Autonomous Workload Regulation Mechanism in Foraging Ants

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As the basic mechanism to enable task allocation in ant colonies without a leader, the primary role of the caste system has been discussed [1], through which system, specific tasks are autonomously assigned to individual workers according to their size, age, and other factors. Even among specialized ants that are involved in the same task, a hierarchical structure, namely, a heterogeneity of workload is observed.

In the present study, we introduced an experimental system to observe the statistical behavior of colonies of ants, *Camponotus japonicus*, using tiny RFID tags attached to the bodies of all ants in 5 colonies (Fig.1) [4]. By analyzing the "big data of ant society" focusing on foraging behavior obtained through more than three months of continuous measurement, we found various kinds of statistical characteristics of the ant society; i)The emergence of the foraging workload hierarchy, namely, the heterogeneity of the diligence on foraging task, that obeys a simple mathematical form of distribution, ii)Autonomous workload compensation after the separation of each colony into two different groups; the diligent half before separation, and, the lazy half, and, iii)The slowly decreasing correlation of rank-order of diligence with a characteristic duration of a month.

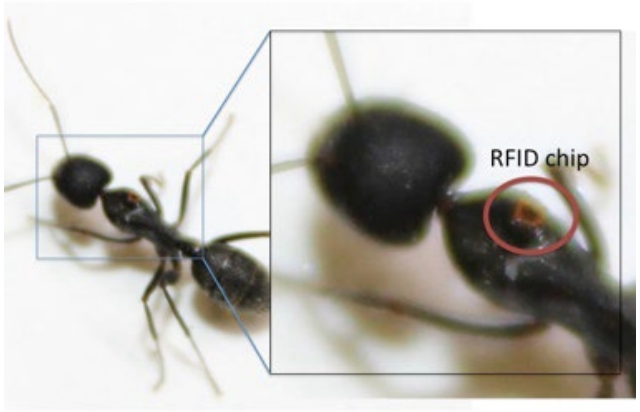

Fig.1 RFID tag is affixed to the center of the red circle in the enlarged image.

As a mathematical model to numerically reproduce the characteristic behavior of social insects; ants and bees, the response threshold model [3] is widely known. To analytically treat the response model, we introduce a corresponding master equation. In conjunction with foraging behavioral data obtained through the above-mentioned long-term observation using tiny RFID tags [4], we found that a master equation approach is effective in quantitatively describing the statistical features of the collective foraging-task engagement of ants. Specifically, the following two kinds of statistical characters related to the autonomous workload compensation in ant colonies were indicated; i) Response threshold θ for starting the foraging task is not uniformly nor normally distributed but largely skewed among ants in each colony(Fig.2). ii)Foraging-task in a colony is carried only by a small fraction of workers in a colony.

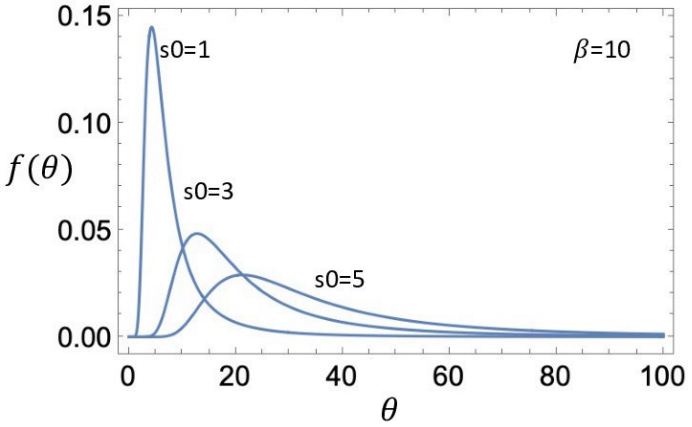

Fig.2 Estimated distributions of the response threshold f (θ) of the foraging task through the combinatory analysis of master equation and the experimental outcomes of the goraging activity of Camponotus japonicus's colony. The shape of f (θ) varies according to the experimentally unconfirmed values of parameters, α, β, and δ. However, if β is fixed, the change of α and δ is reflected in s0, then, all graphs overlap after rescaling.

References

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