*IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*
*e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 11, Issue 5 Ver. I (May 2018), PP 30-33*
*www.iosrjournals.org*

# Thermal regulation in the honey bee colony *Apis mellifera* L. and the effect of temperature under Libyan condition

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***Abstract:*** *Honey bees are social insects that live as an organized social unit and have a mechanism for thermal regulation. In the presence of brood, the bees are of great interest and keep their temperature within 35 ° C. In addition to the role of workers, drones played an important role in the thermal regulation of the colony. They found that Genetic diversity among individuals has important role in this process, when the heat regulation mechanism of the brood is disturbed, their effects on adults appear to increase mortality, reduce the longevity of the worker, become more sensitive to pesticides, and reduce their ability to learn and transmit information. In cold countries, bee colonies suffer from low temperature stress while In Libya suffers from high temperature stress.*

***Key words:*** *Libya, Honey bee. Apis mellifera L, thermal regulation, bee colony, bee brood*

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Date of Submission: 21-04-2018 Date of acceptance: 08-05-2018

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## I. Introduction

Among all other honey bee stresses, temperature is a fundamental ecological factor that has been shown to affect honey bee survival (Wang et al.2016). The ability of the honey bee colony to regulate temperature which enables to survive in adverse climates regardless of outside temperature, provided honey is available,in this respect the honey bee colony resembles birds and mammals more closely than other insects (Gojmerac 1980). the honey bees appear to be the only group that have achieved a high degree of homoeothermy in their nests, keeping the brood combs at temperatures which, although never constant, vary within a relatively narrow window of ≈3°C, despite outside temperatures (Tautz et. al. 2003).

A heat budget for foraging honey bees *Apis mellifera* L. indicated that at 30-35 °C all bees are in positive heat balance during flight. Observations of honey bees returning to their hives at high ambient temperatures support the conjecture that honey bees regulate head and thorax temperatures at high ambient temperature by regurgitating droplets of honey stomach contents which are then evaporated (Cooper et al. 1985). Roberts and Harrison 1999 conclude that the variation in metabolic heat production is the dominant mechanism of maintaining thermal stability during flight between air temperature values of 21 and 33 °C, but variations in metabolic heat production and evaporative heat loss are equally important to the prevention of overheating during flight at air temperature values between 33 and 45 °C.

Survival rates were monitored among three honey bee subspecies under Saudi Arabia conditions and the results indicate low tolerance of the exotic honey bee subspecies *Apis mellifera carnica*, and *A. m. ligustica* to temperatures extremes compared with local subspecies *Apismelliferajemenitica*during the summer (Alattal and AlGhamdi 2015).

When the Metabolism and the upper lethal thermal limits of The Western honeybees *Apis mellifera carnica* and *A. m. ligustica* are studied, the standard metabolic rate was higher in the *A. m. ligustica* population only at a high temperature. The lethal temperature (LT50, 8h) revealed higher tolerance and survival rates of the Ligustica bees. Possibly favoring Ligustica in a warming environment (Kovac et al. 2014).

(Tan et al. 2012) found that *A. ceranas*tart foraging earlier and at lower temperatures than do *A. mellifera* , At the same ambient temperature, departing *A. mellifera* foragers and workers sampled from the brood nest had a higher thoracic temperature than departing *A. cerana* foragers and brood nest workers. .

(Graham et al 2006and Jones et al., 2004) investigate the effects of intracolonialdiversity,they observed that single patriline colonies maintained, on average, less stable brood nest temperatures than multiple patriline colonies. This provides further support for the hypothesis that geneticallybased variability in task thresholds among patrilines within honey bee colonies is an important contributor to the ability of colonies to precisely thermoregulate their nests.

(Switanek et al. 2017) found that warmer and drier weather conditions in the preceding year were accompanied by increased winter mortality. They subsequently built a statistical model to predict colony mortality using temperature and precipitation data as predictors.

(Wang et al.2016) found that longer durations of low temperature during capped brood led to higher mortality, higher incidences of misorientation inside cells and shorter worker longevity.Lower rearing temperature had no significant effects on larval mortality and adult emergence, but adult bee mortality was strongly affected. Moreover, adult workers emerging at 33°C were significantly more susceptible to pesticide, thus low temperature brood rearing could be another stress factor for colonies. (Medrzychi, et al. 2010).When honey bee pupae incubated under different temperatures, bees raised at 36°C performed as expected for bees typically classified as ‘‘good learners,’’ whereas bees raised at 32°C and 34.5°C performed significantly less well (Tautz et al. 2003).

## II. Thermal regulation in the honey bee colony

Honey bee brood area is maintained between 33° and 35°C, when the ambient temperature drop to 14°C bees form a cluster and regulation of both the insulation by the mantle bees and endothermic heat production by the inner bees due to metabolizing honey and thoracic muscle movements, is necessary to achieve thermal stability, so the bees act as generators and insulators (Gojmerac 1980, Stabentheiner et. al. 2003, 2010).As the ambient temperature decreases, bees around the edge extend their wings forming a cover which prevents heat loss, and at the same time perform frequent and quick movements with the thorax. As the temperature drops lower, they bury their heads and thoraxes into the cluster with their abdomens exposed (Gojmerac 1980).

(Himmer 1927, reviewed in Winston 1987) found daily fluctuations of only 0.6°C, and a monthly range of 33.2-36°C, while (Simpson 1961, reviewed in Winston 1987) reported temperatures maintained within 0.5°C of 35°C. (Keronenberg and Heller 1982) suggest that workers adjust their metabolic rate in response to the temperature of the capped brood rather than to their own body temperature. As ambient temperature rise, nest cooling becomes increasingly important. Temperature above 36°C are harmful to brood, and excesses of only 1-2°C can cause developmental abnormalities and death (Himmer 1927, reviewed in Winston, 1987 ).

To cool the nest workers dispersal through the colony. As internal nest temperature rise, workers begin to ventilate by fanning, evaporating water and even partially evacuating the nest under extreme conditions.If further nest cooling is needed, the workers will leave the nest and cluster outside (Winston 1987; Gojmerac 1980).

Heat-shielding is a method used by honey bee workers to insulate temperature sensitive brood from localized heat stress during development (Siegel et al. 2005). In addition to honeybee workers, drones also contribute to colonial thermoregulation, the frequency of endothermic drones and the intensity of endothermy increased with decreasing temperature (Kovac et al. 2009 and Harrison 1987).

## III. Temperature under Libyan conditionsandquestionnaire results

Libya is situated between the Mediterranean and the Sahara, its climate is affected by both. The larger part of Libya has a desert climate with hot, very dry summer and warm winter.The coastal areas have a Mediterranean climate with hot and dry summer and mild winter; the hot season extendsfrom June to September, with an average daily high temperature above 30°C. Occasionally in the summer the temperature rise and exceed 40 c°.

On 13 September 1922, a temperature of 58°C (136.4°F) was purportedly recorded at El Azizia (approximately 40 km south-southwest of Tripoli) as the highest recorded temperature for the planet. Although, based on some concerns, the WMO World Archive of Weather and Climate Extremes rejected this temperature extreme of 58°C as the highest temperature officially recorded on the planet (El Fadli 2013)

The year 2016 was the warmest on record in all major global surface temperature datasets, and significant high temperatures were also reported in Morocco, Tunisia, Libya and the United Arab Emirates (WMO 2017).

A questionnaire was distributed to Libyan beekeepers in 2017 to determine the damage caused by the effect of low and high temperatures on honey bee colonies. The results of the questionnaire showed that 42.9% of beekeepers hadexperience more than 10 years’ in beekeeping, and 53.3% of them owned an average of 40 bee colonies per beekeeper, And in terms of winter loss, it was found that 60% of them reported that they did not lost any colony, while 13.3% of them were have lost part of their colonies due to infection by diseases and 26.7% of them have colony loses due to hunger, The results showed that the cold weather had no effect unless the colony was infected with diseases and parasites or hungry. In contrast, the effect of high temperatures during the summer, which runs between June and September, especially in periods of hot waves, the bees suffer from heat stress, where temperature may exceed 40 c° and may take more than one day, where the Libyan meteorological record 49 c° as maximum Temperature during the summer of 2016 resulted in losses in bee colonies, And the results of questionnaire showed that 35.7% of beekeepers encountered a loss in the bee colonies on this day because they did not harvest honey crop and do not shading their hives, while 64.3%

reported that they placed their hives in the completely shade and provide source of water near the apiary and harvest honey crop to prevent losses due to the temperature rise. Beekeepers who had experience mentioned that the new comb very sensitive to melt by high temperature in the summer and when harvest the honey crop they collect the new comb. When the colony exhausted its water supply, or the temperature rise more thanthe level which the bees tolerant many of the new wax combs melted and honey drop to obstacle the cooling mechanism finally colony die as in fig. (1a, 1b)

The results also showed that some beekeepers faced the problem of migration of some colonies and this may be due to leave it in the sun or lack of adequate food in the hive or the entry of insects to the hive such as ants.

Fig.1-a:New wax comb melted inside the hive by high temperature in summer 2016. (Photo by Alfallah).

Fig.1-b: Honey bee colony died in the summer due to wax comb melt and honey escape to obstacle cooling. (Photo by Alfallah)

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