heat

The intense cooperative organization of behavior - to maintain *precise year-round temperature regulation of the brood comb* by the bees in their hive - is a central feature that defines each entire *Apis mellifera* ***colony*** as the relevant individual of the species, the *superorganism*. The colony is the unit which must successfully survive and reproduce itself, the unit experiencing selective pressures at the hand of nature.

In the heat of summer, air conditioning is provided by collection and coordinated distribution of water over the comb surfaces and ventilation by fanner bees, generating circulation of air that promotes evaporative cooling of the brood comb, where the larval sisterhood must be kept between 92 and 97 deg. F (33 to 36 deg. C) for proper development. Energy for this activity is supplied by honey, since carbohydrates are the fuel source of honeybee flight muscle.

For thousands of years, humans have collected honey from the hive, first by destructive methods and, more recently, by manipulating hives to encourage overproduction of honey, harvesting the surplus and leaving the hive intact. (Only much more recently, with the booming of the human population, which has required industrialization of agriculture and massive monoculture crop techniques, have the hard-to-duplicate pollination services of the honeybee become the prime focus of most commercial beekeepers.)

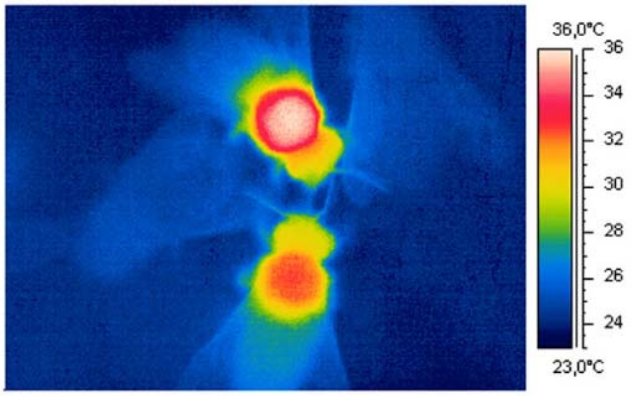


Figure 1. Close-up thermogram of honeybees. Left and right: ectothermic bees (light blue: $T_{thorax} = 25.2°C$ and 24.9°C). Top and bottom: endothermic bees (white: $T_{thorax} = 35.6°C$; orange: $T_{thorax} = 32.4°C$). $T_a = 25°C$, $T_{cell\ rim} \sim 24°C$. Measurement performed in a peripheral area of an observation hive during high cold stress ($T_{exp} = 20°C$).
doi:10.1371/journal.pone.0008967.g001

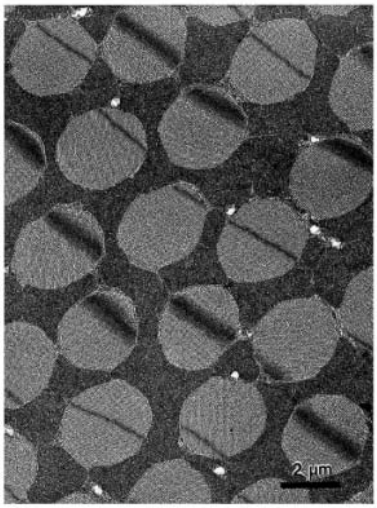


Fig. 1. Electron micrograph showing flight muscle myofibrils in cross section surrounded by abundant mitochondria. The latter appear darker because of their high cristae surface density. Small white areas are tracheae in cross section. Scale bar, 2 µm.

During the cooler months and in winter, however, the true importance of honey to the bee can be understood. Fully 2/3 of honey produced by a colony is consumed for the purpose of heating the comb in its hive. Shivering of thoracic muscles – and the waste output of heat by rhythmic contraction of striated muscles which power the wings for flight - is the furnace that heats the winter cluster. As in most other hive activities, however, a complex, coordinated interaction - communicated among many bees serving varied roles - is used to deliver elegant functionality.

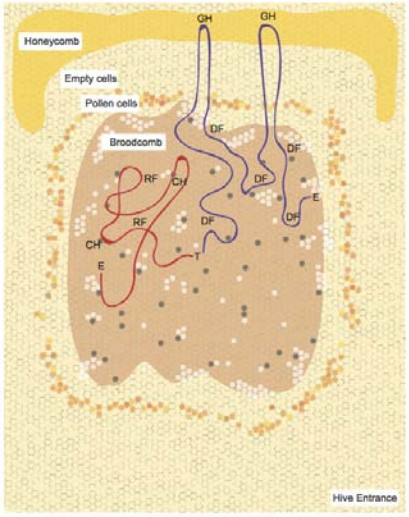
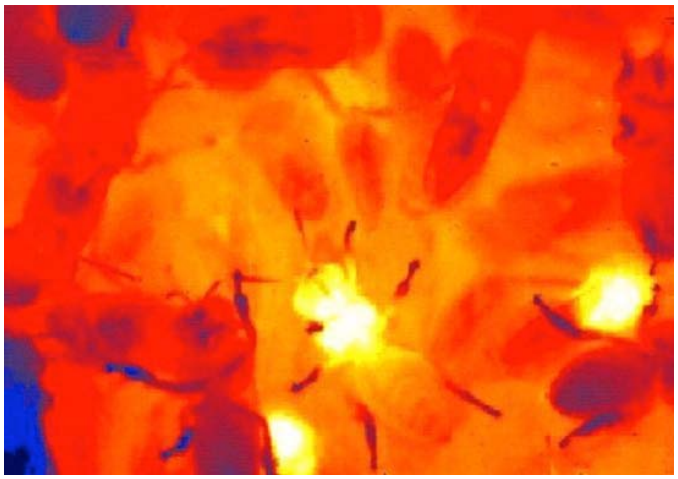
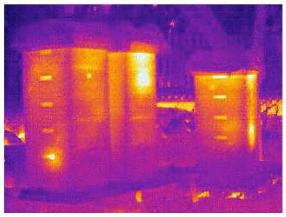
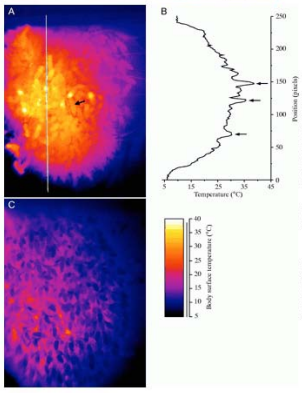


Fig. 1. Map depicting the position of broodcomb and honeycomb in a two-frame observation hive. The different areas and the cell contents in the hive with tracks of a donor bee (blue line) and a receiving bee (red line) after the trophallactic contact give an example of how the data was collected. The different behaviours of donor and receiving bee are abbreviated (T = trophallaxis, RF = receiving food, DF = donating food, CH = cell-heating, GH = gathering honey, E = end of observation). The "shuttling" behaviour of the donor bee is noticeable by the tracks which lead to the honeycomb and back to the broodcomb which is how they



Bee Hives - in Infrared





"Fig. (A) Infrared thermogram of the bees on the central comb of a broodless winter cluster (3.5 s after cage opening was started, FLIR ThermaCam SC2000). Note the warm thorax (yellow and white spots) of the endothermic bees with shivering thermogenesis. Two additional measurements in the same cluster confirmed this finding (not shown). The arrow points to the queen. Bees that visited the surface are visible at the lower left end of the cluster.

(B) Temperature profile along the line marked in A; arrows mark the thoraces of endothermic bees hit by the line.

(C) Infrared thermogram of the bees on the flat side of an outer comb (same cluster as in A); one (periphery) to four (centre) bee layers. Ambient temperature was 5.5°C 3 cm beneath the cluster and 3.7°C 1m outside the open cluster cage." Full article

The attached references give an idea of what is going on inside the hive as late fall turns to winter.

http://imagessays.com/#/heat/

image sources:
http://jeb.biologists.org/content/203/5/905.full.pdf+html
http://jeb.biologists.org/content/206/2/353.full.pdf+html
https://www.bienenforschung.biozentrum.uni-wuerzburg.de/uploads/media/ZOOL25132.pdf