A Study on The Behavior of A Few Ant Workers

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Abstract: It is well-known that social insects such as ants show interesting collective behaviors. To expand understanding of collective behaviors of ants, we focused on ants, Diacamma sp, and analyzed the behavior of a few individuals. We placed a few ant workers in hemisphere without a nest, food, the queen, and the trajectory of them is recorded. As a result, we found following characteristics: 1. Activity of individuals increases and decreases periodically in anti-phase. 2. Spontaneous meeting process is observed between two ants and it may cause an anti-phase synchronization.

Keywords: *Diacamma sp*, behavior of a few ants, anti-phase synchronization

I. INTRODUCTION

Many social insects have some interesting characteristics and show organized group behaviors. Especially, ants' colonies are highly organized and exhibit number of remarkable behaviors. Their colonies consist of numerous individuals and engage in nest construction/maintenance, taking care of eggs, defending, foraging and so on by well-organized division of labor. These collective behaviors do not require a special individual that controls the behavior of the entire group. Hereditarily homogeneous individuals achieve these collective behaviors by interacting with each other through direct sight or chemical materials, such as pheromones.

Many researchers have been investigating behaviors of ants[1-3] and lots of interesting results have reported. However, not so large number of researches have treated single or some ants' behaviors[4,5]. We consider that the essential point of the collective behavior greatly depends on the local interaction of a few ants, and that the observation of group behavior in a small scale provides some significant knowledge. This means, in other words, the knowledge of the relationship between the colony-level behaviors and the individual level behaviors is not enough at this stage.

Through the observation of one or more ants' behavior, we aim to describe their behavior by simple model. Modeling is one of the most effective approaches to confirm and understand the individual-level behaviors and colony-level behaviors. We aim to describe ants' behavior as the dynamics of interacting self-driven particles. By treating ants' behaviors from physical viewpoint, we aim to construct a universal model of ants' behaviors.

This kind of approach is considered to be very attractive not only for biologist and scientist but also for engineers. In robotics, especially, many researchers have investigated multi-robot systems, and some of them were inspired by such biological systems and analyzed their performance using real robot systems[6-8]. If we can construct the abstract model of ants' behaviors, it is considered to be helpful for developing useful multi-robot system.

II. METHOD

In this paper, we treat the behavior of Diacamma sp. Diacamma sp is a large ponerine ant, which live in Okinawa and several islands in Japan. Average size of the worker is about 10mm length, and their colony comprises 20 to 400 workers.

In order to analyze the ant worker's behaviors, two ants are randomly picked up and placed in acrylic hemisphere (30cm in diameter) field in our experiment. The hemisphere is covered by a transparent acrylic board during the experiment. CCD camera is equipped at the top of the experimental equipment, which size is 40cm x 40cm x 90cm height. Trajectory of the ant in hemisphere is recorded (Fig.1) and we analyze the trajectory of ants as a function of time.

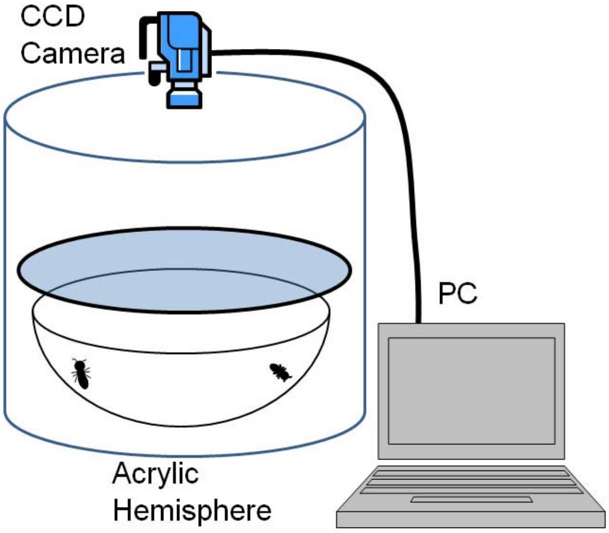

Fig.1: Experimental set up: Trajectory of ants placed in hemisphere is recorded from above.

III. RESULTS

We analyzed two ants' behavior. As same as the case of single ant, we made some trials using some individuals under the same condition. We discuss the feature using some typical results.

1. Trajectory

Fig.2 shows the trajectory of two ants overlapped in one picture. Green circle denotes the place where the distance of two ants is less than one body length, which is regarded as a meeting spot of two ants. High density spot of trajectories overlaps with meeting spot of two ants. It can be concluded that two ants meet at the certain position.

2. Velocity

Typical time series of each ant's velocity is shown in Fig.3. Individual activity is same as the case of single ant, i.e. the ant walks actively in the first 60 - 100 minutes, and after that, the movement gradually decreases and eventually becomes inactive at 100 minutes. After 100 minutes, they repeat active and inactive role. Even when two ants are in the experimental field, each ant has some rhythmic component in its activity.

3. Power spectrum of the velocity

The spectrum of their velocities is shown in Fig.4. We can see a peak at 0.064 /min, i.e. approximately 16-minute periodicity in each ant.

From the analysis of power spectrum, we know both ants have the same frequency component.

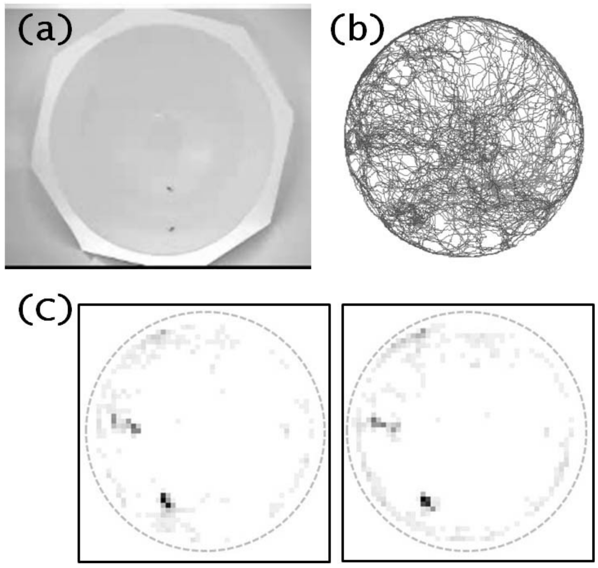

Fig.2: (a) A snapshot of experimental field. (b) Overlapped trajectories of two ants. Some high density area can be seen. (c) Existing rate of ant A (left) and ant B (right) in the field. The rate is expressed the darkness.

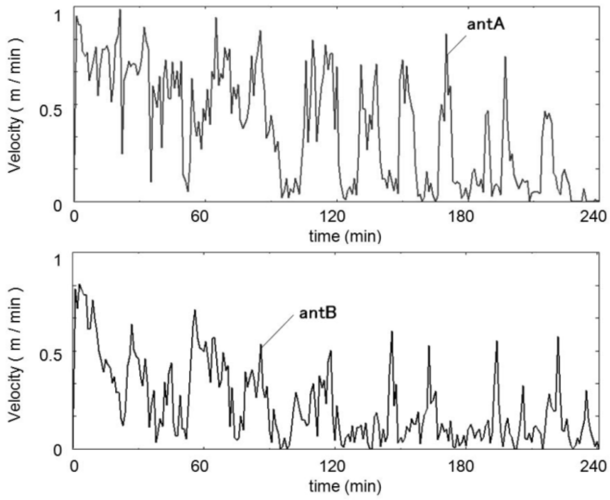

Fig.3: Time series of two ants' velocity. After 100 minutes, they repeat active and inactive role.

Next, we focus on the phase of their active-inactive repetition. Do they oscillate in the same phase or antiphase? For simple analysis, we binarize their activity based on the average velocity, and calculate $d = A - B + 2AB$, in which the activity of ant A and ant B is denoted as A={0,1}, B={0,1}. Here we show two examples in Fig.5.

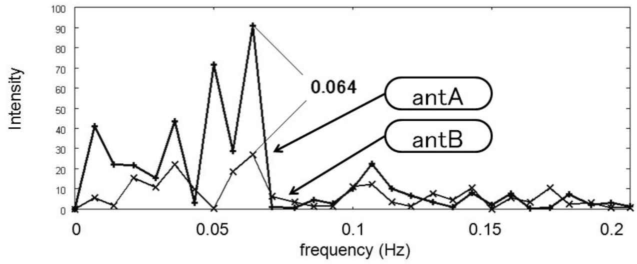

Fig.4: Power spectrum of two ants' velocity.

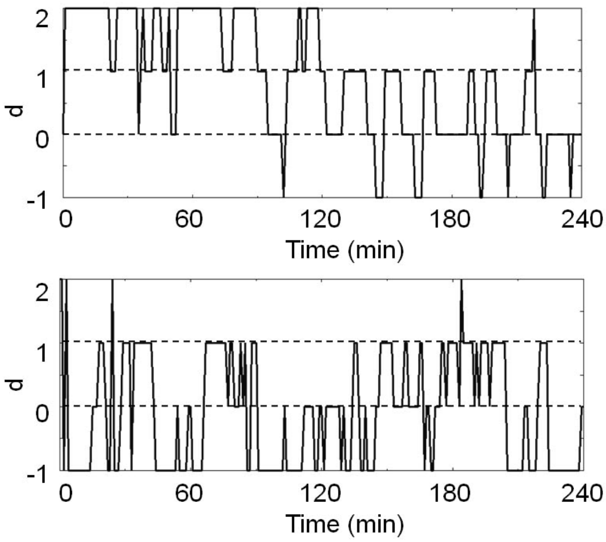

Fig.5: Two examples of two ants' active-inactive phase.

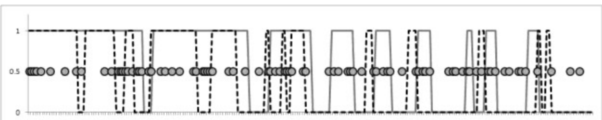

Fig.6: Binarized behavior of two ants (lines) and the moment they have a physical contact (plot).

Discussion and conclusion

In Fig.5, we can see the repetition of 1 and -1 in both cases. It means active-inactive behavior of ant A and ant B is alternately turned on and off in antiphase. In addition, spontaneous physical contact process is also observed between two ants as shown in Fig.6. These results imply that the contact process may cause the anti-phase synchronization.

In order to shed light on the collective behavior of ants, we analyzed the behavior of a few ant workers. From this bottom-up approach, we conclude following points;

1. Spontaneous contact process is observed between two ants.
2. Periodic behavior of two ants synchronizes in anti-phase.
3. It is considered that the contact process causes the anti-phase synchronization.

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