Bee Clusters in Winter

Honey bees play it both ways during the winter- they act both as 'cold-blooded' insects, and as a 'warm-blooded' super organism. There are a few reasons that this is advantageous.
First, an individual bee reaches 'chill coma' at about 44°F(6.7°C), and will die if held at the edge of freezing for a few days. So the cluster must generate and conserve enough heat to keep all members of the colony at least above that temperature for the duration of the winter.
This process requires only a small amount of honey consumption - less than a pound a week, even under severely cold winter conditions. The cluster must also maintain the ability to warm up enough to move, to reach new areas of the hive in order to access their food stores.

This is how the winter cluster forms:

- There is a fairly loose core of bees in the centre that maintains a temperature of about 80-95°F(26-35°C). In small clusters, the core temperature may drop to 60-70°F (15-20°C).
- Around the core, there is a tightly packed layer of bees that maintain a temperature of about 56°F(13°C). A critical temperature, below which the cluster will die.
- At the very outside, or 'mantle' of the cluster, individual bees do not allow their body temperatures to drop below about 44°F, which i s just above their 'chill coma' temperature. These bees may burrow deeper into the cluster from time to time and very rapidly raise their body temperature, then return to the mantle after several hours. And if a bee's temperature falls below 45°F(8°C) it is no longer able to flex its muscles to generate heat.
- The actual cluster size is dependent upon the ambient temperature - it can expand or contract to an amazing extent.

The core of the cluster is an otherworldly environment. The bees actually modify the atmosphere in order to allow themselves to enter into a 'hypoxia-induced ultra-low metabolic rate', (Van Neuman 1997). They restrict ventilation in the oxygen content to drop from the normal 21% down to only about 15%, and allow CO2 to rise to 5-6% (up from 0.038% in normal air). This atmosphere would be toxic to humans, but allows the bees to go into a form of suspended animation.
Water loss in the winter cluster is very important. Insects lose water vapour with each breath, just as mammals do, but they have no source of drinkable water within the winter hive. In cold winter areas, the extremely low moisture content of the air means that when the cluster creates heat, that the relative humidity of the cluster atmosphere drops extremely low. Insects in hold their breath, (for up to a day at a time), in order to prevent water loss. And it likely that
bees in the cluster do the same. When animals and bees metabolise carbohydrates, such as sugar, they create 'metabolic water' as a byproduct. If the bees can conserve this metabolic water enough to be in excess of that lost to respiration and any body waste, then they can actually realize a net gain of water.

So how much water do bees get out of honey? A pound of honey at 83% sugars, contains 0.17 lb of water, and creates 0.48 lb of metabolic water, for a total of 0.65 lb of water freed from each pound of honey consumed. That means
that a colony typically consuming 0.8 lb of honey a week, (Holte 1970), would produce about a half a pound (1 cup) of water per week. It may be a challenge for a large colony to live on this amount of water - so good reason to
provide an available source of water; together with hive insulation, and good hive ventilation for your winter bees