ELISA GABRIELLA MARTINS

HABITUATION FACILITATES HOST-INQUILINE COHABITATION IN TERMITES

Dissertação apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Entomologia, para obtenção do título de *Magister Scientiae*.

Orientador: Og Francisco Fonseca de Souza

Coorientadora: Gladys Julieth C. Quiroga

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A minha mãe, Isabel Cristina Martins, sem a qual eu não estaria aqui.

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“Talvez não tenha conseguido fazer o melhor, mas lutei para que o melhor fosse feito. Não sou o que deveria ser, mas Graças a Deus, não sou o que era antes”. (Marthin Luther King)

Abstract

MARTINS, Elisa G., M.Sc., Universidade Federal de Viçosa, August, 2021. **Habituation facilitates host-inquiline cohabitation in termites**. Advisor: Og Francisco Fonseca de Souza. Co-advisor: Gladys Julieth Castiblanco Quiroga.

Termite nests offer an environment with favorable conditions for several invertebrate species and, among them, other termites known as inquilines. However, the biological mechanisms surrounding this cohabitation remain unveiled. Termites, like other social insects, are able to distinguish nestmates from non-nestmates, being aggressive towards non-nestmates. A mechanism that can reduce aggression is habituation. Habituation is a physiological mechanism by which animals or cells become less reactive to a frequently repeated stimulus. Here we tested the hypothesis that habituation attenuate host-inquiline lethal interactions, favoring cohabitation. To test this hypothesis, we experimentally exposed the nest builder *Cornitermes cumulans* termites to their inquiline *Curvitermes odontognathus* in assays where host and inquilines were kept apart but shared headspace, prior to being let to establish physical contact to each other. We found that as the prior exposition time increased the duration of lethal interactions between hosts and inquilines decreased. This result could not be attributed to individual exhaustion, as both inquilines and hosts survived longer in longer treatments, as opposed to individuals in shorter treatments. We also found that the duration of resting increased with the prior heterospecific exposure time. This suggests that the hosts reduced patrolling activities, possibly because they were already familiar with the inquilines. This result suggests that habituation facilitates cohabitation in termites, lowering the intensity of host-inquiline lethal interactions.

Keywords: Inquilinism · Hosts · Habituation

Resumo

MARTINS, Elisa G., M.Sc., Universidade Federal de Viçosa, agosto de 2021. **Habituação facilita a coabitação entre inquilinos e hospedeiros em cupins**. Orientador: Og Francisco Fonseca de Souza. Coorientadora: Gladys Julieth Castiblanco Quiroga.

Ninhos de cupins oferecem ambientes com condições favoráveis para várias espécies de invertebrados e, entre eles, outros cupins, conhecidos como inquilinos. No entanto, os mecanismos biológicos que envolvem essa coabitação ainda não foram totalmente elucidados. Cupins são capazes de diferenciar e reconhecer companheiros de ninho de não companheiros, sendo agressivos com seus não companheiros. Um mecanismo que pode reduzir essa agressão é a habituação. A habituação é um mecanismo fisiológico pelo qual animais ou células tornam-se menos reativos a um estímulo que tenha sido repetido com frequência. Aqui testamos a hipótese de que a habituação diminui as interações letais entre hospedeiro-inquilino, favorecendo a coabitação. Para testar nossa hipótese, expusemos experimentalmente os cupins construtores de ninhos *Cornitermes cumulans* a seus inquilinos *Curvitermes odontognathus* em ensaios onde hospedeiros e inquilinos foram mantidos separados mas compartilharam o mesmo ambiente, antes de serem liberados para contato físico. Verificamos que com o aumento do tempo de exposição, a duração das interações letais entre hospedeiros e inquilinos diminuiu. Este resultado não pode ser atribuído à exaustão dos indivíduos, uma vez que após 180 minutos, tanto inquilinos quanto hospedeiros sobreviveram mais tempo do que em tratamentos com menor tempo prévio de exposição. Também descobrimos que a duração do repouso dos hospedeiros e inquilinos aumentou com o aumento do tempo prévio de exposição insterespecífica. Isso sugere que os hospedeiros reduziram as atividades de patrulhamento, possivelmente por já estarem familiarizados com os inquilinos. Esses resultados sugerem que a habituação facilita a coabitação em cupins, reduzindo a intensidade das interações letais hospedeiro-inquilino.

Palavras-chave: Inquilinismo · Hospedeiros · Habituação

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Chapter 1

Introduction

Termite nests provide an environment with favorable conditions: from an optimal micro climate to protection against natural enemies (Korb, 2010). Termite nests are also a reservoir of food resources (Redford, 1984). For these reasons, termite nests are attractive to other animals, both vertebrates and invertebrates. Animals that inhabit termite nests are called: (i) inquilines, when a termite species inhabit the nest of another termite; or (ii) thermophiles, which is used to refer to all the other nest invading animals, mainly insects (Kistner, 1990). The biological mechanisms behind such a cohabitation, however, remain yet to be fully unveilled. Termites, like other social insects (Guerrieri et al., 2009; Yusuf et al., 2010), are able to recognize nestmates from non-nestmates. Although this recognition is more common through cuticular hydrocarbons (Kaib et al., 2002), it can also be through intestinal bacteria. *Reticulitermes speratus* termites has a colony-specific chemical cues which are provided by an intestinal bacteria composition that play an important role in nestmate recognition (Matsuura, 2001). Upon recognition, termites tend to be aggressive against non-nestmates (Marins and DeSouza, 2008).

Probably, such aggressiveness could work as a defense against invasions, as it has been showed for other insects societies (Blight et al., 2010). Actually, there are highly aggressive Nasutitermes species that have no records of inquilines inside their nests (Leponce et al., 1996). However, inquilines are frequently recorded in many termite species, and some genera, like *Cornitermes* (Termitidae: Syntermitinae), can harbor more than 26 different inquilines species (Redford, 1984; Costa et al., 2009).

So far, the reasons by which hosts accept termite inquilines seem to include: (i) no competition for resources between hosts and inquilines (Florencio et al., 2013); (ii) low patrolling activity of termite hosts (DeSouza et al., 2016); (iii) strategies to attenuate host aggressive behaviour by inquilines (Hugo et al., 2020; Cristaldo et al., 2016); and (iv) remain unnoticed to hosts (via chemical insignificance of inquilines) (Cristaldo et al., 2014).

Aggressiveness is an adaptive character (Sirot, 2000). However, being aggressive involves a cost and a benefit for both hosts and inquilines. It is beneficial for builders since acting aggressively can prevent the invasion of their nest (Wcislo, 1997; Turillazzi et al., 1990), but on the other hand there will be a high energy cost for the individuals involved in the combat. The same goes for invaders, who will have a greater chance of success if they are more aggressive, although it also implies a high cost of energy. Maybe, this cost-benefit dynamics has favoured the emergence of strategies used by inquilines to attenuate the hosts aggressive response. Among these one can notice (i) evasive manoeuvres like reversing direction (Hugo et al., 2020); (ii) decode and avoid host foraging trails (Cristaldo et al., 2014); and (iii) decode host alarm cues (Cristaldo et al., 2016).

An unexplored mechanism to reduce aggression is habituation, a physiological mechanism by which animals or cells become less reactive to a frequently repeated stimulus. A classical example is the decrease in the response to permanent and pervasive odor (Langen et al., 2000). Habituation towards a non-nestmate can occur in animals residing in urban areas, which are less aggressive towards humans than rural animals (Mccleery, 2009; Shen et al., 2020). It has been shown for ants (Langen et al., 2000; Stroeymeyt et al., 2010; Nowbahari, 2007), where the level of aggressiveness decreased with the previously exposition between workers from different colonies.

There are no records of habituation regarding cohabitation in termites. Here we propose to test the hypothesis: habituation lowers the host-inquiline lethal interactions, favoring cohabitation in termites. We predicted that the lethality of host-inquiline aggressive interactions would decrease as the longer the period of the previous exposition to each other before the encounter.

To test our hypothesis we forced host-inquiline termite encounters between the nest builder termites *Cornitermes cumulans* and their termite inquiline *Curvitermes odontognathus* in controlled assays after 0, 60, 120, and 180 minutes of previous exposition to each other. Here we argue that habituation facilitates cohabitation in termites, lowering the intensity of the host-inquiline lethal interactions.

Chapter 2

Methods

2.1 Biological model

2.1.1 Nest builder

Cornitermes spp. is a genus of neotropical termites. They are found in habitats such as forests, savannas and environments modified by man, such as pastures and even some gardens within cities (Cancello, 1989; Constantino, 1999). Many species of the genus build epigeal nests that are often large and abundant. *Cornitermes* spp. nests are frequently inhabited by many species of termitophiles including termite inquilines and some vertebrates (Redford, 1984; Costa et al., 2009). Particularly, *C. cumulans* holds the label of "keystone species" because their nests harbor a impressive diversity of cohabiting animal species (Redford, 1984).

2.1.2 Inquiline

Curvitermes odontognathus is a genus of mandibulate nasutes with a frontal tube. They can inhabit both the Amazon and the Cerrado (Constantino, 1999). They can live in the soils, or inside nests of other termites, such as *C. cumulans* (Redford, 1984).

2.2 Sampling

The experiments were conducted at the farm Princesa do Pará in the municipality of Rio Maria - PA. Six nests over 60L were collected containing both inquilines and hosts (Figure 2.1). The nests were broken at the field and some pieces were transferred to the experimental room, where they were placed in a fresh and dark environment.

Figure 2.1: (a) Nest of *C. cumulans* at the sampling area; (b) A piece of the *Cornitermes cumulans* nest containing *Curvitermes odontognathus* inquilines workers and soldiers

2.3 Experimental setup

Petri dishes (⌀ = 5 cm, height = 3 cm) sterilized with 80% alcohol were used as experimental arenas. Filter paper was used to cover the floor of the Petri dishes in order to ease the movement of the individuals. A barrier made with carton paper (length = 4.9 cm, height = 1.5 cm, thickness = 0.1 cm) wrapped in film paper was ajusted across the diameter of the Petri dishes to physically separate hosts and inquilines in the behavioural assays, allowing odors to pass above the barrier (crossing area = 7.35 cm^2). All the experiments were conducted in the experimental room with temperature varying between 23-25ºC on cold white LED light. The light was needed for the video recordings to the behavioural assays. In addition, it has already been showed that cold white LED light does not affect termite survival, indeed it is equivalent to being in darkness (de Carvalho et al., 2018).

A total of 120 *C. cumulans* and 216 *C. odontognathus* from six *C. cumulans* nests, were analysed. We used a density between 0.12 and 0.20 which is considered optimal for behaviour analysis (Miramontes and DeSouza, 2008). Five individuals of *C. cumulans* in a 4:1 workers:soldier ratio (Haverty, 1977) and nine individuals of *C. odontognathus* in a 8:1 workers:soldier ratio were used in each assay. The caste ratio for *C. odontognathus*. was defined by calculating the proportions of workers and soldiers from a piece of the first nest we collected.

2.4 Behavioural assay

We exposed hosts to their own inquilines during four previous exposure times: 0, 60, 120 and 180 minutes. "Exposure" consisted of placing hosts and inquilines in the same closed Petri dish, but in monospecific groups, separated by the barrier which allowed exchanges of odor and other signals but prevented direct physical contact between individuals of distinct species (Figure 2.2). We used a different barrier for each Petri dish. After the prior heterospecific exposure times, the barrier was removed by hand, the plate was closed again, and the host-inquiline interactions were video recorded for 5 minutes. The four prior heterospecific exposure times were tested for all the nests using independent termite groups in each assay. Therefore, each nest has four 5 minute videos recordings, one for each prior heterospecific exposure time. To reduce the chances of uncontrolled situations affecting the experimental arenas, such as, premature death of individuals injured by handling, or accidental encounters between host and inquiline before the end of the prior heterospecific exposure time, each assay was replicated twice. So, from each nest, eight experimental termite groups were submitted to one of the four habituation times. Posteriorly, if there was no problem with any of the replicates, we haphazardly chosen a single replicate from each nest and assay, to proceed to the analysis.

2.5 Survival assay

After each one of the 5 minutes video recorded, we followed the survival of inquilines and hosts. For this, we analysed each plate and counted how many individuals were dead, and countinued to do this every hour until all of them were dead. This analysis would show us if the prior heterospecific times could influence the survival of the individuals.

To make sure that the experimental timeframe was shorter than the time needed for death in experimental conditions, we ran an additional assay in which hosts and inquilines were kept in separate arenas (monospecific groups), under the same densities and caste ratio of the heterospecific assays. In these monospecific arenas we followed individuals until their death, in order to compute the meantime to death of hosts in the absence of the inquilines and vice-versa. This parameter gave us a baseline on which to interpret the deaths that occur in the heterospecific assays.

The monospecific assays were carried out using termites from six nests. From each nest, we set up three arenas containing only hosts and three arenas containing only inquilines.

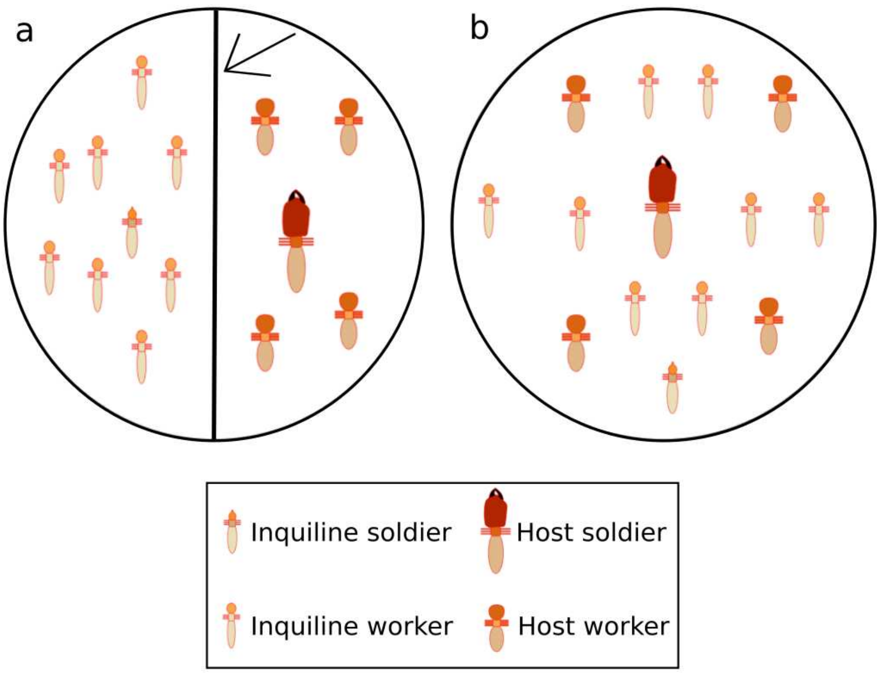

Figure 2.2: Setup: (a) t=0, t=60, t=120 and t=180 min, inquilines and hosts on a plate separated by a physical barrier (black arrow); (b) Plate after barrier removal, which allowed heterospecific interaction.

2.6 Ethogram

The responses of each experimental group were video-recorded for 5 minutes after removing by hand the physical barrier. We have six nests and each nest has four assays, so a total of twenty-four 5 minutes video recordings were gathered. These videos were analyzed using the Boris software (Friard and Gamba, 2016), which allowed us to compile an ethogram based on the behaviours listed in Table 1.1. The types of behaviours were selected based on preliminary observations and on behaviours listed in other works (Hugo et al., 2020). Individuals unable to perform any behaviour as a consequence of aggressive interaction were recorded as "injured", restarting the analysis with another individual.

Actions performed by the individuals during the host-inquiline encounters were classified into three types: (i) aggressive behaviours, when individuals performed hostile interactions during the encounter (Biting and Attack); (ii) non-aggressive behaviours, when the host-inquiline encounter did not result in hostile interactions

(Antennating non-nestmate, Ignoring, Passing and Reversing); and (iii) non-interactive behaviours (Resting and Walking).

Table 2.1: List of behaviours that were used to do the etogram.

Behaviour	Description	Classification 1	Classification 2
Antennating nestmate	Focal termite encounters nestmate and performs only antennation.	Non-aggressive	Within-species
Antennating non-nestmate	Focal termite encounters non-nestmate and performs only antennation.	Non-aggressive	Between-species
Antennating wall	Focal termite reaches the arena wall and performs only antennation.	Non-aggressive	Within-species
Attack	Focal termite encounters non-nestmate and performs aggression.	Aggressive	Between-species
Biting	Focal termite encounters non-nestmate and performs a continue aggression.	Aggressive	Between-species
Ignoring	Focal termite encounters non-nestmate and do not react.	Non-aggressive	Between-species
Passing	Focal termite encounters non-nestmate and performs a bypass manoeuvre.	Non-aggressive	Between-species
Resting	Focal termite remains stationary at the same place.	Non-interactive	Within-species
Reversing	Focal termite encounters non-nestmate and performs u-turn manoeuvre.	Non-aggressive	Between-species
Walking	Focal termite moves freely around the arena.	Non-interactive	Within-species

2.7 Statistical analyses

Statistical analyses aimed to test: (i) the effect of prior heterospecific times on the lethality of host-inquiline encounter; and (ii) the effect of of experimental conditions on the survival of hosts and inquilines. To measure the point (i) we tested: (a) if the host-inquiline encounter impacted the survival of individuals assayed; (b) if the prior heterospecific exposure times modulated the survival time of hosts and inquilines during the encounter; (c) if the duration of biting and non-interactive behaviours changed with the increments in the prior heterospecific exposure times to explain the pattern found in (b); and (iv) finally, if the number of aggressive, non-aggressive and non-interactive behaviours were modulated by the prior heterospecific exposure times also to explain the pattern found in (b). All data was analyzed using the RStudio (Team et al., 2015).

2.7.1 Survival analysis

To test if the host-inquiline encounter impacted the survival of termites, we subjected the data to censored survival analysis, under Weibull distribution, both for the monospecific and heterospecific conditions. Then we used ANOVA to test whether the meantimes to death of heterospecific groups differed from that of monospecific groups. The meantime to death corresponds to the moment when 50% of the individuals were still alive in the arenas.

Then, to test if the prior heterospecific exposure times modulated the survival time of hosts and inquilines, we calculated the mean time to death for each one of the prior heterospecific exposure times. The mean times to death were calculated for workers and soldiers of both hosts and inquilines. The complete statistical model for heterospecific condition includes mean times to death as a response variable; and group (host/inquiline), caste (soldier/worker) and prior heterospecific exposure times (0, 60, 120, 180 minutes), as predictor variables. The models were ranked by AIC to select the most suitable models. The curves were built using the averaged of the coefficients of the models with $AIC_{\Delta} \leq 2$.

Finally, we tested whether the experimental timeframe was shorter than the amount of time needed for natural death to occur (e.g., due to exhaustion). For this we made a Weibull using the monospecific groups. The complete statistical model for monoespecific condition includes time of death as a response variable; and group (host/inquiline), caste (soldier/worker), and nest (01-06) as a block, as predictor variables. The models were ranked by AIC to select the most suitable models. The curves were built using the averaged of the coefficients of the models with $AIC_{\Delta} \leq 2$.

2.7.2 Duration of behaviours

To verify the effect of prior heterospecific exposure times on the duration of Biting, Walking and Resting, we used a Generalized Linear Modeling (GLM) under Gaussian distribution for each one of these behaviours separately. Only these three behaviours were considered because among the behaviours listed in Table 1.1, they were the only ones with duration of time. The complete statisticals models includes the duration of each one of these behaviours as a response variable; and prior heterospecific exposure times (0, 60, 120, 180 minutes), group (host/inquiline), caste (soldier/worker), and nest (01-06) as predictor variables. The nests were included to filter out the effect of the origin of termites on their behaviour. The models were ranked by AIC to select the most suitable models. The curves were built using the averaged of the coefficients of the models with $AIC_{\Delta} \leq 2$.

2.7.3 Frequency of behaviours

To verify the effect of prior heterospecific exposure times on the number of times that individuals performed non-interactive, interactive non-aggressive, and interactive aggressive behaviours, a Generalized Linear Modeling (GLM) under Poisson distribution was used. Overdispersion was corrected using Negative Binomial error distribution. The full statistical model included the frequency of these behaviours as a response variable; and prior heterospecific exposure times (0, 60, 120, 180 minutes), group (host /

inquiline), caste (soldier / worker) and nest (01-06) as predictor variables. The models were ranked by AIC to select the most suitable models. The curves were built using the averaged of the coefficients of the models with $AIC_{\Delta} \leq 2$. For the non-aggresive behaviours we performed a contrast analysis for model simplification. To do this analysis we made new models by trying to group the non-aggressive behaviours. We used the AIC value to compare the models, if the AIC value of the new model was smaller than that of the previous model, it meant that these behaviours were not statistically different and we could group them.

Chapter 3

Results

3.1 Survival

Survival of hosts and inquilines in monospecific groups was higher than in heterospecific groups (Figure 3.1 and Table 3.1). However, in heterospecific groups both hosts and inquilines survived progressively longer when they were exposed prior to the encounter longer to each other (Figure 3.2 and Table 3.2). For all exposure times, soldiers survived longer than workers in both hosts and inquilines groups. When kept in monospecific groups (Figure 3.3 and Table 3.3) hosts survived longer than inquilines, but both survived had a meantime to death longer than 2000 minutes.

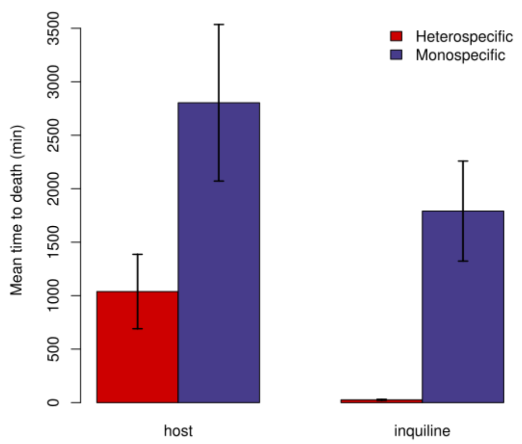

Figure 3.1: Effect of the host-inquiline encounter. Both host and inquilines survived longer in monospecific than heterospecific groups.

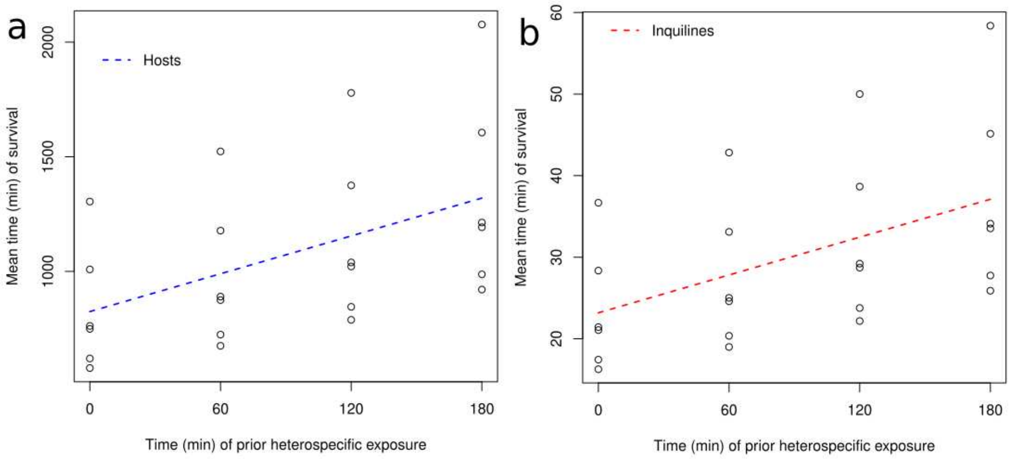

Figure 3.2: Effect of the prior heterospecific exposure times on the survival of hosts (a) and inquilines (b) after the encounter. Hosts (a) and inquilines (b) survived longer with increments in prior heterospecific exposure time. Each dot is the meantime to death of a given arena.

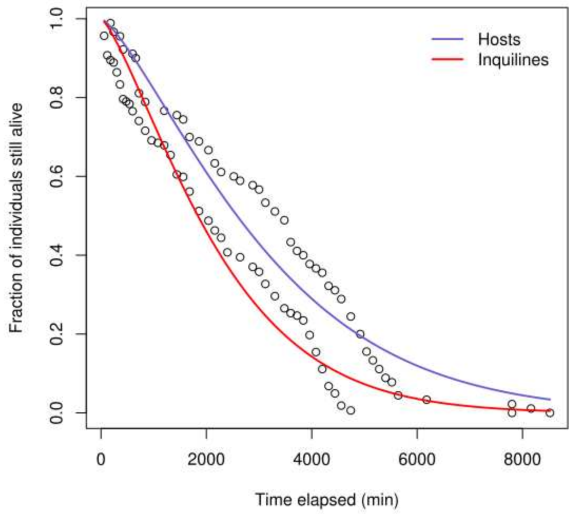

Figure 3.3: Survival of inquilines and hosts in monoespecific groups, where hosts survived longer than inquilines. Each dot represents the proportion of individuals still alive in a given arena at a given time.

Table 3.1: More plausible statistical models predicting the effect of the group composition (heterospecific and monospecific) on the meantime to death of hosts and inquilines. Column headings: id = model identification; (Int) = model intercept; group = inquiline and host; nest = nest of origin; conditions = heterospecific and monospecific group composition; df = degree of freedom; logLik = log-likelihood; AICc = second-order Akaike information criterion; Δ = AICc difference between the model in concern and the best model; weight = Akaike weight.

id	(Int)	group	nest	condition	df	logLik	AICc	Δ	weight
8	1441.35	+	+	+	9	-168.7	368.2	0.0	0.59
6	1038.61	+		+	4	-179.4	369.0	0.7	0.41
5	532.31			+	3	-190.0	387.1	18.9	0.00

Table 3.2: More plausible statistical models for heterospecific survival predicting the effect of the previous exposure times on the survival of hosts and inquilines in heterospecific condition. Column headings: id = model identification; (Int) = model intercept; caste = worker and soldier; group = inquiline and host; nest = nest of origin; phet = prior heterospecific exposure times: 0, 60, 120 and 180 minutes; df = degree of freedom; logLik = log-likelihood; AICc = second-order Akaike information criterion; Δ = AICc difference between the model in concern and the best model; weight = Akaike weight.

id	(Int)	caste	group	nest	phet	df	logLik	AICc	Δ	weight
15	7.61		+	+	0.00	9	-1734.8	3488.1	0.0	0.43
16	7.83	+	+	+	0.00	10	-1733.8	3488.3	0.2	0.38
7	7.84		+	+		8	-1737.8	3492.0	3.9	0.06

Table 3.3: More plausible statistical models for monospecific survival predicting the effect of the survival of hosts and inquilines in monospecific condition. Column headings id = model identification; (Int) = model intercept; caste = worker and soldier; group = inquiline and host; nest = nest of origin; df = degree of freedom; logLik = log-likelihood; AICc = second-order Akaike information criterion; Δ = AICc difference between the model in concern and the best model; weight = Akaike weight.

id	(Int)	caste	group	nest	df	logLik	AICc	Δ	weight
7	8.40		+	+	8	-2202.0	4420.6	0.0	0.65
8	8.50	+	+	+	9	-2201.5	4421.8	1.2	0.35
3	8.14		+		3	-2214.9	4435.8	15.2	0.00

3.2 Duration of behaviours

Duration of biting decreased, both in hosts and inquilines, as the prior heterospecific exposure times increased, with soldiers being more aggressive than workers in both groups (hosts and inquilines) (Figure 3.4 and Table 3.4). Duration of walking did not change while the duration of resting increased both in hosts and inquilines as the prior heterospecific exposure times increased. Soldiers of hosts and inquilines walked more than workers, while workers of both group rested more than soldiers (Figure 3.5 and Table 3.4).

Table 3.4: More plausible statistical models predicting the effect of the prior heterospecific exposure times on biting, walking and resting duration. Column headings: beh = behaviour (biting, walking or resting); id = model identification; (Int) = model intercept; caste = worker and soldier; group = inquiline and host; nest = nest of origin; phet = prior heterospecific exposure times: 0, 60, 120 and 180 minutes; df = degree of freedom; logLik = log-likelihoo; AICc = second-order Akaike information criterion; Δ = AICc difference between the model in concern and the best model; weight = Akaike weight.

beh	id	(Int)	caste	group	nest	phet	df	logLik	AICc	Δ	weight
biting	7	47.14		+	+		8	-733.6	1484.3	0.0	0.36
	8	65.39	+	+	+		9	-733.1	1485.7	1.3	0.19
	15	54.75		+	+	-0.07	9	-733.2	1485.9	1.5	0.17
	16	73.77	+	+	+	-0.07	10	-732.7	1487.2	2.8	0.09
walking	8	221.21	+	+	+		9	-1718.0	3454.6	0.0	0.51
	16	223.29	+	+	+	-0.02	10	-1717.9	3456.6	2.0	0.19
resting	13	119.05			+	0.19	8	-1734.5	3485.6	0.0	0.29
	15	109.20		+	+	0.19	9	-1733.7	3486.0	0.4	0.23
	14	107.88	+		+	0.19	9	-1734.1	3486.8	1.2	0.16
	16	100.18	+	+	+	0.19	10	-1733.3	3487.4	1.9	0.11
	9	111.15				0.19	3	-1741.5	3489.1	3.5	0.05

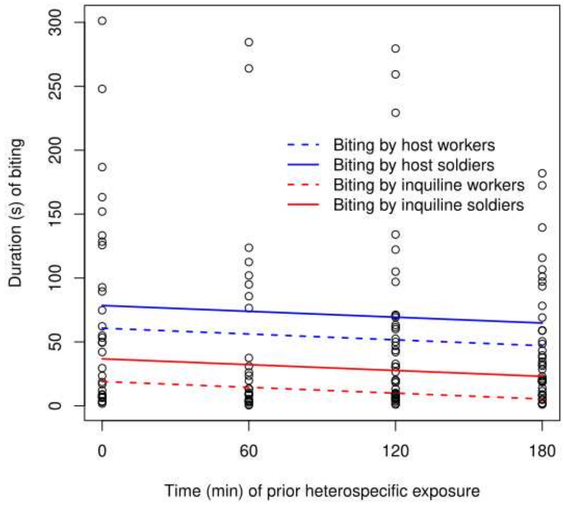

Figure 3.4: Effect of the prior heterospecific exposure times on duration of biting, both in hosts and inquilines. Duration of biting decreased with the increased of the prior heterospecific exposure times in workers and soldiers.

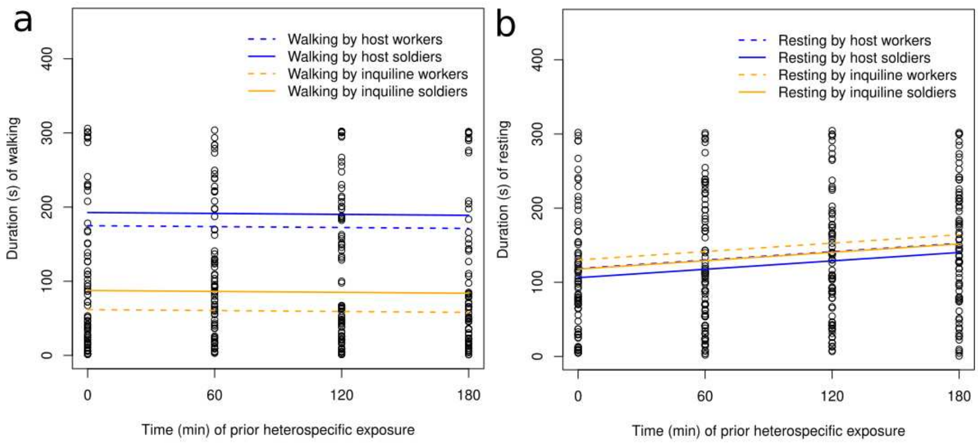

Figure 3.5: Effect of the prior heterospecific exposure times on duration of walking and resting, both in inquilines and hosts. Duration of walking did not change (a) while duration of resting increased (b) as the prior heterospecific exposure times increased. Soldiers of inquilines and hosts walked more time (a) and workers of inquilines and hosts rested more time

3.2.1 Frequency of behaviours

The number of times non-aggressive behaviours was performed by individuals decreased while the number of times aggressive behaviours was performed by individuals increased both in hosts and inquilines as the prior heterospecific exposure times increased (Figure 3.6 and Table 3.5), with hosts performing more non-aggressive behaviours than inquilines. As for aggressive behaviours, hosts soldiers were more aggressives than hosts soldiers and inquilines soldiers and workers. The AIC values of the models of the contrast analysis of non-aggressive behaviours are in Table 3.7, all new models had an AIC value smaller than the older one. Therefore we used the model m3 to do frequency analysis of non-aggressive behaviours.
The number of times that hosts and inquilines walked and rested increased as the prior heterospecific exposure times increased, with inquiline and host workers walking and resting more times than soldiers (Figure 3.7 and Table 3.6).

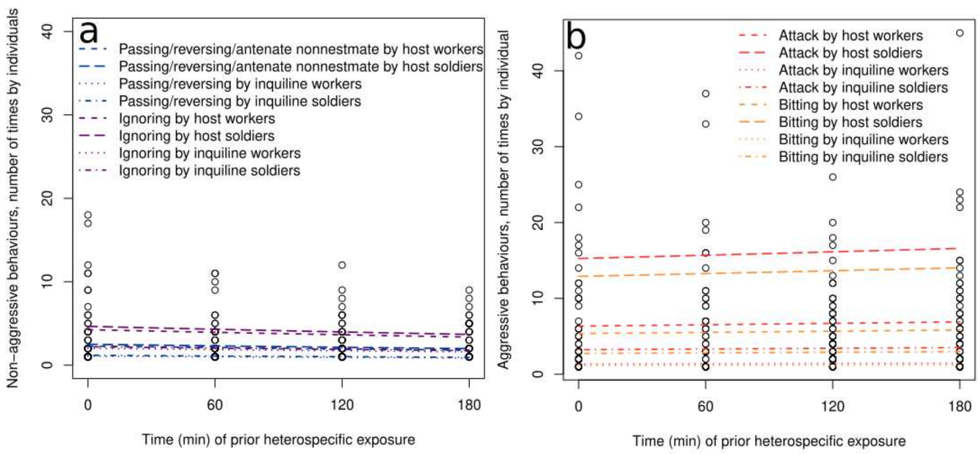

Figure 3.6: Effect of the prior heterospecific exposure times on the number of non-aggressive and aggressive behaviours in inquilines and hosts. Non-aggressive behaviours decreased (a) and aggressive behaviours increased (b) as the prior heterospecific exposure times increased.

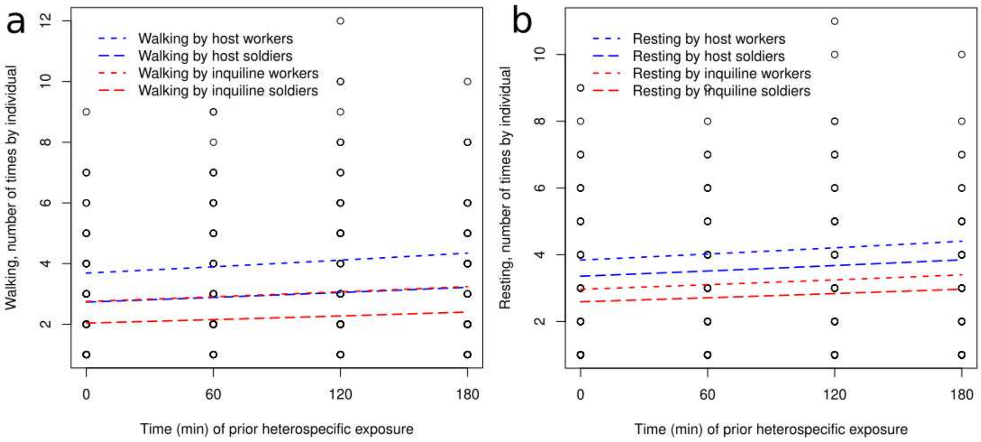

Figure 3.7: Effect of the prior heterospecific exposure times on walking and resting behaviours in inquilines and hosts. The numbers of times that hosts and inquilines performed walking (a) and resting (b) increased as the prior heterospecific exposure times increased. Inquilines and hosts workers performed walking and resting more time than the soldiers in both groups.

Table 3.5: More plausible statistical models predicting the effect of the prior heterospecific exposure time on the number of times that hosts and inquilines performed non-aggressive and aggressive behaviours. Column headings: type of behaviour = nag: non-aggressive, ag: aggressive; id = model identification; (Int) = model intercept; beh = behaviours: Passing, Reversing, Antenate nonnestmate and Ignoring; caste = worker and soldier; group = inquiline and host; nest = nest of origin; phet = prior heterospecific exposure times: 0, 60, 120 and 180 minutes; df = degree of freedom; logLik = log-likelihood; AICc = second-order Akaike information criterion; Δ = AICc difference between the model in concern and the best model, weight = Akaike weight.

type	id	(Int)	beh	caste	group	nest	phet	df	logLik	AICc	Δ	weight
nag	14	1.40	+		+	+		9	-438.5	895.8	0.0	0.19
	22	1.58	+		+		-0.00	5	-442.8	895.9	0.1	0.18
	30	1.47	+		+	+	-0.00	10	-437.5	896.1	0.3	0.16
	6	1.46	+		+			4	-444.3	896.7	0.9	0.12
	16	1.49	+	+	+	+		10	-437.9	896.9	1.1	0.11
	32	1.56	+	+	+	+	-0.00	11	-437.0	897.2	1.4	0.09
	24	1.63	+	+	+		-0.00	6	-442.6	897.6	1.8	0.08
	8	1.52	+	+	+			5	-444.1	898.4	2.6	0.05
ag	8	2.74	+	+	+			5	-657.8	1325.9	0.0	0.39
	7	2.73		+	+			4	-659.1	1326.4	0.5	0.30
	24	2.70	+	+	+		0.00	6	-657.6	1327.5	1.7	0.17
	23	2.69		+	+		0.00	5	-658.9	1328.1	2.2	0.13

Table 3.6: More plausible statistical models predicting the effect of the prior heterospecific exposure time on the number of times that hosts and inquilines performed walking and resting. Column headings: beh = behaviour (walking or resting); id = model identification; (Int) = model intercept; caste = worker and soldier; group = inquiline and host; nest = nest of origin; phet = prior heterospecific exposure times: 0, 60, 120 and 180 minutes; df = degree of freedom; logLik = log-likelihood; AICc = second-order Akaike information criterion; Δ = AICc difference between the model of concern and the best model, weight = Akaike weight.

beh	id	(Int)	caste	group	nest	phet	df	logLik	AICc	Δ	weight
	16	0.81	+	+	+	0.00	10	-596.0	1212.8	0.0	0.60
walking	8	0.90	+	+	+		9	-597.7	1214.0	1.2	0.33
	15	1.05		+	+	0.00	9	-599.7	1218.1	5.3	0.04
	7	1.26		+	+		8	-586.5	1189.5	0.0	0.29
	8	1.14	+	+	+		9	-585.6	1189.9	0.4	0.23
resting	15	1.20		+	+	0.00	9	-585.7	1190.0	0.5	0.23
	16	1.09	+	+	+	0.00	10	-584.8	1190.4	0.9	0.18
	5	1.11			+		7	-590.0	1194.3	4.8	0.03

Table 3.7: Contrast analysis for non-aggressive behaviours model. Each line correponds to a given contrast between Model A and Model B. "Freq" is the number of times these behaviours where performed by the individuals. "P" = passing, "R" = resting, "A" = antennate nonnestmate, "I" = ignoring. In parentheses we have the behaviours amalgamated. All models also included the prior heterospecific exposure times (0, 60, 120 and 180 min), group (host and inquiline) and caste (worker and soldier) as predictor variables. Column headings: Model A = previous models used to group non-aggressive behaviours, Model B = models used to group non-aggressive behaviours; df A = degree of freedom of the previous model; df B = degree of freedom of the new model; AIC A = Akaike information criterion of the previous model; AIC B = Akaike information criterion of the new model.

Model A	Model B	df A	df B	AIC A	AIC B
Freq ˜ P,R,A,I	Freq ˜ (P+R),A,I	13	12	897.5685	896.1369
Freq ˜ (P+R),A,I	Freq ˜ (P+R+A),I	12	11	896.1369	895.9703

Chapter 4

Discussion

Aggressive behaviours imply in energetic costs which may be quite relevant. After all, struggles between individuals, conspecific or not, can cause damage to parts of the body that are more vulnerable, leading to injuries and death (Georgiev et al., 2013). Indeed, this is what we observed in our assays. (Figure 3.1 and Table 3.1). Hosts and inquilines survived longer when they were on separate plates (monospecific condition) than when they encountered each other in the heterospecific assay. This happened, most likely as a consequence of fights between the individuals, which resulted in an energy drain, injuries and early deaths.

Survival times of hosts and inquilines, however, depended on prior heterospecific exposure times. Both groups survived longer after being previously exposed for 180 minutes than when exposed for shorter periods (Figure 3.2 an Table 3.2). It seems, hence, valid to state that some form of habituation was in place so that to reduce the negative impacts of the encounter between hosts and inquilines. This result may have occurred because individuals spent longer in contact with their neighbors' signals at 180 min than at 0, 60 or 120. Due to that, they might have gotten more familiar with these signals and that increased their thresholds to detect strangers, making the encounter less costly for both by softening or even avoiding agressive contends.

Indeed, even though aggressive interactions did increase with prior heterospecific exposure time (Figure. 3.6b and Table 3.5), a simultaneous decrease in the duration of biting (Figure 3.4 and Table 3.4) and an increment in survival times (Figure. 3.2) were recorded. In urban Oriental reed warbles there was a decreased in the duration of the alarm call to human intruders as the frequency of encounters increased, indicating that they habituated to the presence of humans (Shen et al., 2020). And in *Pheidole* ants there was a decrease in fighting when they were exposed to each other's odor, both in conspecific (same species but different colonies) and heterospecific (different species) interactions (Langen et al., 2000).

Furthermore, increments in resting duration (Figure 3.5b and Table 3.4) suggest that patrolling activities of hosts and inquilines dropped as prior heterospecific exposure time increased. This seems to indicate that they got used to the presence of their neighbors, spending less time checking out the surroundings. Additionally, it may also imply in less energy comsuption, with consequent low lethality.

Even though under reduced host-inquiline lethal interactions, we did observe a simultaneous decrement of the number of non-aggressive behaviours and an increment in aggressive ones (Figure 3.6 and Table 3.5). It seems that hosts getting used to the presence of inquilines did not mean that inquilines were going to be recognized as members of the colony. Rather than that, our results indicate that hosts simply came to perceive inquilines as less challenging as the habituation time increased. These results indicate that habituation can be a mechanism that facilitates cohabitation in termites.

An alternative view of these results would be that, rather than habituating to each other, hosts and inquilines might have gotten exhausted over the course of the assays, especially for long exposure times. However, the increments in the frequency of walking (Figure 3.7a and Table 3.6) and in the survival at 180 min seem to indicate that exhaustion was not in place. Moreover, it is worth noting that termites in the monospecific condition survived far longer than our longest heterospecific assay, showing (Figure 3.3 and Table 3.3) to a meantime to death of 2000 min, when our longest prior heterospecific exposure time was only 180 minutes. This seem to indicate that termites could be still vigorous after spending mere 180 min before being force to meet their cohabitants.

We also observed differences between the behaviours of soldiers and workers of hosts and inquilines. Soldiers from both groups (hosts and inquilines) performed more aggressive behaviours than workers. This is probably due to the fact that soldiers are responsible for the nest defense (Traniello and Leuthold, 2000). While the workers, besides helping with nest defense, are mainly responsible for the construction/repair of the nest, foraging and parental care.

The soldiers are also the first to arrive at a disturbance in the nest, being also responsible for the nest patrol (DeSouza et al., 2016). This is probably why they spent more time walking and less time resting as compared to workers.

As for the differences between the behaviours of hosts and inquilines. We know that inquilines, when forced to encounter their hosts, performed more peaceful and evasive behaviours towards them, to avoid conflict escalation (Hugo et al., 2020). Futhermore, inquilines are able to identify alarm cues from their hosts, not responding to them, and thus avoiding encounters and conflicts with their hosts (Cristaldo et al., 2016). This could explain the results we found, where inquilines spent more time resting and less time walking. This low mobility could explain the low number of aggressive and non-aggressive behaviours in inquilines sinced a low mobility reduces the probability of encountering the host. Also, during the video analysis, we noticed that it was rare for a inquiline to initiate aggressive behaviour towards their hosts, although they could fight back the host attacks. Something similar was observed by Costa (2015).

Our data showed that inquilines use a variety of behaviours to go unnoticed and avoid aggressive interactions with their host. These behaviours, such as rest or reversing, could contribute to the habituation between host-inquiline. Even if inquilines avoid contact with hosts, eventually they become physically close. This was observed during the collection of nests, where in the same piece, and in nearby galleries, we found inquiline and hosts. This proximity could allow exposure to chemical (odors) and/or physical (vibration) cues between hosts and inquilines. Futhermore, stimulus that are more frequent can result in a faster habituation (Rankin et al., 2009). Therefore, non-aggressive behaviours from inquilines could allow their hosts to become habituated towards them, facilitating cohabitation in termites.

Chapter 5

Conclusion

Our results suggest that habituation facilitates cohabitation in termites, lowering the intensity of host-inquiline lethal interactions. A decreased in lethal interactions also decreases the risk of serious injury or death. Our results showed an increase in the survival of individuals as the habituation time increased.

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Chapter 6

Appendix

6.1 Survival Analysis

Rationale Here, we propose to test the survival of hosts and inquilines under the following conditions: (i) monospecific where groups were on separate plates; and (ii) heterospecific, where survival was counted after the interaction of the two groups, with both on the same plate. The heterospecific condition is divided into treatments: 0, 60, 120 and 180 min.

Data Column headers:

1. nest ID: simplified name of the nest from which termites were extracted.
2. treatmentM: treatment as continuous variable in minutes. 0 (hosts and inquilines are placed on the same petri dish without prior contact); 60 (hosts and inquilines are on the same petri dish, but separated by a barrier for a period of habituation of one hour); 120 (two hours habituation); 180 (three hour habituation).
3. group: termite individuals classified as host (Cornitermes individuals) and inquilines (inquiline sp.) from which observations were made.
4. caste: caste of the focal individuals analysed.
5. ID: number given for each individual analysed.

6. censor: 1 for dead individuals; and 0 for the ones we do not know what happen (we only have the time they where last seen).

7. time: time of death of the individual (or the time they were last seen if the censor is 0).

8. condition: heterospecific (host and inquilines on the same plate); monospecific (host and inquilines on diferent plates).

```
> dados <- read.csv("survival.csv",
+                    header = TRUE, sep = ",")
> head(dados, n = 5)
```

```
  ID group caste censor time nestID treatmentM      condition
1  1  host     W      1  360    n01          0 heterospecific
2  2  host     W      0  720    n01          0 heterospecific
3  3  host     W      0  720    n01          0 heterospecific
4  4  host     W      0  720    n01          0 heterospecific
5  5  host     S      0  720    n01          0 heterospecific
```

Subset

```
> hetero <- subset(dados, condition == "heterospecific")
> mono <- subset(dados, condition == "monospecific")
```

Survival of host and inquilines monospecific interaction

```
> library(MuMIn)
> options(na.action = "na.fail")
> library(survival)
> m3 <- survreg(Surv(mono$time,mono$censor)~ mono$nestID +
+                   mono$group + mono$caste)
> mt3A <- m3
> rAb3 <- dredge(mt3A, rank = "AICc")
> summary(get.models(rAb3, 1)[[1]])
```

```
Call:
survreg(formula = Surv(mono$time, mono$censor) ~ mono$group +
    mono$nestID + 1)
                      Value Std. Error     z       p
(Intercept)          8.4037     0.1375 61.12 < 2e-16
mono$groupinquiline -0.4482     0.1009 -4.44 8.9e-06
mono$nestIDn02      -0.6096     0.1611 -3.78 0.00015
mono$nestIDn03       0.1225     0.1580  0.78 0.43821
mono$nestIDn04      -0.3025     0.1613 -1.88 0.06068
mono$nestIDn05      -0.3706     0.1581 -2.34 0.01907
mono$nestIDn06      -0.2105     0.1607 -1.31 0.19023
Log(scale)          -0.3235     0.0525 -6.17 7.0e-10

Scale= 0.724

Weibull distribution
Loglik(model)= -2202   Loglik(intercept only)= -2221.1
        Chisq= 38.24 on 6 degrees of freedom, p= 1e-06
Number of Newton-Raphson Iterations: 7
n= 252
```

```
> rAb3
```

```
Global model call: survreg(formula = Surv(mono$time, mono$censor) ~ mono$nestID +
    mono$group + mono$caste)
---
Model selection table
  (Int) mon$cst mon$grp mon$nID df    logLik   AICc delta weight
7 8.404               +       +  8 -2202.020 4420.6  0.00  0.646
8 8.497       +       +       +  9 -2201.549 4421.8  1.21  0.353
3 8.138               +          3 -2214.866 4435.8 15.20  0.000
```

```
6 8.298       +               + 8 -2209.916 4436.4 15.79  0.000
4 8.204       +       +         4 -2214.656 4437.5 16.84  0.000
5 8.067                       + 7 -2211.863 4438.2 17.55  0.000
2 8.096       +                 3 -2220.016 4446.1 25.50  0.000
1 7.925                         2 -2221.138 4446.3 25.69  0.000
Models ranked by AICc(x)

> ###############
>
> m4 <- update(m3, .~. - mono$nestID)
> mt4 <- m4
> rAb4 <- dredge(mt4, rank = "AICc")
> rAb4

Global model call: survreg(formula = Surv(mono$time, mono$censor) ~ mono$group +
    mono$caste)
---
Model selection table
  (Int) mon$cst mon$grp df    logLik   AICc delta weight
3 8.138               +  3 -2214.866 4435.8  0.00  0.689
4 8.204       +       +  4 -2214.656 4437.5  1.64  0.303
2 8.096       +          3 -2220.016 4446.1 10.30  0.004
1 7.925                  2 -2221.138 4446.3 10.49  0.004
Models ranked by AICc(x)

> summary(get.models(rAb4, 1)[[1]])

Call:
survreg(formula = Surv(mono$time, mono$censor) ~ mono$group +
    1)
                      Value Std. Error      z       p
(Intercept)          8.1381     0.0803 101.29 < 2e-16
```

```
mono$groupinquiline -0.3487     0.0991  -3.52 0.00044
Log(scale)          -0.2829     0.0534  -5.30 1.1e-07

Scale= 0.754

Weibull distribution
Loglik(model)= -2214.9   Loglik(intercept only)= -2221.1
        Chisq= 12.54 on 1 degrees of freedom, p= 4e-04
Number of Newton-Raphson Iterations: 7
n= 252
```

```
> summary(m4)

Call:
survreg(formula = Surv(mono$time, mono$censor) ~ mono$group +
    mono$caste)
                      Value Std. Error     z       p
(Intercept)          8.2036     0.1310 62.64 < 2e-16
mono$groupinquiline -0.3318     0.1023 -3.24  0.0012
mono$casteW         -0.0896     0.1399 -0.64  0.5218
Log(scale)          -0.2836     0.0534 -5.32 1.1e-07

Scale= 0.753

Weibull distribution
Loglik(model)= -2214.7   Loglik(intercept only)= -2221.1
        Chisq= 12.96 on 2 degrees of freedom, p= 0.0015
Number of Newton-Raphson Iterations: 7
n= 252
```

Figure

```
> mu4 <- tapply(predict(m4),mono$group,mean)
> fit4 <- survfit(Surv(time,censor) ~ group, data=mono)
> s4 <- summary(fit4)
> dfw4 <- data.frame(surv=s4$surv, group=s4$strata, time=s4$time)

> alpha4 <- 1/m4$scale
> alpha4

[1] 1.327934

> plot((dfw4$surv~dfw4$time),xlab="Time elapsed (min)",ylab = "Fraction of indivic
> tapply(predict(m4), mono$group, mean)

     host inquiline
 3403.505  2422.437

> c1f4 <- tapply(predict(m4), mono$group, mean)[1] #Host
> c1f4

    host
3403.505

> c2f4 <- tapply(predict(m4), mono$group, mean)[2] #Inquiline
> c2f4

inquiline
 2422.437

> #Host
> curve(exp((-c1f4^(-alpha4))*(x^alpha4)), col="slateblue3",lwd=1.9,lty=1,add=T)
> #Inquiline
> curve(exp((-c2f4^(-alpha4))*(x^alpha4)), col="red",lwd=1.9,lty=1,add=T)
> legend(6000,1,legend= c("Hosts",
+                             "Inquilines"),
```

```
+         col = c("slateblue3",
+                 "red"),
+         lwd=1.9, lty = c(1,1), bty = "n")
```

Mean time to death: host and inquilines monospecific interactions

```
> #monospecific host
> TMmh <- (log(0.5)/(-c1f4^(-alpha4)))^(1/alpha4)
> TMmh

    host
2582.617

> #monospecific inquiline
> TMmi <- (log(0.5)/(-c2f4^(-alpha4)))^(1/alpha4)
> TMmi

inquiline
 1838.172
```

Mean time to death: host and inquilines in monospecific interaction - group by nest

```
> mM <- survreg(Surv(mono$time,mono$censor)~ mono$group + mono$nestID)
> alfamM <- 1/mM$scale
> tapply(predict(mM), list(mono$group, mono$nestID), mean)

               n01      n02      n03      n04      n05      n06
host      4463.623 2426.264 5045.352 3298.331 3081.388 3616.469
inquiline 2851.347 1549.889 3222.953 2106.962 1968.380 2310.187

> #hostn01
> c1bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[1]
> c1bf4

[1] 4463.623
```

```
> #inquilinen01
> c2bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[2]
> c2bf4

[1] 2851.347

> #hostn02
> c3bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[3]
> c3bf4

[1] 2426.264

> #inquilinen02
> c4bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[4]
> c4bf4

[1] 1549.889

> #hostn03
> c5bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[5]
> c5bf4

[1] 5045.352

> #inquilinen03
> c6bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[6]
> c6bf4

[1] 3222.953

> #hostn04
> c7bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[7]
> c7bf4

[1] 3298.331
```

```
> #inquilinen04
> c8bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[8]
> c8bf4

[1] 2106.962

> #hostn05
> c9bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[9]
> c9bf4

[1] 3081.388

> #inquilinen05
> c10bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[10]
> c10bf4

[1] 1968.38

> #hostn06
> c11bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[11]
> c11bf4

[1] 3616.469

> #inquilinen06
> c12bf4 <- tapply(predict(mM), list(mono$group, mono$nestID), mean)[12]
> c12bf4

[1] 2310.187
```

Mean time to death by nest - Heterospecific

```
> #HOSTN01
> Hn01M <- (log(0.5)/(-c1bf4^(-alfamM)))^(1/alfamM)
> Hn01M
```

```
[1] 3423.8

> #INQN01

> In01M <- (log(0.5)/(-c2bf4^(-alfamM)))^(1/alfamM)

> In01M

[1] 2187.111

> #HOSTN02

> Hn02M <- (log(0.5)/(-c3bf4^(-alfamM)))^(1/alfamM)

> Hn02M

[1] 1861.054

> #INQN01

> In02M <- (log(0.5)/(-c4bf4^(-alfamM)))^(1/alfamM)

> In02M

[1] 1188.834

> #HOSTN03

> Hn03M <- (log(0.5)/(-c5bf4^(-alfamM)))^(1/alfamM)

> Hn03M

[1] 3870.012

> #INQN03

> In03M <- (log(0.5)/(-c6bf4^(-alfamM)))^(1/alfamM)

> In03M

[1] 2472.15

> #HOSTN04

> Hn04M <- (log(0.5)/(-c7bf4^(-alfamM)))^(1/alfamM)

> Hn04M
```

```
[1] 2529.968

> #INQN04
> In04M <- (log(0.5)/(-c8bf4^(-alfamM)))^(1/alfamM)
> In04M

[1] 1616.135

> #HOSTN05
> Hn05M <- (log(0.5)/(-c9bf4^(-alfamM)))^(1/alfamM)
> Hn05M

[1] 2363.563

> #INQN05
> In05M <- (log(0.5)/(-c10bf4^(-alfamM)))^(1/alfamM)
> In05M

[1] 1509.836

> #HOSTN06
> Hn06M <- (log(0.5)/(-c11bf4^(-alfamM)))^(1/alfamM)
> Hn06M

[1] 2773.994

> #INQN06
> In06M <- (log(0.5)/(-c12bf4^(-alfamM)))^(1/alfamM)
> In06M

[1] 1772.018
```

Survival of host and inquilines with heterospecific interaction

Survival of host and inquilines with heterospecific interaction

```
> library(MuMIn)
> options(na.action = "na.fail")
> library(survival)
> m5 <- survreg(Surv(hetero$time,hetero$censor)~ hetero$nestID +
+                  hetero$group + hetero$treatmentM)
> mt5A <- m5
> rAb5 <- dredge(mt5A, rank = "AICc")
> summary(get.models(rAb5, 1)[[1]])

Call:
survreg(formula = Surv(hetero$time, hetero$censor) ~ hetero$group +
    hetero$nestID + hetero$treatmentM + 1)
                          Value Std. Error      z       p
(Intercept)             7.60854    0.24794  30.69 < 2e-16
hetero$groupinquiline -3.57152    0.15956 -22.38 < 2e-16
hetero$nestIDn02      -0.81323    0.26103  -3.12  0.0018
hetero$nestIDn03      -0.55452    0.26381  -2.10  0.0356
hetero$nestIDn04      -0.53745    0.25457  -2.11  0.0348
hetero$nestIDn05      -0.74363    0.25042  -2.97  0.0030
hetero$nestIDn06      -0.25734    0.25053  -1.03  0.3043
hetero$treatmentM      0.00258    0.00104   2.49  0.0126
Log(scale)             0.17108    0.04340   3.94 8.1e-05

Scale= 1.19

Weibull distribution
Loglik(model)= -1734.8   Loglik(intercept only)= -1933.3
        Chisq= 396.98 on 7 degrees of freedom, p= 1.1e-81
Number of Newton-Raphson Iterations: 6
n= 336
```

```
> rAb5

Global model call: survreg(formula = Surv(hetero$time, hetero$censor) ~ hetero$nest
    hetero$group + hetero$treatmentM)
---
Model selection table
  (Int) htr$grp htr$nID   htr$trM df    logLik   AICc  delta weight
8 7.609       +       + 0.0025830  9 -1734.764 3488.1   0.00  0.804
4 7.845       +       +            8 -1737.757 3492.0   3.88  0.116
6 7.128       +         0.0025510  4 -1742.413 3492.9   4.87  0.070
2 7.339       +                    3 -1745.390 3496.9   8.77  0.010
1 5.576                            2 -1933.252 3870.5 382.46  0.000
5 5.569                 0.0000760  3 -1933.251 3872.6 384.50  0.000
3 5.992               +            7 -1929.965 3874.3 386.19  0.000
7 5.974               + 0.0001898  8 -1929.960 3876.4 388.28  0.000
Models ranked by AICc(x)

>

> rAb5[rAb5$delta<=2]

Global model call: survreg(formula = Surv(hetero$time, hetero$censor) ~ hetero$nest
    hetero$group + hetero$treatmentM)
---
Model selection table
  (Int) htr$grp htr$nID  htr$trM df    logLik   AICc delta weight
8 7.609       +       + 0.002583  9 -1734.764 3488.1     0      1
Models ranked by AICc(x)

> summary(m5)

Call:
survreg(formula = Surv(hetero$time, hetero$censor) ~ hetero$nestID +
```

```
    hetero$group + hetero$treatmentM)
                          Value Std. Error      z       p
(Intercept)             7.60854    0.24794  30.69 < 2e-16
hetero$nestIDn02       -0.81323    0.26103  -3.12  0.0018
hetero$nestIDn03       -0.55452    0.26381  -2.10  0.0356
hetero$nestIDn04       -0.53745    0.25457  -2.11  0.0348
hetero$nestIDn05       -0.74363    0.25042  -2.97  0.0030
hetero$nestIDn06       -0.25734    0.25053  -1.03  0.3043
hetero$groupinquiline -3.57152    0.15956 -22.38 < 2e-16
hetero$treatmentM       0.00258    0.00104   2.49  0.0126
Log(scale)              0.17108    0.04340   3.94 8.1e-05

Scale= 1.19

Weibull distribution
Loglik(model)= -1734.8   Loglik(intercept only)= -1933.3
        Chisq= 396.98 on 7 degrees of freedom, p= 1.1e-81
Number of Newton-Raphson Iterations: 6
n= 336

> mu5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID),
> fit5 <- survfit(Surv(time,censor) ~ treatmentM+group+nestID, data=hetero)
> s5 <- summary(fit5)
> dfw5 <- data.frame(surv=s5$surv, treatmentMgroupnestID=s5$strata, time=s5$time)
> alpha5 <- 1/m5$scale
> alpha5
[1] 0.8427514

> tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID), mean)

, , n01
```

```
        host inquiline
0   2015.325  56.65714
60  2353.102  66.15314
120 2747.493  77.24071
180 3207.986  90.18661

, , n02

         host inquiline
0    893.6379  25.12298
60  1043.4157  29.33371
120 1218.2971  34.25018
180 1422.4893  39.99066

, , n03

        host inquiline
0   1157.501  32.54101
60  1351.504  37.99504
120 1578.022  44.36318
180 1842.506  51.79866

, , n04

        host inquiline
0   1177.422  33.10106
60  1374.764  38.64895
120 1605.180  45.12669
```

```
180 1874.216  52.69013

, , n05

         host inquiline
0    958.0519  26.93386
60  1118.6258  31.44810
120 1306.1127  36.71895
180 1525.0232  42.87322

, , n06

        host inquiline
0   1558.058  43.80194
60  1819.196  51.14334
120 2124.102  59.71521
180 2480.111  69.72375

> c1f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c1f5 #host n1 0

[1] 2015.325

> c2f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c2f5 #host n1 60

[1] 2353.102

> c3f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c3f5 #host n1 120

[1] 2747.493
```

```
> c4f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c4f5 #host n1 180

[1] 3207.986

> c5f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c5f5 #inquiline n1 0

[1] 56.65714

> c6f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c6f5 #inquiline n1 60

[1] 66.15314

> c7f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c7f5 #inquiline n1 120

[1] 77.24071

> c8f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c8f5 #inquiline n1 180

[1] 90.18661

> c9f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestID)
> c9f5 #host n2 0

[1] 893.6379

> c10f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestI
> c10f5 #host n2 60

[1] 1043.416

> c11f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestI
> c11f5 #host n2 120
```

```
[1] 1218.297

> c12f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c12f5 #host n2 180

[1] 1422.489

> c13f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c13f5 #inquiline n2 0

[1] 25.12298

> c14f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c14f5 #inquiline n2 60

[1] 29.33371

> c15f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c15f5 #inquiline n2 120

[1] 34.25018

> c16f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c16f5 #inquiline n2 180

[1] 39.99066

> c17f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c17f5 #host n3 0

[1] 1157.501

> c18f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c18f5 #host n3 60

[1] 1351.504
```

```
> c19f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c19f5 #host n3 120

[1] 1578.022

> c20f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c20f5 #host n3 180

[1] 1842.506

> c21f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c21f5 #inquiline n3 0

[1] 32.54101

> c22f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c22f5 #inquiline n3 60

[1] 37.99504

> c23f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c23f5 #inquiline n3 120

[1] 44.36318

> c24f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c24f5 #inquiline n3 180

[1] 51.79866

> c25f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c25f5 #host n4 0

[1] 1177.422

> c26f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII
> c26f5 #host n4 60
```

```
[1] 1374.764

> c27f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c27f5 #host n4 120

[1] 1605.18

> c28f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c28f5 #host n4 180

[1] 1874.216

> c29f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c29f5 #inquiline n4 0

[1] 33.10106

> c30f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c30f5 #inquiline n4 60

[1] 38.64895

> c31f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c31f5 #inquiline n4 120

[1] 45.12669

> c32f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c32f5 #inquiline n4 180

[1] 52.69013

> c33f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c33f5 #host n5 0

[1] 958.0519
```

```
> c34f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c34f5 #host n5 60

[1] 1118.626

> c35f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c35f5 #host n5 120

[1] 1306.113

> c36f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c36f5 #host n5 180

[1] 1525.023

> c37f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c37f5 #inquiline n5 0

[1] 26.93386

> c38f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c38f5 #inquiline n5 60

[1] 31.4481

> c39f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c39f5 #inquiline n5 120

[1] 36.71895

> c40f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c40f5 #inquiline n5 180

[1] 42.87322

> c41f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestIl
> c41f5 #host n6 0
```

```
[1] 1558.058

> c42f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c42f5 #host n6 60

[1] 1819.196

> c43f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c43f5 #host n6 120

[1] 2124.102

> c44f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c44f5 #host n6 180

[1] 2480.111

> c45f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c45f5 #inquiline n6 0

[1] 43.80194

> c46f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c46f5 #inquiline n6 60

[1] 51.14334

> c47f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c47f5 #inquiline n6 120

[1] 59.71521

> c48f5 <- tapply(predict(m5), list(hetero$treatmentM, hetero$group, hetero$nestII

> c48f5 #inquiline n6 180

[1] 69.72375
```

Mean time to death: host and inquilines with heterospecific interaction

```
> # n1:
> # Hosts:
> # 0
> H0n1 <- (log(0.5)/(-c1f5^(-alpha5)))^(1/alpha5)
> H0n1

[1] 1304.578

> # 60
> H60n1 <- (log(0.5)/(-c2f5^(-alpha5)))^(1/alpha5)
> H60n1

[1] 1523.232

> # 120
> H120n1 <- (log(0.5)/(-c3f5^(-alpha5)))^(1/alpha5)
> H120n1

[1] 1778.532

> # 180
> H180n1 <- (log(0.5)/(-c4f5^(-alpha5)))^(1/alpha5)
> H180n1

[1] 2076.623

> # Inquilines:
> # 0
> I0n1 <- (log(0.5)/(-c5f5^(-alpha5)))^(1/alpha5)
> I0n1

[1] 36.67582
```

```
> # 60
> I60n1 <- (log(0.5)/(-c6f5^(-alpha5)))^(1/alpha5)
> I60n1

[1] 42.82285

> # 120
> I120n1 <- (log(0.5)/(-c7f5^(-alpha5)))^(1/alpha5)
> I120n1

[1] 50.00016

> # 180
> I180n1 <- (log(0.5)/(-c8f5^(-alpha5)))^(1/alpha5)
> I180n1

[1] 58.38042

> # n2:
> # Hosts:
> # 0
> H0n2 <- (log(0.5)/(-c9f5^(-alpha5)))^(1/alpha5)
> H0n2

[1] 578.4778

> # 60
> H60n2 <- (log(0.5)/(-c10f5^(-alpha5)))^(1/alpha5)
> H60n2

[1] 675.4334

> # 120
> H120n2 <- (log(0.5)/(-c11f5^(-alpha5)))^(1/alpha5)
> H120n2
```

```
[1] 788.6392

> # 180
> H180n2 <- (log(0.5)/(-c12f5^(-alpha5)))^(1/alpha5)
> H180n2

[1] 920.8188

> # Inquilines:
> # 0
> I0n2 <- (log(0.5)/(-c13f5^(-alpha5)))^(1/alpha5)
> I0n2

[1] 16.26284

> # 60
> I60n2 <- (log(0.5)/(-c14f5^(-alpha5)))^(1/alpha5)
> I60n2

[1] 18.98856

> # 120
> I120n2 <- (log(0.5)/(-c15f5^(-alpha5)))^(1/alpha5)
> I120n2

[1] 22.17114

> # 180
> I180n2 <- (log(0.5)/(-c16f5^(-alpha5)))^(1/alpha5)
> I180n2

[1] 25.88712

> # n3:
> # Hosts:
```

```
> # 0
> H0n3 <- (log(0.5)/(-c17f5^(-alpha5)))^(1/alpha5)
> H0n3

[1] 749.2843

> # 60
> H60n3 <- (log(0.5)/(-c18f5^(-alpha5)))^(1/alpha5)
> H60n3

[1] 874.8678

> # 120
> H120n3 <- (log(0.5)/(-c19f5^(-alpha5)))^(1/alpha5)
> H120n3

[1] 1021.5

> # 180
> H180n3 <- (log(0.5)/(-c20f5^(-alpha5)))^(1/alpha5)
> H180n3

[1] 1192.708

> # Inquilines:
> # 0
> I0n3 <- (log(0.5)/(-c21f5^(-alpha5)))^(1/alpha5)
> I0n3

[1] 21.06475

> # 60
> I60n3 <- (log(0.5)/(-c22f5^(-alpha5)))^(1/alpha5)
> I60n3
```

```
[1] 24.5953

> # 120
> I120n3 <- (log(0.5)/(-c23f5^(-alpha5)))^(1/alpha5)
> I120n3

[1] 28.71758

> # 180
> I180n3 <- (log(0.5)/(-c24f5^(-alpha5)))^(1/alpha5)
> I180n3

[1] 33.53078

> # n4:
> # Hosts:
> # 0
> H0n4 <- (log(0.5)/(-c25f5^(-alpha5)))^(1/alpha5)
> H0n4

[1] 762.1797

> # 60
> H60n4 <- (log(0.5)/(-c26f5^(-alpha5)))^(1/alpha5)
> H60n4

[1] 889.9246

> # 120
> H120n4 <- (log(0.5)/(-c27f5^(-alpha5)))^(1/alpha5)
> H120n4

[1] 1039.08
```

```
> # 180
> H180n4 <- (log(0.5)/(-c28f5^(-alpha5)))^(1/alpha5)
> H180n4
[1] 1213.235
> # Inquilines:
> # 0
> I0n4 <- (log(0.5)/(-c29f5^(-alpha5)))^(1/alpha5)
> I0n4
[1] 21.42728
> # 60
> I60n4 <- (log(0.5)/(-c30f5^(-alpha5)))^(1/alpha5)
> I60n4
[1] 25.01859
> # 120
> I120n4 <- (log(0.5)/(-c31f5^(-alpha5)))^(1/alpha5)
> I120n4
[1] 29.21182
> # 180
> I180n4 <- (log(0.5)/(-c32f5^(-alpha5)))^(1/alpha5)
> I180n4
[1] 34.10786
> # n5:
> # Hosts:
> # 0
> H0n5 <- (log(0.5)/(-c33f5^(-alpha5)))^(1/alpha5)
> H0n5
```

```
[1] 620.1749

> # 60

> H60n5 <- (log(0.5)/(-c34f5^(-alpha5)))^(1/alpha5)

> H60n5

[1] 724.1191

> # 120

> H120n5 <- (log(0.5)/(-c35f5^(-alpha5)))^(1/alpha5)

> H120n5

[1] 845.4848

> # 180

> H180n5 <- (log(0.5)/(-c36f5^(-alpha5)))^(1/alpha5)

> H180n5

[1] 987.1919

> # Inquilines:

> # 0

> I0n5 <- (log(0.5)/(-c37f5^(-alpha5)))^(1/alpha5)

> I0n5

[1] 17.43507

> # 60

> I60n5 <- (log(0.5)/(-c38f5^(-alpha5)))^(1/alpha5)

> I60n5

[1] 20.35727

> # 120

> I120n5 <- (log(0.5)/(-c39f5^(-alpha5)))^(1/alpha5)

> I120n5
```

```
[1] 23.76925

> # 180
> I180n5 <- (log(0.5)/(-c40f5^(-alpha5)))^(1/alpha5)
> I180n5

[1] 27.75308

> # n6:
> # Hosts:
> # 0
> H0n6 <- (log(0.5)/(-c41f5^(-alpha5)))^(1/alpha5)
> H0n6

[1] 1008.577

> # 60
> H60n6 <- (log(0.5)/(-c42f5^(-alpha5)))^(1/alpha5)
> H60n6

[1] 1177.619

> # 120
> H120n6 <- (log(0.5)/(-c43f5^(-alpha5)))^(1/alpha5)
> H120n6

[1] 1374.993

> # 180
> H180n6 <- (log(0.5)/(-c44f5^(-alpha5)))^(1/alpha5)
> H180n6

[1] 1605.448
```

```
> # Inquilines:
> # 0
> I0n6 <- (log(0.5)/(-c45f5^(-alpha5)))^(1/alpha5)
> I0n6

[1] 28.35427

> # 60
> I60n6 <- (log(0.5)/(-c46f5^(-alpha5)))^(1/alpha5)
> I60n6

[1] 33.10658

> # 120
> I120n6 <- (log(0.5)/(-c47f5^(-alpha5)))^(1/alpha5)
> I120n6

[1] 38.65539

> # 180
> I180n6 <- (log(0.5)/(-c48f5^(-alpha5)))^(1/alpha5)
> I180n6

[1] 45.13421

>
```

Mean time to death: host and inquilines in heterospecific interaction - group by nest

```
> mH <- survreg(Surv(hetero$time,hetero$censor)~ hetero$group + hetero$nestID)
> alfamH <- 1/mH$scale
> tapply(predict(mH), list(hetero$group, hetero$nestID), mean)
```

```
                n01        n02        n03        n04        n05        n06
host      2552.87325 1136.52470 1541.07846 1389.87712 1166.23769 1948.66143
inquiline   72.73034   32.37913   43.90471   39.59704   33.22564   55.51658
```

```
> #hostn01
> c1bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[1]
> c1bf5

[1] 2552.873

> #inquilinen01
> c2bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[2]
> c2bf5

[1] 72.73034

> #hostn02
> c3bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[3]
> c3bf5

[1] 1136.525

> #inquilinen02
> c4bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[4]
> c4bf5

[1] 32.37913

> #hostn03
> c5bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[5]
> c5bf5

[1] 1541.078
```

```
> #inquilinen03
> c6bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[6]
> c6bf5

[1] 43.90471

> #hostn04
> c7bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[7]
> c7bf5

[1] 1389.877

> #inquilinen04
> c8bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[8]
> c8bf5

[1] 39.59704

> #hostn05
> c9bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[9]
> c9bf5

[1] 1166.238

> #inquilinen05
> c10bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[10]
> c10bf5

[1] 33.22564

> #hostn06
> c11bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[11]
> c11bf5

[1] 1948.661
```

```
> #inquilinen06
> c12bf5 <- tapply(predict(mH), list(hetero$group, hetero$nestID), mean)[12]
> c12bf5

[1] 55.51658
```

Mean time to death by nest - Heterospecific

```
> #HOSTN01
> Hn01 <- (log(0.5)/(-c1bf5^(-alfamH)))^(1/alfamH)
> Hn01

[1] 1634.045

> #INQN01
> In01 <- (log(0.5)/(-c2bf5^(-alfamH)))^(1/alfamH)
> In01

[1] 46.55328

> #HOSTN02
> Hn02 <- (log(0.5)/(-c3bf5^(-alfamH)))^(1/alfamH)
> Hn02

[1] 727.4675

> #INQN02
> In02 <- (log(0.5)/(-c4bf5^(-alfamH)))^(1/alfamH)
> In02

[1] 20.72526

> #HOSTN03
> Hn03 <- (log(0.5)/(-c5bf5^(-alfamH)))^(1/alfamH)
> Hn03
```

```
[1] 986.4146

> #INQN03

> In03 <- (log(0.5)/(-c6bf5^(-alfamH)))^(1/alfamH)

> In03

[1] 28.10256

> #HOSTN04

> Hn04 <- (log(0.5)/(-c7bf5^(-alfamH)))^(1/alfamH)

> Hn04

[1] 889.6335

> #INQN04

> In04 <- (log(0.5)/(-c8bf5^(-alfamH)))^(1/alfamH)

> In04

[1] 25.3453

> #HOSTN05

> Hn05 <- (log(0.5)/(-c9bf5^(-alfamH)))^(1/alfamH)

> Hn05

[1] 746.4862

> #INQN05

> In05 <- (log(0.5)/(-c10bf5^(-alfamH)))^(1/alfamH)

> In05

[1] 21.26709

> #HOSTN06

> Hn06 <- (log(0.5)/(-c11bf5^(-alfamH)))^(1/alfamH)

> Hn06
```

```
[1] 1247.301
```

```
> #INQN06
> In06 <- (log(0.5)/(-c12bf5^(-alfamH)))^(1/alfamH)
> In06
```

```
[1] 35.53509
```

Analysis of mean time to death hetero vs monospecific interactions: host x inquiline interaction affects survival?

```
> dados2 <- data.frame(nest=c("n01","n01","n02","n02","n03","n03",
+                             "n04","n04","n05","n05","n06","n06",
+                             "n01","n01","n02","n02","n03","n03",
+                             "n04","n04","n05","n05","n06","n06"),
+         type = c("mono","mono","mono","mono","mono","mono",
+                  "mono","mono","mono","mono","mono","mono",
+                  "hetero","hetero","hetero","hetero","hetero","hetero",
+                  "hetero","hetero","hetero","hetero","hetero","hetero"),
+         group = c("host","inquiline","host","inquiline","host","inquiline",
+                   "host","inquiline","host","inquiline","host","inquiline",
+                   "host","inquiline","host","inquiline","host","inquiline",
+                   "host","inquiline","host","inquiline","host","inquiline"),
+          mean_time = c(3423.8,2187.111,1861.054,1188.834,3870.012,2472.15,
+                                   2529.968,1616.135,2363.563,1509.836,2773.994,
+                                   1634.045,25.3453,727.4675,20.72526,986.4146,2
+                                   889.6335,25.3453,746.4862,21.26709,1247.301,3
> dados2
```

```
   nest   type     group  mean_time
1   n01   mono      host 3423.80000
2   n01   mono inquiline 2187.11100
```

```
3   n02   mono      host 1861.05400
4   n02   mono inquiline 1188.83400
5   n03   mono      host 3870.01200
6   n03   mono inquiline 2472.15000
7   n04   mono      host 2529.96800
8   n04   mono inquiline 1616.13500
9   n05   mono      host 2363.56300
10  n05   mono inquiline 1509.83600
11  n06   mono      host 2773.99400
12  n06   mono inquiline 1772.01800
13  n01 hetero      host 1634.04500
14  n01 hetero inquiline   25.34530
15  n02 hetero      host  727.46750
16  n02 hetero inquiline   20.72526
17  n03 hetero      host  986.41460
18  n03 hetero inquiline   28.10256
19  n04 hetero      host  889.63350
20  n04 hetero inquiline   25.34530
21  n05 hetero      host  746.48620
22  n05 hetero inquiline   21.26709
23  n06 hetero      host 1247.30100
24  n06 hetero inquiline   35.53509
```

```
> library(MuMIn)
> options(na.action = "na.fail")
> MH2 <- glm(dados2$mean_time~dados2$type+dados2$group+dados2$nest, family = "gaus
> rMH2 <- dredge(MH2, rank = "AICc", extra = "adjR^2")
> rMH2
```

```
Global model call: glm(formula = dados2$mean_time ~ dados2$type + dados2$group +
    dados2$nest, family = "gaussian")
```

```
---
Model selection table
   (Int) dd2$grp dd2$nst dd2$typ  adjR^2 df   logLik  AICc delta weight
8 1441.0       +       +       + 0.93880  9 -168.674 368.2  0.00  0.593
6 1039.0       +               + 0.85020  4 -179.424 369.0  0.75  0.407
5  532.3                       + 0.63960  3 -189.956 387.1 18.91  0.000
7  935.0               +       + 0.72830  8 -186.567 398.7 30.53  0.000
2 1921.0       +                 0.21050  3 -199.367 405.9 37.73  0.000
1 1415.0                         0.00000  2 -202.204 409.0 40.77  0.000
4 2324.0       +       +         0.29920  8 -197.938 421.5 53.27  0.000
3 1818.0               +         0.08866  7 -201.090 423.2 54.97  0.000
Models ranked by AICc(x)
```

Barplot

```
> dadosp1 <- aggregate(dados2$mean_time,
+                        by= list(options = dados2$type, dados2$group),
+                        FUN = function(x) c(mean = mean(x),
+                                            sd = sd(x), n = length(x),
+                                            perm = mean(x)*100/5,
+                                            persd = sd(x)*100/5))
> dadosp1
```

```
  options   Group.2      x.mean        x.sd         x.n      x.perm
1  hetero      host 1038.557967  347.896273    6.000000 20771.159333
2    mono      host 2803.731833  732.073630    6.000000 56074.636667
3  hetero inquiline   26.053433    5.411139    6.000000   521.068667
4    mono inquiline 1791.014000  467.646109    6.000000 35820.280000
      x.persd
1  6957.925459
2 14641.472602
```

```
3   108.222790
4  9352.922181

> dadosp1 <- do.call(data.frame, dadosp1) #Criando o dataframe
> dadosp1

  options   Group.2     x.mean       x.sd x.n     x.perm    x.persd
1  hetero      host 1038.55797 347.896273   6 20771.1593  6957.9255
2    mono      host 2803.73183 732.073630   6 56074.6367 14641.4726
3  hetero inquiline   26.05343   5.411139   6   521.0687   108.2228
4    mono inquiline 1791.01400 467.646109   6 35820.2800  9352.9222

> dadosp1$se <- dadosp1$x.sd / sqrt(dadosp1$x.n)
> dadosp1

  options   Group.2     x.mean       x.sd x.n     x.perm    x.persd         se
1  hetero      host 1038.55797 347.896273   6 20771.1593  6957.9255 142.028059
2    mono      host 2803.73183 732.073630   6 56074.6367 14641.4726 298.867808
3  hetero inquiline   26.05343   5.411139   6   521.0687   108.2228   2.209088
4    mono inquiline 1791.01400 467.646109   6 35820.2800  9352.9222 190.915725

> colnames(dadosp1) <- c("cat", "group","mean", "sd", "n", "perm", "persd", "se")
> dadosp1$names <- (paste(dadosp1$cat))
> dadosp1

     cat     group       mean         sd n       perm      persd         se
1 hetero      host 1038.55797 347.896273 6 20771.1593  6957.9255 142.028059
2   mono      host 2803.73183 732.073630 6 56074.6367 14641.4726 298.867808
3 hetero inquiline   26.05343   5.411139 6   521.0687   108.2228   2.209088
4   mono inquiline 1791.01400 467.646109 6 35820.2800  9352.9222 190.915725
   names
1 hetero
2   mono
```

```
3 hetero
4   mono
```

```
> plotTop1 <- max(dadosp1$mean)
> barCenTers1 <- barplot(tapply(dados2$mean_time,
+                               list(dados2$type,dados2$group),mean),
+         ylab="Mean time to death (min)",
+         ylim= c(0,3600), beside = TRUE,
+         col=c("red3","slateblue4", "red3","slateblue4"))
> text(x = barCenTers1 + 20, y = par("usr")[3] - 2, srt = 30,
+      adj = 1, labels = dadosp1$names, xpd = TRUE)
> segments(barCenTers1, dadosp1$mean - dadosp1$sd, barCenTers1,
+          dadosp1$mean + dadosp1$sd, lwd = 1.5)
> arrows(barCenTers1, dadosp1$mean - dadosp1$sd, barCenTers1,
+        dadosp1$mean + dadosp1$sd, lwd = 1.5, angle = 90,
+        code = 3, length = 0.05)
> legend("topright",
+        legend = c("Heterospecific", "Monospecific"),
+        fill = c("red3", "slateblue4"),
+        bty="n")
```

6.1.1 Survival Analysis for heteroespecific condition

Rationale Here, we propose to test the survival of hosts and inquilines under the following conditions: (i) monospecific where groups were on separate plates; and (ii) heterospecific, where survival was counted after the interaction of the two groups, with both on the same plate. The heterospecific condition is divided into treatments: 0, 60, 120 and 180 min.

Data Column headers:

1. treatmentM: treatment as continuous variable in minutes. 0 (hosts and inquilines are placed on the same petri dish without prior contact); 60 (hosts and inquilines

are on the same petri dish, but separated by a barrier for a period of habituation of one hour); 120 (two hours habituation); 180 (three hour habituation).

2. group: termite individuals classified as host (Cornitermes individuals) and inquilines (inquiline sp.) from which observations were made.

3. caste: caste of the focal individuals analysed.

4. mean: mean time of survival for each caste and grupo.

```
> dados <- read.csv("meantime.csv",
+                   header = TRUE, sep = ",")
> head(dados, n = 5)

   meantime treatment nest group
1 1304.5780         0   n1  host
2 1523.2320        60   n1  host
3 1778.5320       120   n1  host
4 2076.6230       180   n1  host
5  578.4778         0   n2  host

> library(MuMIn)
> options(na.action = "na.fail")
> TM <- glm(meantime~treatment,
+           family = "gaussian",
+           data = dados)
> rTM <- dredge(TM, rank = "AICc", extra = "adjR^2")
> rTM

Global model call: glm(formula = meantime ~ treatment, family = "gaussian", data =
---
Model selection table
  (Intrc) trtmn adjR^2 df   logLik AICc delta weight
```

```
2   824.7  2.75 0.2435  3 -172.884  353  0.00  0.884
1  1072.0       0.0000  2 -176.232  357  4.07  0.116
Models ranked by AICc(x)
```

```
> summary(get.models(rTM, 1)[[1]])

Call:
glm(formula = meantime ~ treatment + 1, family = "gaussian",
    data = dados)


Deviance Residuals:
   Min      1Q  Median      3Q     Max
-398.9  -251.0  -110.7   196.0   756.9


Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  824.664    116.029   7.107 3.97e-07 ***
treatment      2.750      1.034   2.661   0.0143 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for gaussian family taken to be 115394.9)


    Null deviance: 3355651  on 23  degrees of freedom
Residual deviance: 2538688  on 22  degrees of freedom
AIC: 351.77


Number of Fisher Scoring iterations: 2

> plot(TM,which=c(1,2))
```

Coefficients

```
> int <- 824.7
> treat <- 2.75

> plot(dados$mean~dados$treatment,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Mean time (min) of survival",
+      xaxt = "n")
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> curve(int + treat*x, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> legend(0,2000, legend = c("Hosts"),
+ col = c("blue"),
+ lty = c(2),
+ lwd= c(1.7),
+ box.lty = 0)

> dados <- read.csv("meantime.csv",
+                   header = TRUE, sep = ",")
> head(dados, n = 5)

  meantime treatment nest     group
1 36.67582         0   n1 inquiline
2 42.82285        60   n1 inquiline
3 50.00016       120   n1 inquiline
4 58.38042       180   n1 inquiline
5 16.26284         0   n2 inquiline

> library(MuMIn)
> options(na.action = "na.fail")
> TM <- glm(meantime~treatment,
+           family = "gaussian",
+           data = dados)
```

```
> rTM <- dredge(TM, rank = "AICc", extra = "adjR^2")
> rTM

Global model call: glm(formula = meantime ~ treatment, family = "gaussian", data =
---
Model selection table
  (Intrc)   trtmn adjR^2 df  logLik  AICc delta weight
2   23.18 0.07732 0.2436  3 -87.167 181.5  0.00  0.884
1   30.14         0.0000  2 -90.515 185.6  4.07  0.116
Models ranked by AICc(x)

> summary(get.models(rTM, 1)[[1]])

Call:
glm(formula = meantime ~ treatment + 1, family = "gaussian",
    data = dados)


Deviance Residuals:
    Min       1Q   Median       3Q      Max
-11.215   -7.057   -3.111    5.511   21.279


Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 23.18392    3.26194   7.107 3.97e-07 ***
treatment    0.07732    0.02906   2.661   0.0143 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for gaussian family taken to be 91.20233)


    Null deviance: 2652.1  on 23  degrees of freedom
```

```
Residual deviance: 2006.5  on 22  degrees of freedom
AIC: 180.33

Number of Fisher Scoring iterations: 2
```

```
> plot(TM,which=c(1,2))
```

Coefficients

```
> int <- 23.18
> treat <- 0.07732

> plot(dados$mean~dados$treatment,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Mean time (min) of survival",
+      xaxt = "n")
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> curve(int + treat*x, add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> legend(0,60, legend = c("Inquilines"),
+ col = c("red"),
+ lty = c(2),
+ lwd= c(1.7),
+ box.lty = 0)
```

6.2 Duration Analysis

Rationale Here, we propose to test the hypothesis: (i) hosts habituate to the presence of inquilines, being less aggressive towards them. To test our hypothesis we will use individuals of the genus Cornitermes spp. versus the species of inquiline that is present in greater abundance in all collected nests. For this we will: (i) place inquilines and hosts on a plate without a physical barrier (time = zero); (ii) place inquilines and hosts on a plate but separated by a physical barrier, which allows the exchange of smells. The plates with the barrier will have the same removed after a period of 1h, 2h and 3 hours of habituation. Less aggression is expected as the individuals spend more time in the presence of each other, even if separated by the physical barrier.

Data Column headers:

1. nest ID: simplified name of the nest from which termites were extracted.
2. treatmentM: treatment as continuous variable in minutes. 0 (hosts and inquilines are placed on the same petri dish without prior contact); 60 (hosts and inquilines are on the same petri dish, but separated by a barrier for a period of habituation of one hour); 120 (two hours habituation); 180 (three hour habituation).
3. group: termite individuals classified as host (Cornitermes individuals) and inquilines (inquiline sp.) from which observations were made.
4. caste: caste of the focal individuals analysed.
5. subject: name given for each individual analysed.
6. behavior: behaviour performed by each individual.
7. class: pf (pacific behaviours); ex (exploratory behaviours); ag (agressive behaviours); wr (walking e resting).
8. type: b is a behavior and r is a result (injured).
9. dur: total duration of behaviors in seconds.

```
> dados <- read.csv("duration.csv",
+                     header = TRUE, sep = ",")
> head(dados, n = 5)

  nestID treatmentM group caste        subject            behavior duration
1    n01          0  Host     S HostSoldier001             Resting    5.487
2    n01          0  Host     S HostSoldier001             Walking  306.027
```

```
3    n01          0  Host     S HostSoldier001     AntennatingWall    4.000
4    n01          0  Host     S HostSoldier001 AntennatingNestmate    1.000
5    n01          0  Host     S HostSoldier001            Ignoring    2.000
  type class
1    b    pf
2    b    ex
3    b    ex
4    b    ex
5    b    pf
```

Data subsets

```
> #Subset by type, behaviours = b and result = r
> b <- subset(dados, type == "b")
> r <- subset(dados, type == "r")
> #Data subset agressive behaviour
>
> bit <- subset(b, behavior == "Biting")
> #Data subset walking e resting
> wr <- subset(b, behavior == "Resting" |
+                behavior == "Walking")
> w <- subset(b, behavior == "Walking")
> r <- subset(b, behavior == "Resting")
>
```

Duration of behaviours

Agressive behaviour

```
> library(MuMIn)
> options(na.action = "na.fail")
> mbit <- glm(duration~treatmentM + group + caste + nestID,
+           family = "gaussian",
```

```
+           data = bit)
> rbit <- dredge(mbit, rank = "AICc", extra = "adjR^2")
> rbit

Global model call: glm(formula = duration ~ treatmentM + group + caste + nestID,
    family = "gaussian", data = bit)
---
Model selection table
   (Intrc) caste group nstID    trtmM    adjR^2 df   logLik   AICc delta weight
7    47.14             +     +          0.1826000  8 -733.589 1484.3  0.00  0.362
8    65.39     +       +     +          0.1886000  9 -733.095 1485.7  1.32  0.188
15   54.75             +     + -0.07025 0.1874000  9 -733.200 1485.9  1.52  0.169
16   73.77     +       +     + -0.07270 0.1937000 10 -732.676 1487.2  2.82  0.089
3    72.42             +                0.0923800  3 -740.552 1487.3  2.95  0.083
11   79.34             +       -0.07601 0.0981600  4 -740.127 1488.6  4.23  0.044
4    89.72     +       +                0.0974000  4 -740.183 1488.7  4.34  0.041
12   97.65     +       +       -0.07888 0.1036000  5 -739.723 1489.9  5.58  0.022
5    43.47                   +          0.0846800  7 -741.114 1497.1 12.78  0.001
13   56.10                   + -0.11490 0.0977000  8 -740.161 1497.5 13.14  0.001
1    56.22                              0.0000000  2 -746.997 1498.1 13.75  0.000
9    67.54                     -0.11510 0.0135100  3 -746.093 1498.4 14.03  0.000
6    40.60     +             +          0.0848400  8 -741.102 1499.4 15.03  0.000
14   54.96     +             + -0.11450 0.0977200  9 -740.159 1499.8 15.44  0.000
2    53.66     +                        0.0001329  3 -746.988 1500.2 15.82  0.000
10   66.82     +               -0.11490 0.0135200  4 -746.092 1500.5 16.16  0.000
Models ranked by AICc(x)

>

> rbit[rbit$delta<=2]

Global model call: glm(formula = duration ~ treatmentM + group + caste + nestID,
```

```
    family = "gaussian", data = bit)
---
Model selection table
   (Intrc) caste group nstID    trtmM adjR^2 df   logLik   AICc delta weight
7    47.14           +     +           0.1826  8 -733.589 1484.3  0.00  0.504
8    65.39     +     +     +           0.1886  9 -733.095 1485.7  1.32  0.261
15   54.75           +     + -0.07025 0.1874  9 -733.200 1485.9  1.52  0.235
Models ranked by AICc(x)
```

```
> summary(get.models(rbit, 1)[[1]])

Call:
glm(formula = duration ~ group + nestID + 1, family = "gaussian",
    data = bit)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-93.31  -38.65  -11.50   15.72  213.61

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)      47.142     17.863   2.639 0.009363 **
groupInquiline  -44.110     11.353  -3.885 0.000164 ***
nestIDn02        47.335     22.280   2.125 0.035577 *
nestIDn03        47.915     21.551   2.223 0.027972 *
nestIDn04         2.500     23.014   0.109 0.913666
nestIDn05        31.800     22.078   1.440 0.152255
nestIDn06         6.159     22.258   0.277 0.782472
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
(Dispersion parameter for gaussian family taken to be 3818.447)

    Null deviance: 588607  on 132  degrees of freedom
Residual deviance: 481124  on 126  degrees of freedom
AIC: 1483.2

Number of Fisher Scoring iterations: 2

> plot(mbit,which=c(1,2))
> model.avg(object = rbit[rbit$delta <= 2])

Call:
model.avg(object = rbit[rbit$delta <= 2])

Component models:
‘23’  ‘123’ ‘234’

Coefficients:
       (Intercept) groupInquiline nestIDn02 nestIDn03 nestIDn04 nestIDn05
full      53.69434      -44.60365  46.96918  47.98601  2.589501  32.01931
subset    53.69434      -44.60365  46.96918  47.98601  2.589501  32.01931
       nestIDn06     casteW  treatmentM
full    5.889582  -5.120621 -0.01651944
subset  5.889582 -19.619964 -0.07025443
> mbit2 <- update(mbit,.~.-nestID)
> rbit2 <- dredge(mbit2, rank = "AICc", extra = "adjR^2")
> rbit2
Global model call: glm(formula = duration ~ treatmentM + group + caste, family = "g
    data = bit)
---
```

```
Model selection table
  (Intrc) caste group    trtmM    adjR^2 df   logLik   AICc delta weight
3   72.42           +           0.0923800  3 -740.552 1487.3  0.00  0.433
7   79.34           + -0.07601 0.0981600  4 -740.127 1488.6  1.28  0.229
4   89.72     +     +           0.0974000  4 -740.183 1488.7  1.39  0.216
8   97.65     +     + -0.07888 0.1036000  5 -739.723 1489.9  2.63  0.116
1   56.22                       0.0000000  2 -746.997 1498.1 10.80  0.002
5   67.54             -0.11510 0.0135100  3 -746.093 1498.4 11.08  0.002
2   53.66     +                 0.0001329  3 -746.988 1500.2 12.87  0.001
6   66.82     +       -0.11490 0.0135200  4 -746.092 1500.5 13.21  0.001
Models ranked by AICc(x)

> model.avg(object = rbit2[rbit2$delta <= 2])

Call:
model.avg(object = rbit2[rbit2$delta <= 2])


Component models:
'2'  '23' '12'


Coefficients:
       (Intercept) groupInquiline  treatmentM     casteW
full      78.48499      -41.71763 -0.01980278  -4.369212
subset    78.48499      -41.71763 -0.07601016 -17.739110
```

Coefficients

```
> int2 <- 78.48499
> tre2 <- -0.07601016
> inq2 <- -41.71763
> wor2 <- -17.739110
```

```
> plot(bit$duration~bit$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Duration (s) of biting",
+      xaxt = "n")
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #comportamento biting por operários do hospedeiro
> curve(int2 + tre2*x + wor2, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #comportamento biting por soldados do hospedeiro
> curve(int2 + tre2*x, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 1)
> #comportamento biting por operários do inquilino
> curve(int2 + tre2*x + wor2 + inq2, add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #comportamento biting por soldados do inquilino
> curve(int2 + tre2*x + inq2, add = TRUE,
+       col = "red", lwd = 1.7, lty = 1)
> legend(70,220, legend = c("Biting by host workers",
+ "Biting by host soldiers",
+ "Biting by inquiline workers",
+ "Biting by inquiline soldiers"),
+ col = c("blue", "blue", "red", "red"),
+ lty = c(2,1,2,1),
+ lwd= c(1.7,1.7,1.7,1.7),
+ box.lty = 0)
```

Walking

```
> options(na.action = "na.fail")
> mw <- glm(duration~treatmentM + group  + caste + nestID,
+          family = "gaussian",
```

```
+            data = w)
> rw <- dredge(mw, rank = "AICc", extra = "adjR^2")
> rw

Global model call: glm(formula = duration ~ treatmentM + group + caste + nestID,
    family = "gaussian", data = w)
---
Model selection table
   (Intrc) caste group nstID    trtmM    adjR^2 df    logLik   AICc  delta
8    221.2     +     +     +           3.534e-01  9 -1717.984 3454.6   0.00
16   223.3     +     +     + -0.02381 3.537e-01 10 -1717.920 3456.6   2.01
7    200.6           +     +           3.439e-01  8 -1720.170 3456.8   2.25
15   202.6           +     + -0.02389 3.441e-01  9 -1720.106 3458.8   4.24
4    192.1     +     +                 3.190e-01  4 -1725.725 3459.6   5.00
12   194.0     +     +       -0.02069 3.192e-01  5 -1725.679 3461.6   6.97
3    171.6           +                 3.094e-01  3 -1727.833 3461.7   7.16
11   173.5           +       -0.02063 3.096e-01  4 -1727.787 3463.7   9.12
6    174.2     +           +           6.715e-02  8 -1772.775 3562.0 107.46
14   175.5     +           + -0.01480 6.725e-02  9 -1772.758 3564.1 109.55
2    141.9     +                       2.594e-02  3 -1779.237 3564.6 109.96
10   142.8     +             -0.01078 2.600e-02  4 -1779.228 3566.6 112.00
5    138.7                 +           4.179e-02  7 -1776.785 3568.0 113.36
13   139.9                 + -0.01462 4.189e-02  8 -1776.768 3570.0 115.44
1    106.3                             0.000e+00  2 -1783.167 3570.4 115.78
9    107.2                   -0.01034 5.264e-05  3 -1783.159 3572.4 117.81
   weight
8   0.510
16  0.186
7   0.166
15  0.061
```

```
4   0.042
12  0.016
3   0.014
11  0.005
6   0.000
14  0.000
2   0.000
10  0.000
5   0.000
13  0.000
1   0.000
9   0.000
Models ranked by AICc(x)

>

> rw[rw$delta<=2]

Global model call: glm(formula = duration ~ treatmentM + group + caste + nestID,
    family = "gaussian", data = w)
---
Model selection table
  (Intrc) caste group nstID adjR^2 df    logLik   AICc delta weight
8   221.2     +     +     + 0.3534  9 -1717.984 3454.6     0      1
Models ranked by AICc(x)

> summary(get.models(rw, 1)[[1]])

Call:
glm(formula = duration ~ caste + group + nestID + 1, family = "gaussian",
    data = w)
```

```
Deviance Residuals:
     Min        1Q    Median        3Q       Max
-186.069   -46.319    -8.338    56.738   203.006

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)      221.21      15.82  13.980  < 2e-16 ***
casteW           -25.64      12.39  -2.070  0.03931 *
groupInquiline  -103.96       9.16 -11.350  < 2e-16 ***
nestIDn02        -12.35      15.93  -0.775  0.43872
nestIDn03        -43.73      15.43  -2.833  0.00493 **
nestIDn04        -29.08      15.23  -1.910  0.05716 .
nestIDn05        -45.88      15.44  -2.972  0.00321 **
nestIDn06        -45.12      15.51  -2.909  0.00391 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 5888.62)

    Null deviance: 2650085  on 298  degrees of freedom
Residual deviance: 1713588  on 291  degrees of freedom
AIC: 3454

Number of Fisher Scoring iterations: 2

> plot(mw,which=c(1,2))
> model.avg(object = rw)

Call:
model.avg(object = rw)
```

```
Component models:
‘123’    ‘1234’   ‘23’     ‘234’    ‘12’     ‘124’
‘2’      ‘24’     ‘13’     ‘134’    ‘1’      ‘14’
‘3’      ‘34’     ‘(Null)’ ‘4’

Coefficients:
       (Intercept)    casteW groupInquiline nestIDn02 nestIDn03 nestIDn04
full      214.4335 -19.33320      -104.5921 -11.14198 -40.25857 -26.79384
subset    214.4335 -25.65724      -104.5921 -12.07297 -43.62248 -29.03267
       nestIDn05 nestIDn06   treatmentM
full   -42.33562 -41.55161 -0.006328387
subset -45.87308 -45.02355 -0.023584918
> mw2 <- update(mw,.~.-nestID)
> rw2 <- dredge(mw2, rank = "AICc", extra = "adjR^2")
> rw2
Global model call: glm(formula = duration ~ treatmentM + group + caste, family = "g
    data = w)
---
Model selection table
  (Intrc) caste group    trtmM    adjR^2 df    logLik   AICc  delta weight
4   192.1     +     +          3.190e-01  4 -1725.725 3459.6   0.00  0.544
8   194.0     +     + -0.02069 3.192e-01  5 -1725.679 3461.6   1.98  0.202
3   171.6           +          3.094e-01  3 -1727.833 3461.7   2.16  0.185
7   173.5           + -0.02063 3.096e-01  4 -1727.787 3463.7   4.12  0.069
2   141.9     +                2.594e-02  3 -1779.237 3564.6 104.97  0.000
6   142.8     +       -0.01078 2.600e-02  4 -1779.228 3566.6 107.01  0.000
1   106.3                      0.000e+00  2 -1783.167 3570.4 110.79  0.000
5   107.2             -0.01034 5.264e-05  3 -1783.159 3572.4 112.81  0.000
Models ranked by AICc(x)
```

```
> model.avg(object = rw2[rw2$delta <= 2])

Call:
model.avg(object = rw2[rw2$delta <= 2])


Component models:
‘12’  ‘123’


Coefficients:
       (Intercept)    casteW groupInquiline   treatmentM
full      192.6331 -25.82295      -105.1255 -0.005613651
subset    192.6331 -25.82295      -105.1255 -0.020691797
```

Coefficients

```
> int3 <- 192.6331
> tre3 <- -0.020691797
> inq3 <- -105.1255
> wor3 <- -25.82295

> plot(w$duration~w$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Duration (s) of walking",
+      xaxt = "n",
+      ylim=c(0,450))
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #comportamento walking por operários do hospedeiro
> curve(int3 + tre3*x + wor2, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #comportamento walking por soldados do hospedeiro
> curve(int3 + tre3*x, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 1)
```

```
> #comportamento walking por operários do inquilino
> curve(int3 + tre3*x + wor3 + inq3, add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #comportamento walking por soldados do inquilino
> curve(int3 + tre3*x + inq3, add = TRUE,
+       col = "red", lwd = 1.7, lty = 1)
> legend(70,450, legend = c("Walking by host workers",
+ "Walking by host soldiers",
+ "Walking by inquiline workers",
+ "Walking by inquiline soldiers"),
+ col = c("blue", "blue",
+ "red","red"),
+ lty = c(2,1,2,1),
+ lwd= c(1.7,1.7,1.7,1.7),
+ box.lty = 0)
```

Resting

```
> options(na.action = "na.fail")
> mrest <- glm(duration~treatmentM + group + caste +nestID,
+           family = "gaussian",
+           data = r)
> rest <- dredge(mrest, rank = "AICc", extra = "adjR^2")
> rest

Global model call: glm(formula = duration ~ treatmentM + group + caste + nestID,
    family = "gaussian", data = r)
---
Model selection table
   (Intrc) caste group nstID  trtmM   adjR^2 df    logLik   AICc delta weight
13  119.00                 + 0.1868 0.066550  8 -1734.530 3485.6  0.00  0.286
```

```
15  109.20           +     + 0.1861 0.071860  9 -1733.680 3486.0  0.43  0.231
14  107.90     +           + 0.1859 0.069410  9 -1734.073 3486.8  1.21  0.156
16  100.20     +     +     + 0.1855 0.073980 10 -1733.339 3487.4  1.89  0.112
9   111.20                   0.1889 0.021790  3 -1741.509 3489.1  3.54  0.049
11  103.30           +       0.1884 0.025790  4 -1740.899 3489.9  4.38  0.032
5   135.30                 +        0.045270  7 -1737.888 3490.2  4.61  0.029
10  100.50     +             0.1881 0.024340  4 -1741.120 3490.4  4.82  0.026
7   125.30           +     +        0.050720  8 -1737.035 3490.6  5.01  0.023
6   123.70     +           +        0.048320  8 -1737.412 3491.3  5.77  0.016
12   94.61     +     +       0.1877 0.027710  5 -1740.604 3491.4  5.86  0.015
8   115.90     +     +     +        0.052990  9 -1736.678 3492.0  6.42  0.012
1   127.90                          0.000000  2 -1744.791 3493.6  8.07  0.005
3   119.80           +              0.004120  3 -1744.176 3494.4  8.88  0.003
2   116.80     +                    0.002739  3 -1744.382 3494.8  9.29  0.003
4   110.70     +     +              0.006198  4 -1743.865 3495.9 10.31  0.002
Models ranked by AICc(x)

> rest[rest$delta<=2]

Global model call: glm(formula = duration ~ treatmentM + group + caste + nestID,
    family = "gaussian", data = r)
---
Model selection table
   (Intrc) caste group nstID  trtrmM  adjR^2 df    logLik   AICc delta weight
13   119.0                 + 0.1868 0.06655  8 -1734.530 3485.6  0.00  0.365
15   109.2           +     + 0.1861 0.07186  9 -1733.680 3486.0  0.43  0.295
14   107.9     +           + 0.1859 0.06941  9 -1734.073 3486.8  1.21  0.199
16   100.2     +     +     + 0.1855 0.07398 10 -1733.339 3487.4  1.89  0.142
Models ranked by AICc(x)

> summary(get.models(rest, 1)[[1]])
```

```
Call:
glm(formula = duration ~ nestID + treatmentM + 1, family = "gaussian",
    data = r)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-149.947   -65.808    -9.913    52.435   205.886

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 119.04743   14.22002   8.372 2.42e-15 ***
nestIDn02   -22.93990   18.24089  -1.258   0.2095
nestIDn03   -18.51554   17.28033  -1.071   0.2848
nestIDn04   -16.64083   16.91810  -0.984   0.3261
nestIDn05   -18.77416   16.91810  -1.110   0.2680
nestIDn06    26.72096   16.85361   1.585   0.1139
treatmentM    0.18676    0.07251   2.576   0.0105 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 6816.028)

    Null deviance: 2124876  on 297  degrees of freedom
Residual deviance: 1983464  on 291  degrees of freedom
AIC: 3485.1

Number of Fisher Scoring iterations: 2

> plot(mrest,which=c(1,2))
> model.avg(object = rest[rest$delta <= 2])
```

```
Call:
model.avg(object = rest[rest$delta <= 2])


Component models:
'34'   '234'  '134'  '1234'


Coefficients:
       (Intercept) nestIDn02 nestIDn03 nestIDn04 nestIDn05 nestIDn06 treatmentM
full      111.2485 -23.61709 -18.30973 -16.04639 -18.17972  27.26811  0.1862288
subset    111.2485 -23.61709 -18.30973 -16.04639 -18.17972  27.26811  0.1862288
       groupInquiline    casteW
full         5.729223  4.218787
subset      13.123425 12.382160
> mrest2 <- update(mrest,.~.-nestID)
> rest2 <- dredge(mrest2, rank = "AICc", extra = "adjR^2")
> rest2
Global model call: glm(formula = duration ~ treatmentM + group + caste, family = "g
    data = r)
---
Model selection table
  (Intrc) caste group  trtmM   adjR^2 df    logLik   AICc delta weight
5  111.20             0.1889 0.021790  3 -1741.509 3489.1  0.00  0.362
7  103.30           + 0.1884 0.025790  4 -1740.899 3489.9  0.83  0.238
6  100.50     +       0.1881 0.024340  4 -1741.120 3490.4  1.28  0.191
8   94.61     +     + 0.1877 0.027710  5 -1740.604 3491.4  2.32  0.114
1  127.90                    0.000000  2 -1744.791 3493.6  4.52  0.038
3  119.80           +        0.004120  3 -1744.176 3494.4  5.33  0.025
2  116.80     +              0.002739  3 -1744.382 3494.8  5.75  0.020
4  110.70     +     +        0.006198  4 -1743.865 3495.9  6.77  0.012
```

```
Models ranked by AICc(x)

> model.avg(object = rest2[rest2$delta <= 2])

Call:
model.avg(object = rest2[rest2$delta <= 2])


Component models:
'3'  '23' '13'


Coefficients:
       (Intercept) treatmentM groupInquiline    casteW
full      106.2193  0.1885776       3.470277  2.990436
subset    106.2193  0.1885776      11.521113 12.382221
```

Coefficients

```
> int4 <- 106.2193
> tre4 <- 0.1885776
> inq4 <- 11.521113
> wor4 <- 12.382221

> plot(r$duration~r$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Duration (s) of resting",
+      xaxt = "n",
+      ylim = c(0,450))
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #comportamento resting por operários do hospedeiro
> curve(int4 + tre4*x + wor4, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #comportamento resting por soldados do hospedeiro
```

```
> curve(int4 + tre4*x, add = TRUE,
+       col = "blue", lwd = 1.7, lty = 1)
> #comportamento resting por operários do inquilino
> curve(int4 + tre4*x + wor4 + inq4, add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #comportamento resting por soldados do inquilino
> curve(int4 + tre4*x + inq4, add = TRUE,
+       col = "red", lwd = 1.7, lty = 1)
> legend(70,450, legend = c("Resting by host workers",
+ "Resting by host soldiers",
+ "Resting by inquiline workers",
+ "Resting by inquiline soldiers"),
+ col = c("blue", "blue",
+ "red","red"),
+ lty = c(2,1,2,1),
+ lwd= c(1.7,1.7,1.7,1.7),
+ box.lty = 0)
```

6.3 Frequency Analysis

Rationale Here, we propose to test the hypothesis: (i) hosts habituate to the presence of inquilines, being less aggressive towards them. To test our hypothesis we will use individuals of the genus Cornitermes spp. versus the species of inquiline that is present in greater abundance in all collected nests. For this we will: (i) place inquilines and hosts on a plate without a physical barrier (time = zero); (ii) place inquilines and hosts on a plate but separated by a physical barrier, which allows the exchange of smells. The plates with the barrier will have the same removed after a period of 1h, 2h and 3 hours of habituation. Less aggression is expected as the individuals spend more time in the presence of each other, even if separated by the physical barrier.

Data Column headers:

1. nest ID: simplified name of the nest from which termites were extracted.
2. treatmentM: treatment as continuous variable in minutes. 0 (hosts and inquilines are placed on the same petri dish without prior contact); 60 (hosts and inquilines are on the same petri dish, but separated by a barrier for a period of habituation of one hour); 120 (two hours habituation); 180 (three hour habituation).
3. group: termite individuals classified as host (Cornitermes individuals) and inquilines (inquiline sp.) from which observations were made.
4. caste: caste of the focal individuals analysed.
5. subject: name given for each individual analysed.
6. behavior: behaviour performed by each individual.
7. class: pf (pacific behaviours); ex (exploratory behaviours); ag (agressive behaviours); wr (walking e resting).
8. type: b is a behavior and r is a result (injured).
9. frequency: absolut frequency of each behaviour performed by individuals. This means, the number of times that each individual performed a specific behaviour.

```
> dados <- read.csv("frequencyDatav2.csv",
+                   header = TRUE, sep = ",")
> head(dados, n = 5)

  nestID treatmentM group caste        subject            behavior class type
1    n01          0  Host     S HostSoldier001             Resting    pf    b
2    n01          0  Host     S HostSoldier001             Walking    ex    b
3    n01          0  Host     S HostSoldier001     AntennatingWall    ex    b
4    n01          0  Host     S HostSoldier001 AntennatingNestmate    ex    b
5    n01          0  Host     S HostSoldier001            Ignoring    pf    b
  frequency
```

```
1          1
2          2
3          4
4          1
5          2
>
```

Data subsets

```
> #Subset by type, behaviours = b and result = r
> b <- subset(dados, type == "b")
> r <- subset(dados, type == "r")
> #Data subset non-aggressive behaviours
> pf <- subset(b, behavior == "Ignoring" |
+               behavior == "Reversing" |
+               behavior == "Passing" |
+               behavior == "AntennatingNonNestmate")
> #Data subset exploratory behaviours
> ex <- subset(b, behavior == "AntennatingNestmate" |
+               behavior == "Walking" |
+               behavior == "AntennatingWall")
> #Data subset agressive behaviours
> Ag <- subset(b, behavior == "Attack" |
+               behavior == "Biting")
> #Data subset walking e resting
> wr <- subset(b, behavior == "Resting" |
+               behavior == "Walking")
> w <- subset(b, behavior == "Walking")
> r <- subset(b, behavior == "Resting")
```

Is the absolute frequency of behaviors a function of the habituation time?

```
> library(MuMIn)
> options(na.action = "na.fail")
> m1A <- glm(frequency~treatmentM + group + nestID + subject + caste + behavior,
+            family = "poisson",
+            data = b)
> mt1A <- m1A
> rAb <- dredge(mt1A, rank = "AICc", extra = "adjR^2")
> rAb

Global model call: glm(formula = frequency ~ treatmentM + group + nestID + subject
    caste + behavior, family = "poisson", data = b)
---
Model selection table
   (Intrc) behvr caste group nstID sbjct      trtmM    adjR^2  df    logLik
16   1.508     +     +     +     +                 0.5778000  17 -3216.284
48   1.517     +     +     +     +       -1.003e-04 0.5779000  18 -3216.176
8    1.530     +     +     +                       0.5690000  12 -3229.181
40   1.543     +     +     +             -1.574e-04 0.5692000  13 -3228.914
14   1.353     +           +     +                 0.5671000  16 -3232.012
46   1.364     +           +     +       -1.202e-04 0.5672000  17 -3231.857
6    1.373     +           +                       0.5579000  11 -3245.138
38   1.388     +           +             -1.798e-04 0.5581000  12 -3244.789
18   1.533     +                       +           0.7801000 339 -2809.021
20   1.533     +     +                 +           0.7801000 339 -2809.021
22   1.533     +           +           +           0.7801000 339 -2809.021
24   1.533     +     +     +           +           0.7801000 339 -2809.021
26   1.533     +                 +     +           0.7801000 339 -2809.021
28   1.533     +     +           +     +           0.7801000 339 -2809.021
30   1.533     +           +     +     +           0.7801000 339 -2809.021
32   1.533     +     +     +     +     +           0.7801000 339 -2809.021
```

50	1.533	+				+		0.7801000	339	-2809.021
52	1.533	+	+			+		0.7801000	339	-2809.021
54	1.533	+		+		+		0.7801000	339	-2809.021
56	1.533	+	+	+		+		0.7801000	339	-2809.021
58	1.533	+			+	+		0.7801000	339	-2809.021
60	1.533	+	+		+	+		0.7801000	339	-2809.021
62	1.533	+		+	+	+		0.7801000	339	-2809.021
64	1.533	+	+	+	+	+		0.7801000	339	-2809.021
12	1.540	+	+		+			0.4621000	16	-3367.955
44	1.554	+	+		+		-1.594e-04	0.4623000	17	-3367.683
4	1.541	+	+					0.4518000	11	-3379.762
36	1.560	+	+				-2.173e-04	0.4523000	12	-3379.252
10	1.375	+			+			0.4463000	15	-3386.030
42	1.390	+			+		-1.672e-04	0.4466000	16	-3385.731
2	1.373	+						0.4356000	10	-3398.077
34	1.393	+					-2.275e-04	0.4361000	11	-3397.519
15	1.775		+	+	+			0.3871000	8	-3449.710
47	1.774		+	+	+		1.090e-05	0.3871000	9	-3449.709
7	1.800		+	+				0.3752000	3	-3461.819
39	1.805		+	+			-4.665e-05	0.3752000	4	-3461.795
13	1.592			+	+			0.3650000	7	-3471.901
45	1.594			+	+		-1.399e-05	0.3650000	8	-3471.899
5	1.612			+				0.3522000	2	-3484.403
37	1.619			+			-7.717e-05	0.3523000	3	-3484.338
17	1.883					+		0.6698000	330	-3062.714
19	1.883		+			+		0.6698000	330	-3062.714
21	1.883			+		+		0.6698000	330	-3062.714
23	1.883		+	+		+		0.6698000	330	-3062.714
25	1.883				+	+		0.6698000	330	-3062.714

```
27   1.883           +           +     +            0.6698000 330 -3062.714
29   1.883                 +     +     +            0.6698000 330 -3062.714
31   1.883           +     +     +     +            0.6698000 330 -3062.714
49   1.883                             +            0.6698000 330 -3062.714
51   1.883           +                 +            0.6698000 330 -3062.714
53   1.883                 +           +            0.6698000 330 -3062.714
55   1.883           +     +           +            0.6698000 330 -3062.714
57   1.883                       +     +            0.6698000 330 -3062.714
59   1.883           +           +     +            0.6698000 330 -3062.714
61   1.883                 +     +     +            0.6698000 330 -3062.714
63   1.883           +     +     +     +            0.6698000 330 -3062.714
11   1.611           +           +                  0.0696400   7 -3711.566
43   1.612           +           +       -1.386e-05 0.0696400   8 -3711.564
3    1.607           +                              0.0539000   2 -3722.099
35   1.613           +                   -7.039e-05 0.0539800   3 -3722.045
9    1.380                       +                  0.0174600   6 -3745.822
41   1.382                       +       -1.931e-05 0.0174700   7 -3745.818
1    1.365                                          0.0000000   1 -3756.884
33   1.373                               -8.171e-05 0.0001151   2 -3756.811
     AICc   delta weight
16 6467.1    0.00  0.715
48 6468.9    1.84  0.285
8  6482.6   15.55  0.000
40 6484.1   17.06  0.000
14 6496.5   29.40  0.000
46 6498.2   31.15  0.000
6  6512.5   45.43  0.000
38 6513.8   46.77  0.000
18 6546.9   79.82  0.000
```

20	6546.9	79.82	0.000
22	6546.9	79.82	0.000
24	6546.9	79.82	0.000
26	6546.9	79.82	0.000
28	6546.9	79.82	0.000
30	6546.9	79.82	0.000
32	6546.9	79.82	0.000
50	6546.9	79.82	0.000
52	6546.9	79.82	0.000
54	6546.9	79.82	0.000
56	6546.9	79.82	0.000
58	6546.9	79.82	0.000
60	6546.9	79.82	0.000
62	6546.9	79.82	0.000
64	6546.9	79.82	0.000
12	6768.3	301.29	0.000
44	6769.9	302.80	0.000
4	6781.7	314.68	0.000
36	6782.8	315.69	0.000
10	6802.4	335.38	0.000
42	6803.9	336.84	0.000
2	6816.3	349.27	0.000
34	6817.3	350.19	0.000
15	6915.5	448.47	0.000
47	6917.6	450.50	0.000
7	6929.7	462.60	0.000
39	6931.6	464.56	0.000
13	6957.9	490.83	0.000
45	6959.9	492.85	0.000

```
5  6972.8  505.75  0.000
37 6974.7  507.63  0.000
17 7020.8  553.78  0.000
19 7020.8  553.78  0.000
21 7020.8  553.78  0.000
23 7020.8  553.78  0.000
25 7020.8  553.78  0.000
27 7020.8  553.78  0.000
29 7020.8  553.78  0.000
31 7020.8  553.78  0.000
49 7020.8  553.78  0.000
51 7020.8  553.78  0.000
53 7020.8  553.78  0.000
55 7020.8  553.78  0.000
57 7020.8  553.78  0.000
59 7020.8  553.78  0.000
61 7020.8  553.78  0.000
63 7020.8  553.78  0.000
11 7437.2  970.16  0.000
43 7439.2  972.18  0.000
3  7448.2  981.15  0.000
35 7450.1  983.05  0.000
9  7503.7 1036.65  0.000
41 7505.7 1038.66  0.000
1  7515.8 1048.71  0.000
33 7517.6 1050.57  0.000
Models ranked by AICc(x)
```

```
> plot(m1A,which=c(1,2))
> summary(m1A) #O modelo está superdispersso, corrigir com binomial negativa
```

```
Call:
glm(formula = frequency ~ treatmentM + group + nestID + subject +
    caste + behavior, family = "poisson", data = b)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-4.4601  -0.8369  -0.0392   0.4916   5.8612

Coefficients: (8 not defined because of singularities)
                                Estimate Std. Error z value Pr(>|z|)
(Intercept)                     1.533334   0.157870   9.713  < 2e-16 ***
treatmentM                     -0.008032   0.008413  -0.955  0.33971
groupInquiline                  0.123579   1.628352   0.076  0.93950
nestIDn02                      -0.364990   1.154962  -0.316  0.75199
nestIDn03                      -0.025329   0.677462  -0.037  0.97018
nestIDn04                       0.287682   0.763763   0.377  0.70642
nestIDn05                      -0.582549   1.155948  -0.504  0.61429
nestIDn06                       0.173131   0.667098   0.260  0.79523
subjectHostSoldier002          -0.053389   0.565847  -0.094  0.92483
subjectHostSoldier003           0.594968   1.041815   0.571  0.56794
subjectHostSoldier004           1.553159   1.529456   1.015  0.30987
subjectHostSoldier005           0.615573   1.175849   0.524  0.60062
subjectHostSoldier006           1.318309   1.275698   1.033  0.30142
subjectHostSoldier007           1.236583   1.553442   0.796  0.42602
subjectHostSoldier008           2.331590   1.915577   1.217  0.22354
subjectHostSoldier009           0.355062   0.703252   0.505  0.61364
subjectHostSoldier010           0.685485   0.869532   0.788  0.43050
subjectHostSoldier011          -0.141255   1.282498  -0.110  0.91230
subjectHostSoldier012           1.260373   1.676433   0.752  0.45216
```

subjectHostSoldier013	-0.212613	0.791768	-0.269	0.78829	
subjectHostSoldier014	-0.042578	0.944614	-0.045	0.96405	
subjectHostSoldier015	-0.658838	1.329496	-0.496	0.62021	
subjectHostSoldier016	1.259736	1.709920	0.737	0.46129	
subjectHostSoldier017	0.641743	1.184390	0.542	0.58793	
subjectHostSoldier018	1.182740	1.281059	0.923	0.35588	
subjectHostSoldier019	1.684602	1.549824	1.087	0.27705	
subjectHostSoldier020	1.912819	1.919869	0.996	0.31909	
subjectHostSoldier021	0.007879	0.696804	0.011	0.99098	
subjectHostSoldier022	0.051707	0.987636	0.052	0.95825	
subjectHostSoldier023	0.949125	1.397429	0.679	0.49702	
subjectHostSoldier024	0.995402	1.866280	0.533	0.59378	
subjectHostWorker001	-0.029423	0.215172	-0.137	0.89123	
subjectHostWorker002	0.191565	0.205050	0.934	0.35018	
subjectHostWorker003	-0.735989	0.259384	-2.837	0.00455	**
subjectHostWorker004	-0.297639	0.224803	-1.324	0.18550	
subjectHostWorker005	-0.552544	0.726748	-0.760	0.44708	
subjectHostWorker006	-0.532521	0.648311	-0.821	0.41142	
subjectHostWorker007	0.186144	0.556093	0.335	0.73783	
subjectHostWorker008	-0.329401	0.691493	-0.476	0.63382	
subjectHostWorker009	0.638487	1.036849	0.616	0.53803	
subjectHostWorker010	0.934752	1.032576	0.905	0.36533	
subjectHostWorker011	0.736927	1.035289	0.712	0.47658	
subjectHostWorker012	0.412576	1.038447	0.397	0.69115	
subjectHostWorker013	1.385596	1.529305	0.906	0.36492	
subjectHostWorker014	0.875163	1.534000	0.571	0.56833	
subjectHostWorker015	0.901293	1.535049	0.587	0.55711	
subjectHostWorker016	0.563422	1.540608	0.366	0.71458	
subjectHostWorker017	0.064320	1.176867	0.055	0.95641	

subjectHostWorker018	-0.133571	1.178574	-0.113	0.90977
subjectHostWorker019	0.651748	1.171671	0.556	0.57804
subjectHostWorker020	-1.539688	1.535389	-1.003	0.31596
subjectHostWorker021	0.019929	1.289703	0.015	0.98767
subjectHostWorker022	-0.014423	1.301530	-0.011	0.99116
subjectHostWorker023	-0.365611	1.333109	-0.274	0.78389
subjectHostWorker024	0.936119	1.276348	0.733	0.46329
subjectHostWorker025	0.657304	1.558825	0.422	0.67327
subjectHostWorker026	0.564532	1.555124	0.363	0.71659
subjectHostWorker027	1.017299	1.553720	0.655	0.51263
subjectHostWorker028	0.520080	1.555759	0.334	0.73816
subjectHostWorker029	1.286304	1.919786	0.670	0.50284
subjectHostWorker030	1.081536	1.922488	0.563	0.57373
subjectHostWorker031	0.020527	1.995861	0.010	0.99179
subjectHostWorker032	1.812309	1.915937	0.946	0.34419
subjectHostWorker033	-0.348069	0.714236	-0.487	0.62602
subjectHostWorker034	-0.676350	0.762247	-0.887	0.37491
subjectHostWorker035	-0.263512	0.712565	-0.370	0.71153
subjectHostWorker036	-1.036376	0.769603	-1.347	0.17810
subjectHostWorker037	0.164994	0.876294	0.188	0.85065
subjectHostWorker038	-0.521426	0.893698	-0.583	0.55959
subjectHostWorker039	-0.202972	0.884110	-0.230	0.81842
subjectHostWorker040	0.312611	0.877208	0.356	0.72156
subjectHostWorker041	-0.046936	1.274886	-0.037	0.97063
subjectHostWorker042	1.239993	1.233183	1.006	0.31465
subjectHostWorker043	0.644580	1.238473	0.520	0.60274
subjectHostWorker044	0.955545	1.235366	0.773	0.43923
subjectHostWorker045	1.234840	1.673715	0.738	0.46065
subjectHostWorker046	1.185689	1.678778	0.706	0.48001

subjectHostWorker047	1.368915	1.675977	0.817	0.41405
subjectHostWorker048	1.168241	1.676759	0.697	0.48597
subjectHostWorker049	-0.856009	0.846565	-1.011	0.31194
subjectHostWorker050	-0.874208	0.807976	-1.082	0.27927
subjectHostWorker051	-0.994848	0.822611	-1.209	0.22652
subjectHostWorker052	-0.309289	0.799087	-0.387	0.69872
subjectHostWorker053	-0.239689	0.947287	-0.253	0.80025
subjectHostWorker054	-0.051677	0.942595	-0.055	0.95628
subjectHostWorker055	0.351739	0.941047	0.374	0.70857
subjectHostWorker056	-0.318789	0.958528	-0.333	0.73945
subjectHostWorker057	-0.279196	1.294928	-0.216	0.82929
subjectHostWorker058	0.163178	1.287203	0.127	0.89912
subjectHostWorker059	0.302726	1.285931	0.235	0.81389
subjectHostWorker060	0.457132	1.286254	0.355	0.72229
subjectHostWorker061	0.924666	1.709706	0.541	0.58862
subjectHostWorker062	0.886940	1.713296	0.518	0.60468
subjectHostWorker063	1.254145	1.707703	0.734	0.46270
subjectHostWorker064	0.784040	1.712159	0.458	0.64701
subjectHostWorker065	0.582923	1.183694	0.492	0.62239
subjectHostWorker066	0.280848	1.185594	0.237	0.81275
subjectHostWorker067	-0.514476	1.234810	-0.417	0.67694
subjectHostWorker068	0.589265	1.178697	0.500	0.61712
subjectHostWorker069	1.041605	1.307247	0.797	0.42557
subjectHostWorker070	0.301342	1.314413	0.229	0.81867
subjectHostWorker071	0.557734	1.286931	0.433	0.66474
subjectHostWorker072	1.220889	1.278178	0.955	0.33949
subjectHostWorker073	1.237008	1.551572	0.797	0.42530
subjectHostWorker074	1.693766	1.548460	1.094	0.27403
subjectHostWorker075	1.172956	1.552424	0.756	0.44991

subjectHostWorker076	1.453258	1.550107	0.938	0.34849
subjectHostWorker077	1.370508	1.938924	0.707	0.47967
subjectHostWorker078	1.246984	1.932075	0.645	0.51866
subjectHostWorker079	1.659699	1.926769	0.861	0.38902
subjectHostWorker080	1.783135	1.919363	0.929	0.35288
subjectHostWorker081	0.054324	0.694414	0.078	0.93765
subjectHostWorker082	-0.743676	0.710788	-1.046	0.29544
subjectHostWorker083	-0.194738	0.707429	-0.275	0.78310
subjectHostWorker084	-0.183747	0.699672	-0.263	0.79284
subjectHostWorker085	-0.240016	0.997616	-0.241	0.80987
subjectHostWorker086	0.211987	0.983012	0.216	0.82926
subjectHostWorker087	0.124884	0.985811	0.127	0.89919
subjectHostWorker088	0.465209	0.981849	0.474	0.63564
subjectHostWorker089	0.428787	1.405615	0.305	0.76033
subjectHostWorker090	0.328073	1.402869	0.234	0.81509
subjectHostWorker091	0.898249	1.396615	0.643	0.52012
subjectHostWorker092	0.684748	1.399045	0.489	0.62453
subjectHostWorker093	0.837875	1.882288	0.445	0.65622
subjectHostWorker094	1.307975	1.866057	0.701	0.48335
subjectHostWorker095	1.318278	1.858116	0.709	0.47803
subjectHostWorker096	0.819718	1.864653	0.440	0.66022
subjectInquilineSoldier001	-0.709828	1.654807	-0.429	0.66796
subjectInquilineSoldier002	-1.408171	1.533892	-0.918	0.35860
subjectInquilineSoldier003	0.754875	0.794387	0.950	0.34198
subjectInquilineSoldier004	0.087330	0.690465	0.126	0.89935
subjectInquilineSoldier005	-0.888978	1.854439	-0.479	0.63167
subjectInquilineSoldier006	-1.066858	1.534462	-0.695	0.48689
subjectInquilineSoldier007	-0.116913	1.260416	-0.093	0.92610
subjectInquilineSoldier008	0.420338	1.061177	0.396	0.69203

subjectInquilineSoldier009	-1.420380	1.658291	-0.857	0.39170
subjectInquilineSoldier010	-1.130741	1.214672	-0.931	0.35190
subjectInquilineSoldier011	-0.458197	0.739742	-0.619	0.53565
subjectInquilineSoldier012	0.198460	0.485987	0.408	0.68301
subjectInquilineSoldier013	-1.445708	1.671214	-0.865	0.38700
subjectInquilineSoldier014	-1.017609	1.181736	-0.861	0.38918
subjectInquilineSoldier015	-0.491093	0.778688	-0.631	0.52826
subjectInquilineSoldier016	0.448248	0.591948	0.757	0.44890
subjectInquilineSoldier017	-0.532744	1.859507	-0.286	0.77450
subjectInquilineSoldier018	0.129569	1.489451	0.087	0.93068
subjectInquilineSoldier019	-0.343720	1.502155	-0.229	0.81901
subjectInquilineSoldier020	0.350215	1.080807	0.324	0.74591
subjectInquilineSoldier021	-1.427099	1.371023	-1.041	0.29792
subjectInquilineSoldier022	-0.858445	0.886430	-0.968	0.33283
subjectInquilineSoldier023	-0.144208	0.585859	-0.246	0.80557
subjectInquilineSoldier024	0.403965	0.441385	0.915	0.36008
subjectInquilineWorker001	-1.851173	1.768132	-1.047	0.29512
subjectInquilineWorker002	-1.890074	1.904372	-0.992	0.32096
subjectInquilineWorker004	0.094737	1.642473	0.058	0.95400
subjectInquilineWorker005	-0.347096	1.654509	-0.210	0.83383
subjectInquilineWorker006	-0.146425	1.648393	-0.089	0.92922
subjectInquilineWorker007	-0.410919	1.651670	-0.249	0.80352
subjectInquilineWorker008	-1.810698	1.904490	-0.951	0.34173
subjectInquilineWorker009	0.253305	1.198918	0.211	0.83267
subjectInquilineWorker010	-0.116508	1.222817	-0.095	0.92409
subjectInquilineWorker011	-0.452980	1.245964	-0.364	0.71619
subjectInquilineWorker012	0.213908	1.193578	0.179	0.85777
subjectInquilineWorker013	-1.369271	1.361038	-1.006	0.31439
subjectInquilineWorker014	-0.285691	1.223490	-0.234	0.81537

subjectInquilineWorker015	-0.963806	1.298368	-0.742	0.45789
subjectInquilineWorker016	-0.116508	1.222817	-0.095	0.92409
subjectInquilineWorker017	-0.194221	0.915481	-0.212	0.83199
subjectInquilineWorker018	-0.887368	1.043123	-0.851	0.39495
subjectInquilineWorker019	-0.926268	1.260382	-0.735	0.46239
subjectInquilineWorker020	0.329743	0.845382	0.390	0.69650
subjectInquilineWorker021	0.498926	0.844456	0.591	0.55464
subjectInquilineWorker022	0.904392	0.819414	1.104	0.26972
subjectInquilineWorker023	-0.714237	0.869686	-0.821	0.41150
subjectInquilineWorker024	0.211244	0.868777	0.243	0.80789
subjectInquilineWorker028	-0.444365	1.154924	-0.385	0.70042
subjectInquilineWorker029	0.510826	0.730297	0.699	0.48425
subjectInquilineWorker030	0.847298	0.690066	1.228	0.21950
subjectInquilineWorker031	0.191740	0.690398	0.278	0.78122
subjectInquilineWorker032	NA	NA	NA	NA
subjectInquilineWorker034	-1.525084	2.072397	-0.736	0.46179
subjectInquilineWorker035	-1.486183	1.947658	-0.763	0.44543
subjectInquilineWorker036	-1.525084	2.072397	-0.736	0.46179
subjectInquilineWorker037	-1.025370	1.849834	-0.554	0.57937
subjectInquilineWorker038	-1.486183	1.947658	-0.763	0.44543
subjectInquilineWorker039	-1.037935	1.869679	-0.555	0.57880
subjectInquilineWorker040	-1.525084	2.072397	-0.736	0.46179
subjectInquilineWorker041	0.094332	1.478593	0.064	0.94913
subjectInquilineWorker042	-1.004281	1.587316	-0.633	0.52694
subjectInquilineWorker043	-1.043181	1.738127	-0.600	0.54839
subjectInquilineWorker044	-1.043181	1.738127	-0.600	0.54839
subjectInquilineWorker045	-1.078490	1.588081	-0.679	0.49707
subjectInquilineWorker046	-1.043181	1.738127	-0.600	0.54839
subjectInquilineWorker047	1.192944	1.440530	0.828	0.40760

subjectInquilineWorker048	-0.114249	1.470768	-0.078	0.93808
subjectInquilineWorker049	-0.561278	1.502294	-0.374	0.70869
subjectInquilineWorker050	0.801339	1.157437	0.692	0.48872
subjectInquilineWorker051	0.730385	1.182443	0.618	0.53678
subjectInquilineWorker052	0.170769	1.226912	0.139	0.88930
subjectInquilineWorker053	0.576234	1.192468	0.483	0.62893
subjectInquilineWorker054	0.170769	1.226912	0.139	0.88930
subjectInquilineWorker055	-0.522378	1.324883	-0.394	0.69337
subjectInquilineWorker056	-0.561278	1.502294	-0.374	0.70869
subjectInquilineWorker057	1.345819	1.060945	1.269	0.20462
subjectInquilineWorker058	1.463602	1.054379	1.388	0.16510
subjectInquilineWorker059	0.652672	1.118304	0.584	0.55947
subjectInquilineWorker060	1.058137	1.080403	0.979	0.32739
subjectInquilineWorker061	0.364990	1.154962	0.316	0.75199
subjectInquilineWorker062	0.652672	1.118304	0.584	0.55947
subjectInquilineWorker063	-0.079375	1.415003	-0.056	0.95527
subjectInquilineWorker064	NA	NA	NA	NA
subjectInquilineWorker065	-1.936222	1.708579	-1.133	0.25712
subjectInquilineWorker066	-1.864745	1.848516	-1.009	0.31308
subjectInquilineWorker067	-1.825845	1.707804	-1.069	0.28502
subjectInquilineWorker068	-1.633013	1.632706	-1.000	0.31722
subjectInquilineWorker069	-0.579139	1.586590	-0.365	0.71510
subjectInquilineWorker070	-0.483828	1.583722	-0.306	0.75998
subjectInquilineWorker071	-1.825845	1.707804	-1.069	0.28502
subjectInquilineWorker072	-1.825845	1.707804	-1.069	0.28502
subjectInquilineWorker073	-0.608061	1.144779	-0.531	0.59531
subjectInquilineWorker074	-1.406519	1.215614	-1.157	0.24725
subjectInquilineWorker075	-1.301209	1.215395	-1.071	0.28435
subjectInquilineWorker076	0.101653	1.101913	0.092	0.92650

subjectInquilineWorker077	-1.343942	1.281948	-1.048	0.29447
subjectInquilineWorker078	-0.938477	1.215205	-0.772	0.43995
subjectInquilineWorker079	-0.938477	1.215205	-0.772	0.43995
subjectInquilineWorker080	-0.761172	1.181154	-0.644	0.51930
subjectInquilineWorker081	0.236573	0.739188	0.320	0.74893
subjectInquilineWorker082	-0.001431	0.672038	-0.002	0.99830
subjectInquilineWorker083	-0.103318	0.686020	-0.151	0.88029
subjectInquilineWorker084	-0.138012	0.760947	-0.181	0.85608
subjectInquilineWorker085	-0.924617	0.844632	-1.095	0.27365
subjectInquilineWorker086	-0.283443	0.700929	-0.404	0.68593
subjectInquilineWorker087	-0.456574	0.844432	-0.541	0.58872
subjectInquilineWorker088	-0.131303	0.710698	-0.185	0.85342
subjectInquilineWorker089	0.614551	0.465040	1.322	0.18633
subjectInquilineWorker090	0.025329	0.677462	0.037	0.97018
subjectInquilineWorker091	-0.419037	1.061232	-0.395	0.69295
subjectInquilineWorker092	0.515414	0.464934	1.109	0.26761
subjectInquilineWorker093	-0.085048	0.677397	-0.126	0.90009
subjectInquilineWorker094	0.296097	0.500353	0.592	0.55400
subjectInquilineWorker095	0.250433	0.540342	0.463	0.64303
subjectInquilineWorker096	NA	NA	NA	NA
subjectInquilineWorker097	-2.138856	1.744407	-1.226	0.22015
subjectInquilineWorker098	-2.138856	1.744407	-1.226	0.22015
subjectInquilineWorker099	-2.388948	1.696783	-1.408	0.15915
subjectInquilineWorker100	-2.138856	1.744407	-1.226	0.22015
subjectInquilineWorker101	-2.138856	1.744407	-1.226	0.22015
subjectInquilineWorker102	-2.138856	1.744407	-1.226	0.22015
subjectInquilineWorker103	-2.096122	1.696253	-1.236	0.21656
subjectInquilineWorker104	-1.445708	1.671214	-0.865	0.38700
subjectInquilineWorker105	-1.656953	1.330072	-1.246	0.21285

subjectInquilineWorker106	-0.270658	1.180717	-0.229	0.81869
subjectInquilineWorker107	-0.963806	1.232515	-0.782	0.43422
subjectInquilineWorker108	-0.270658	1.180717	-0.229	0.81869
subjectInquilineWorker109	-1.208705	1.212768	-0.997	0.31893
subjectInquilineWorker110	-1.656953	1.330072	-1.246	0.21285
subjectInquilineWorker111	-1.656953	1.330072	-1.246	0.21285
subjectInquilineWorker112	-0.963806	1.232515	-0.782	0.43422
subjectInquilineWorker113	0.116394	0.767052	0.152	0.87939
subjectInquilineWorker114	0.205048	0.751335	0.273	0.78492
subjectInquilineWorker115	-0.544480	0.820060	-0.664	0.50672
subjectInquilineWorker116	-1.213950	1.226878	-0.989	0.32244
subjectInquilineWorker117	-0.481903	0.868777	-0.555	0.57911
subjectInquilineWorker118	-0.769585	0.915481	-0.841	0.40055
subjectInquilineWorker119	0.341816	0.741505	0.461	0.64482
subjectInquilineWorker120	1.127535	0.744831	1.514	0.13007
subjectInquilineWorker121	-0.287682	0.763763	-0.377	0.70642
subjectInquilineWorker122	0.086120	0.584366	0.147	0.88284
subjectInquilineWorker123	0.693147	0.612372	1.132	0.25767
subjectInquilineWorker125	0.710612	0.572124	1.242	0.21421
subjectInquilineWorker126	0.559616	0.626783	0.893	0.37194
subjectInquilineWorker127	0.916291	0.591608	1.549	0.12143
subjectInquilineWorker128	NA	NA	NA	NA
subjectInquilineWorker129	-0.710575	1.844606	-0.385	0.70008
subjectInquilineWorker130	-0.863160	1.903656	-0.453	0.65024
subjectInquilineWorker131	-1.095494	1.859799	-0.589	0.55584
subjectInquilineWorker132	-1.268625	1.946940	-0.652	0.51466
subjectInquilineWorker133	-1.307525	2.071480	-0.631	0.52791
subjectInquilineWorker134	-0.127279	1.844508	-0.069	0.94499
subjectInquilineWorker135	-0.489358	1.839320	-0.266	0.79020

subjectInquilineWorker136	-0.245062	1.848269	-0.133	0.89452
subjectInquilineWorker137	0.910187	1.439950	0.632	0.52732
subjectInquilineWorker138	-0.381257	1.533557	-0.249	0.80366
subjectInquilineWorker139	1.005037	1.449758	0.693	0.48816
subjectInquilineWorker140	-0.463126	1.489057	-0.311	0.75579
subjectInquilineWorker141	-0.381257	1.533557	-0.249	0.80366
subjectInquilineWorker142	-0.561617	1.505996	-0.373	0.70921
subjectInquilineWorker143	0.853029	1.441084	0.592	0.55389
subjectInquilineWorker144	-0.491634	1.533460	-0.321	0.74851
subjectInquilineWorker145	1.242552	1.146026	1.084	0.27826
subjectInquilineWorker146	0.325750	1.192255	0.273	0.78468
subjectInquilineWorker147	-0.367397	1.260213	-0.292	0.77064
subjectInquilineWorker148	0.894246	1.156670	0.773	0.43945
subjectInquilineWorker149	0.419207	1.206418	0.347	0.72823
subjectInquilineWorker150	0.025596	1.227192	0.021	0.98336
subjectInquilineWorker151	0.419207	1.206418	0.347	0.72823
subjectInquilineWorker152	-0.304819	1.325104	-0.230	0.81807
subjectInquilineWorker153	1.371114	1.062087	1.291	0.19672
subjectInquilineWorker154	1.391668	1.029709	1.352	0.17653
subjectInquilineWorker155	0.870231	1.119323	0.777	0.43689
subjectInquilineWorker156	0.390285	1.156012	0.338	0.73565
subjectInquilineWorker157	0.870231	1.119323	0.777	0.43689
subjectInquilineWorker158	0.870231	1.119323	0.777	0.43689
subjectInquilineWorker159	0.114506	1.155190	0.099	0.92104
subjectInquilineWorker160	NA	NA	NA	NA
subjectInquilineWorker161	-1.618839	1.438155	-1.126	0.26032
subjectInquilineWorker162	-0.771542	1.370334	-0.563	0.57341
subjectInquilineWorker163	-1.618839	1.438155	-1.126	0.26032
subjectInquilineWorker164	-1.084552	1.344569	-0.807	0.41989

subjectInquilineWorker165	-2.086882	1.438722	-1.451	0.14692	
subjectInquilineWorker166	-0.076502	1.338731	-0.057	0.95443	
subjectInquilineWorker167	-1.300278	1.390460	-0.935	0.34971	
subjectInquilineWorker168	-1.007561	1.354719	-0.744	0.45703	
subjectInquilineWorker169	-0.652371	0.909755	-0.717	0.47332	
subjectInquilineWorker170	-1.581302	1.297997	-1.218	0.22312	
subjectInquilineWorker171	-1.241409	0.900412	-1.379	0.16798	
subjectInquilineWorker172	-1.136937	1.008788	-1.127	0.25973	
subjectInquilineWorker173	-1.581302	1.297997	-1.218	0.22312	
subjectInquilineWorker174	-0.596081	0.873316	-0.683	0.49489	
subjectInquilineWorker175	-0.916075	0.899833	-1.018	0.30865	
subjectInquilineWorker176	-0.849255	0.966603	-0.879	0.37962	
subjectInquilineWorker177	0.548939	0.493184	1.113	0.26569	
subjectInquilineWorker178	1.018943	0.453575	2.246	0.02467	*
subjectInquilineWorker179	0.454089	0.458034	0.991	0.32150	
subjectInquilineWorker180	-0.655034	0.690336	-0.949	0.34269	
subjectInquilineWorker181	-0.481903	0.504750	-0.955	0.33971	
subjectInquilineWorker182	0.028923	0.458616	0.063	0.94971	
subjectInquilineWorker183	0.548939	0.493184	1.113	0.26569	
subjectInquilineWorker184	NA	NA	NA	NA	
subjectInquilineWorker185	-0.617496	1.054645	-0.586	0.55821	
subjectInquilineWorker186	0.968264	0.421918	2.295	0.02174	*
subjectInquilineWorker187	0.733217	0.472257	1.553	0.12052	
subjectInquilineWorker188	-0.617496	1.054645	-0.586	0.55821	
subjectInquilineWorker189	1.126152	0.450105	2.502	0.01235	*
subjectInquilineWorker190	-0.617496	1.054645	-0.586	0.55821	
subjectInquilineWorker191	0.933888	0.450361	2.074	0.03811	*
subjectInquilineWorker192	NA	NA	NA	NA	
casteW	NA	NA	NA	NA	

```
behaviorAntennatingNonNestmate -0.312353   0.098125  -3.183  0.00146 **
behaviorAntennatingWall         0.552366   0.071974   7.675 1.66e-14 ***
behaviorAttack                  0.810761   0.068658  11.809  < 2e-16 ***
behaviorBiting                  0.371344   0.076127   4.878 1.07e-06 ***
behaviorIgnoring                0.060158   0.081096   0.742  0.45820
behaviorPassing                -0.803579   0.254080  -3.163  0.00156 **
behaviorResting                 0.233161   0.072627   3.210  0.00133 **
behaviorReversing              -0.663806   0.124007  -5.353 8.65e-08 ***
behaviorWalking                 0.153786   0.071125   2.162  0.03060 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 3851.6  on 1258  degrees of freedom
Residual deviance: 1955.9  on  920  degrees of freedom
AIC: 6296

Number of Fisher Scoring iterations: 5
```

```
> library(MASS)
> m2A <- glm.nb(frequency~treatmentM + group + nestID + subject+ caste + behavior,
+            data = b)
> anova(m2A, test = "Chisq")
```

```
Analysis of Deviance Table

Model: Negative Binomial(5.8187), link: log

Response: frequency
```

```
Terms added sequentially (first to last)


           Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
NULL                         1258     2105.1
treatmentM   1     0.09      1257     2105.1   0.76926
group        1   333.56      1256     1771.5 < 2.2e-16 ***
nestID       5    14.98      1251     1756.5   0.01043 *
subject    322   497.44       929     1259.1 1.154e-09 ***
caste        0     0.00       929     1259.1
behavior     9   238.04       920     1021.0 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> mt2A <- m2A
> rAb2 <- dredge(mt2A, rank = "AICc", extra = "adjR^2")
> rAb2

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + subje
    caste + behavior, data = b, init.theta = 5.818740868, link = log)
---
Model selection table
   (Intrc) behvr caste group nstID sbjct      trtmM    adjR^2 df    logLik
16   1.441     +     +     +     +                  2.712e-01  18 -2843.940
14   1.361     +           +     +                  2.696e-01  17 -2845.299
48   1.441     +     +     +     +       -4.728e-06 2.712e-01  19 -2843.940
46   1.362     +           +     +       -1.824e-05 2.696e-01  18 -2845.298
8    1.452     +     +     +                        2.631e-01  13 -2850.861
6    1.373     +           +                        2.615e-01  12 -2852.182
40   1.457     +     +     +             -7.021e-05 2.631e-01  14 -2850.838
38   1.379     +           +             -8.381e-05 2.616e-01  13 -2852.150
```

12	1.462	+	+		+			1.978e-01	17	-2903.789
10	1.361	+			+			1.952e-01	16	-2905.755
44	1.470	+	+		+		-1.076e-04	1.978e-01	18	-2903.739
4	1.473	+	+					1.893e-01	12	-2910.304
42	1.371	+			+		-1.262e-04	1.953e-01	17	-2905.687
36	1.486	+	+				-1.661e-04	1.895e-01	13	-2910.185
2	1.373	+						1.868e-01	11	-2912.232
34	1.388	+					-1.846e-04	1.870e-01	12	-2912.085
15	1.778		+	+	+			1.696e-01	9	-2925.251
7	1.774		+	+				1.625e-01	4	-2930.592
47	1.765		+	+	+		1.673e-04	1.698e-01	10	-2925.133
39	1.765		+	+			1.012e-04	1.626e-01	5	-2930.549
13	1.617			+	+			1.610e-01	8	-2931.737
5	1.612			+				1.541e-01	3	-2936.836
45	1.605			+	+		1.347e-04	1.611e-01	9	-2931.661
37	1.605			+			6.940e-05	1.541e-01	4	-2936.816
3	1.607		+					1.830e-02	3	-3029.722
35	1.608		+				-2.133e-05	1.830e-02	4	-3029.720
11	1.619		+		+			2.459e-02	8	-3025.706
43	1.615		+		+		4.429e-05	2.460e-02	9	-3025.699
1	1.365							0.000e+00	2	-3041.254
33	1.373						-8.124e-05	3.943e-05	3	-3041.230
9	1.380				+			6.024e-03	7	-3037.482
41	1.381				+		-1.685e-05	6.025e-03	8	-3037.480
22	1.425	+		+		+		4.803e-01	340	-2633.812
54	1.425	+		+		+		4.803e-01	340	-2633.812
26	1.425	+			+	+		4.803e-01	340	-2633.812
58	1.425	+			+	+		4.803e-01	340	-2633.812
20	1.425	+	+			+		4.803e-01	340	-2633.812

30	1.425	+		+	+	+	4.803e-01	340	-2633.812
52	1.425	+	+			+	4.803e-01	340	-2633.812
62	1.425	+		+	+	+	4.803e-01	340	-2633.812
32	1.425	+	+	+	+	+	4.803e-01	340	-2633.812
64	1.425	+	+	+	+	+	4.803e-01	340	-2633.812
18	1.425	+				+	4.803e-01	340	-2633.812
28	1.425	+	+		+	+	4.803e-01	340	-2633.812
50	1.425	+				+	4.803e-01	340	-2633.812
60	1.425	+	+		+	+	4.803e-01	340	-2633.812
24	1.425	+	+	+		+	4.803e-01	340	-2633.812
56	1.425	+	+	+		+	4.803e-01	340	-2633.812
17	1.883					+	3.821e-01	331	-2741.323
19	1.883		+			+	3.821e-01	331	-2741.323
29	1.883			+	+	+	3.821e-01	331	-2741.323
49	1.883					+	3.821e-01	331	-2741.323
51	1.883		+			+	3.821e-01	331	-2741.323
61	1.883			+	+	+	3.821e-01	331	-2741.323
21	1.883			+		+	3.821e-01	331	-2741.323
23	1.883		+	+		+	3.821e-01	331	-2741.323
27	1.883		+		+	+	3.821e-01	331	-2741.323
53	1.883			+		+	3.821e-01	331	-2741.323
55	1.883		+	+		+	3.821e-01	331	-2741.323
59	1.883		+		+	+	3.821e-01	331	-2741.323
25	1.883				+	+	3.821e-01	331	-2741.323
31	1.883		+	+	+	+	3.821e-01	331	-2741.323
57	1.883				+	+	3.821e-01	331	-2741.323
63	1.883		+	+	+	+	3.821e-01	331	-2741.323

	AICc	delta	weight
16	5724.4	0.00	0.366

14	5725.1	0.66	0.263
48	5726.5	2.06	0.131
46	5727.1	2.72	0.094
8	5728.0	3.58	0.061
6	5728.6	4.18	0.045
40	5730.0	5.58	0.022
38	5730.6	6.16	0.017
12	5842.1	117.64	0.000
10	5843.9	119.52	0.000
44	5844.0	119.60	0.000
4	5844.9	120.43	0.000
42	5845.9	121.44	0.000
36	5846.7	122.23	0.000
2	5846.7	122.24	0.000
34	5848.4	123.99	0.000
15	5868.6	144.21	0.000
7	5869.2	144.78	0.000
47	5870.4	146.01	0.000
39	5871.1	146.71	0.000
13	5879.6	155.16	0.000
5	5879.7	155.26	0.000
45	5881.5	157.04	0.000
37	5881.7	157.23	0.000
3	6065.5	341.03	0.000
35	6067.5	343.04	0.000
11	6067.5	343.10	0.000
43	6069.5	345.11	0.000
1	6086.5	362.09	0.000
33	6088.5	364.05	0.000

9	6089.1	364.62	0.000
41	6091.1	366.64	0.000
22	6200.2	475.79	0.000
54	6200.2	475.79	0.000
26	6200.2	475.79	0.000
58	6200.2	475.79	0.000
20	6200.2	475.79	0.000
30	6200.2	475.79	0.000
52	6200.2	475.79	0.000
62	6200.2	475.79	0.000
32	6200.2	475.79	0.000
64	6200.2	475.79	0.000
18	6200.2	475.79	0.000
28	6200.2	475.79	0.000
50	6200.2	475.79	0.000
60	6200.2	475.79	0.000
24	6200.2	475.79	0.000
56	6200.2	475.79	0.000
17	6381.7	657.31	0.000
19	6381.7	657.31	0.000
29	6381.7	657.31	0.000
49	6381.7	657.31	0.000
51	6381.7	657.31	0.000
61	6381.7	657.31	0.000
21	6381.7	657.31	0.000
23	6381.7	657.31	0.000
27	6381.7	657.31	0.000
53	6381.7	657.31	0.000
55	6381.7	657.31	0.000

```
59 6381.7 657.31  0.000
25 6381.7 657.31  0.000
31 6381.7 657.31  0.000
57 6381.7 657.31  0.000
63 6381.7 657.31  0.000
Models ranked by AICc(x)
```

```
> plot(m2A, which = c(1,2))
```

There is no a pattern of the absolute frequency of behaviours as a function of the habituation time.

Is the absolute frequency of non-aggressive behaviours a function of the habituation time?

```
> library(MuMIn)
> options(na.action = "na.fail")
> m1pA <- glm(frequency~treatmentM + group + nestID + caste + behavior,
+           family = "poisson",
+           data = pf)
> mt1pA <- m1pA
> r1BinpA <- dredge(mt1pA, rank = "AICc", extra = "adjR^2")
> r1BinpA
```

```
Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste +
    behavior, family = "poisson", data = pf)
---
Model selection table
   (Intrc) behvr caste group nstID      trtmM  adjR^2 df   logLik   AICc  delta
32   1.230     +     +     +     + -0.0011680 0.46730 12 -454.099  933.7   0.00
30   1.110     +           +     + -0.0012170 0.46110 11 -455.394  934.0   0.36
16   1.151     +     +     +     +            0.45860 11 -455.902  935.0   1.37
14   1.023     +           +     +            0.45150 10 -457.343  935.7   2.04
```

22	1.187	+		+		-0.0013950	0.41390	6	-464.713	941.8	8.15
24	1.273	+	+	+		-0.0013550	0.41740	7	-464.051	942.6	8.95
6	1.069	+		+			0.39950	5	-467.411	945.1	11.43
8	1.169	+	+	+			0.40390	6	-466.592	945.6	11.90
31	1.395		+	+	+	-0.0012280	0.36050	9	-474.418	967.7	34.00
12	1.267	+	+		+		0.36180	10	-474.188	969.4	35.74
15	1.310		+	+	+		0.34890	8	-476.423	969.5	35.85
28	1.331	+	+		+	-0.0008627	0.36760	11	-473.182	969.6	35.93
29	1.244			+	+	-0.0012670	0.34650	8	-476.821	970.3	36.64
13	1.155			+	+		0.33400	7	-478.940	972.4	38.73
26	1.165	+			+	-0.0009079	0.35150	10	-475.971	973.0	39.30
10	1.096	+			+		0.34500	9	-477.078	973.0	39.33
23	1.460		+	+		-0.0013230	0.29370	4	-485.483	979.1	45.48
21	1.343			+		-0.0013590	0.28510	3	-486.826	979.8	46.10
7	1.350		+	+			0.27780	3	-487.958	982.0	48.36
5	1.224			+			0.26820	2	-489.439	982.9	49.27
20	1.304	+	+			-0.0009811	0.27860	6	-487.834	988.1	54.39
4	1.225	+	+				0.27000	5	-489.165	988.6	54.94
18	1.156	+				-0.0010240	0.26620	5	-489.745	989.8	56.10
2	1.069	+					0.25660	4	-491.190	990.6	56.90
27	1.302		+		+	-0.0011080	0.18460	8	-501.506	1019.7	86.01
11	1.222		+		+		0.17240	7	-503.169	1020.9	87.19
25	1.101				+	-0.0011390	0.15200	7	-505.882	1026.3	92.61
9	1.021				+		0.13870	6	-507.623	1027.6	93.96
19	1.324		+			-0.0011510	0.04133	3	-519.599	1045.3	111.64
3	1.226		+				0.02529	2	-521.455	1047.0	113.30
17	1.149					-0.0011730	0.01702	2	-522.401	1048.9	115.19
1	1.047						0.00000	1	-524.322	1050.7	117.00

weight

32	0.366
30	0.306
16	0.184
14	0.132
22	0.006
24	0.004
6	0.001
8	0.001
31	0.000
12	0.000
15	0.000
28	0.000
29	0.000
13	0.000
26	0.000
10	0.000
23	0.000
21	0.000
7	0.000
5	0.000
20	0.000
4	0.000
18	0.000
2	0.000
27	0.000
11	0.000
25	0.000
9	0.000
19	0.000

```
3   0.000
17  0.000
1   0.000
Models ranked by AICc(x)
```

> r1BinpA[r1BinpA$delta<=2]

```
Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste +
    behavior, family = "poisson", data = pf)
---
Model selection table
   (Intrc) behvr caste group nstID     trtmM adjR^2 df   logLik  AICc delta
32   1.230     +     +     +     + -0.001168 0.4673 12 -454.099 933.7  0.00
30   1.110     +           +     + -0.001217 0.4611 11 -455.394 934.0  0.36
16   1.151     +     +     +     +           0.4586 11 -455.902 935.0  1.37
   weight
32  0.428
30  0.357
16  0.215
Models ranked by AICc(x)
```

> summary(get.models(r1BinpA, 1)[[1]])#o modelo está ligeramente superdispersso

```
Call:
glm(formula = frequency ~ behavior + caste + group + nestID +
    treatmentM + 1, family = "poisson", data = pf)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.3737  -0.9436  -0.2014   0.4396   4.6190

Coefficients:
```

```
                   Estimate Std. Error z value Pr(>|z|)
(Intercept)        1.2301250  0.1502467   8.187 2.67e-16 ***
behaviorIgnoring   0.3910717  0.0966219   4.047 5.18e-05 ***
behaviorPassing   -0.4130550  0.2609553  -1.583  0.11345
behaviorReversing -0.1816506  0.1372851  -1.323  0.18578
casteW            -0.1556347  0.0954946  -1.630  0.10315
groupInquiline    -0.7335720  0.1248122  -5.877 4.17e-09 ***
nestIDn02          0.3841813  0.1305650   2.942  0.00326 **
nestIDn03         -0.0175978  0.1358254  -0.130  0.89691
nestIDn04         -0.1851087  0.1480560  -1.250  0.21120
nestIDn05          0.0998737  0.1480884   0.674  0.50004
nestIDn06         -0.0155381  0.1448131  -0.107  0.91455
treatmentM        -0.0011679  0.0006159  -1.896  0.05792 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 447.14  on 225  degrees of freedom
Residual deviance: 306.69  on 214  degrees of freedom
AIC: 932.2

Number of Fisher Scoring iterations: 5
> plot(m1pA,which=c(1,2))
> library(MASS)
> m2pA <- glm.nb(frequency~treatmentM + group + nestID
+                + caste + behavior,
+            data = pf)
> m2pF <- m2pA
```

```
> rAbpF <- dredge(m2pF, rank = "AICc", extra = "adjR^2")
> rAbpF

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + caste
    behavior, data = pf, init.theta = 5.5702872, link = log)
---
Model selection table
   (Intrc) behvr caste group nstID      trtmM   adjR^2 df   logLik  AICc delta
22   1.185     +           +       -0.0013350 0.259000  7 -441.479 897.5  0.00
14   1.048     +           +     +            0.285900 11 -437.376 898.0  0.51
30   1.119     +           +     + -0.0010570 0.291900 12 -436.453 898.4  0.90
6    1.069     +           +                  0.248700  6 -443.003 898.4  0.92
16   1.169     +     +     +     +            0.290200 12 -436.706 898.9  1.40
24   1.261     +     +     +       -0.0013220 0.260700  8 -441.215 899.1  1.62
32   1.239     +     +     +     + -0.0010510 0.296100 13 -435.784 899.3  1.81
8    1.150     +     +     +                  0.250600  7 -442.716 899.9  2.47
15   1.313           +     +     +            0.213800  9 -448.034 914.9 17.43
31   1.386           +     +     + -0.0010860 0.220200 10 -447.127 915.3 17.81
21   1.338                 +       -0.0013030 0.173100  4 -453.632 915.4 17.97
13   1.156                 +     +            0.204000  8 -449.413 915.5 18.02
29   1.229                 +     + -0.0010840 0.210300  9 -448.520 915.9 18.40
5    1.224                 +                  0.163000  3 -454.984 916.1 18.60
23   1.453           +     +       -0.0012900 0.178200  5 -452.946 916.2 18.69
7    1.342           +     +                  0.168300  4 -454.280 916.7 19.27
12   1.315     +     +           +            0.216700 11 -447.631 918.5 21.02
10   1.135     +                 +            0.206100 10 -449.118 919.3 21.79
28   1.376     +     +           + -0.0008536 0.220700 12 -447.062 919.6 22.12
26   1.193     +                 + -0.0008429 0.210000 11 -448.571 920.4 22.90
2    1.069     +                              0.151700  5 -456.464 923.2 25.73
18   1.170     +                   -0.0011550 0.159700  6 -455.419 923.2 25.75
```

4	1.210	+	+			0.157800	6	-455.673	923.7	26.26
20	1.308	+	+		-0.0011450	0.165600	7	-454.639	923.8	26.32
11	1.247		+	+		0.090860	8	-464.161	945.0	47.51
27	1.310		+	+	-0.0009319	0.095880	9	-463.546	945.9	48.45
9	1.021			+		0.069730	7	-466.716	947.9	50.47
25	1.081			+	-0.0009095	0.074530	8	-466.140	948.9	51.47
3	1.226		+			0.012510	3	-473.356	952.8	55.35
19	1.323		+		-0.0011310	0.020680	4	-472.430	953.0	55.57
1	1.047					0.000000	2	-474.756	953.6	56.09
17	1.145				-0.0011380	0.008316	3	-473.827	953.8	56.29

	weight
22	0.214
14	0.165
30	0.136
6	0.135
16	0.106
24	0.095
32	0.086
8	0.062
15	0.000
31	0.000
21	0.000
13	0.000
29	0.000
5	0.000
23	0.000
7	0.000
12	0.000
10	0.000

```
28  0.000
26  0.000
2   0.000
18  0.000
4   0.000
20  0.000
11  0.000
27  0.000
9   0.000
25  0.000
3   0.000
19  0.000
1   0.000
17  0.000
Models ranked by AICc(x)
>
```

The absolute frequency of the non-aggressive behaviours is a function of the habituation time.

```
> rAbpF[rAbpF$delta<=2]

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + caste
    behavior, data = pf, init.theta = 5.5702872, link = log)
---
Model selection table
   (Intrc) behvr caste group nstID     trtmM adjR^2 df   logLik  AICc delta
22   1.185     +           +       -0.001335 0.2590  7 -441.479 897.5  0.00
14   1.048     +           +     +           0.2859 11 -437.376 898.0  0.51
30   1.119     +           +     + -0.001057 0.2919 12 -436.453 898.4  0.90
6    1.069     +           +                 0.2487  6 -443.003 898.4  0.92
```

```
16   1.169     +     +     +     +           0.2902 12 -436.706 898.9  1.40
24   1.261     +     +     +       -0.001322 0.2607  8 -441.215 899.1  1.62
32   1.239     +     +     +     + -0.001051 0.2961 13 -435.784 899.3  1.81
   weight
22  0.228
14  0.176
30  0.145
6   0.144
16  0.113
24  0.101
32  0.092
Models ranked by AICc(x)
```

```
> model.avg(object = rAbpF[rAbpF$delta <= 2])
```

```
Call:
model.avg(object = rAbpF[rAbpF$delta <= 2])


Component models:
‘135’   ‘134’   ‘1345’  ‘13’    ‘1234’  ‘1235’
‘12345’


Coefficients:
       (Intercept) behaviorIgnoring behaviorPassing behaviorReversing
full      1.145433        0.3780241      -0.3849731        -0.2002361
subset    1.145433        0.3780241      -0.3849731        -0.2002361
       groupInquiline    treatmentM nestIDn02   nestIDn03  nestIDn04  nestIDn05
full       -0.7320701 -0.0006885908 0.1733578 -0.03502559 -0.1219410 0.03296749
subset     -0.7320701 -0.0012151137 0.3291744 -0.06650713 -0.2315435 0.06259918
         nestIDn06      casteW
full   -0.01301405 -0.03890923
```

```
subset -0.02471127 -0.12704922
```

Constrast analysis

```
> sort(tapply(predict(m2pA),pf$behavior,mean))

              Passing              Reversing AntennatingNonNestmate
            0.3375100              0.4289375              1.0535839
             Ignoring
            1.2221345

> sort(tapply(predict(m2pA),pf$nestID,mean))

      n04       n06       n05       n03       n01       n02
0.8064994 0.8126700 0.8498803 0.8502492 0.9248288 1.4660875

> library(carData)
> library(car)
> pf$behaviorpf <- recode(pf$behavior,"c('Passing','Reversing')='PR'")

> #Passing e reversing
>
> mPR <- glm.nb(frequency~treatmentM + group + nestID
+                 + caste + behaviorpf,
+            data = pf)
> AIC(m2pA, mPR)

     df      AIC
m2pA 13 897.5685
mPR  12 896.1369

>
> #posso juntar os comportamentos passing e reversing
>
```

```
> #passing, reversing, antennating
> pf$behaviorpfa <- recode(pf$behavior,"c('Passing','Reversing',
+                          'AntennatingNonNestmate')='PRA'")
> mPRA <- glm.nb(frequency~treatmentM + group + nestID
+                  + caste + behaviorpfa,
+            data = pf)
> AIC(mPR, mPRA)

     df      AIC
mPR  12 896.1369
mPRA 11 895.9703

>
> #posso juntar os comportamentos passing, reversing e antenning

> m2PR <- mPRA
> rAbPR <- dredge(m2PR, rank = "AICc", extra = "adjR^2")
> rAbPR

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + caste
    behaviorpfa, data = pf, init.theta = 5.441071853, link = log)
---
Model selection table
   (Intrc) bhvrp caste group nstID      trtmM   adjR^2 df   logLik  AICc delta
14   1.398     +           +     +            0.278800  9 -438.470 895.8  0.00
22   1.575     +           +       -0.0013100 0.250100  5 -442.796 895.9  0.09
30   1.470     +           +     + -0.0010620 0.284900 10 -437.543 896.1  0.34
6    1.460     +           +                  0.240100  4 -444.263 896.7  0.93
16   1.487     +     +     +     +            0.282400 10 -437.915 896.9  1.08
32   1.559     +     +     +     + -0.0010590 0.288500 11 -436.985 897.2  1.43
24   1.630     +     +     +       -0.0013000 0.251400  6 -442.603 897.6  1.82
8    1.519     +     +     +                  0.241500  5 -444.053 898.4  2.61
```

15	1.313		+	+	+		0.213800	9	-448.034	914.9	19.13
31	1.386		+	+	+	-0.0010860	0.220200	10	-447.127	915.3	19.50
21	1.338			+		-0.0013030	0.173100	4	-453.632	915.4	19.67
13	1.156			+	+		0.204000	8	-449.413	915.5	19.71
29	1.229			+	+	-0.0010840	0.210300	9	-448.520	915.9	20.10
5	1.224			+			0.163000	3	-454.984	916.1	20.30
23	1.453		+	+		-0.0012900	0.178200	5	-452.946	916.2	20.39
7	1.342		+	+			0.168300	4	-454.280	916.7	20.97
12	1.429	+	+		+		0.167200	9	-454.422	927.7	31.90
10	1.283	+			+		0.157100	8	-455.764	928.2	32.42
28	1.488	+	+		+	-0.0008654	0.171400	10	-453.855	928.7	32.96
26	1.338	+			+	-0.0008496	0.161100	9	-455.226	929.3	33.51
2	1.302	+					0.092550	3	-463.955	934.0	38.24
18	1.398	+				-0.0011160	0.100300	4	-463.004	934.2	38.42
4	1.411	+	+				0.097600	4	-463.335	934.9	39.08
20	1.506	+	+			-0.0011110	0.105300	5	-462.388	935.0	39.27
11	1.247		+		+		0.090860	8	-464.161	945.0	49.21
27	1.310		+		+	-0.0009319	0.095880	9	-463.546	945.9	50.15
9	1.021				+		0.069730	7	-466.716	947.9	52.17
25	1.081				+	-0.0009095	0.074530	8	-466.140	948.9	53.17
3	1.226		+				0.012510	3	-473.356	952.8	57.05
19	1.323		+			-0.0011310	0.020680	4	-472.430	953.0	57.27
1	1.047						0.000000	2	-474.756	953.6	57.79
17	1.145					-0.0011380	0.008316	3	-473.827	953.8	57.99

	weight
14	0.193
22	0.185
30	0.163
6	0.121

16	0.113
32	0.095
24	0.078
8	0.053
15	0.000
31	0.000
21	0.000
13	0.000
29	0.000
5	0.000
23	0.000
7	0.000
12	0.000
10	0.000
28	0.000
26	0.000
2	0.000
18	0.000
4	0.000
20	0.000
11	0.000
27	0.000
9	0.000
25	0.000
3	0.000
19	0.000
1	0.000
17	0.000

```
Models ranked by AICc(x)
```

```
> model.avg(object = rAbPR[rAbPR$delta <= 2])

Call:
model.avg(object = rAbPR[rAbPR$delta <= 2])


Component models:
‘134’   ‘135’   ‘1345’  ‘13’    ‘1234’  ‘12345’
‘1235’


Coefficients:
       (Intercept) behaviorpfaPRA groupInquiline nestIDn02     nestIDn03
full      1.498704     -0.4801348      -0.809662 0.2288609 -0.0005735820
subset    1.498704     -0.4801348      -0.809662 0.3846887 -0.0009641249
        nestIDn04  nestIDn05  nestIDn06   treatmentM     casteW
full   -0.1061970 0.08015806 0.02958830 -0.000650951 -0.0353484
subset -0.1785049 0.13473642 0.04973451 -0.001185167 -0.1174800
```

Tirando o ninho

```
> m3PR <- update(mPR,.~.-nestID)
> m3PRt <- m3PR
> rAbPR3 <- dredge(m3PRt, rank = "AICc", extra = "adjR^2")
> rAbPR3

Global model call: glm.nb(formula = frequency ~ treatmentM + group + caste + behavi
    data = pf, init.theta = 4.873093387, link = log)
---
Model selection table
   (Intrc) bhvrp caste group     trtmM   adjR^2 df   logLik  AICc delta weight
14   1.182     +           + -0.001298 0.257900  6 -441.639 895.7  0.00  0.412
6    1.069     +           +           0.248100  5 -443.088 896.4  0.79  0.278
16   1.257     +     +     + -0.001285 0.259600  7 -441.384 897.3  1.62  0.183
```

```
8    1.149     +     +     +                0.250000  6 -442.810 898.0  2.34  0.128
13   1.338                 + -0.001303 0.173100  4 -453.632 915.4 19.78  0.000
5    1.224                 +                0.163000  3 -454.984 916.1 20.42  0.000
15   1.453           +     + -0.001290 0.178200  5 -452.946 916.2 20.50  0.000
7    1.342           +     +                0.168300  4 -454.280 916.7 21.08  0.000
2    1.069     +                            0.151400  4 -456.502 921.2 25.52  0.000
10   1.168     +               -0.001129 0.159100  5 -455.498 921.3 25.61  0.000
4    1.208     +     +                      0.157400  5 -455.726 921.7 26.06  0.000
12   1.304     +     +         -0.001116 0.164800  6 -454.737 921.9 26.20  0.000
3    1.226           +                      0.012510  3 -473.356 952.8 57.16  0.000
11   1.323           +         -0.001131 0.020680  4 -472.430 953.0 57.38  0.000
1    1.047                                  0.000000  2 -474.756 953.6 57.91  0.000
9    1.145                     -0.001138 0.008316  3 -473.827 953.8 58.10  0.000
Models ranked by AICc(x)
> model.avg(object = rAbPR3[rAbPR3$delta <= 2])
Call:
model.avg(object = rAbPR3[rAbPR3$delta <= 2])


Component models:
'134'  '13'   '1234'


Coefficients:
       (Intercept) behaviorpfIgnoring behaviorpfPR groupInquiline    treatmentM
full      1.161874          0.3750111   -0.2446875     -0.7488127 -0.0008822009
subset    1.161874          0.3750111   -0.2446875     -0.7488127 -0.0012938207
            casteW
full   -0.01872059
subset -0.08918807
```

COEFFICIENTS

```
> INpf <- 1.161874
> treatpf <- -0.0012938207
> wpf <- -0.08918807
> inquipf <- -0.7488127
> ignpf <- 0.3750111
> pra <- -0.2446875

> plot(pf$frequency~pf$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Non-aggressive behaviours, number of times per five minutes",
+      xaxt = "n",
+      ylim = c(0,40))
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #comportamento PRA por operários do hospedeiro
> curve(exp(INpf + treatpf*x + pra + wpf), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #comportamento PRA por soldados do hospedeiro
> curve(exp(INpf + treatpf*x + pra), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 5)
> #comportamento PRA por operários do inquilino
> curve(exp(INpf + treatpf*x + pra + wpf + inquipf), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 3)
> #comportamento PRA por soldados do inquilino
> curve(exp(INpf + treatpf*x + pra + inquipf), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 4)
> #comportamento ignorar por operários do hospedeiro
> curve(exp(INpf + treatpf*x + ignpf + wpf), add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #comportamento ignorar por soldados do hospedeiro
> curve(exp(INpf + treatpf*x + ignpf), add = TRUE,
```

```
+       col = "red", lwd = 1.7, lty = 5)
> #comportamento ignorar por operários do inquilino
> curve(exp(INpf + treatpf*x + ignpf + wpf + inquipf), add = TRUE,
+       col = "red", lwd = 1.7, lty = 3)
> #comportamento PR por soldados do inquilino
> curve(exp(INpf + treatpf*x + ignpf + inquipf), add = TRUE,
+       col = "red", lwd = 1.7, lty = 4)
> legend(-10,40,
+ legend = c("Passing/reversing/antenate nonnestmate by host workers",
+ "Passing/reversing/antenate nonnestmate by host soldiers",
+ "Passing/reversing by inquiline workers",
+ "Passing/reversing by inquiline soldiers",
+ "Ignoring by host workers",
+ "Ignoring by host soldiers",
+ "Ignoring by inquiline workers",
+ "Ignoring by inquiline soldiers"),
+ col = c("blue", "blue", "blue", "blue",
+ "red","red","red","red"),
+ lty = c(2,5,3,4,2,5,3,4),
+ lwd= c(1.7,1.7,1.7,1.7,1.7,1.7, 1.7, 1.7),
+ box.lty = 0)
```

Is the absolute frequency of the agressive behaviours a function of the habituation time?

```
> options(na.action = "na.fail")
> m1AG <- glm(frequency~treatmentM + group + nestID + caste + behavior,
+           family = "poisson",
+           data = Ag)
> mt1AG <- m1AG
> r1BinAG <- dredge(mt1AG, rank = "AICc", extra = "adjR^2")
```

```
> r1BinAG

Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste +
    behavior, family = "poisson", data = Ag)
---
Model selection table
   (Intrc) behvr caste group nstID      trtmM   adjR^2 df    logLik   AICc
16   2.900     +     +     +     +            0.953400  9  -798.561 1615.8
8    2.871     +     +     +                  0.951300  4  -804.491 1617.1
32   2.870     +     +     +     +  3.187e-04 0.953600 10  -798.222 1617.3
24   2.842     +     +     +        3.332e-04 0.951500  5  -804.119 1618.5
15   2.888           +     +     +            0.951600  8  -803.668 1623.9
7    2.856           +     +                  0.949600  3  -808.984 1624.1
31   2.855           +     +     +  3.612e-04 0.951800  9  -803.230 1625.2
23   2.824           +     +        3.709e-04 0.949800  4  -808.521 1625.2
14   2.275     +           +     +            0.875200  8  -929.565 1875.7
30   2.265     +           +     +  1.007e-04 0.875200  9  -929.532 1877.8
6    2.216     +           +                  0.867800  3  -937.195 1880.5
22   2.203     +           +        1.370e-04 0.867800  4  -937.134 1882.4
13   2.119                 +     +            0.830900  7  -969.896 1954.2
29   2.112                 +     +  6.978e-05 0.830900  8  -969.879 1956.3
5    2.031                 +                  0.822600  2  -976.219 1956.5
21   2.020                 +        1.192e-04 0.822700  3  -976.172 1958.4
28   2.739     +     +           + -7.310e-04 0.728300  9 -1032.908 2084.5
12   2.662     +     +           +            0.724700  8 -1034.686 2085.9
20   2.570     +     +             -6.550e-04 0.693400  4 -1048.995 2106.1
4    2.507     +     +                        0.690000  3 -1050.435 2107.0
27   2.713           +           + -8.761e-04 0.662300  8 -1061.854 2140.3
11   2.621           +           +            0.655600  7 -1064.437 2143.3
19   2.500           +             -8.160e-04 0.617300  3 -1078.462 2163.0
```

```
3    2.419          +                       0.610800  2 -1080.722 2165.5
10   2.173    +                 +           0.475700  7 -1120.315 2255.1
26   2.229    +                 + -5.392e-04 0.479500  8 -1119.363 2255.3
2    1.995    +                             0.395100  2 -1139.330 2282.7
18   2.037    +                   -4.546e-04 0.398300  3 -1138.646 2283.4
25   2.068                      + -7.143e-04 0.154600  7 -1183.859 2382.2
9    1.992                      +           0.143800  6 -1185.541 2383.4
17   1.795                        -6.159e-04 0.009494  2 -1204.920 2413.9
1    1.736                                  0.000000  1 -1206.189 2414.4
    delta weight
16    0.00  0.432
8     1.31  0.224
32    1.48  0.206
24    2.64  0.115
15    8.07  0.008
7     8.23  0.007
31    9.34  0.004
23    9.37  0.004
14 259.86  0.000
30 261.94  0.000
6  264.66  0.000
22 266.59  0.000
13 338.40  0.000
29 340.49  0.000
5  340.66  0.000
21 342.61  0.000
28 468.69  0.000
12 470.11  0.000
20 490.32  0.000
```

```
4  491.14  0.000
27 524.44  0.000
11 527.48  0.000
19 547.19  0.000
3  549.66  0.000
10 639.24  0.000
26 639.46  0.000
2  666.88  0.000
18 667.56  0.000
25 766.33  0.000
9  767.58  0.000
17 798.06  0.000
1  798.57  0.000
Models ranked by AICc(x)
> r1BinAG[r1BinAG$delta<=2]
Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste +
    behavior, family = "poisson", data = Ag)
---
Model selection table
   (Intrc) behvr caste group nstID     trtmM adjR^2 df   logLik   AICc delta
16   2.900     +     +     +     +           0.9534  9 -798.561 1615.8  0.00
8    2.871     +     +     +                 0.9513  4 -804.491 1617.1  1.31
32   2.870     +     +     +     + 0.0003187 0.9536 10 -798.222 1617.3  1.48
   weight
16  0.501
8   0.260
32  0.239
Models ranked by AICc(x)
> summary(get.models(r1BinAG, 3)[[1]])#o modelo está ligeramente superdispersso
```

```
Call:
glm(formula = frequency ~ behavior + caste + group + nestID +
    treatmentM + 1, family = "poisson", data = Ag)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-4.729  -1.367  -0.109   0.763   5.612

Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)     2.8703216  0.0812268  35.337  < 2e-16 ***
behaviorBiting -0.1856158  0.0588589  -3.154  0.00161 **
casteW         -0.9956083  0.0590467 -16.861  < 2e-16 ***
groupInquiline -1.6323807  0.0914536 -17.849  < 2e-16 ***
nestIDn02       0.0881202  0.0876247   1.006  0.31458
nestIDn03       0.0153177  0.0870532   0.176  0.86033
nestIDn04      -0.1596857  0.0939952  -1.699  0.08934 .
nestIDn05       0.0050695  0.0909230   0.056  0.95554
nestIDn06      -0.1455496  0.0928344  -1.568  0.11692
treatmentM      0.0003187  0.0003868   0.824  0.41003
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 1587.92  on 265  degrees of freedom
Residual deviance:  771.98  on 256  degrees of freedom
AIC: 1616.4
```

```
Number of Fisher Scoring iterations: 5

> plot(m1AG,which=c(1,2))

> m2AG <- glm.nb(frequency~treatmentM + group + nestID
+                 + caste + behavior,
+            data = Ag)
> m2tAG <- m2AG
> rAbAG2 <- dredge(m2tAG, rank = "AICc", extra = "adjR^2")
> rAbAG2

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + caste
    behavior, data = Ag, init.theta = 2.807512734, link = log)
---
Model selection table
   (Intrc) behvr caste group nstID     trtmM   adjR^2 df   logLik   AICc
8    2.737     +     +     +                 0.495400  5 -657.814 1325.9
7    2.726           +     +                 0.490400  4 -659.112 1326.4
24   2.696     +     +     +       0.0004659 0.496200  6 -657.603 1327.5
23   2.685           +     +       0.0004528 0.491200  5 -658.914 1328.1
16   2.800     +     +     +     +           0.500300 10 -656.519 1333.9
15   2.816           +     +     +           0.494800  9 -657.959 1334.6
32   2.753     +     +     +     + 0.0004303 0.501000 11 -656.344 1335.7
31   2.773           +     +     + 0.0003932 0.495400 10 -657.814 1336.5
6    2.213     +           +                 0.406900  4 -679.171 1366.5
22   2.179     +           +       0.0003789 0.407400  5 -679.052 1368.3
14   2.246     +           +     +           0.416000  9 -677.121 1372.9
30   2.208     +           +     + 0.0003438 0.416400 10 -677.024 1374.9
5    2.031                 +                 0.363300  3 -688.538 1383.2
21   2.003                 +       0.0003064 0.363700  4 -688.464 1385.1
13   2.126                 +     +           0.370600  8 -687.022 1390.6
```

29	2.103			+	+	0.0002111	0.370700	9	-686.988	1392.7
4	2.438	+	+				0.165700	4	-724.319	1456.8
20	2.467	+	+			-0.0003194	0.166100	5	-724.250	1458.7
3	2.419		+				0.144300	3	-727.659	1461.4
12	2.627	+	+		+		0.182200	9	-721.665	1462.0
19	2.449		+			-0.0003316	0.144800	4	-727.587	1463.3
28	2.684	+	+		+	-0.0005040	0.183300	10	-721.495	1463.9
11	2.668		+		+		0.161900	8	-724.916	1466.4
27	2.733		+		+	-0.0005756	0.163200	9	-724.701	1468.1
2	1.995	+					0.089560	3	-735.879	1477.8
18	2.037	+				-0.0004541	0.090480	4	-735.745	1479.6
10	2.156	+			+		0.112800	8	-732.457	1481.5
26	2.224	+			+	-0.0006046	0.114300	9	-732.223	1483.1
1	1.736						0.000000	2	-748.311	1500.7
17	1.793					-0.0005966	0.001616	3	-748.096	1502.3
9	1.992				+		0.026640	7	-744.732	1503.9
25	2.087				+	-0.0008355	0.029710	8	-744.314	1505.2

	delta	weight
8	0.00	0.388
7	0.52	0.299
24	1.67	0.168
23	2.20	0.129
16	8.04	0.007
15	8.76	0.005
32	9.87	0.003
31	10.63	0.002
6	40.64	0.000
22	42.48	0.000
14	47.09	0.000

```
30  49.05  0.000
5   57.31  0.000
21  59.22  0.000
13  64.75  0.000
29  66.82  0.000
4  130.93  0.000
20 132.87  0.000
3  135.55  0.000
12 136.17  0.000
19 137.47  0.000
28 137.99  0.000
11 140.53  0.000
27 142.25  0.000
2  151.99  0.000
18 153.78  0.000
10 155.62  0.000
26 157.29  0.000
1  174.81  0.000
17 176.43  0.000
9  178.04  0.000
25 179.33  0.000
Models ranked by AICc(x)

>

> model.avg(object = rAbAG2[rAbAG2$delta <= 2])

Call:
model.avg(object = rAbAG2[rAbAG2$delta <= 2])


Component models:
```

```
'123'  '23'   '1234'

Coefficients:
       (Intercept) behaviorBiting     casteW groupInquiline   treatmentM
full      2.725231     -0.1089100 -0.8777488      -1.551583 9.159699e-05
subset    2.725231     -0.1675176 -0.8777488      -1.551583 4.658691e-04
```

COEFFICIENTS

```
> INAg <- 2.725231
> Btt <- -0.1675176
> WAg <- -0.8777488
> InAg <- -1.551583
> tratAg <- 4.658691e-04

> plot(Ag$frequency~Ag$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Aggressive behaviours, number of times per five minutes",
+      xaxt = "n")
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #comportamento morder por operários do hospedeiro
> curve(exp(INAg + tratAg*x + Btt + WAg), add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #comportamento morder por soldados do hospedeiro
> curve(exp(INAg + tratAg*x + Btt), add = TRUE,
+       col = "red", lwd = 1.7, lty = 5)
> #comportamento morder por operários do inquilino
> curve(exp(INAg + tratAg*x + Btt + WAg + InAg), add = TRUE,
+       col = "red", lwd = 1.7, lty = 3)
> #comportamento morder por soldados do inquilino
> curve(exp(INAg + tratAg*x + Btt + InAg), add = TRUE,
```

```
+       col = "red", lwd = 1.7, lty = 4)
> #comportamento atacar por operários do hospedeiro
> curve(exp(INAg + tratAg*x + WAg), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #comportamento atacar por soldados do hospedeiro
> curve(exp(INAg + tratAg*x), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 5)
> #comportamento atacar por operários do inquilino
> curve(exp(INAg + tratAg*x + WAg + InAg), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 3)
> #comportamento atacar por soldados do inquilino
> curve(exp(INAg + tratAg*x + InAg), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 4)
> legend(70,47, legend = c("Attack by host workers",
+ "Attack by host soldiers",
+ "Attack by inquiline workers",
+ "Attack by inquiline soldiers",
+ "Bitting by host workers",
+ "Bitting by host soldiers",
+ "Bitting by inquiline workers",
+ "Bitting by inquiline soldiers"),
+ col = c("blue", "blue", "blue", "blue",
+ "red","red","red","red"),
+ lty = c(2,5,3,4,2,5,3,4),
+ lwd= c(1.7,1.7,1.7,1.7,1.7,1.7,1.7,1.7),
+ box.lty = 0)
```

Is the absolute frequency of the exploratory behaviours a function of the habituation time?

Mobility of individuals as a function of the habituation time

Walking

```
> library(MuMIn)
> options(na.action = "na.fail")
> m1WR <- glm(frequency~treatmentM + group + nestID + caste,
+           family = "poisson",
+           data = w)
> mt1WR <- m1WR
> r1BinWR <- dredge(mt1WR, rank = "AICc", extra = "adjR^2")
> r1BinWR
```

```
Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste,
    family = "poisson", data = w)
---
Model selection table
   (Intrc) caste group nstID     trtmM  adjR^2 df   logLik   AICc delta weight
16  0.7947     +     +     + 0.0010330 0.19630  9 -600.909 1220.4  0.00  0.735
8   0.8879     +     +     +           0.18440  8 -603.076 1222.6  2.21  0.244
15  1.0450           +     + 0.0010270 0.16900  8 -605.825 1228.1  7.70  0.016
7   1.1370           +     +           0.15670  7 -607.972 1230.3  9.89  0.005
14  0.6653     +           + 0.0010680 0.13590  8 -611.559 1239.6 19.17  0.000
6   0.7605     +           +           0.12220  7 -613.873 1242.1 21.69  0.000
12  0.9644     +     +       0.0008887 0.09780  4 -617.903 1243.9 23.50  0.000
13  0.8871                 + 0.0010600 0.11520  7 -615.039 1244.5 24.02  0.000
4   1.0470     +     +                 0.08788  3 -619.511 1245.1 24.66  0.000
5   0.9808                 +           0.10140  6 -617.322 1246.9 26.49  0.000
11  1.2150           +       0.0008870 0.06646  3 -622.927 1251.9 31.49  0.000
3   1.2970           +                 0.05622  2 -624.532 1253.1 32.66  0.000
10  0.8316     +             0.0009193 0.03565  3 -627.708 1261.5 41.05  0.000
2   0.9163     +                       0.02432  2 -629.427 1262.9 42.45  0.000
9   1.0560                   0.0009146 0.01151  2 -631.349 1266.7 46.30  0.000
```

```
1   1.1400                            0.00000  1 -633.054 1268.1 47.68  0.000
Models ranked by AICc(x)

> r1BinWR[r1BinWR$delta<=2]

Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste,
    family = "poisson", data = w)
---
Model selection table
   (Intrc) caste group nstID    trtmM adjR^2 df   logLik   AICc delta weight
16  0.7947     +     +     + 0.001033 0.1963  9 -600.909 1220.4     0      1
Models ranked by AICc(x)

> summary(get.models(r1BinWR, 2)[[1]])#o modelo está ligeramente superdispersso

Call:
glm(formula = frequency ~ caste + group + nestID + 1, family = "poisson",
    data = w)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9137  -1.0319  -0.3953   0.6344   3.8335

Coefficients:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)     0.88789    0.12707   6.988 2.80e-12 ***
casteW          0.30204    0.10015   3.016 0.002562 **
groupInquiline -0.30886    0.06605  -4.676 2.93e-06 ***
nestIDn02      -0.18616    0.13386  -1.391 0.164320
nestIDn03       0.13456    0.11962   1.125 0.260635
nestIDn04       0.26557    0.11501   2.309 0.020939 *
nestIDn05       0.21742    0.11752   1.850 0.064300 .
```

```
nestIDn06       0.43060    0.11301   3.810 0.000139 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 422.81  on 298  degrees of freedom
Residual deviance: 362.85  on 291  degrees of freedom
AIC: 1222.2

Number of Fisher Scoring iterations: 5

> plot(m1WR,which=c(1,2))

> library(MASS)
> m2WR <- glm.nb(frequency~treatmentM + group
+                 + nestID  + caste,
+            data = w)
> m2tWR <- m2WR
> rAbWR2 <- dredge(m2tWR, rank = "AICc", extra = "adjR^2")
> rAbWR2

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + caste
    data = w, init.theta = 12.04942988, link = log)
---
Model selection table
   (Intrc) caste group nstID     trtmM   adjR^2 df   logLik   AICc delta weight
16  0.8126     +     +     + 0.0010290 0.144600 10 -596.027 1212.8  0.00  0.596
8   0.9017     +     +     +           0.135000  9 -597.678 1214.0  1.16  0.334
15  1.0550           +     + 0.0010330 0.122800  9 -599.726 1218.1  5.26  0.043
7   1.1440           +     +           0.113000  8 -601.352 1219.2  6.38  0.025
```

```
14  0.6760     +          + 0.0010380 0.098730  9 -603.703 1226.0 13.21  0.001
12  0.9666     +     +      0.0009117 0.069390  5 -608.409 1227.0 14.21  0.000
6   0.7642     +          +           0.088960  8 -605.287 1227.1 14.25  0.000
4   1.0500     +     +                0.061770  4 -609.607 1227.4 14.53  0.000
13  0.8920                + 0.0010410 0.082770  8 -606.281 1229.1 16.24  0.000
5   0.9808                +           0.072910  7 -607.853 1230.1 17.27  0.000
11  1.2120           +      0.0009249 0.047020  4 -611.900 1231.9 19.12  0.000
3   1.2970           +                0.039160  3 -613.107 1232.3 19.48  0.000
10  0.8326     +            0.0009248 0.024930  4 -615.270 1238.7 25.86  0.000
2   0.9163     +                      0.017070  3 -616.451 1239.0 26.17  0.000
9   1.0540                  0.0009347 0.008056  3 -617.793 1241.7 28.85  0.000
1   1.1400                            0.000000  2 -618.983 1242.0 29.19  0.000
Models ranked by AICc(x)

>

> m3WR <- update(m2WR,.~.-nestID)
> m3WRt <- m3WR
> rAbWR3 <- dredge(m3WRt, rank = "AICc", extra = "adjR^2")
> rAbWR3

Global model call: glm.nb(formula = frequency ~ treatmentM + group + caste, data =
    init.theta = 8.361183923, link = log)
---
Model selection table
  (Intrc) caste group     trtmM   adjR^2 df   logLik   AICc delta weight
8  0.9666     +     + 0.0009117 0.069390  5 -608.409 1227.0  0.00  0.497
4  1.0500     +     +           0.061770  4 -609.607 1227.4  0.33  0.422
7  1.2120           + 0.0009249 0.047020  4 -611.900 1231.9  4.91  0.043
3  1.2970           +           0.039160  3 -613.107 1232.3  5.27  0.036
6  0.8326     +       0.0009248 0.024930  4 -615.270 1238.7 11.65  0.001
```

```
2  0.9163     +                0.017070  3 -616.451 1239.0 11.96  0.001
5  1.0540           0.0009347 0.008056  3 -617.793 1241.7 14.65  0.000
1  1.1400                     0.000000  2 -618.983 1242.0 14.98  0.000
Models ranked by AICc(x)

> model.avg(object = rAbWR3[rAbWR3$delta <= 2])

Call:
model.avg(object = rAbWR3[rAbWR3$delta <= 2])


Component models:
‘123’ ‘12’


Coefficients:
       (Intercept)    casteW groupInquiline   treatmentM
full      1.004688 0.3001063     -0.2926698 0.0004931544
subset    1.004688 0.3001063     -0.2926698 0.0009117081

>
```

COEFFICIENTS

```
> INw <- 1.004688
> Ww <- 0.3001063
> Inw <- -0.2926698
> tratw <- 0.0009117081

> plot(w$frequency~w$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Walking, number of times per five minutes",
+      xaxt = "n")
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #mobilidade operários do hospedeiro
```

```
> curve(exp(INw + tratw*x + Ww), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #mobilidade soldados do hospedeiro
> curve(exp(INw + tratw*x), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 5)
> #mobilidade operários do inquilino
> curve(exp(INw + tratw*x + Ww + Inw), add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #mobilidade soldados do inquilino
> curve(exp(INw + tratw*x + Inw), add = TRUE,
+       col = "red", lwd = 1.7, lty = 5)
> legend(0,12, legend = c("Walking by host workers",
+ "Walking by host soldiers",
+ "Walking by inquiline workers",
+ "Walking by inquiline soldiers"),
+ col = c("blue", "blue",
+ "red","red"),
+ lty = c(2,5,2,5),
+ lwd= c(1.7,1.7,1.7,1.7),
+ box.lty = 0)
```

Resting

```
> options(na.action = "na.fail")
> mrest1 <- glm(frequency~treatmentM + group + nestID + caste,
+           family = "poisson",
+           data = r)
> mtr1 <- mrest1
> rest1 <- dredge(mtr1, rank = "AICc", extra = "adjR^2")
> rest1
```

```
Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste,
    family = "poisson", data = r)
---
Model selection table
   (Intrc) caste group nstID     trtmM   adjR^2 df   logLik   AICc delta weight
8   1.1390     +     +     +            0.184400  8 -588.451 1193.4  0.00  0.276
7   1.2600           +     +            0.178000  7 -589.592 1193.6  0.17  0.254
16  1.0810     +     +     + 0.0006655 0.189300  9 -587.569 1193.8  0.36  0.230
15  1.2000           +     + 0.0006749 0.183100  8 -588.685 1193.9  0.47  0.219
5   1.1070                 +            0.151400  6 -594.258 1200.8  7.40  0.007
13  1.0470                 + 0.0006708 0.156500  7 -593.361 1201.1  7.71  0.006
6   1.0060     +           +            0.155400  7 -593.560 1201.5  8.11  0.005
14  0.9483     +           + 0.0006647 0.160500  8 -592.680 1201.9  8.46  0.004
11  1.2230           +       0.0007224 0.051490  3 -610.544 1227.2 33.77  0.000
4   1.1710     +     +                  0.051490  3 -610.544 1227.2 33.77  0.000
3   1.2870           +                  0.044760  2 -611.580 1227.2 33.80  0.000
12  1.1090     +     +       0.0007134 0.058000  4 -609.534 1227.2 33.80  0.000
1   1.1200                              0.000000  1 -618.293 1238.6 45.20  0.000
9   1.0560                   0.0007094 0.006800  2 -617.292 1238.6 45.23  0.000
2   1.0310     +                        0.003627  2 -617.760 1239.6 46.16  0.000
10  0.9695     +             0.0007036 0.010290  3 -616.776 1239.6 46.23  0.000
Models ranked by AICc(x)
```

> rest1[rest1$delta<=2]

```
Global model call: glm(formula = frequency ~ treatmentM + group + nestID + caste,
    family = "poisson", data = r)
---
Model selection table
   (Intrc) caste group nstID     trtmM adjR^2 df   logLik   AICc delta weight
8    1.139     +     +     +            0.1844  8 -588.451 1193.4  0.00  0.282
```

```
7    1.260         +     +           0.1780  7 -589.592 1193.6  0.17  0.259
16   1.081    +    +     + 0.0006655 0.1893  9 -587.569 1193.8  0.36  0.235
15   1.200         +     + 0.0006749 0.1831  8 -588.685 1193.9  0.47  0.223
Models ranked by AICc(x)
```

```
> summary(get.models(rest1, 2)[[1]])

Call:
glm(formula = frequency ~ group + nestID + 1, family = "poisson",
    data = r)


Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.1234  -0.9435  -0.3111   0.6559   3.5890


Coefficients:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)     1.25957    0.10093  12.479  < 2e-16 ***
groupInquiline -0.21353    0.06923  -3.084  0.00204 **
nestIDn02      -0.27592    0.13795  -2.000  0.04548 *
nestIDn03      -0.35421    0.13126  -2.699  0.00696 **
nestIDn04       0.03409    0.11667   0.292  0.77012
nestIDn05       0.03409    0.11667   0.292  0.77012
nestIDn06       0.31508    0.11020   2.859  0.00425 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for poisson family taken to be 1)


    Null deviance: 400.4  on 297  degrees of freedom
Residual deviance: 343.0  on 291  degrees of freedom
```

```
AIC: 1193.2

Number of Fisher Scoring iterations: 5

> #ta um pouco maior que 1, então o modelo está ligeramente superdispersso

> plot(mrest1,which=c(1,2))

> mrest2 <- glm.nb(frequency~treatmentM + group
+                 + nestID  + caste,
+           data = r)
> mtr2 <- mrest2
> rest2 <- dredge(mtr2, rank = "AICc", extra = "adjR^2")
> rest2

Global model call: glm.nb(formula = frequency ~ treatmentM + group + nestID + caste
    data = r, init.theta = 15.88365503, link = log)
---
Model selection table
   (Intrc) caste group nstID     trtmM   adjR^2 df   logLik   AICc delta weight
7   1.2590           +     +           0.138100  8 -586.500 1189.5  0.00  0.286
8   1.1440     +     +     +           0.143200  9 -585.635 1189.9  0.40  0.234
15  1.1980           +     + 0.0007144 0.143000  9 -585.666 1190.0  0.46  0.227
16  1.0850     +     +     + 0.0007044 0.147900 10 -584.819 1190.4  0.91  0.182
5   1.1070                 +           0.117300  7 -589.978 1194.3  4.84  0.025
13  1.0470                 + 0.0006908 0.121900  8 -589.222 1194.9  5.44  0.019
6   1.0090     +           +           0.120600  8 -589.439 1195.4  5.88  0.015
14  0.9516     +           + 0.0006833 0.125000  9 -588.697 1196.0  6.52  0.011
3   1.2870           +                 0.032590  3 -603.387 1212.9 23.36  0.000
11  1.2210           +       0.0007618 0.038180  4 -602.538 1213.2 23.72  0.000
4   1.1750     +     +                 0.037230  4 -602.683 1213.5 24.00  0.000
12  1.1110     +     +       0.0007524 0.042690  5 -601.851 1213.9 24.41  0.000
```

```
1   1.1200                            0.000000  2 -608.239 1220.5 31.02  0.000
9   1.0560                  0.0007132 0.004923  3 -607.516 1221.1 31.62  0.000
2   1.0310     +                      0.002626  3 -607.853 1221.8 32.29  0.000
10  0.9696     +            0.0007058 0.007443  4 -607.144 1222.4 32.93  0.000
Models ranked by AICc(x)

>

>

> mrest3 <- update(mrest2,.~.-nestID)
> mtr3 <- mrest3
> rest3 <- dredge(mtr3, rank = "AICc", extra = "adjR^2")
> rest3

Global model call: glm.nb(formula = frequency ~ treatmentM + group + caste, data =
    init.theta = 9.060483601, link = log)
---
Model selection table
  (Intrc) caste group     trtmM   adjR^2 df   logLik   AICc delta weight
3  1.2870           +           0.032590  3 -603.387 1212.9  0.00  0.312
7  1.2210           + 0.0007618 0.038180  4 -602.538 1213.2  0.36  0.261
4  1.1750     +     +           0.037230  4 -602.683 1213.5  0.65  0.226
8  1.1110     +     + 0.0007524 0.042690  5 -601.851 1213.9  1.05  0.184
1  1.1200                       0.000000  2 -608.239 1220.5  7.66  0.007
5  1.0560             0.0007132 0.004923  3 -607.516 1221.1  8.26  0.005
2  1.0310     +                 0.002626  3 -607.853 1221.8  8.93  0.004
6  0.9696     +       0.0007058 0.007443  4 -607.144 1222.4  9.57  0.003
Models ranked by AICc(x)

> model.avg(object = rest3[rest3$delta <= 2])

Call:
model.avg(object = rest3[rest3$delta <= 2])
```

```
Component models:
‘2’   ‘23’  ‘12’  ‘123’

Coefficients:
       (Intercept) groupInquiline   treatmentM     casteW
full      1.210983     -0.2593628 0.0003432995 0.05632851
subset    1.210983     -0.2593628 0.0007578733 0.13499273
```

COEFFICIENTS

```
> Ir <- 1.210983
> InGr <- -0.2593628
> Treatr <- 0.0007578733
> Cr <- 0.13499273

> plot(r$frequency~r$treatmentM,
+      xlab= "Time (min) of prior heterospecific exposure",
+      ylab= "Resting, number of times per five minutes",
+      xaxt = "n")
> axis(1, at = seq(0,180, by=60), labels = TRUE)
> #imobilidade operários do hospedeiro
> curve(exp(Ir + Treatr*x + Cr), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 2)
> #imobilidade soldados do hospedeiro
> curve(exp(Ir + Treatr*x), add = TRUE,
+       col = "blue", lwd = 1.7, lty = 5)
> #imobilidade operários do inquilino
> curve(exp(Ir + Treatr*x + Cr + InGr), add = TRUE,
+       col = "red", lwd = 1.7, lty = 2)
> #imobilidade soldados do inquilino
```

```
> curve(exp(Ir + Treatr*x + InGr), add = TRUE,
+       col = "red", lwd = 1.7, lty = 5)
> legend(0,11, legend = c("Resting by host workers",
+ "Resting by host soldiers",
+ "Resting by inquiline workers",
+ "Resting by inquiline soldiers"),
+ col = c("blue", "blue",
+ "red","red"),
+ lty = c(2,5,2,5),
+ lwd= c(1.7,1.7,1.7,1.7),
+ box.lty = 0)
```

The mobility behaviours are a function of the habituation time