



Review

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EFFECTS OF NEURAL GENE EXPRESSIONS ON GROOMING BEHAVIOR IN HONEY BEES

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Abstract


Grooming behavior, which is one of the behavioral resistance mechanisms based on the genetic basis in honeybees, is a defense response against parasitic mites, especially *Varroa* mite. In recent years, scientists and beekeepers have focused on bee breeding in terms of grooming behavior, because honey bees showing grooming behavior have the potential to can protect themselves against *Varroa destructor*. It is of great importance to determine the genes and gene regions related to this behavior before starting the breeding studies in terms of grooming behavior. In this respect, the right honey bee species or races can be selected and the success rate will increase. In researches, it was found that bees exhibit different grooming behaviors level according to species and races. Therefore, some species and races were found to be more successful than others. Especially in neural, developmental, detoxification and health-related gene expression studies, it has been shown that some gene expression is in direct proportion to the intensity of grooming behavior. While the genes responsible for grooming behavior are not known exactly, studies are underway to solve the genetic mechanism of this behavior. In this study, we reviewed the effects of neural gene expression on grooming behavior.

Keywords: Neural gene, Grooming behavior, Honey bee

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1. Introduction

Honey bees have important roles in food production and pollination of plants, as well as a model animal for studies on the molecular and neural basis of social behavior (Kamikouchi et al., 1998; Rybak and Menzel, 1998; Menzel and Giurfa, 2001; Takeuchi et al., 2001; Takeuchi et al., 2002; Kucharski and Maleszka, 2002; Kiya et al., 2007; Sen Sarma et al., 2009; Kaneko et al., 2013; Boylu and Önder, 2019). These social insects with economic value have been threatened in recent years by Colony Collapse Disorder (CCD) caused by

different factors such as pathogens and parasites. It is clear that the number of individual and social bees decreases, even though there is a debate on whether there is a global pollinator crisis (Allsopp et al., 2008; Ghazoul 2005a; Ghazoul 2005b; Steffan-Dewenter et al., 2005). Honey bees are susceptible to various diseases and environmental threats that have significantly increased over the last 10 years (Genersch, 2010). Among these factors ectoparasitic mite *Varroa destructor* is the biggest threat to beekeeping. No other pathogen has had a similar effect

on beekeeping and honey bee researches throughout the history of beekeeping (Rosenkranz et al., 2010). The *Varroa destructor*-infected colony, which feeds on the hemolymph of the larvae and adult honey bees, collapses in 2-3 years. Various chemicals used for Varroa control did not achieve the desired success because mites develop resistance to these chemicals (Pettis, 2004; Maggi et al., 2010). More importantly, these chemicals negatively affect human health by leaving residues in bee products. For these reasons, scientists and beekeepers have focused on Varroa resistant bee breeding. Resistance mechanisms in honey bees work with behavioral, physical and immune system pathways. Behavioral resistance is a highly preferred strategy in Varroa control studies. This natural mechanism is more harmless and sustainable than chemical control. Behavioral resistance is generally examined under two headings as grooming behavior and hygienic behavior. The most well-known behavioral resistance mechanism in honey bees is hygienic behavior. This behavior was first described by Park (1937). It comprises detecting diseased brood in the larval and pupal stages and removing all infected brood, thereby decreasing the infection (Arathi et al., 2000). Hygienic behavior has been shown to be an effective behavioral mechanism against many diseases and Varroa parasites (Laidlaw and Page, 1997). Grooming behavior is relatively simple, involving removal or destruction of adult mites on the external surfaces of adult bees (Pritchard, 2016).

2. Grooming Behaviour

Grooming behavior, which is one of the mechanisms of behavioral resistance in honeybees, is a common strategy for getting rid of ectoparasites among vertebrates and arthropods (Aumeier, 2001). This behavior of bees has evolved to protect both individual and colony health (De Figueiró Santos et al., 2016). Grooming behavior is named in two ways according to the way it is performed: auto-grooming or self-grooming and allo-grooming or social grooming. Auto-Grooming is the self-cleaning behavior with the movement of mouth parts or pro- / mesothoracic legs. Allogrooming can be one-on-one, or socially involving several bee acting together. During social grooming, bees use their mouth parts to remove mite and debris of mite from the wing bases and other body parts of other bees (Milum, 1947).

The grooming dance involves quickly self-cleaning with the legs and wagging and bending of the body of the bees (Milum, 1947). This provokes social grooming behavior in temporarily specialized groomer bees, and often clean several other bees in a row (Kolmes, 1989).

It is known that bees exhibit different grooming behaviors according to species and races. Africanized bees show a more effective grooming behavior than European bees (Aumeier, 2001; Guzman-Novoa et al., 1999; Guzman-

Novoa et al., 2012; Moretto et al., 1993). In the USA, Rinderer et al. (2001), reported that bees brought from the region of Primorsky (Russia), showed more grooming behavior than bees from Louisiana. The basis of these differences is undoubtedly based on genetic diversity. Villa and Rinderer (2008), reported that the genetic basis of auto-grooming is polygenic and some alleles have a strong dominance. While the genes responsible for grooming behavior are not known exactly, studies are underway to solve genetic mechanism of this behavior.

3. The Effects of Neural Gene Expressions on Grooming Behavior

Arechavaleta-Velasco et al. (2012), have used QTL mapping approach for identification of candidate genes in honey bee grooming behavior. They reported that the Neurexin-1 gene associated with grooming behavior in mice was associated with grooming behavior in honey bees.

Tsuruda et al. (2014), investigated the possible neurexin gene involvement by following their QTL mapping related to grooming. As a result of the expression of Neurexin in B form between the bees making intensive and slow grooming. This difference in Neurexin expression was also effective in the response times of bees against Varroa.

Najavas et al. (2008), attempted to solve the differences in sensitivity to Varroa parasitism and whether Varroa infestation caused changes in *Apis mellifera* gene expression. As a result of the study, most of the genes expressed differently between tolerant and sensitive bees have been found to play a role in the development of nervous system.

Hamiduzzaman et al. (2017), investigated associations between grooming behavior and the expressions of immune, neural, detoxification, developmental and health-related genes. Neurexin-1 expression was found to be significantly higher in bees showing intense grooming behavior. As a result, Neurexin-1 has been reported to be useful as a biomarker for behavioral characteristics in bees.

Mustard et al. (2010), studied the effect of dopamine and D1-like dopamine receptor (AmDOP2) on the modulation of locomotor behavior (behaviors such as grooming, fanning and gait) in honey bees. They reported in their result that the AmDOP2 gene affected behaviors such as fan and grooming.

4. Results and Discussion

Recently, the effects of neural genes expressions are noteworthy in the results of gene expression studies that may be related to grooming behavior. Although gene expression studies related to honey bee grooming behaviors are very few in, generally similar results are obtained.

Grooming behavior is a widely studied subject in rats and fruit flies. Barradale et al. (2017), have defined grooming behavior as a strong behavior involving the coordination of multiple independent motor programs. They also stated that grooming behavior is ideal for neural circuits and neurotransmitter studies. In their study in drosophila, they reported that DopR gene, acting in neural and hormonal regulation, was effective in grooming behavior. And other studies also have found a relationship between grooming behavior and expression of neural genes (Arechavaleta-Velasco et al., 2012; Tsuruda et al., 2014; Najavas et al., 2008; Hamiduzzaman et al., 2017; Mustard et al., 2010).

In gene expression studies in honey bees, expression of neural genes was found to be directly proportional to the behavior of grooming. However, the number of neural genes in the studies is very few and generally has been studied with similar genes. More gene expression studies are needed to better understand the genetic mechanism of grooming behavior in honeybees and more neural genes should be included.

Conflict of interest

The authors declare that there is no conflict of interest.

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