Proteins, Honey Bee Nutrition and Amino-B Booster™

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Abstract: We discuss proteins, amino acids, honey bee nutrition, pollen digestion by honey bees, and introduce a new product, Amino-B Booster™. The new product is a Proprietary Apiary Blend of selected amino acids that provides all necessary nutrition for assimilation of protein. Amino-B Booster™ is added to sucrose sugar syrup with Honey-B-Healthy® (HBH) and fed to bees at times when pollen is not available or pollen protein is deficient. Free amino acids are rapidly absorbed in the midgut and delivered to growing tissues. Several benefits to honey bees and to beekeepers are listed.

Key words – Amino-B Booster™, amino acids, proteins, pollen, honey bee nutrition, Honey-B-Healthy®.

Honey bees need protein in their diet for production of cuticle, muscle, glands, cell walls, enzymes, etc. The bees obtain protein by digesting pollen grains in the midgut. Different pollen types have different amounts of protein (Bell et al. 1983; De Groot 1953; Honeybee Australis 2010; Oliver 2010; Somerville 2005; Stace 1996; Wikipedia 2010).

Pollens relatively rich in protein are those plants that are insect or bee-pollinated: dandelions, apples and other fruit trees, clovers, alfalfa, false indigo, and many other plants. Even some of these may be deficient in one or more essential amino acids.

Pollens poor in protein are most grasses, sedges, conifers, ragweeds, and other plants that have wind as a pollenizing agent. These will not support growth of honey bees.

In all cases, the needed protein is digested in the honey bee midgut. When eating pollen, the bees must secrete enzymes into the midgut lumen; these must then penetrate the tough pollen grains where the various proteins (if present) are digested into smaller fragments called peptides and polypeptides until finally, the protein is digested to free amino acids. These small molecules are then able to be absorbed by the midgut cells where they quickly enter the hemolymph, or are transferred to various hemocytes [blood cells] which circulate throughout the body, carrying the needed amino acids to growing tissues, glands, muscles, etc. The tough pollen grains often limit the amount of the pollen that can be digested (Bell et al. 1983) to a fraction of that which may be present. Bees need a wide variety of pollens in order to insure adequate nutrition (Somerville 2005).

The following 21 amino acids (AA) are found in most animals and honey bees. Essential AA [must be in the diet]: isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Nonessential AA (* = essential in some situations): alanine, asparaginine, aspartic acid, cysteine*, glutamic acid, glutamine*, glycine*, proline*, selenocysteine*, serine*, tyrosine, arginine and histidine. The nonessential AA can be produced in the bees by secondary metabolism from the eight essential AA (Wikipedia.org 2010). In many pollens in Australia, isoleucine is a limiting amino acid; de Groot found that the threshold of good development of bees requires a minimum of 4mg isoleucine per 16 mg protein (De Groot 1953, Somerville 2005, Stace 1996). In our opinion, the availability of free amino acids in the diet circumvents this limitation.

Feeding "Amino-B Booster™" to Honey Bees.

We began experimenting with a proprietary free amino acid blend, "Amino-B Booster™", in late January 2009. The blend

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Figure 1. Three half quarts of feeding mixes were placed on the top of a colony late December, 2008. Within a short time many bees were clustered on the HBH/Amino-B Booster™ jar on the right with only a few bees on the Amino-B Booster™ mix in the center and HBH mix on the left.

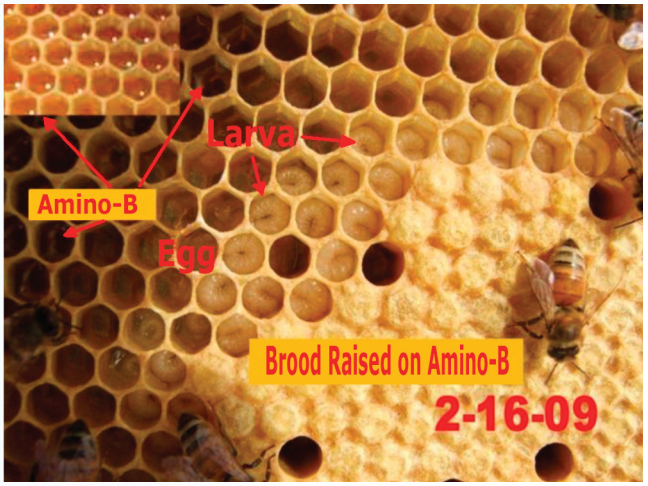

Figure 2. Brood raised in early February, 2009, in Cumberland MD, from the feeding of Amino-B Booster™ in sucrose sugar syrup (1:1) with Honey-B-Healthy®. The amino jelly is stored in a band around the brood. Inset shows a close-up of the amino jelly which stays liquid and is not capped.

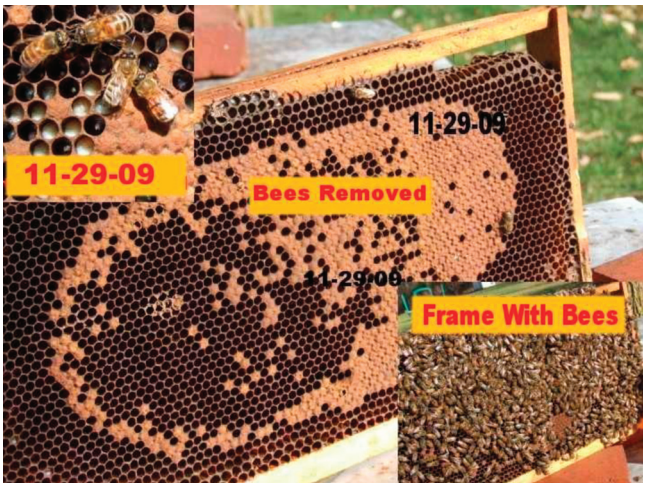

Figure 3. Brood produced in late October and November 2009 as a result of feeding of Amino-B Booster™ in sucrose sugar syrup (1:1) in Cumberland, MD; date of photograph is 29 Nov 2009. Lower right inset shows bees covering the brood frame taken from the hive. The center frame shows brood after bees are shaken off. Upper left inset is a close-up of the brood and bees.

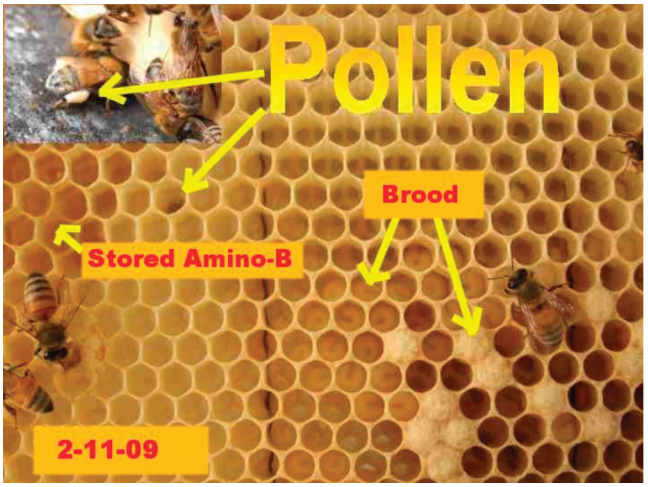

Figure 4. On a warm day in Feb. 2009 (Cumberland, MD) the bees were observed carrying pollen (inset) and a cell with a bit of pollen was found. The amino jelly was stored in cells where pollen is typically stored, in a band around the brood.

contains 20 amino acids including all of the essential amino acids and most of the non-essential amino acids.

Ingesting free amino acids with Honey-B-Healthy® in sucrose sugar syrup provides a distinct set of advantages to the honey bees.

1. The bees do not need to secrete enzymes into the midgut to digest protein.

2. Pollen grains with their tough exines do not need to be penetrated to obtain the protein.

3. The free amino acids are absorbed immediately by the midgut cells.

4. The ratio of amino acids is not critical; the bees immediately acquire and absorb the amino acids they need. Proteins in pollen must have specific AA in minimum levels to allow adequate digestion of the protein and assimilation of the needed AA (Stace 1996). Free AA in the diet circumvents this restriction.

Bees flocked to the Amino-B Booster™ & HBH sugar syrup feeders (Figure 1) in greater numbers than to any other syrup we have tested. The syrup is rapidly converted by the bees into 'amino jelly' and stored with the HBH which acts as a preservative plus providing the benefits of HBH. The amino jelly is placed in cells in the pollen-cell zone of brood frames (Figure 2). The amino jelly is then available in the brood nest for feeding larvae, newly emerged bees and other adults as needed.

Protein is cycled in worker bees as follows: first, to the food glands in the head: the mandibular and hypopharyngeal glands (young nurse bees, ages 1 d to ~12 days, need the protein to produce the rich secretions for bee milk and royal jelly). Then, to the 8 wax glands in the abdominal sternites, which increase in size and sequester protein to make the many enzymes in order to rapidly secrete high quality wax. The protein is then broken down to free amino acids and moved to the flight muscles for the foraging bees. All of these transfers of protein require considerable secondary metabolism to convert some of the old proteins to amino acids for transport. This overall plan can be reversed, depending on the needs of the colony.

By providing free amino acids in Amino-B Booster™, all of these processes can be improved and accelerated: food glands can theoretically grow larger and secrete richer proteins and vitellogenin. Wax glands can grow more quickly as amino acids are provided direct from the diet and need not be rapidly sequestered from the food glands. Flight muscles can grow more rapidly in bees > 18 days old for the same reason.

Our experiments show that feeding Amino-B Booster™ in early spring, during dearth and in the fall leads to immediate brood production in the hive. This can be a good thing if you are moving bees into early pollination contracts or preparing for honey production from plants that have an early bloom, such as the Autumn Olive (*Elaeagnus umbellata* Thunb., Elaeagnaceae) in WV.

Brood production at the wrong time can stress hives during severe winters or stress hives that are in weakened condition without sufficient honey stores. Increased brood production requires a great increase in honey consumption in order to maintain the 94° F (34° C) degree brood temperature. For this reason, we recommend that Amino-B Booster™ not be used after September in most cases, unless you are preparing bees for movement into almonds and/or other early crops in February or March, and your bees have sufficient honey to support the higher brood temperatures.

Rapid increase of brood production will encourage swarm production by many colonies; beekeepers need to be ready to control swarming or be ready to produce nucs and make divisions to keep up with the rapid increase in bee populations.

Autumn bees go into winter with up to 67% stored protein and vitellogenin in the fat body, and draw on this body-protein during winter stress and to raise late winter brood if needed when there is poor, low or no pollen stores in the hive. They can consume body-protein to create royal jelly and bee milk to feed their brood. "The level of body protein in adult bees ranges from 21% to 67% in direct relationship to the quantity and composition of available pollen protein and work load imposed by reproduction and honey collection" (Kleinschmidt and Kondos 1977).

In late January of 2009, all pollen was removed from four colonies (Figure 2) and they were fed HBH/ Amino-B Booster™ syrup and we were amazed to see healthy brood raised from this one test before learning about stored body protein and Amino-B Booster™ being a source of protein; not a complete diet. More research needs to be done to see if Amino-B Booster™ will be a viable product for beekeepers, especially commercial beekeepers preparing for almond pollination who can possibly double their colony sizes on syrup feedings alone. And for queen breeders who need an early amino acid jump-start in order to produce healthy, hardy queens. The bees store the amino jelly as they do pollen (see Figure 2 top left).

On Oct. 10, 2009 all of our colonies were void of brood except for the four that were fed Amino-B Booster™; we removed the feeding jars on this date. On Oct. 28 we began to feed one colony not previously fed Amino-B Booster™. On Nov. 09 we found brood; and much more brood on Nov. 29 (Figure 3) and continually through Decem-

ber, 2009, and January, 2010. The bees had a few frames of brood all winter in this Amino-B Booster™ fed colony. This was only a test and is not recommended to do prior to long winter clustering.

Figure 4. On a warm day in Feb. 2009 the bees were observed carrying pollen (inset) and a cell with a bit of pollen was found. After four days of the bees not flying, Feb. 16, the small bit of pollen was gone: consumed by the bees. This observation proves that the bees, even though feeding on HBH/Amino-B Booster™ syrups, will still gather pollen; their natural protein supply. Therefore, the HBH/Amino-B Booster™ feeding does not appear to interfere with the bees normal nectar or pollen gathering.

Amino-B Booster™ is being released in 2010 on a limited basis [test market by Dadant & Sons].

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