



Food consumption and winter mortality in bee colonies wintering in hives made from different materials with lattice and solid bottom

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Abstract. *The objective of the present study is to examine the changes in some indicators characterizing the winter hardiness of bee colonies settled in hives made of different material (polystyrene, wood, ceramics) and with different type of bottom (lattice or solid). Some parameters which characterize the wintering of bee colonies (amount of dead bees and quantity of food consumption in winter) have been investigated. The bee colonies were housed in 10-frame Dadant Blatt hives with a lattice and solid bottom situated at the Training Apiary of the Faculty of Agriculture, Trakia University, Stara Zagora, Bulgaria. Two inspections of the bee colonies were carried out (during wintering in November 2020 and at the beginning of the active season in March 2021). Amount of bees in the bee hive (strength) and amount of capped honey in the honeycombs were reported. In bee colonies wintering in hives with a lattice bottom, the consumption of food per 1 kg of bees was 1.639 kg (50%) higher than in hives with a solid bottom. Winter mortality of bees in hives with a lattice bottom was higher compared to this indicator in the hives with a solid bottom, $16.19 \pm 10.72\%$ and $12.59 \pm 3.57\%$, respectively, which can be considered excellent wintering below 15% and good wintering in the range of 15.0-19.99%.*

Keywords: food supply, honey bee, polystyrene, strength of bee colony, type of hive bottom, wooden and ceramics hives, winter hardiness

Introduction

The activity of honey bees depends on environmental conditions. Climatic features in many countries, including Bulgaria, determine two main seasons in the life of bee colonies: season of active work; season of relative rest. The season of relative dormancy coincides with the autumn-winter period, when bee colonies prepare for wintering and do winter. The preparation for wintering is a very important activity and is considered the beginning of the new beekeeping season. This activity includes: providing an optimal amount of food supplies (honey and pollen); providing conditions for raising brood in order to stock the bee colonies with young bees that will spend the winter; narrowing the bees' nests and determining the size of the entrance to the hive to ensure optimal ventilation and to help the bees maintain the microclimate. These activities are related to wintering, respectively to the winter hardiness of bee colonies (Nenchev and Zhelyazkova, 2010).

One of the factors influencing the winter hardiness of bee colonies is the hive construction - size, material which it is made of, type of bottom, etc. In recent years, beehives have been introduced in the beekeeping practice made of a material different from the wooden hives used so far - polystyrene, ceramics, etc. These materials have different insulation characteristics compared to wood, in which bees would more

easily or with more difficulty maintain the optimal microclimate (Erdogan, 2019; Lepkova et al., 2019, 2020). Erdogan (2019) points out the advantages and disadvantages of wooden and polystyrene hives: wooden hives are strong and made of natural material, but with not very good thermal insulation, they are heavy and difficult to work with in mobile beekeeping; polystyrene hives are light, preferred in mobile beekeeping, but can be easily damaged during operation and have not very good ventilation characteristics.

Lepkova et al. (2020) accept that if the classical wooden walls of the hives are changed with ceramic tiles, this would increase the thermal comfort of the bee family. According to the authors, wood and ceramics have different porosity and they absorb different quantity of moisture from the air. The higher moisture resistance of the ceramic walls improves the living environment and decreases the risks of development of different harmful microorganisms.

Many beekeepers keep bee colonies in hives with lattice bottoms. The lattice bottom improves the ventilation in the beehive and prevents the appearance of moisture and the formation of mold on the walls of the hive and on the combs. On the other hand, the entry of more cold air through the lattice bottom forces bees to release more heat in order to maintain the optimum temperature.

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The temperature maintained by worker bees in the bee hive is highly stable, especially in the brood area (Eskov, 1981, 1983; Petz et al., 2004; Ohashi et al., 2009; Stabentheiner et al., 2010). Abou-Shaara et al. (2017) point out that in the various activities performed in the colony (nest warming, home guarding, food mobilization, brood rearing, queen rearing, etc.), bees maintain certain limits of temperature and humidity. A number of studies (Owens, 1971; Villumstad, 1974; Detroy et al., 1982) are related to the minimization of winter mortality rate of bee colonies by maintaining the temperature in the hives. According to Detroy et al. (1982), a hive that provides better insulation significantly reduces honey consumption.

Due to the fact that wintering is a crucial and difficult period in the life of honey bees, it is necessary to look for ways to improve it – by maintaining optimal temperature, humidity and ventilation in the bees' nest. According to Vorobeva et al. (2020), this is an urgent task, the solution of which can minimize food consumption and reduce winter mortality.

Winter hardiness of bee colonies can be determined by a number of indicators, but the Bulgarian Regulation 35/2004 on the terms and conditions for carrying out the selection and reproduction in beekeeping points out two major criteria - the amount of food consumption in winter and the amount of dead bees in winter (winter loss) - Nenchev and Zhelyazkova (2010).

The objective of the present study is to examine the changes in some indicators characterizing the winter hardiness of bee colonies settled in hives made of different material (polystyrene, wood, ceramics) and with different type of bottom (lattice or solid).

Material and methods

The study was conducted at the end of beekeeping season 2020 and the beginning of the 2021 season at the Training Apiary of the Beekeeping Section at the Faculty of Agriculture of Trakia University, Stara Zagora. The study included bee colonies, equalized by the method of analogues, with queen bees at the same age and origin provided by the Bulgarian Bee Breeding Association (BBBA). The bee colonies were housed in 10-frame Dadant Blatt system hives, made of different materials - wood, polystyrene and ceramic.

Bee colonies are divided into 3 groups according to the material of the hive - polystyrene hives, wooden hives and ceramic hives. Each group comprised 2 hives - one with a lattice bottom and one with a solid bottom (Figure 1).

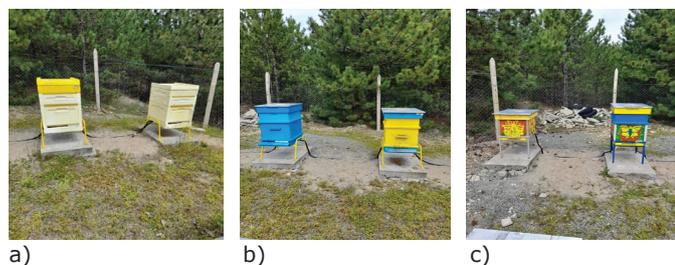


Figure 1. Type of hives: a- polystyrene; b- wooden; c- ceramic

Two major inspections of the bee colonies were carried out – at the beginning of the wintering period in November 2020 and at the beginning of the beekeeping season in March 2021. The following indicators were determined:

- Amount of bees in the bee nest (Strength) – in frames tightly covered with bees and calculated in kg (on 1 frame from Dadant Blatt hive there are 0.250 kg bees);
- Amount of honey stock – measuring the capped honey in the honeycomb with a measuring frame with squares of 5×5 cm and calculating in kg (in 4 squares of the measuring frame the honey is 0.175 kg).

Based on the data obtained from the reviews, the following indicators were calculated (Regulation 35/2004; Nenchev and Zhelyazkova, 2010):

1) The amount of food consumption from the bee colony in the winter - the difference between the amount of honey during wintering and the amount of honey in the spring inspection. Food consumption per unit of bees is calculated by the formula:

$$M = C/0.5(A + B),$$

Where: M- consumed food per unit of bees (frames, number, kg) in winter; C- the total amount of consumed food, kg; A- strength of the bee colony in the autumn (frames, number, kg); B- strength of the bee colony in the spring (frames, number, kg).

2) Quantity of dead bees (winter loss) – difference between the strength of the bee colony in the autumn and in the spring. The relative value (%) of this indicator is more objective. The following formula is used:

$$P = (A - B)/A.100,$$

Where: P- dead bees (winter loss); A- strength of the bee colony in the autumn; B- strength of the bee colony in the spring.

An assessment of the bee colonies was made by the signs characterizing their winter resistance according to the criteria of Regulation 35/2004.

Results and discussion

The data in Table 1 show that upon inspection at the beginning of the wintering period (06 November 2020) the strength of bee colonies varied from 1.125 kg (4.5 interframe spaces) to 1.750 kg (7 interframe spaces), while the quantity of food stock (honey bee) was from 5.381 kg to 9.538 kg. Judging by the criterion generally accepted in the beekeeping practice for determining the optimum amount of honey for the winter (2 kg per interframe space tightly covered by bees), it is evident that the available amount of honey is close to the lower limit. Due to that reason in February 2021 each bee colony was provided 1 kg (0.500 kg twice) of honey-sugar cake, pollen included.

The results from the spring inspection (29 March 2021) showed that the quantity of bees in bee colonies was less (1.000-1.250 kg bees) compared to the autumn inspection (1.125-1.750 kg bees) (Table 1). The decrease in terms of the strength of bee colonies is the smallest (10-11%) in polystyrene hives (with lattice and solid bottom), wooden

hive with lattice bottom and ceramic hive with solid bottom, and the largest (28.6%) in the ceramic bee hive with a lattice bottom. The greatest difference in food stock between the autumn and the spring inspection was found in wooden

and in ceramic hives with lattice bottom (77.5% and 59.2%, respectively), while the smallest one was in polystyrene hives. In bee hives with solid bottom reduction varied between 24 and 30%.

Table 1. Condition of bee colonies at the beginning of the wintering period 2020 and at the beginning of the beekeeping season 2021

Type of hive	06 November 2020		29 March 2021	
	Quantity of bees, kg	Quantity of honey, kg	Quantity of bees, kg	Quantity of honey, kg
Polystyrene hive - lattice bottom	1.250	6.300	1.125	4.156
Polystyrene hive - solid bottom	1.250	6.916	1.125	5.250
Wooden hive - lattice bottom	1.250	6.431	1.125	1.444
Wooden hive - solid bottom	1.500	9.494	1.250	6.606
Ceramic hive - lattice bottom	1.750	9.538	1.250	3.894
Ceramic hive - solid bottom	1.125	5.381	1.000	3.944

Based on the data in Table 1, the indicators characterizing the winter hardiness of bee colonies have been calculated - food consumption per 1 kg of bees (Figure 2) and winter mortality (Figure 3). The graphical representation of *winter food consumption* (Figure 2) shows the highest values in bee colonies housed in wooden hives, followed by colonies in ceramic hives. In both types of hives food consumption was higher in the ones with lattice bottom - 50% more than in hives with solid bottom. The amount of food consumed in the winter is the least in colonies in polystyrene hives, where the food consumption was also higher (by 22%) in the hives with lattice bottom than in hives with solid bottom. The obtained results regarding the differences in food consumption in bee colonies wintering in hives with lattice and solid bottom are logical in terms of the following: the entry of more cold air through the bottom lattice lowers the temperature in the bees' nests; bees consume more honey to release more heat and maintain the optimum temperature in the bee ball. The results obtained confirm the findings of Detroy et al. (1982), Erdogan (2019) and Lepkova et al. (2020) that in hives providing better insulation (in this case, hives with a solid bottom), bees consume significantly less honey.

winter from 1 kg of bees can be determined as "good" and "very good" for the bee wintering, regardless of the material which the hive is made of and the type of bottom (lattice or solid). The established food consumption in the present study is in the range of 1.353-4.201 kg of honey per 1 kg of bees (Table 2), which is included in the range for "very good" wintering (2.4-4.0 kg) and for "good" wintering (4.2-5.6 kg), specified in Regulation 35/2004 and by Nenchev and Zhelyazkova (2010).

Figure 3 presents graphically the results for *winter mortality rate* of bee colonies included in the study. The highest mortality was found in the ceramic hive with lattice bottom (average 28.6%), winter mortality average 16.7% was reported in the wooden hive with solid bottom. For the other hives (polystyrene with lattice and solid bottom, wooden hive with lattice bottom and ceramic hive with solid bottom) similar results were obtained according to the above indicator (10-11.1%).

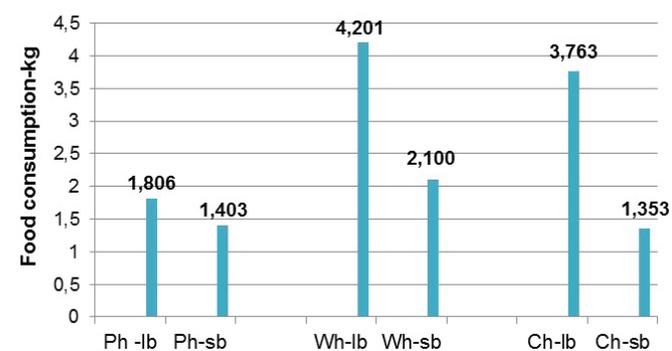


Figure 2. Food consumption (per 1 kg of bees) during winter in bee colonies settled in hives of different material and with different type of bottom

Legend: Ph-lb: Polystyrene hive - lattice bottom; Ph-sb: Polystyrene hive - solid bottom; Wh-lb: Wooden hive - lattice bottom; Wh-sb: Wooden hive - solid bottom; Ch-lb: Ceramic hive - lattice bottom; Ch-sb: Ceramic hive - solid bottom

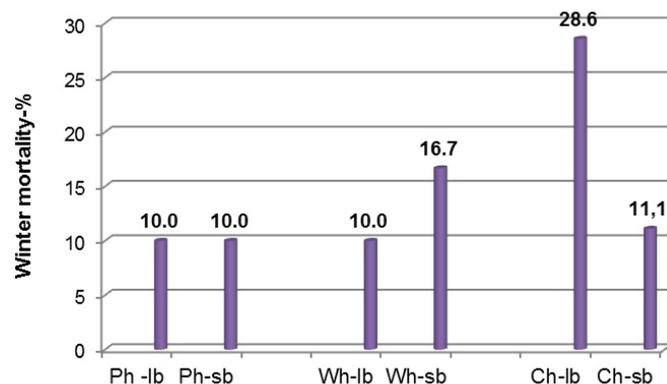


Figure 3. Winter mortality in bee colonies settled in hives of different material and with different type of bottom

Legend: Ph-lb: Polystyrene hive - lattice bottom; Ph-sb: Polystyrene hive - solid bottom; Wh-lb: Wooden hive - lattice bottom; Wh-sb: Wooden hive - solid bottom; Ch-lb: Ceramic hive - lattice bottom; Ch-sb: Ceramic hive - solid bottom

The assessment of bee colonies, according to the criteria in Regulation 35/2004, by the indicator food consumption in

According to the evaluation criteria for winter mortality rate specified in Regulation 35/2004, the bee colonies reared in ceramic hive with lattice bottom and in wooden hive with solid bottom can be assessed as "good" (15-29.9%), and the bee colonies reared in the others hives can be assessed as "excellent" as their mortality is less than 15%, the upper limit for that assessment in the standard (Nenchev and Zhelyazkova, 2010).

The summarized results concerning the indicators characterizing winter hardiness of bee colonies settled in hives with lattice or solid bottom are given in Table 2. It is evident from the data that food consumption in winter for 1 kg of bees and winter mortality in bee

colonies in hives with lattice bottom are approximately 50% and 22%, respectively, more than the bee colonies in hives with solid bottom. The reported differences between the obtained results for the two monitored indicators are statistically unproven.

Table 2. Food consumption (kg) and winter mortality (%) total for hives with lattice and solid bottom

Type of bottom	Food consumption				Winter mortality			
	mean	SD	min	max	mean	SD	min	max
Lattice bottom (n=3)	3.257	1.27	1.806	4.201	16.19	10.72	10.00	28.57
Solid bottom (n=3)	1.618	0.42	1.353	2.100	12.59	3.57	10.00	16.67
p	p = 0.102				p = 0.611			

Conclusion

Based on the results obtained the following conclusions can be made: 1) Food consumption per 1 kg of bees was in the highest amount in bee colonies settled in wooden hives, followed by colonies in ceramic hives; the food consumption in both types of hives was higher (by 50%) in the ones with the lattice bottom than in the hives with solid bottom; the food consumed was the least in winter in the colonies in polystyrene hives (22% higher in the hive with lattice bottom than in the hive with solid bottom); the assessment of bee colonies according to the criteria of Regulation 35/2004 for food consumption in winter is determined as “good” and “very good” for the wintering, regardless of the material which the hive is made of and the type of bottom (lattice or solid). 2) The winter bee mortality was the highest (average 28.6%) in the ceramic hive with lattice bottom, lower (average 16.7%) in the wooden hive with solid bottom and the lowest (10-11.1%) in the other hives (polystyrene, wooden with lattice bottom and ceramic with solid bottom); by the criteria of Regulation No 35/2004, the bee colonies included in the study can be assessed as “good” (15-29.9% mortality) and “excellent” wintered ones (under 15% mortality). 3) Food consumption in winter for 1 kg of bees and winter mortality of bee colonies in hives with lattice bottom were approximately 50% and 22%, respectively, more than the bee colonies in hives with solid bottom ($p > 0.05$). 4) The present study for assessment of the winter hardiness of bee colonies settled in hives made of different materials and with different types of bottom is the first for our country and it is necessary to expand research in that direction.

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