different wood species.

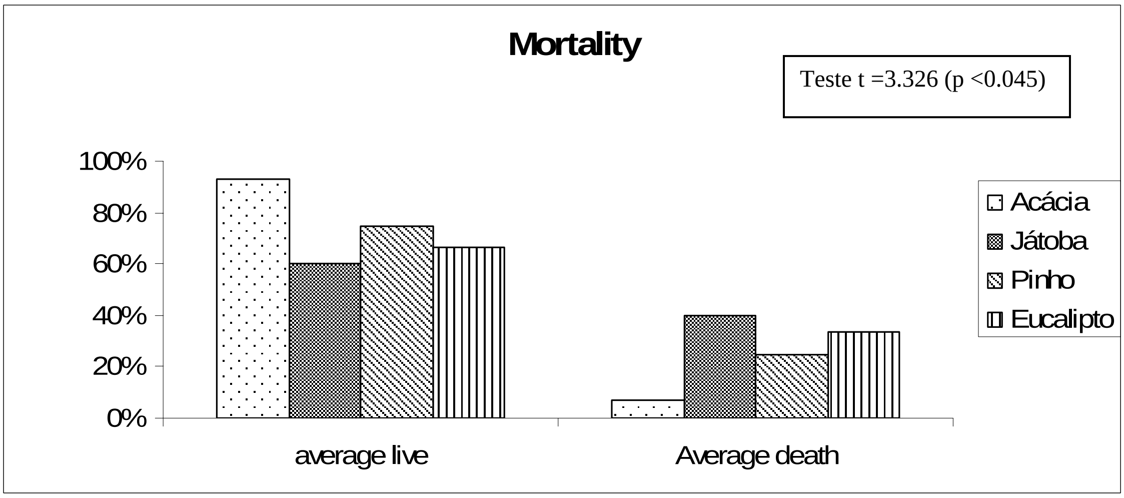

Figure 19. Average percent mortality of colonies on four wood species.

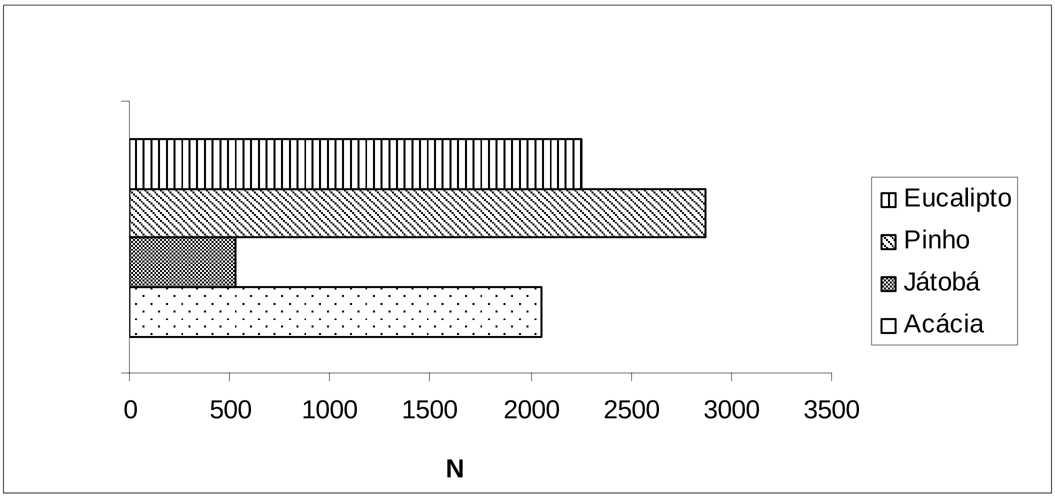

Figure 20. Total pellet production on four wood species.

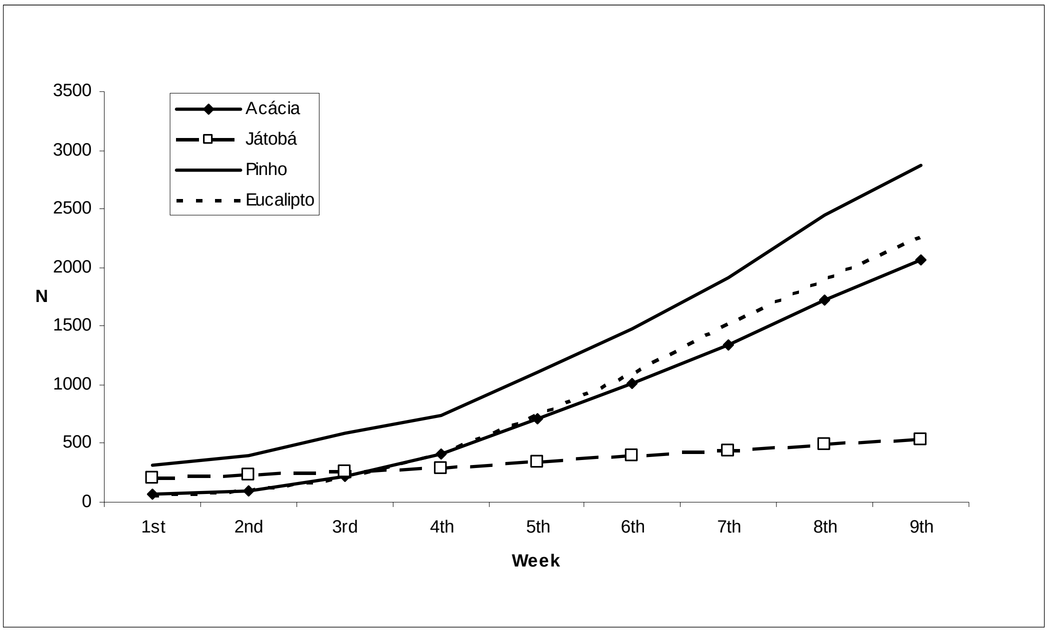

Figure 21. Cumulative fecal pellet production over the monitoring period.

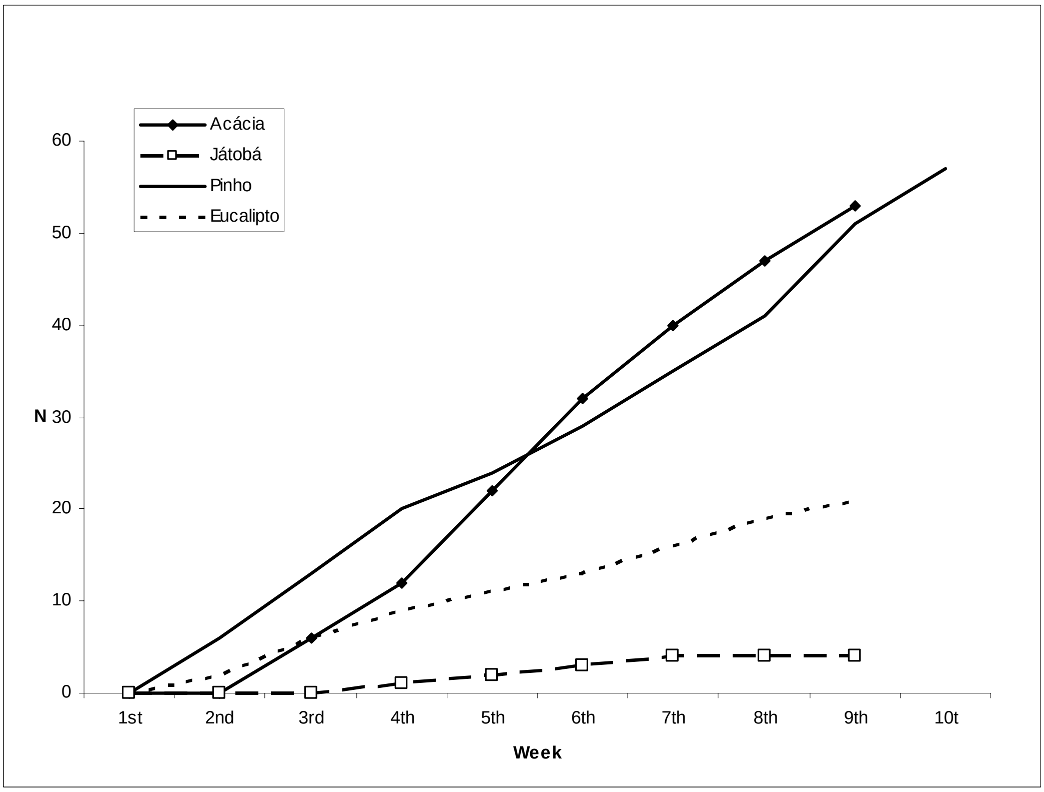

Figure 22. Cumulative egg production over the monitoring period.

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From Figures 20, 21 and 22 it may be surmised that *Pinus*, *Eucalyptus* and *Acácia* are the better to promote feeding to *C. brevis*. *Játobá* is a harder and more resistent wood against this termite´s attack. It is possible to see how feeding and colony development are related. When feeding on *Acácia* or *Pinus* there was a comparatively rapid increase in egg production. A slightly slower increase was seen when the termites fed on *Eucalyptus.* It is possible to conclude unequivocally that *Játobá* is the most resistant of the four wood species tested in suppressing the colony development and therefore would be more durable under termite attack. *Cryptomeria, Eucalyptus, Acácia* and *Pinus* are all are very vulnerable to termite attack and therefore these woods should have some kind of wood preservative treatment.

Table 1. Estimated periods of duration for flight and colony foundation behaviour.

Behaviour	Approximate Duration
flight	2 to 10 minutes
de-alation	less than 1 minute
searching	1 to 5 minutes (depends on availability)
sealing copularium	10 hours to 4 days (depends on diameter)
de-antennation	within first week
time to oviposit first egg	2 to 3 weeks
time to oviposit second egg	2 to 6 weeks
time to oviposit third egg	2 to 9 weeks
time to hatch (incubation period)	8 to 9 weeks after first oviposition

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Because of the fact that *Cryptotermes brevis*, a dry wood termite which live their entire life cycle inside of wood it is crucial to have some way to prevent their penetration. Further research is needed to develop effective pressure treatment with wood preservatives for these woods. Surface applied paints or varnish would also be helpful in deterring penetration in any wood. Paint or putty to close beetle emergence holes would also be a good deterrent to colony foundation.

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