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Daily activity patterns of *Platythyrea parallela* in Peninsular Malaysia

Nurul Ashikin[1*] and Rosli Hashim[1]

[1]Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia.

[*]corresponding author's email: nurulantz@gmail.com

ABSTRACT. The study observed the daily activity patterns at natural nests of *Platythyrea parallela* in the tropical rainforest and was conducted at Ulu Gombak Forest Reserve, Peninsular Malaysia. The 24 hours observation was performed at two stable colonies of this species with a total of 240 hours collected. From the result obtained, *P. parallela* was classified as 'diurnal' species. Most individuals were observed to be active during midday. Activity patterns differed significantly between day and nighttime. This may also be related to the temperature regime. The daily activity was found to be positively correlated with temperature.

Keywords: *Platythyrea*, Peninsular Malaysia, daily activity, temperature.

INTRODUCTION

Activity patterns of ants can be seen from two perspectives, one, the daily activity pattern and the other, the seasonal activity pattern. Daily activity pattern can be the daily routine of individuals as whether they are foragers, soldiers, or taking care of the queen and the brood and also of nest maintenance and sanitation. Some species are very strictly specialized in the division of labor, but many species tend to be generalized. Measurement for activity patterns can include the time budget for foraging, nest maintenance and other activities of workers within colony for 24 hours. The seasonal activity pattern can reflect the response to seasonal variation such as winter and summer. Various factors (biotic and abiotic) can affect the daily and seasonal activity of ants. Common abiotic factors affecting ant activity patterns include temperature and moisture (Cerda *et al*. 1998a; Dean 1992; Levings & Windsor 1984; Whitford 1999) and also the ambient light levels (Narendra *et al*. 2010). Temperature has been known as a major factor influencing prey-size selection and foraging behavior in ants (Cerda *et al*. 1998b; Crist & William 1999; Traniello *et al*. 1984). Biotic factors such as inter-specific competition (Carroll & Janzen 1973), natural enemies (Orr & Seike 1998), and variation in resource availability may also influence activity patterns, both, on a daily and seasonal basis (Raimundo *et al*. 2009; Whitford 1999).

Among species of ants, the daily activity pattern is one of the most distinctive characteristics (Holldobler & Wilson 1990). From the daily activity patterns, we can see if ants are active during day, night or twilight period. Most are active during daytime, known as "diurnal" species, but some are active during nighttime and are known as "nocturnal". Others can be active during twilight time (during dusk and dawn) and are known as "crepuscular". Like other animals, ants also can be active during specific periods of the year and at specific times of the day (Jayatilaka *et al*. 2011). Larger ant species were found to forage actively during nighttime compared to smaller ants (Chambers 2011).

The activity patterns of *Platythyrea* are almost unknown, although, there was some research on their reproductive strategies and behavior (Brunner *et al*. 2009; Hartmann *et al*. 2005; Hartmann & Heinze 2003; Hartmann *et al*. 2003; Heinze & Holldobler 1995; Ito 1994), phylogeographic distribution (Seal *et al*. 2011), predatory behavior (Dejean 2011; Djieto-Lordon *et al*. 2001a, 2001b) and commensalistic association (Yeo *et al*. 2006). Ecological study on *Platythyrea* has been limited in the Asian region with only one report from Ito (1994) on the sexual reproduction of *Platythyrea tricuspidata* Emery, 1900 and *Platythyrea quadridenta* Donisthorpe, 1941.

As known, *Platythyrea parallela* (Smith, 1859) is distributed throughout Asia/Australia region from the Seychelles Island and India to the Philippines including Polynesia, East Australia and Borneo (Brown 1975; Pfeiffer *et al*. 2011). Generally, ants of the genus *Platythyrea* tend to be predators of other insect groups and forage solitarily (Schmidt 2009). To date, little is known about the ecology and behavior of this species. Since there is lack of information on *P. parallela*, we carried out this research to study the daily variations in their activity patterns. We also related the activity patterns with abiotic factors, particularly to air temperature.

MATERIALS AND METHODS

Study site

This field study was conducted in July until August 2011 in the Ulu Gombak Forest Reserve (UGFR) (Selangor, 3°19'N; 101°45'E; 250 m a.s.l.). This hill forest is located about 30 kilometers from Kuala Lumpur, with an altitude ranging from 100 to 800 m (Ezyan & Ramli 2013). The most common and dominant tree that can be found in this forest is *Shorea curtisii* (Hashim *et al*. 2001). The mean annual temperature was about 26-27°C with high percentage of relative humidity around 83%-85% (Ezyan & Ramli 2013).

Studied species

We studied *Platythyrea parallela* (Smith, 1859), a species that may contain several undescribed subspecies. In this study, we only look for colonies of small sized *P. parallela* (Weber's length less than 1.50 mm) with white hind tibia, though there are other members of this taxon with similar morphological characteristics (manuscript in preparation).

Colony and nest seeking process

For seeking nests of our focus species, every single tree (> 20cm dbh) in the forest, especially trees with solid trunk and rough bark, in the vicinity of the field station was examined. Besides that, large dead logs and fallen branches were also checked for nesting colonies. It has been reported (Brown 1975; Ito 1994) that *Platythyrea* ants can be found on logs or tree trunks, in rotten wood, or in beetle burrows, hollow twigs, and similar cavities in standing live or fallen dead trees. Being a rare species, the success rate of our search on nests of *P. parallela* was very low. During the seeking process, we only found two 'stable' colony nests in the study site. Stable colony was referred to as a colony that did not move to another nest site within one week of observation.

Foraging activity rhythm

The rhythm of daily activity of two colonies was studied in the field. At each nest entrance, the number of workers leaving and returning (carrying or not carrying food items, marked or unmarked) to the nest within 24 hours period was recorded. This observation method is similar to that of Pol & de Casenave (2004). The whole observation is referred to as "general foraging activity". Observation was done continuously for 12 hours during day period (07:00 h until 19:00 h) and night period (19:00 h until 07:00 h) for altogether five days. A total of 240 hours was spent to collect the data from both nests. During the observation period, air temperature (≈ 1 m above ground) and relative humidity was monitored at 1 hour intervals using the digital thermo-hygrometer (sensor probe measurement; range: -50+70°C, accuracy: ±1°C). In addition to direct observations, ant activities were also recorded by using a Video camera (Sony Handycam HDR CX700E) to make sure we did not miss any important data. Later the 240 hours of video recording was processed in the lab to compare it with our direct observations.

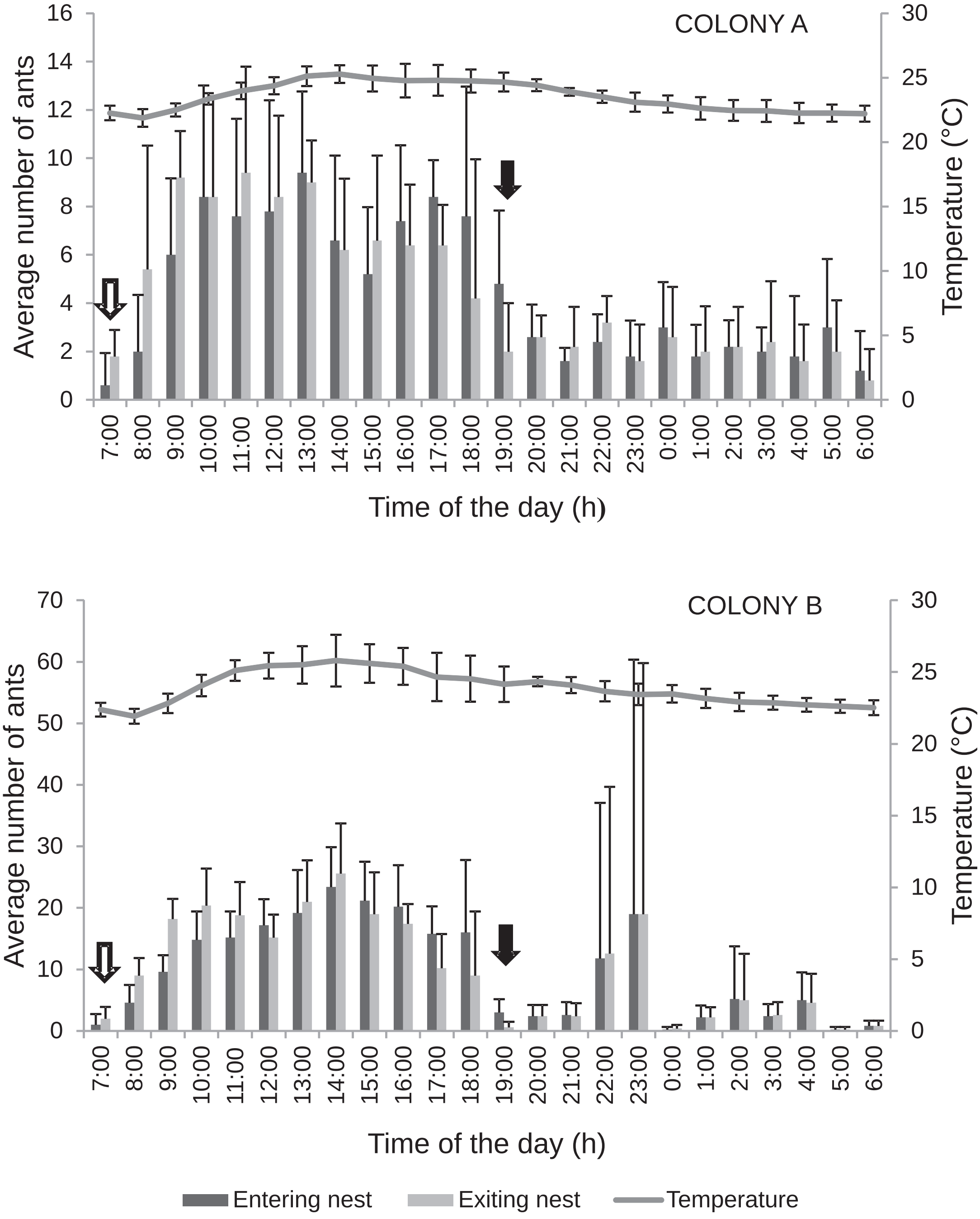

Fig. 1. Activity schedule of *P. parallela* (bars) and air temperature (solid line) in a secondary rainforest (Ulu Gombak Reserve Forest) in Peninsular Malaysia during dry season (July and August). The arrows indicate sunrise (white) and sunset (black). Data are means ± SD.

Statistical analysis

The type of analyses that were chosen depended on the distribution of the data. We performed the Mann-Whitney U test to analyse the difference between daily activity and period of the day (daytime and nighttime) for both colonies. This non-parametric test was chosen because the frequency distributions of values for all variables were significantly different from normal distribution even after log-transformed.

One of the objectives of this study was to determine whether there was a significant relationship between daily activity rhythm and air temperature. Initial analysis for normality test using the Shapiro-Wilk test showed the data were normally distributed for both colonies. Colony A: daily activity ($W = 0.93$, $p = 0.16$, n.s.) and Colony B: daily activity ($W = 0.91$, $p = 0.06$, n.s.). Therefore, linear regression analysis was used to calculate the relationship. The regression analysis was also carried out to observe the relation between activities during active time (daytime) with air temperature. All the tests were calculated with STATISTICA 8 software (StatSoft 2007).

RESULTS

Natural history

Nests of *P. parallela* were located on the tree trunk, with the chamber under the bark of the tree. Every nest had only one entrance, with measures ≈ 0.5 cm in diameter. They did not build their own nest, but they usually used deserted nests of other species, especially of beetles, or they made use of hollow twigs and cavities under the rough tree bark. The nest of Colony A was found on a standing large dead log with the nest entrance located about 0.5 m above the ground. While the nest of Colony B was found on a large living Dipterocarp tree with the nest entrance located about 0.5 m above the ground. Both of the nests were located about 1 km away from each other.

Before we started the observation on this species, we found several nests, but mostly they were unstable. The colony was frequently migrating to new nest sites on the same host tree every two or three days. This was probably due to disturbance or unsuitability of the nest sites. Since the colonies are small (approximately 20 to 30 foragers), they are sensitive to disturbance and cannot tolerate the presence of larger ant colonies nearby (*pers. obs*.). They even did not try to defend their territory, and mostly they will give up and try to find a new nest. In this study, the non-dominant *P. parallela* avoided the dominant colonies of *Crematogaster* spp.

Foraging activity rhythm

Platythyrea parallela workers were active during the day period, from 07:00 h (sunrise) until 19:00 h (sunset). Even though there were activities during the nighttime, the numbers of workers leaving and entering the nest were very low and basically they were just wandering around the nest entrance for a few second. This could be one or two individuals that are taking night watch, while others may stay in a complete rest in the nest. It can be stated that they were 24 hours active, but more than 95% of activity occurred during daytime. Observations throughout a 24 hours study period suggested that this pattern was consistent, with workers actively leaving the nest from 07:00 h until 11:00 h and actively returning from 11:00 h until 19:00 h (Fig. 1). However in Colony B (Fig. 1) there was an indication of high activities between 22:00 h and 23:00 h. This was actually due to one individual moving in and out of the nest carrying wood dust. This is rather unusual, it may be possibly due to some disturbance within nest that has made the particular individual active (it was a marked individual). During the observations, the air temperatures around both nests were ranging between 21-25°C. The highest peak activity was recorded during midday, which is the hottest time throughout the day with a temperature around 25°C.

For both colonies foraging activity during daytime differed significantly from that of the nighttime: Colony A (Mann-Whitney U test: $U = 522.00$, $p < 0.001$, Fig. 2) and Colony B (Mann-Whitney U test: $U = 335.50$, $p < 0.001$, Fig. 3). The foraging activities performed by workers of both colonies were high during daytime.

Regression analysis demonstrated that daily activities of *P. parallela* workers of both

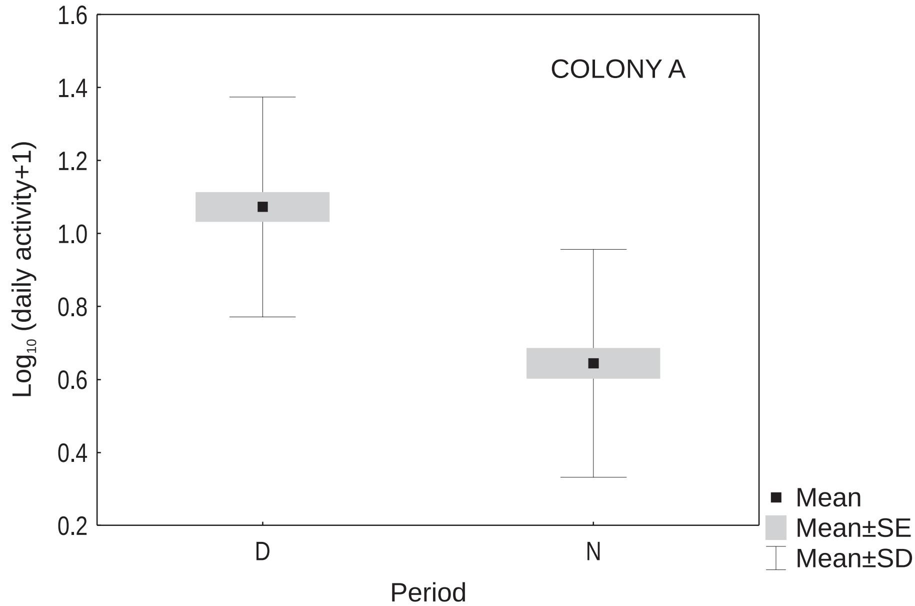

Fig. 2. Box-Whisker plot of the daily activity (log transformed) in the two different periods: D = daytime, N = nighttime (Mann-Whitney U test: $U = 522.00$, $p < 0.001$).

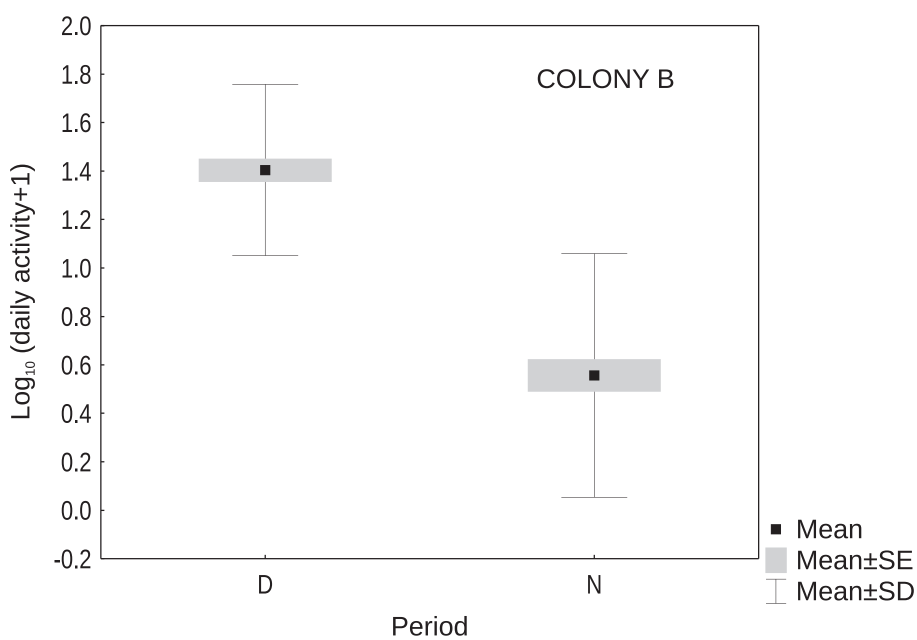

Fig. 3. Box-Whisker plot of the daily activity (log transformed) in the two different periods: D = daytime, N = nighttime (Mann-Whitney U test: $U = 335.50$, $p < 0.001$).

colonies were impacted by air temperature (Fig. 4 a, b): Colony A (F (1, 22) = 13.24, r^2 = 0.39, p < 0.01) and Colony B (F (1, 22) = 23.18, r^2 = 0.50, p < 0.001). Since *P. parallela* is known as diurnal species, regression analysis was also calculated to check impact of air temperature on activities during active time only (daytime, 12 hours). We used combined data of both colonies and found a significant positive influence of air temperature on daily activities during active time (diurnal activity) (F (1, 17) = 11.54, r^2 = 0.40, p < 0.01), demonstrating that when air temperature increased, ant workers activities increased as well.

DISCUSSION

Natural history

Both colonies of *P. parallela* that were observed in this study were located on the tree trunk. Generally, the genus *Platythyrea* is known as an arboreal ant species (Brown 1975; Djieto-Lordon *et al*. 2001a; Molet & Peeters 2006; Yeo *et al*. 2006), but the information on the habitat and nest structure of *P. parallela* is limited since this species is rare and difficult to collect in the field. The most appropriate method to collect this ant is using manual techniques (Ito *et al*. 2001; Malsch *et al*. 2003; Torchote *et al*. 2010). During sampling, only a small number of individuals were collected from this species. In a study at Lambir Hills National Park, Sarawak, only one colony of *P. parallela* was collected (Tanaka *et al*. 2010) while in a study at Temengor, Perak, only two individuals of this species were obtained (Nur-Zati *et al*. 2011). So far, no behavioral study focused on this species.

P. parallela can be classified as arboreal species with a foraging area on the tree trunks and near the ground or on the ground around the canopy trees (Malsch *et al*. 2003). As arboreal ants, they forage solitarily on their host trees. The solitary foraging habit is common within non-dominant arboreal ant species and their foraging area is restricted to the host tree crown including tree crowns nearby. The nature of plant architecture has influence on the foraging strategies of arboreal ants (Ganeshaiah & Veena 1988). The densities of food sources might be low in the arboreal habitat compared to the ground habitat. This may be the reason why *P. parallela* usually forages solitarily. Ants can change their foraging strategies from collective to individual depending on environmental stress (Traniello 1989). It has been proposed that at low prey densities, with scattered and unstable food sources, solitary foraging can be as efficient as recruitment (Calenbuhr & Deneubourg 1992; Carroll & Janzen 1973).

Daily activity rhythm

In tropical regions, the temperature is constant throughout the year and seasonal changes are less extreme compared to the temperate region. Therefore, the daily activity patterns are more important to understand rather than seasonal patterns. Ants can be active during different periods either of day or night, depending on their tolerance limits to the temperature and humidity in the environment (Holldobler & Wilson 1990). Certain species can be active during the twilight period as well. It has been reported that the active foraging time of *P. parallela* was during daytime (Tanaka *et al*. 2010). From the current study, observation on the foraging activity rhythm of *P. parallela* proofs that this species is a diurnal type. Both observed colonies showed a unimodal pattern with workers' activity confined to midday period. During our study period, air temperature was high during the daytime. As demonstrated by our regression results, temperature had a major impact on ant activity. As temperature increased, activities of *P. parallela* increased as well. Between 39 to 50% of the variability in ant activity could be explained by temperature. The temperature preference of *Platythyrea* nests was observed to be 24.7°C (Mezger & Pfeiffer 2010). Similarly, in this study the peak activities of *P. parallela* were obtained at 25°C. In this study, we focused on the temperature as an important abiotic factor that can regulate the activity levels of ants.

Solitary foraging is the most efficient strategy for subdominant ants that are active at high temperatures, because this can reduce competition for resources with dominant recruiter species (Cerda *et al*. 1998a). Besides the temperature

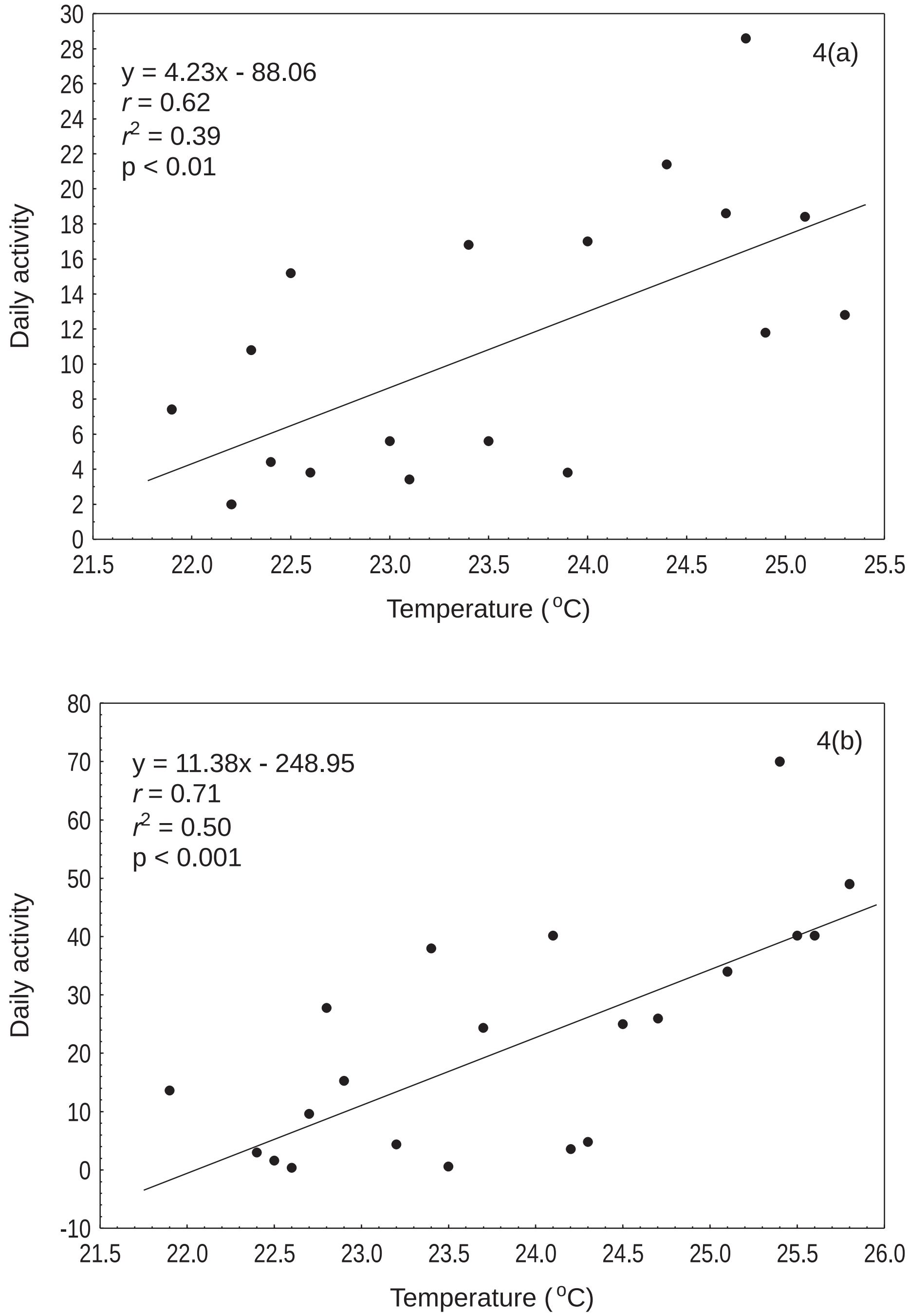

Fig. 4. Linear regression of the mean temperature on daily activity (mean number of workers in and out from the nest within 24 hours, carrying or not food items) for a) Colony A and b) Colony B.

factor, the light intensity could limit the level of foraging activity as well (Retana *et al*. 1988).

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