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Observations on behavioural patterns and probable Influence of diurnal temperature on nest building ability of *Ropalidia marginata*

Kokilamani A L[1], Lekha Y V[2], Latha V[*]
[1] Department of studies in Zoology, Tumkur University, Tumakuru, Karnataka, India
[2,*] Maharani Cluster University, Bangalore, Karnataka, India
[*]Corresponding Author: latha.enscience@gmail.com

Abstract
Ropalidia are eusocial wasps which make a nest from cellulose mixed with saliva. They also exhibit cooperative brood care differentiation of the colony members. The present studies aim at hypothesising the probable role of temperature in nest building ability of R. marginata. The observations revealed that, raise in temperature was inversely proportional to the number of cells built. The statistical analysis revealed that, there was no significant relationship ($p>0.05$) between temperature and nest building ability.

Keywords: *Ropalidia*, behaviour, nest building, temperature

Introduction
Ropalidia spp are the common eusocial paper wasps native to Indian subcontinent being included under the family vespidae. Their common name is due to their nest-making ability from cellulose mixed with their saliva. Of the 180 species currently recognized, 27 species have been recorded from the Indian subcontinent, including 16 species so far known to be endemic to the subcontinent (Kojima *et al.*, 2007) [5]. Eusocial insects are the ones which exhibit cooperative brood care, differentiation of colony into fertile-reproductive castes (queens & king) and sterile- non reproductive castes (workers) and has an overlap of generations such that offspring assist their parents in brood care and other tasks involved in colony maintenance (Gadagkar 1996) [2]. *Ropalidia marginata* has a seasonal indeterminate and perennial colony cycle, which means that nest initiation starts throughout the year, and they are active throughout the year too. Colonies were established more frequently from May to July when food is abundant and less frequently from December to February, when temperatures are comparatively cooler (cool wet season).

Each colony has one reproductive female, a queen and that position can be taken by adapting an abandoned nest taking over queen ship at an existing nest. Wasps are dark reddish coloured with yellow spots on some joints and a yellow ring around the lower abdomen (Fig C).

Review of literature reveals the distribution and prevelance of two species of the Ropalidia group in Indian subcontinent, viz., *R. variegata* (Smith, 1852) [9] and *R. jacobsoni* (du Buysson, 1908) (Kojima 1993) [4]. The distribution of Ropalida marginata extends as far west as Pakistan and as far as east as New Guinea, Queensland and some eastern pacific Island. They are the most common social wasps in India (Kojima et al., 2007) [5]. Behaviour patterns of the wasps, their morphological features and division of labour among the colony individuals has been widely studied. Gadagkar et al. (2015) [3] reported dominance hierarchy among workers of *R. marginata*. The hierarchy influenced the division of labour in the colony such that the subordinate individuals spend more time making trips to places away from the nest to bring back food, building material, water etc. The queens sit around and give alarm reactions. Lamba *et al*., (2007) [6] reported that in *R.marginata* queens are docile and non-aggressive whereas, potential queen exhibits dominance behaviour which is required for its rapid ovarian development, facilitating her speedy establishment as the sole reproductive individual in the colony. Sen and Gadagkar (2009) [7] found that nests of this species were found throughout the year. Sôichi (1986) [8] reported the features of colony building by the wasps and stated that colony was founded by single or multiple (2–4) foundresses, dominance interactions between females were very weak and mostly non-tactile, task allocation observed between females and exhibited serial polygyny. However, no reports are found which have recorded the influence of abiotic factors like temperature on the nest building ability of *R. marginata*. Hence, to fill the existing lacuna, this relevant investigation was conducted.

Methodology
Study zone
Maharanis Science College for women, Palace road, Bengaluru is an integral constituent college of Maharani Cluster University, palace road Bengaluru. The campus covering an area of 11 acres appox. and is surrounded by roads with heavy traffic on two sides and harbours huge trees. The location of the site is given below.

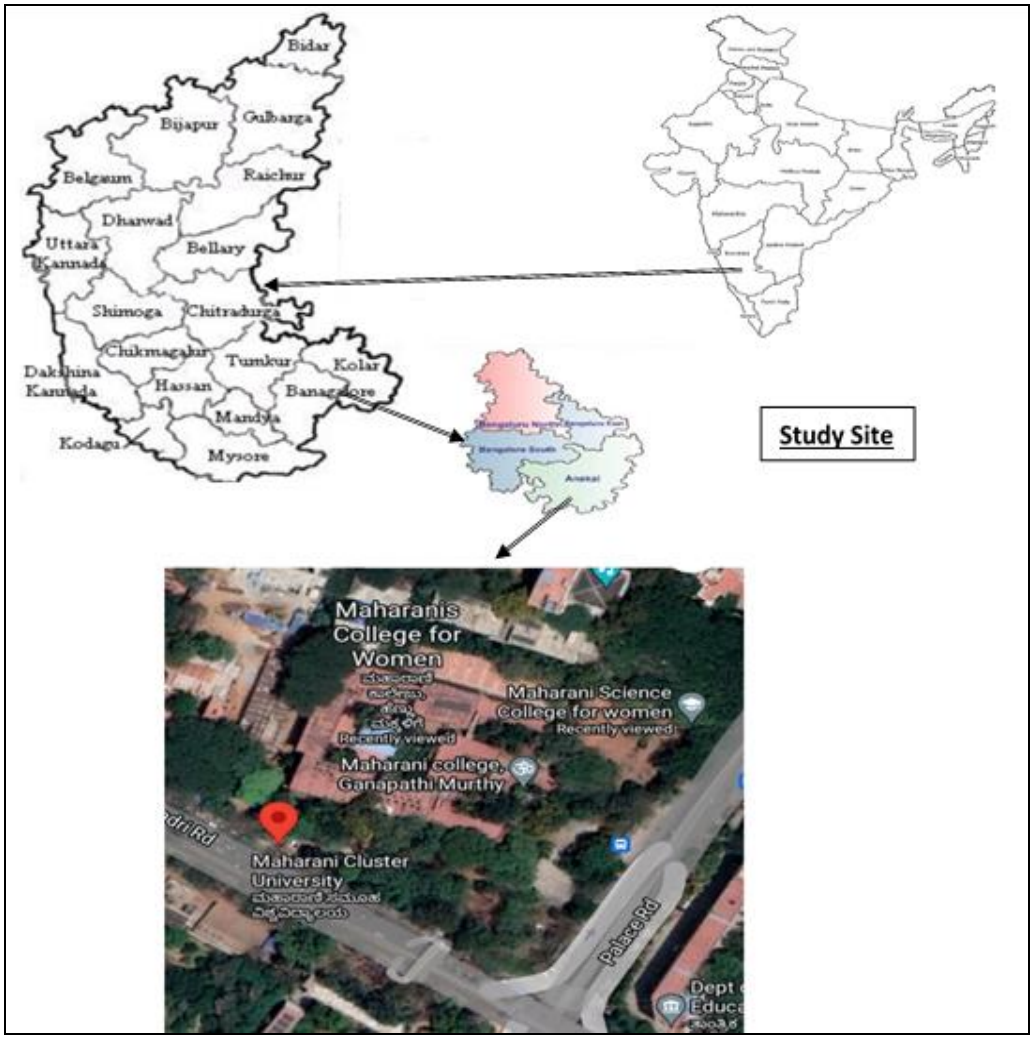

Fig 1

Data analysis

Observed data was tabulated and analysed using Microsoft Excel and graphs were plotted. Statistical analysis was done using one-way ANOVA using MS Excel.

Nests were observed in the aforementioned college campus at various locations between 8:30 am to 10 am on daily basis. Nests were built below the stair case, on the window panes and were seen popping on the walls. All were observed on the first floor of the building. Nests with 4-6 cells were chosen for continuous observation on daily basis and the data was recorded.

Number of cells built on daily basis and diurnal temperature (during study period) were recorded. At a given time 4-7 wasps were seen around the colony performing different tasks.

Results and Discussion

Nest counts of *R. marginata* was observed from January 2021 to November 2021 and the mean number of cells are presented in the table below.

Wasps were seen building their cells with the help of cellulose and saliva. Each layer of the cell were deposited by the foragers. Wasps were seen flying away from the nest and then coming back with cellulose like plant materials. Since there was no intervention from outside, they was no evidence of stinging from the wasps.

Table 1: Nest count of *R.marginata* observed during the study period are presented in the below table.

Month	Temperature (^{0}C)	No. of average wasps observed in colony	Number of functional cells formed	Observed number of incomplete cells (cells under construction)
Jan	19	10	95	05
Feb	18	08	113	08
Mar	22	05	122	09
Apr	25	05	122	07
May	26	04	120	03
Jun	23	06	125	03
Jul	24	06	125	03
Aug	22	07	128	04
Sep	22	09	132	07
Oct	21	10	140	05
Nov	21	13	147	04

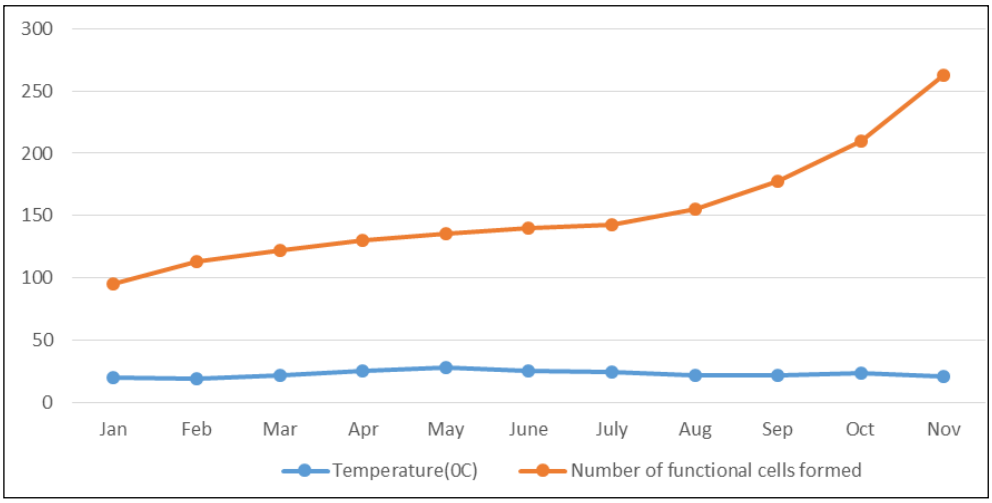

Fig 2: Graph depicting variation in temperature and number of functional cells formed in *R. marginata* colony.

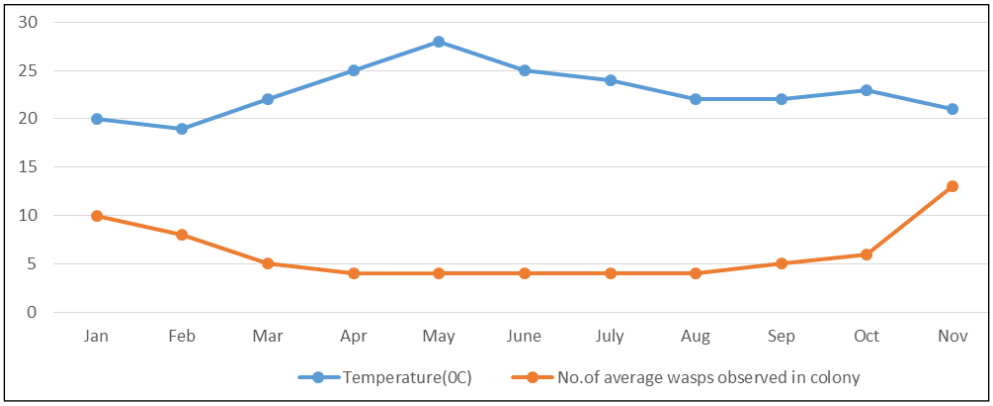

Fig 3: Graph depicting relation between temperature and number of wasps observed in *R. marginata* colony.

Initially, it appeared that rise in temperature restricted the presence of wasps and their nest building ability (Fig 2 &3), upon statistical analysis, using one way ANOVA, there was no significant difference ($p>0.05$) between temperature and number of cells formed and also the presence of wasps.

Behavioural observations and Discussion

Around 4-10 wasps were seen at a time around the colony. One was seen feeding the brood, two-three of them used to guard the colony and nursing behaviour and cleaning of nests were also evident (Fig A,B,C and D).

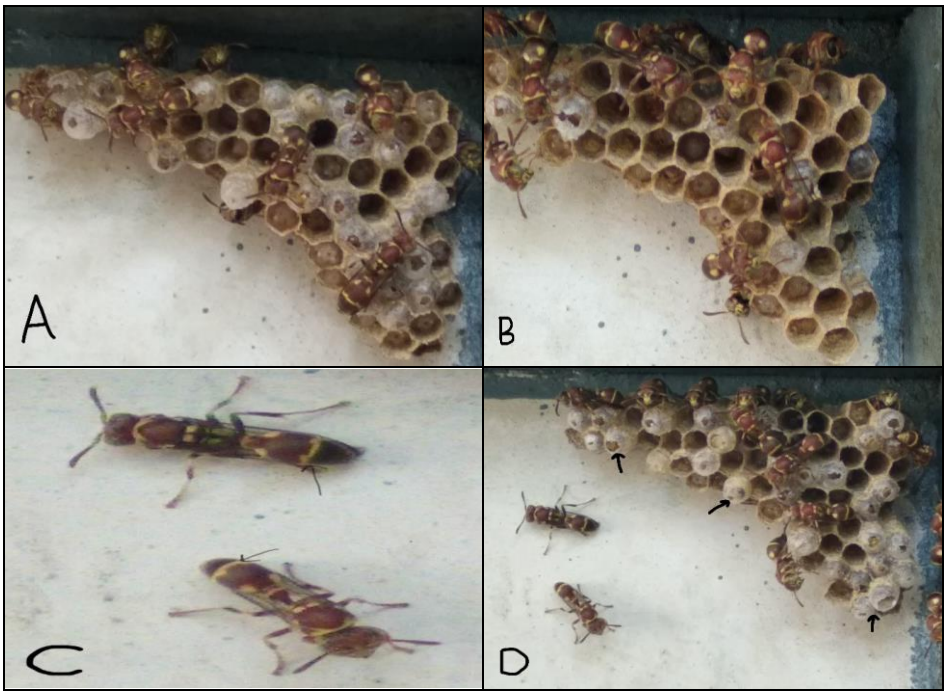

Fig 4

Once the nests were abandoned they were not reused or reinhabited, they just dried and fell off.

Ropalidia nests are made of paper like material (Fig A and D) which are produced by wasps masticating cellulose and mixing it with saliva. The nests are usually found in closed spaces with small openings in natural and man-made structures. As a predator avoidance strategy, nests are often built so as to have accessibility through only small openings thus preventing predators from getting through.

Social wasps like Ropalidia spp are known to build their nests in dry, safe and strong structure with easy access to food. Males differ from females by having a weaker mandibles and lacking a stinger. The female workers are not morphologically different from the queen and are more distinguishable by behaviour. Female workers forage to feed themselves and non-foragers such as the queen, larvae and males help to build the nest and care for the larvae.

The present studies reveal not much significant relation between temperature and no. of wasps found at any given time and also there was no significant difference between temperature and the number of functional cells formed in a colony.

It was found that nest building and its initiation is highly active when food is abundant and the colony members were active throughout the year; hence they are considered to be a seasonal, perennial colony cycle.

There by, it is worth concluding that, the temperature has no much significant influence on nest building, no. of wasps and functional cells, it is highly dependent on activeness of the colony and availability of food and its abundance.

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