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SOME CORRELATIONS BETWEEN ENVIRONMENTAL PARAMETERS AND THE FORAGING BEHAVIOUR OF HONEYBEES (*APIS MELLIFERA*) ON OILSEED RAPE (*BRASSICA NAPUS OLEIFERA*)

Silvia PĂTRUICĂ, Eliza SIMIZ*, Ioan PEȚ, Lavinia ȘTEF

Department Engineering Animal Production, Bioengineering Faculty of Animal Resurces, Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara Romania, 300645, Timișoara, Calea Aradului 119

Corresponding author email: esimiz@yahoo.com

Abstract

The climate changes of recent years are affecting the foraging behaviour of bee colonies. We present correlations found between flight time of foraging worker bees, the quantity of food material harvested expressed in terms of hive weight, and meteorological factors (temperature and humidity). Bee colonies were monitored hourly throughout each 24 hour period using the BeeWatch Professional recording system. Monitoring was carried out during the oilseed rape (Brassica napus oleifera) collection period over a 13 day interval in 2018 and 2019. Results show positive correlations statistically significant (p<0.01) between flight time of foraging workers and temperature. The influence of humidity on flight time shows a negative correlation at the same level of significance (p<0.01). Hive weight is postively correlated with a mean temperature of 20.7˚C and negatively with a mean humidity of 65%.

Key words: *honey bee, foraging behaviour, statistical correlations, meteorological factors.*

INTRODUCTION

Oilseed rape (*Brassica napusoleifera*) has an important place in Romanian agriculture, an area of 632,000 hectares being devoted to its cultivation in 2018. It is also a major source of nectar and pollen, since it is a melliferous plant which supports good bee colony dynamics and significant honey production. Although some varieties of oilseed rape are self-pollinating studies have demonstrated the importance of bees as pollinators. (Cambó et al., 2011; Rosa et al., 2011; Carruthers et al., 2017; Lindström, 2017). The quantities of nectar and pollen harvested by honeybees from oilseed rape may be influenced by the hybrid variety under cultivation, soil type and meteorological conditions (Farcas and Zajácz, 2007).

Studies have shown the influence of a number of factors on the harvest of nectar and pollen by worker bees. Abou-Shaara (2014) grouped these into those interior to the colony (state of the queen, colony vigour, colony health and genetic strain of the colony) and external ones (availability of forageable material, meteorological conditions). Siegel et al. (2012) showed that the ovulation rate of the queen plays an important role in the behaviour of nectar-collecting worker bees.

Clarke and Robert (2018) consider that meteorological conditions influence the entire activity of the bee colony, from its development to the generation of swarms and the build-up of overwintering food stores. Poor weather conditions can also affect pollinating behaviour due to the fall in nectar quality (Corbet, 1990; Lawson and Rands, 2019; Herman et al., 2018).

Temperature is one of the most important environmental factors for bees for their activities both within the hive (nursing the brood) and outside it (gathering nectar and pollen, the nuptial flight of the queen).

The survival rate of honeybees is influenced by external temperature and is also strongly correlated with the subspecies of bee (Ghamdi and Alattal, 2015).

Honeybees are capable of regulating the temperature within the hive in the face of fluctuations in outside temperature (Szopek et al., 2013), a characteristic which allows them to survive through cold spells and to begin raising new brood as early as the middle of winter (Seeley and Visscher, 1985).

Plant nectar secretion is influenced by external temperature, with the optimum time window for secretion depending on species (Pătruică et al., 2017).

Studies have shown close correlations between temperature, solar radiation and the behaviour of foraging worker bees. Results have brought to light the fact that the bees constantly monitor these external factors and that this affects whether they leave the hive on collecting forays (Clarke and Robert, 2018).
The climatic changes the whole world has been facing in recent years may have a direct influence on the behaviour and physiology of honeybees, with implications for the foraging capacity and state of health of colonies. (Le Conte and Navajas, 2008). Climate changes could also be affecting the process of pollination and the ecological equilibrium (Hegland et al., 2009; Rami Reddy et al., 2012; Tanasoiu et al., 2015). Such considerations require a constant monitoring of bee colonies the identification of correlations between their behaviour and environmental factors with an eye to the discovery of solutions to the problems that have appeared.

MATERIALS AND METHODS

The study was carried out at the apiary belonging to the King Michael I of Romania Banat University of Agricultural Science and Veterinary Medicine, Timişoara, Romania in two successive years. The twenty colonies of *Apis mellifera* were transported to Chișoda (Timiș county) to work the oilseed rape (*Brassica napus oleifera*) hybrid *ESTORM*, for the period21 April - 4 May 2018 and in the period to 20 April -3 May 2019 to Sânandrei (Timiș county). The bee colonies were moved when the plants were 20% in flower and the hives were placed about 1 km from the foraging areas.
During the period of study monitoring was carried out of climatic factors (temperature, humidity), intensity of flight activity of the bees and hive weight, using a BeeWatch Professional 45726158 monitoring system placed under a Dadant hive. The bee colony chosen for monitoring was an average one for the apiary, of median vigour with eight frames of brood and working bees arranged in two hive sections. Statistical processing of the data obtained during the two study period was effecting using the IBM SPSS Statistics 23 package and bivariate Pearson and Spearman correlations were calculated.

RESULTS AND DISCUSSIONS

Climate changes impact not only the secretion of nectar in oilseed rape (*Brassica napus oleifera*) but also the behaviour of foraging bees, both of these being correlated with the productive potential of the colony. With a view to establishing the correlations between hive weight, flight time, exterior temperature and humidity during the period in which the bees work the oilseed rape, each colony in the study was monitored on an hourly basis throughout the 24 hours for the whole 13 day period. Taking into account the fact that the meteorological pattern, even for the same calendrical time period, can be very different in different years, the observations were carried out in two years, 2018 and 2019, making it possible for the correlations that exist with respect to the foraging behaviour of worker bees to be analysed under different conditions.
Some authors have held that worker bees start intensively visiting oilseed rape flowers at 08.00, with a peak of visiting between 11.00 and 14.00 (Mesquida et al., 1988; Iordache, 2009) but flight intensity is directly correlated with atmospheric conditions (Pătruică et al., 2017).
The research undertaken in this present study shows a statistically significant ($p<0.01$) positive correlation between hour of flight of foraging bees and temperature. There is also a statistically significant ($p<0.01$) negative correlation between hour of flight and humidity. These interpretations are valid for all the days of the 2018 period of study, when the mean temperature was 20.7˚C and the mean relative humidity was 65.8% (figure 1). A positive correlation ($p<0.01$) was observed between hive weight and hour of flight, a pattern valid for all the days of 2018 studied (table 1). Foraging bees were observed to take flight in large numbers between 11.00 and 12.00, data comparable with the reported finding of Iordache (2009). Temperatures over 13˚C have a positive influence on nectar secretion and the foraging behaviour of worker bees.
Table 1 shows that the feeding behaviour of bee colonies is influenced by atmospheric humidity, with negative correlations (significant, $p<0.01$) between this and the amount of food collected each day.

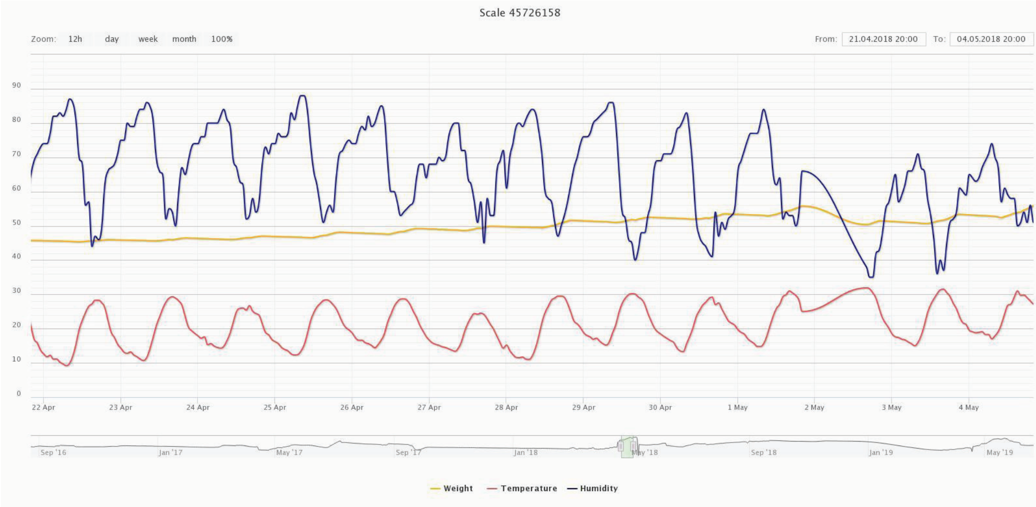

Figure 1. Changes in meteorologicalfactors and hive weightduring oilseed rape nectar harvest 2018

Table 1. Some correlations between hive weight, hour of flight of bees, temperature and humidity during oilseed rape nectar harvest 2018

Day	Hive weight (kg)	Flight time		Temperature (˚C)		Humidity (%)	
		Pearson correlation	Spearman's rho	Pearson correlation	Spearman's rho	Pearson correlation	Spearman's rho
1	45.64	0.666**	0.481*	0.253	0.296	-0.306	-0.395
2	45.95	0.755**	0.630**	0.439*	0.496*	-0.399	-0.582**
3	46.43	0.770**	0.640**	0.302	0.387	-0.491*	-0.578*
4	47.16	0.804**	0.635**	0.478	0.491*	-0.416*	-0.608**
5	48.23	0.802**	0.642**	0.381	0.478*	-0.544**	-0.620**
6	49.19	0.741**	0.595**	0.287	0.365	-0.561**	-0.643**
7	50.23	0.847**	0.691**	0.565**	0.574**	-0.455**	-0.625**
8	51.64	0.802**	0.686**	0.358	0.457*	-0.576**	-0.657**
9	52.52	0.733**	0.534**	0.317	0.333	-0.421*	-0.327
10	53.72	0.572**	0.643**	0.736**	0.841**	-0.604*	-0.834**
11	51.08	0.891**	0.762**	-0.851**	-0.762**	0.740*	0.683
12	51.62	0.789**	0.646**	0.341	0.485*	-0.215	-0.496*
13	53.50	0.747**	0.578**	0.689**	0.705**	-0.705**	-0.718**

* significant at the 0.05 level
** significant at the 0.01 level

In 2019 the average temperature recorded for the period studied was 14.5˚C and the average relative humidity was 73%. This period was characterised by night-time temperatures below 10˚C and spells of heavy rain during the daytime (Figure 2). The meteorological conditions were similar to those of 2017 (Pătruică et al., 2017) but abnormal for this period of the year. Positive correlations were observed between hour of flight of foraging bees and temperature and negative ones between hour of flight and humidity. The correlation coefficients were statistically significant for days when average night temperatures were above 10˚C and average humidity above 65% (Table 2). Cold nights with temperatures between 4.8˚C and 6.9˚C caused the bees to cluster tightly in order to maintain the temperature needed for the brood. On the days after such cold nights changes in food collection behaviour were observed, with negative correlations between hour of flight and temperature ($p<0.01$), and a negative influence on hive weight was also observed (Table 2).

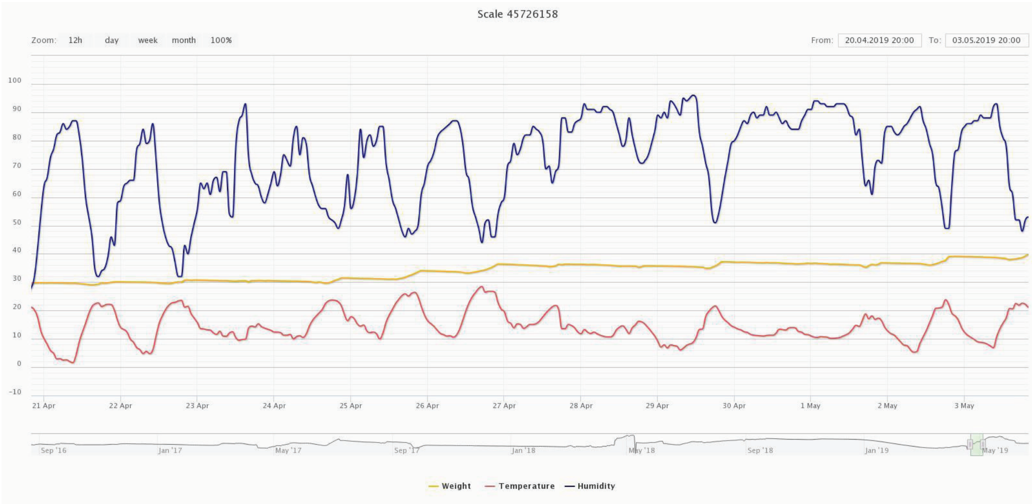

Figure2. Changes in meteorologicalfactors and hive weightduring oilseed rape nectar harvest 2019

Table 2. Some correlations between hive weight, hour of flight of bees, temperature and humidityduring oilseed rape nectar harvest 2019

Day	Hive weight (kg)	Flight time		Temperature (˚C)		Humidity (%)	
		Pearson correlation	Spearman's rho	Pearson correlation	Spearman's rho	Pearson correlation	Spearman's rho
1	29.64	0.026	-0.037	-0.208	-0.101	0.157	0.034
2	30.08	0.344	0.057	0.084	0.080	-0.144	-0.117
3	30.55	-0.519**	-0.549**	0.346	0.420*	-0.346	-0.347
4	30.43	0.333	0.034	-0.001	-0.128	-0.062	0.024
5	31.78	0.742**	0.442*	0.479*	0.527**	-0.414*	-0.521**
6	34.18	0.632**	0.370	0.364	0.381	-0.516**	-0.491*
7	36.08	0.010	0.101	-0.580**	-0.484*	0.274	0.304
8	35.94	-0.534**	-0.477*	-0.602**	-0.479*	0.786**	0.695**
9	35.83	0.497*	0.117	0.223	0.013	-0.306	-0.225
10	36.82	-0.929**	-0.939**	-0.232	-0.189	0.047	0.081
11	36.35	-0.264	-0.315	-0.422*	-0.406*	0.412*	0.416*
12	37.18	0.707**	0.415*	0.470*	0.432*	-0.444*	-0.481*
13	38.80	0.009	0.033	-0.218	-0.137	0.141	0.090

* significant at the 0.05 level
** significant at the 0.01 level

CONCLUSIONS

The meteorological factors studied influence the foraging behaviour of worker bees, hour of flight and hive weight.
Foraging bee flight and hive weight are positively correlated with temperature, with statistically significant differences ($p<0.01$), if this does not fall below 12˚C.
Temperatures below 7˚C have a strong negative effect on food-collecting behavior from oilseed rape the following day and for those days a negative correlation was found between flight time, hive weight and temperature ($p<0.01$).
High humidity (heavy or prolonged spells of rain) has a negative influence on foraging, with a statistically significant ($p<0.01$) correlation coefficient being found between hour of flight, hive weight and average humidity levels of greater that 60%.
With the effects of climate change becoming more serious each year, we need to ask whether bee colonies will be able to adapt to these and at what cost. This question merits continued close monitoring.

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