

Impact of Rainfall on the Nesting Activity of *Solenopsis invicta* in South China

by

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ABSTRACT

Through field observations we found that workers of *Solenopsis invicta* would make prompt repair to the nest after the rainfall as the exits were often blocked with soils in the rain. Therefore, after each rain, the mounds were significantly higher but no significant change was found in diameter. The growth of the mound volume has a very close relationship with the rainfall and its duration. The longer the rain lasted, the greater the rainfall was, the greater the nest volume grew. The results showed that the volume of mounds was not changing constantly during the year, and it was quite different in different seasons. In November each year, the fire ants grew less active as the temperature decreased, and in the following December to February, the number of fire ant nests remained at a very low level. When April began, many new nests appeared as the temperatures rose and the rainfall increased. From May to July, it rained, and some extinct and new mounds appeared at the same time. The total number of active mounds increased significantly. Between August and October, when the temperature was relatively stable with not much rain, the mound number was maintained at a stable level.

Key words: *Solenopsis invicta*; Nesting behavior; Rainfall

INTRODUCTION

Rainfall has a great impact on many aspects for fire ants such as foraging, reproduction and spread (Porter & Tschinkel 1987; Cokendolpher & Francke 1985; Morrison *et al.* 2004). Rain can reduce ants' foraging activity by 40%. Rainfall can affect the ants' recruitment by blocking the underground channels and interfering with pheromones (Porter & Tschinkel 1987), thereby reducing the competitiveness of fire ants. The number of foraging worker ants

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is positively correlated with the monthly rainfall, monthly mean temperature, monthly minimum temperature, monthly maximum temperature and monthly minimum relative humidity, but negatively correlated with the mean pressure and all these correlations were significant (Xi *et al.* 2010). Rainfall increased soil moisture and thus impacted various grades of all instars of fire ants living in the nests. Some studies have shown that rainfall has minimal impact on the workers' mortality (Hood & Tschinkel 1990), but drought greatly influenced the mortality rate of the young ants (Wang 2005). Ants are distributed in tropical and subtropical regions, where there are frequent rainfalls all the year round. The study of the effect of rainfall on fire ants' nest-building activity is of great importance for monitoring the occurrence and spread of the ants' populations. This study investigated the relationship between rainfall and the number of mounds to evaluate the effect of rainfall on the ants' nest-building behavior.

MATERIALS AND METHODS

Test site

This test was conducted on a grassland in the Zengcheng base of South China Agricultural University, and the grass and green belt in Guangzhou University.

Observation of nest-repairing behavior after rainfall

After rainfall in the field, ants' nest repair process was observed and recorded in detail.

The relationship between rainfall and the change of mound size

In early April, we selected ten active nests in the experiment and measured the length, width, height to calculate the volume. Then slender bamboo sticks marked with a scale were inserted at the top of and around the nest. After each rainfall, the height and width changes were recorded. The weather data was provided by the local weather bureau to identify the daily rainfall during the experiment.

Calculation method for mound volume

The nest volume can be calculated as $V = 4/3\pi \cdot a/2 \cdot b/2 \cdot ht$. In these equations, a is the length of the mound, b is its width and ht is its height (Tschinkel 1993).

The mound changes throughout the year

From December 2007 to November 2008, we measured the length, width and height of the tested nests which were free from interference at the end of every month, and calculated the volume according to the formula. Meanwhile we recorded the number of active mounds, extinct mounds and new mounds.

Statistical analysis

All statistical analyses were conducted using SPSS, version 14.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Nest-repair process

Through field observations we found that workers would make prompt repair to the nest after the rainfall as the exits were often blocked with soils in the rain. They would start work when it began to rain mildly, and a few workers could also be found making some urgent repairs when it rained hard. But the large-scale repair was carried out within 12h after the rain. Immediately after rainfall, there were only several exit-holes on the surface of the mound and just a few ants were repairing. Afterwards more and more workers carried soil particles to the top of the mounds, making more and more exit-holes. About one hour after the rain, there were crowded ants and exit-holes on the surface of the mound. Ants carried soil particles from the bottom or inside to the surface of the mound, piling the soil particles at the surroundings of the exit-holes, making the exit-holes more chimney-like. Then the workers constructed a cover on all the chimney-like exit-holes, which increased the height of the mounds constantly. Therefore, after each rain, the mounds were significantly higher but no significant change was found in diameter. The greater damage the rainfall caused to the nests, the more repair efforts the ants made to the nests, and the greater the volume growth was.

The relationship between rainfall and mound growth

From March 30 to April 5 the rain lasted for five days with a total rainfall of 24.6ml, and the mound growth was 90% at this period. During this time, the temperature of Guangzhou rose from 18.8 °C in March to 23.3 °C on April 5, so the temperature range was relatively large. Meanwhile this rainfall

was the largest since the beginning of 2008, therefore after the rain many new nests appeared and the volume of the nests was also growing rapidly, which showed significant change. Between April 6 and April 10, there was no rain and no new nest was found. From April 11 to 17, the rain lasted for four days with a total rainfall of 8.7ml, and mound growth was 11.07%. Between April 18 and 22, the rain lasted for three days with a total rainfall of 85.9ml, and an increase of 37.43% was found in the volume of mounds. From April 23 to 26, it rained just one day, with a rainfall of 1.6mm, so the volume of mounds did not change significantly, (2.6%) and would have been difficult to see only from the exterior without accurate measurement. From the above, we can see the growth of the mound volume has a very close relationship with the rainfall and its duration. The longer the rain lasted, and the greater the rainfall was, the greater the nest volume grew (Table 1).

The dynamics of mound volume

The results showed that the volume of mounds was not changing constantly during the year, and it was quite different in different seasons: (1) From March to April, the mounds for the ant populations could not be easily found after a cold dry winter. The number of the ants trapped during this period was only 100-130 per bottle, but the temperature began to rise during this time, so after the rain the mounds would be easily found there would be emergence of many new nests. (2) From October to February, because of the cold weather, the ants were relatively inactive in its activities including the mound-repair work, so when the rainfall was little or even none, the mound growth was not obvious. Between February and October in 2008, it rained hard for several times in Guangzhou, so the volume of the mounds was significantly reduced because of the ants did not completely fix the mounds. (3) From May to September, which was a period with high temperature and increased rainfalls, the ants became active so the number of ants trapped was 360 per bottle. During this time the ants' mound-repair work was prompt and forceful, so in these months, with the rainfall stimulation, the mounds grew very obviously fast. However, in June 2008, in which it rained for 23 days with a rainfall of 1136.9mm, and each rain was hard so the mounds grew smaller and smaller because of the persistent rain erosion. In this period, the height of mounds decreased very significantly than before the rainfalls (Table 2).

Table 1 The relationship between mound growth and major climatic factors.

Date	Average temperature (°C)	Average relative humidity (%)	Rainy days	Total rainfall (mm)	Average growth amount of mounds (cm ³)	Growth rate (%)
3.30~4.05	18.17	91.71	5	24.6	6636.72±1296.37	90
4.06~4.10	25.12	83.4	0	0.5	0	0
4.11~4.17	24.03	85.14	4	8.7	1465.41±504.39	11.07
4.18~4.22	24.42	86.6	3	85.9	3971.28±612.04	37.43
4.23~4.26	20.63	75.5	1	1.6	407.72±128.55	2.6
4.27~4.30	20.9	84.5	2	41.3	4337.07±128.55	20.07

Table 2. The relationship between mound growth and climatic factors.

Month	Monthly average temperature (°C)	Monthly average relative humidity (%)	Total rainfall (mm)	Rainy days	Average growth of mounds (cm ³)
Jan	12.6	71.39	82.6	9	0
Feb	11.1	68.24	63.9	9	-1914.68±1034.82
Mar	18.8	75.48	79.5	11	6064.59±1171.55
Apr	22.4	84.8	154.9	15	16818.2±2669.9
May	24.5	84.23	357.7	17	18876.06±2678.11
Jun	26	89.27	1136.9	23	-2176.77±1334.55
Jul	27.7	83.94	306.1	21	5478.93±2787.37
Aug	27.8	82.71	131.1	13	1789.13±387.77
Sep	27.3	80.64	103.2	11	1208.56±808.19
Oct	25	79.48	180.1	6	-1308.09±433.21
Nov	18.8	70.6	90.3	3	0
Dec	16.6	70.94	14.1	2	0

Dynamics of Mound Numbers

In November each year, the fire ants grew less active as the temperature decreased. The number of nests reduced a lot for the rain erosion. And in the following December to February, the number of fire ant nests remained at a very low level. When April began, many new nests appeared as the temperatures rose and the rainfall increased. From May to July, it rained, and some extinct and new mounds appeared at the same time. The total number of active mounds increased a lot more than before. Between August and October,

when the temperature was relatively stable with not much rain, the mound number was maintained at a stable level (Fig. 1).

DISCUSSION

Ants are mostly distributed in tropical and subtropical regions (Morrison *et al.* 2004), where there are frequent rainfalls all year, and especially humid and rainy springs, which cause certain difficulties for ant prevention and treatment. But spring and summer is a period of rapid propagation for fire ants, if we gave up prevention and control work in this period, the fire ants will thrive and expand greatly (Porter & Tschinkel 1987; Cokendolpher & Francke 1985), which will also add a huge challenge to ant prevention and control. Therefore, the full understanding of ant population changes during the rainy season is the key to developing effective prevention measures.

According to the previous report, mound height and volume were negatively correlated with temperature, and mound height was positively correlated with rainfall. The results of these studies indicate that in late summer, rainfall triggers mound rebuilding and repair but not a significant increase in size, which occurs as temperatures decrease into fall (Vogt & Smith 2007). Our field investigation found that when the rainfall intensity was 12.5mm/12h (i.e. heavy rain) few workers would even go out, but the rains with very little intensity (e.g. drizzling) had no obvious impact on the ants' mounds and outdoor activities. However, if the rainfall was heavy enough to damage the

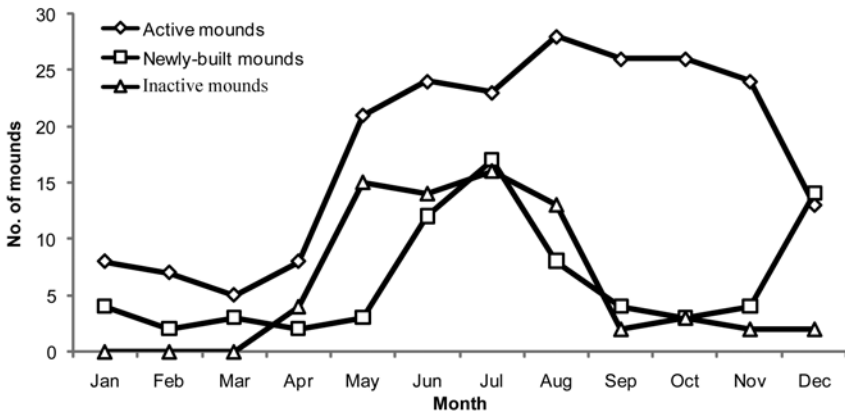


Fig. 1 Annual dynamics of of *S. invicta* mounds

mounds, the rain erosion would reduce the height of the mounds, and then ants will repair the nests, making the mounds larger than before the rain. There was no obvious change in the nest length and width, but the height change is obvious. In addition, from April to July, after each rainfall many new mounds were found, which may be due to nest-moving and nest-dividing (Zhao *et al.* 2009), or the peak of the nuptial flights at this time (Xu *et al.* 2009).

In winter when the ants are relatively inactive, although the ants make some repair work to the mounds after the rain, the size of mounds did not increase obviously, and was sometimes even smaller than before the rainfall. During the period without rainfall, no obvious change was found in the volume of the mounds. So we can see that rainfall is a key external factor for the ants' mound volume change. We can predict that rainfalls are affecting not only the nest size but also the population growth of fire ants, by comparing the annual activity patterns of ants and the curves of their nests, taking into account the significant linear relationship between volume and ant population.

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