Engineering a symbiotic relationship between E. coli and stinkbugs reveals clues about how symbiosis develops

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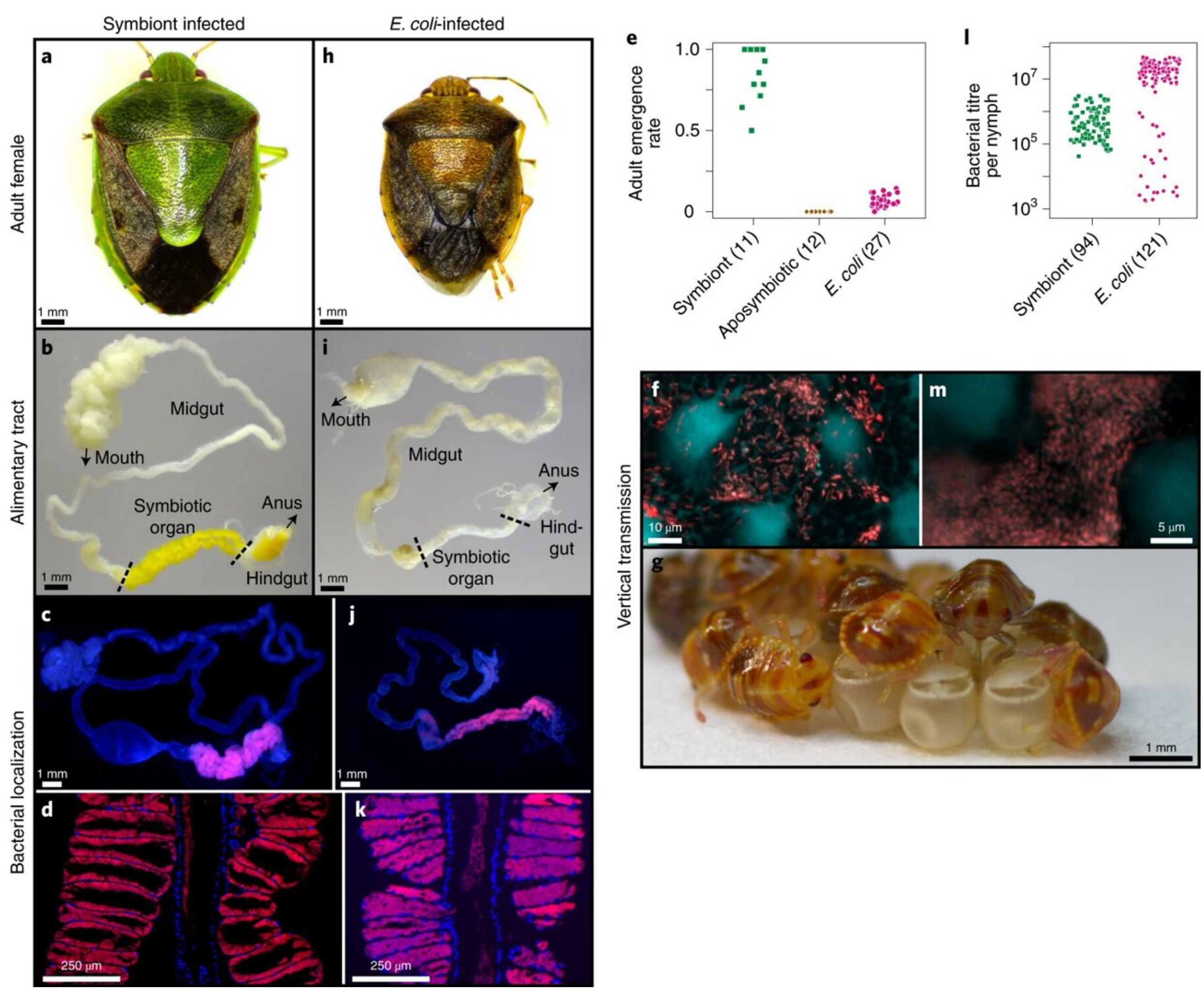

Infection, localization and vertical transmission of E. coli in the gut symbiotic system of P. stali. **a**, Normal symbiotic adult female, large in size and green in color. **b**, Dissected alimentary tract, in which the symbiotic organ is well developed and yellow in color. **c**, FISH localization of symbiont cells to the symbiotic organ. **d**, Magnified FISH image showing symbiont localization to crypt cavities of the symbiotic organ. The image is reconstructed by merging three microscopic images. **e**, Adult emergence rates of newborn nymphs inoculated with normal symbiont (*Pantoea* sp. A), no bacteria (aposymbiotic) and *E. coli*. **f**, Symbiont cells smeared on egg surface. **g**, Newborn nymphs sucking symbiont cells from the eggshell (Supplementary Video 1). **h**, *E. coli*-infected adult female, dwarf in size and brown in color. **i**, Dissected alimentary tract, in which the symbiotic organ is atrophied. **j**, FISH localization of *E. coli* to the symbiotic organ. **k**, Magnified FISH image visualizing *E. coli* localization to crypt cavities of the symbiotic organ. **l**, Bacterial titres in symbiont-inoculated and *E. coli*-inoculated nymphs 1 d after second instar moult in terms of *groEL* and *nptII* gene copies per insect, respectively. **m**, *E. coli* cells smeared on the egg surface. **e**,**l**, The numbers of biological replicates are shown after the strain names. Level adjustments without non-linear change were applied to **c**, **d**, **f**, **j**, **k** and **m**. Credit: *Nature Microbiology* (2022). DOI: 10.1038/s41564-022-01179-9

A team of researchers with members affiliated with several institutions in Japan has learned more about the process involved in the development of natural symbiotic relationships by engineering an artificial one between E. coli and stinkbugs.

In their paper published in the journal *Nature Microbiology*, the group describes how they forced a symbiotic relationship between the bacteria and the insect and what doing so showed them about the evolution of such relationships. Martin Kaltenpoth, with the Max Planck Institute for Chemical Ecology, has published a News & Views piece in the same journal issue outlining the work done by the team in Japan.

Prior research has shown that there are very large numbers of examples of symbiotic relationships in the natural world—the bacteria in the human gut that help process food, for example. But little is known about how such relationships come to exist. In this new effort, the researchers sought to learn more about the process that can lead to very different creatures benefiting mutually from each other's abilities.

The work by the team involved removing Pantoea sp. bacteria from crypts in the gut of several stinkbugs—prior research has shown that the bacteria is necessary for its survival—and replacing it with E. coli. Predictably, just five to ten percent of the stinkbugs survived. Also, those that survived were not very healthy—they turned from green to brown and shrank in size.

The researchers collected E. coli from the healthiest bugs and placed them in the next generation. They did this over and over for successive generations until the stinkbugs began to look healthy again. Once they became as healthy as those in a control group, the researchers collected samples of E. coli from them and undertook a genetic analysis of them to find out what sorts of changes they had undergone to make them useful to the stinkbug.

They found that just one mutated gene made the difference—one that was involved in disrupting the carbon catabolite repression pathway. The researchers were not able to pinpoint why exactly such a mutation made a difference but suspect it had to do with helping the stinkbug get rid of unhealthy carbon sources. They also note that their work has opened the door a little bit to understanding how symbiotic relationships evolve.

More information: Ryuichi Koga et al, Single mutation makes Escherichia coli an insect mutualist, *Nature Microbiology* (2022). DOI: 10.1038/s41564-022-01179-9

Martin Kaltenpoth, Fast track to mutualism, *Nature Microbiology* (2022). DOI: 10.1038/s41564-022-01188-8