HOW MANY INDIVIDUALS SURVIVE WINTER IN INTACT COLONIES OF *Apis mellifera* L. (*Hymenoptera, Apidae*)?

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Abstract

The analyses of 4 carniolan colonies supplied with ready stores (and so considered as "intact") which died in January 1998 (because of improper stores organisation) from the total of 25 similar colonies wintered in vertically orientated hives of the inner dimension 32 x 32 x 122 cm showed the following respective amounts of bees in winter clusters: 13.772 (the swarmed one) 16.309, 19.180 and 22.964. The values are similar or higher in comparison with the data obtained by killing colonies during the steps against Varroa undertaken in former Czechoslovakia in the years 1982 and 1983, and show that no stimulative feeding or other measures are necessary to obtain colonies of sufficient winter strength. According to the authors' experience with wintering bees in larger hive dimensions (43,5 x 43,5 x 70 cm) and Farrar's management methods even more numerous colonies for winter can be obtained. The possible influence of the hive space orientation on the winter colony population is discussed.

Introduction

The size of a winter cluster generally is supposed to be one of the main factors affecting both, the success of a colony in surviving the coldest period of a year as well as its early spring development resulting in the gross yearly productivity. Therefore, many attempts have been made in developing best ways of colony management in order to ensure their successful wintering in the maximum possible strength.

In the USA and Canada currently (but not always) two or even three hive bodies of the Lanstroth standard dimension are considered as an appropriate space for so called "normal colony" in winter (Farrar, 1968, and others). In Europe many colonies still enter winter in single chambers, or if they are given more space similarly to the American approach, the technique of preparing colonies for wintering remains different. Whereas Americans from Demuth's time (Root, 1959) used to leave ample stores of sealed honey toward the end of a season, Europeans mostly take off all honey replacing it by feeding sugar solution, later.

The opinions about numbers of bees in wintering colonies differ considerably. Whereas many Europeans believe on a special treatment of colonies e.g. on stimulative feeding to obtain larger brood nests and consequently populations of young workers during late summer, resist the others on the statement that the bee amount in colonies is given by internal factors and efforts to affect it bring no result (Wille, 1983)

This paper brings some data from the analyses of clusters of colonies which died during winter and enabled so a more accurate investigation of their strength. The gained data are then compared with those obtained from colonies killed deliberately in order to stop spreading of Varroa jacobsoni in former Czechoslovakia, and finely some experiences of

authors in implementation of Farrar's methods are added with the aim to contribute to general understanding of wintering honey bee colonies.

Material and methods

Colonies perished of starvation

Bees were kept in magazine hives on frames 300 (width) x 310 (height) mm in combination with the shallow equipment (300 x 170 mm). Each chamber contained 8 frames 28 mm thick with 10 mm bee space. Hive bodies were double-walled with an 50 mm thick insulation layer of foam polystyrene. The sealed honey amount in large and shallow combs was 2 and 1 kg respectively.

During the active period in 1997, 25 productive colonies were kept on 2 deep brood chambers divided by bee excluder from supers of different dimensions equivalent to two deep ones at least. Towards the end of the honey flow (round July 15) most of colonies were reorganised according to the following scheme: the bee excluder was removed and one shallow chamber containing 8 kg of sealed honey was put just above the brood chambers as the main food reserve. At the very top a deep chamber containing round 8 kg of unsealed honey was placed. As colonies had some honey in brood chambers also, the total winter reserves could be estimated at 20 kg. Besides the reduced main bottom entrance the upper one (25 mm hole) was left open in the second brood chamber in the middle of its front wall.

Bees were expected to move the unsealed honey from the top honey chamber into the brood nest during the fall time, and the mostly empty chamber was supposed to be put away then. The intent was to leave 2 and 1/2 hive bodies for each colony. However, as bees mostly had not met our expectation and let the honey at the top nearly untouched, was the top deep chamber left on colonies through the winter.

In the middle of January 1988 bees of 3 colonies used the short spell of warm weather to shift their position upwards, left the brood chambers and clustered just in the top deep chamber. Finally they died due to the lack of stores despite the fact that they had 8 kg of sealed honey only several cm below the cluster. The 4th colony which died was a swarmed one, which was left to much space and similarly clustered above the stores. As the colonies were not managed on any way to affect their winter population, they can be considered as intact from this point of view. We used the offered possibility to know more about them.

Dead bees fallen on the bottom and adhering to combs were put together. A sample of several hundred bees was taken for determination of the weight of individual bees. The other part of cluster - bees remaining in cells - was removed from the combs in laboratory and similarly a sample was taken from this part of the cluster, too. After we knew the weight of each part of a cluster and of samples taken from them, and the numbers of bees in samples, we were able to estimate the number of bees in each portion of a cluster and finally also the total number of bees wintering in each colony.

Colonies killed as a part of anti-varroa measures

In the autumn 1982 and spring 1983 in several regions of Czechia all honey bee colonies were killed in the efforts of the Bee Research Institute at Dol to stop the invasion of Varroa jacobsoni. As fortunately the weight of killed colonies was recorded, we can use the obtained data, now, to illustrate the amount of bees which occupied hives in common bee keeping practice. The summarised data are shown in Fig. 1, where each apiary is represented by a column the height of which means the average weight of colonies, and the figures above the columns are the numbers of colonies killed in the given apiary.

The Farrar's approach

In early eighties several people in Czechia, including the authors of this article, started to test the methods of Prof. Farrar (1968) to keep strong colonies by mean of ample space and stores of pollen and honey. The common carnica colonies were kept in shallow single-walled equipment (so called "Optimal" hive) adapted to the frame dimension of 420 x 170 mm with 11 combs in each hive body. Colonies were wintered in 4 chambers on 25 - 30 kg of stores. The size of such colony on April 14, 1881 is shown at Fig. 2.

Results and discussion

The results of **the analyse of 4 dead intact colonies** are summarised in Table 1, where in the columns marked by "A" are data for portions of bees fallen on bottoms and adhering on combs, and in those marked by "B" for bees sitting inside the cells.

The weight found per one bee was near 100 mg in the case of bees out of combs (A) what was expected, and seems to be a bit lower in the case of bees taken from cells (B), probably due to their desiccation during the laboratory work. The heaviest bees in the colony No. 3 may not be a random. This colony had largest pollen reserves distributed equally in combs occupied by the cluster and bees might eat pollen instead of honey before they died. The total amount of bees estimated for three normal colonies 1, 3, 17 was 22.964, 19.180 and 16.309, respectively. The smallest was the colony No. 11 which swarmed earlier in the season.

Table 2 brings data illustrating the organisation of the clusters. As it is obvious, 50 - 65 % of bees were found outside of the cells. This might be even more in living colonies which according to bee keeping textbooks should have a more loosened centre. However, in a starving colony, bees occupy all cells inside the cluster in order to reduce its dimension and consequently the losses of temperature. This opinion may be supported by the comparatively small number of intercomb spaces occupied by the clusters. So the colony No.1 which had nearly 23 thousand of bees sat in 6 spaces only and colonies No 17 and 11 even in 5. The exception was the No. 3 which occupied the largest space (but with the same proportion of A and B bees as No.1). The reason was probably the large pollen reserves which prevented tighter clustering.

The phenomenon studied shows that no comb space with insufficient stores should be left on the top of a hive for winter, as wintering bees are able to shift their position vertically (if they don't have any brood) into the warmest sector of the hive, where they may die when the following period of cold is long. For a winter cluster any stores below it are useless before it is warm enough to allow bees to transport honey from below.

To illustrate the event completely it remains to add, that other 21 colonies survived in similarly organised hives successfully, because they remained clustered below the main stores all the winter having so the main honey reserves still at disposal in the proper position.

According to the numbers of 16-23 thousand of wintering bees the colonies investigated can be considered as the middle strong . Even the colony which swarmed still was able to develop a population of 13 thousand bees, what is even above the common level (see below). Comparing similar strong but survived colonies we can estimate that 20 thousand of bees would control round 16 combs of the larger dimension (2 deep chambers or 133 dm^2 of combs) after they release the cluster. Such colonies developed explosively in the given kind of hive. Therefore, as it can be concluded, the sufficient space and stores round 20 kg left in the hive of the given shape are enough to allow the colony of carniolan bee to build up 16-23 thousand of wintering bees.

Now, in this context, let us compare the above discussed data with those collected by registration of the **weight of deliberately killed colonies**. As it can be seen at Fig. 1, the differences are considerable. The line at the 1 kg level enables easier estimation of values.

Only in 8 from 23 apiaries (35%) the average weight of colonies reached over the 1 kg level. The extreme exception were 4 colonies at the level of 2,27 kg. Totally 284 colonies were killed with the average weight of 0,82 kg per colony. This would correspond well with the known founding of Kündig (1972) who reported levels ranging from 750 to 1800 g with averages just round 1 kg. The average weight of those 4 dead colonies (see Tab.1) equals to 1,663 kg, what is twice as high as what was common in our country in early eighties. However, as these data as well as those 4 extremes at Fig.1 show, much better than common results are possible.

The approach according to Farrar (1968) consists in giving bees more space and stores than it is usual. From 1980 the authors have been keeping at least a part of their colonies according to Farrar's instructions. They came to the experience that similar colony population as it was reported from USA is possible in our carnica bee, too. Fig 2. shows one from several first colonies kept in shallow magazines and wintered on 44 frames 420 x 170 mm. The hive was checked on April 14, 1981 and during the very cold spring with night frosts the colony occupied well 3 upper hive bodies reaching even to the bottom one. The estimated strength of the colony was approximately 3 kg of bees.

Evaluating experience in wintering carniolan bees 25 seasons in different hive systems we can conclude, that the ***hive space may affect the strength of wintered colonies limiting it by its least dimension***. As anybody can observe on his own bees, under lowering temperature a colony makes the cluster. The shape of the cluster is the more spherical, the less bees has it and the lower is the temperature. Strong colony's cluster shape is more elongated in the vertical dimension similar to a reversed pear. From above, any cluster looks more or less round. The more bees form a cluster the larger is its horizontal diameter and the longer is it.

In the common bee keeping Middle-European practice considerable numbers of colonies are wintered in one comparatively shallow hive body - let's say 11 combs 420 x 250 mm. In this situation the dimension 250 mm would be limiting for the spherical cluster which could not be larger than those 250 mm and would then hardly use more than 7 combs. This model situation might be the reality in most of the colonies killed in 1982 and 1983 which had the population under or round 1 kg. In our country the frame measure 390 x 240 mm has been used most often and prevailing numbers of colonies are wintered in one hive body only.

If a colony has the unlimited vertical dimension, the least horizontal dimension would limit the size of the cluster. On let's say 8 combs in several hive bodies a cluster could use all 7 spaces between combs and its shape could be vertically elongated. This would enable to winter colonies hawing 15-20 thousand of bees. The length of frames overreaching the width of the hive space has no positive effect here, as this is the comb space uncontrolled by bees in winter. The length of frames would became limiting for a colony population if it is shorter than the width of the hive space given by the number of combs. Then, several side combs would be out of the space covered by clustered bees. The ideal hive for wintering middle strong colonies is that (described above) with several square hive bodies having at least 8 combs in each. Colonies (should) have ample stores above the cluster and winter movement upward corresponds to the bee nature.

The largest colonies can be wintered in equivalently large hives. This is the third case, where colonies have 11 frames 420 mm long in square bodies and several chambers make the vertical dimension large enough to hive the strongest colonies. Clusters of such top colonies use all 10 spaces between combs and after their release bees control round 200 dm^2 of comb area. Such colonies also do not require any stimulative treatment, just space and stores. Not all carniolan colonies can use the maximum dimension hive but only large hives give the possibility of true evaluation of this what actually is inherited.

Conclusions

Evaluating the discussed data and experiences we can conclude that
a) genetic limits enable to keep much stronger carniolan colonies than it is common,
b) the late summer treatment to obtain vigorous colonies is not necessary,
c) ample hive space and stores properly organised are important factors besides the others commonly accepted.
d) the prevalent vertical dimension and square hive bodies are ideal for successful wintering of honey bee colonies.

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References

Kündig W. 1972: Wie wenig Bienen überwintern. Schweizerische Bienenzeitung 1: 18-20
Farrar C. I. 1968: Productive management of honey-bee colonies. Amer. Bee J., 108(8): 3-10.
Root A. I. 1959: ABC and XYZ of bee culture. A. I. Root Company, Medina, Ohio, U.S.A., 289-295
Wille H. 1983: Überlegungen zur Prüfung von Bienenfuttermitteln. Schweizerische Beienenzeitung, 4, 166-179

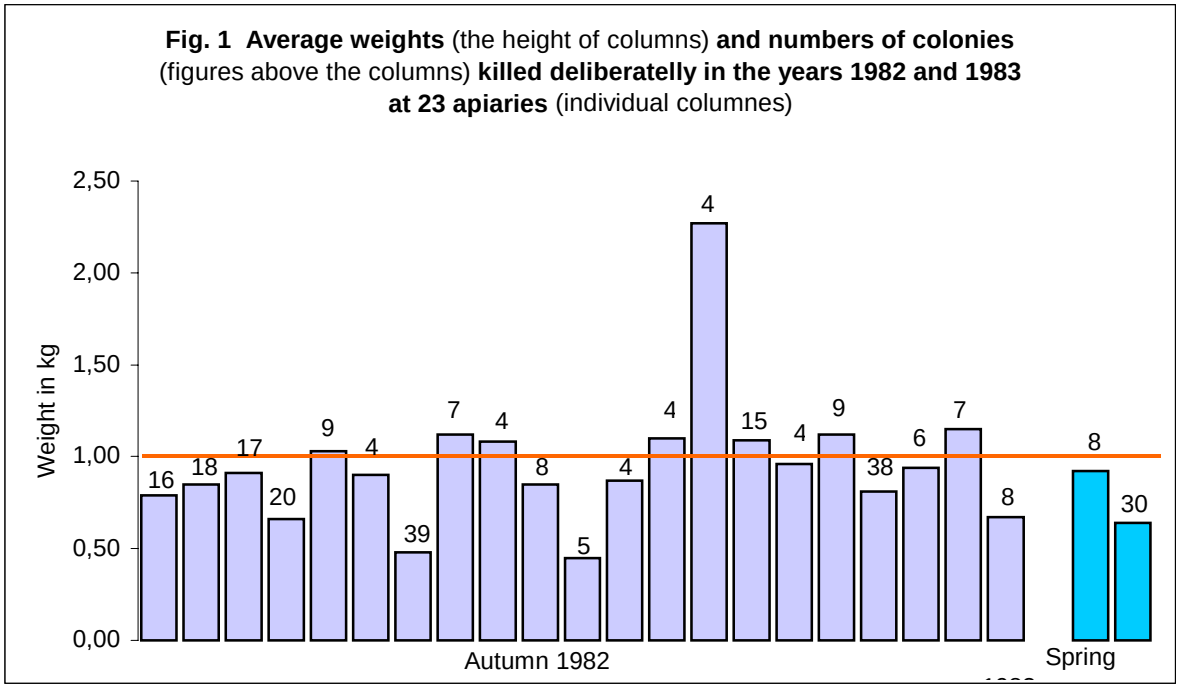

Fig. 1 Average weights (the height of columns) **and numbers of colonies** (figures above the columns) **killed deliberatelly in the years 1982 and 1983 at 23 apiaries** (individual columnes)

Table 1: The estimated size of 4 dead colonies

Hive number	Colony weight in *g*		Bee weight in *mg*		Estimated bee number in hives		Bee number in samples		**Total numbers of bees in hives**
	A	B	A	B	A	B	A	B	
1	1.333	687	92	87	14.489	7.897	411	167	**22.964**
3	1.280	628	106	98	12.075	6.343	533	229	**19.180**
17	898	528	98	81	9.163	6.519	343	286	**16.309**
11*	678	578	99	91	6.918	6.352	256	246	**13.772**

*The swarmed colony
The verage colony weight = **1,663** kg
The average colony population = **18.056** bees

Table 2: The structure of the clusters

Colony number	Number of bees		% of A	Numbers of spaces between combs taken by clusters
	A – bees out of cells	B – bees inside cells		
1	14 900	8 064	64,9	6
3	12 608	6 572	65,7	8*
17	9 504	6 805	58,3	5
11**	7 174	6 598	52,1	5

*Pollen in combs
**The swarmed colony

Fig. 2 The colony wintered in 4 shallow hive bodies (41 frames 420 x 170 mm) and opened in April 14, 1981 (photo L. Anderle)