Research predicts growth, survival of 'superorganism' ant colonies

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(Phys.org)—Smaller ant colonies tend to live faster, die younger and burn up more energy than their larger counterparts, as do the individual ants that make up those colonies, according to new research that views the colonies as "superorganisms" in which social insects function much like the cells of a body.

The research, published in the Dec. 23 issue of the journal Biology Letters, describes a new mathematical model that can predict the survival, growth and life span of ant colonies. Dr. Chen Hou, an assistant professor of biological sciences at Missouri University of Science and Technology, is one of the authors of the study and developed the mathematical models used to predict colony growth and survival.

Hou also collected some of the data used for the *Biology Letters* study, titled "Towards a general life-history model of the superorganism: predicting the survival, growth and reproduction of ant societies."

In the article, Hou and his colleagues compared the rates of metabolism, growth, reproduction and longevity of individual ants with those same traits for entire colonies. He based his models on Kleiber's Law, the observation that the metabolic rate for organisms - the rate at which they process and use energy over time - tends to increase at a rate that is to the 3/4 power of that organism's body mass. Named after Max Kleiber's biological work in the early 1930s, Kleiber's Law is also known as "quarter-power scaling."

As Hou explains it, a horse may be 10,000 times heavier than a mouse, but it doesn't consume 10,000 times more energy. Applying quarter-power scaling, researchers can determine that a horse, which is 10,000 times larger than the mouse, only consumes 1,000 times more energy (because 10,000 to the 3/4 power equals 1,000).

The same phenomena holds true at the cellular level, Hou says. Two similar organ cells from two different organisms -a mouse and a horse, for instance - do not use proportionately equal amounts of energy. "The one from the horse needs and uses much less energy than the one from the mouse," even though both cells have the same purpose and function, Hou says.

In ant colonies, that same phenomenon applies, Hou and his colleagues point out in the *Biology Letters* study. The ants behave more like the cells of animal and their colonies more like the animal itself - which is why the researchers classify colonies as "superorganisms." The individual ants of larger colonies consume and use less energy than their counterparts in smaller colonies, just as the cells of a horse consume and use less energy than the cells of a mouse.

Combining data from actual ant colonies with predictions based on mathematical models, the researchers found that body mass and metabolic rates increased at a consistent, nearly three-quarter-power scaling rate for worker ants and queen ants alike, as well as for their colonies.

Based on these findings, the researchers then developed a mathematical model to predict colony lifespan by linking it with colony size, or mass. They found that the larger colonies tended to live longer and use less energy than smaller colonies.

The research is a continuation of a 2010 study Hou and his colleagues published in the *Proceedings of the National Academy of Sciences*. In that paper, the researchers introduced the idea that insect societies operate like a single superorganism in terms of their physiology and life history.

Hou is first co-author of the *Biology Letters* article with Dr. Jonathan Z. Shik of North Carolina State University. Other contributors to the study are Dr. Adam Kay of the University of St. Thomas in St. Paul, Minn.; Dr. Michael E. Kaspari, Presidential Professor of Biology at the University of Oklahoma; and Dr. James F. Gillooly, associate professor of biology at the University of Florida.

Other researchers are taking quarter-power scaling and applying it to entire cities, to determine whether they too function as "superorganisms" in some respects, such as energy usage. For instance, says Hou, Dr. Geoffrey West, a theoretical physicist and past president of the Santa Fe Institute, and his colleagues found that "proxies of city energy usage, such as number of gas stations, total length of electric cables and so on, scale sub-linearly with the size of the city," says Hou.

"Just like the examples of ants and cells, between two similar people, the one living in the bigger city is more energy-efficient," Hou says. "As you can imagine, the number of gas stations per capita is smaller in New York than St. Louis, and smaller in St. Louis than Rolla, which means more people share one gas station in New York than in St. Louis, than in Rolla."

Hou, an expert in animal energetics, applies similar energy scaling laws to study how animals uptake energy during growth and how they allocate that energy to growth, health maintenance and reproduction. Recently, his focus has been on the effect of food restriction on extending the animals' life spans.

Provided by Missouri University of Science and Technology

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