

Determining the amount of capped honey in honeycombs with AutoCAD program

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Abstract

The study was conducted with bee colonies from the local honey bee (*Apis mellifera* L.) at the Training and Experimental Base of the Beekeeping Section at the Agriculture Faculty of the Thrakia University, Bulgaria. The surface of capped honey was determined for 58 honeycombs. An established method in beekeeping with a measuring frame (squares 5/5 cm) was used and a comparative analysis of the data obtained when measuring the specified indicator with AutoCAD program was performed. A method has been established for accurate determination of the surface of capped honey in honeycombs using the AutoCAD program. The difference between the average value of the capped honey surface measured by the approved method with a measuring frame and using the program AutoCAD is 5.73%.

Key words: honey bees, capped honey, AutoCAD

Определяне количеството на запечатания мед в пчелни пити с програма AutoCAD

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Резюме

Проучването е проведено с пчелни семейства от местната медоносна пчела (*Apis mellifera* L.) на Учебно-експерименталната база на секция „Пчеларство“ към Аграрен факултет на Тракийски университет, България. Определена е площта на запечатания мед при 58 бр. пчелни пити. Използван е утвърден метод в пчеларството с мерителна рамка (квадратчета 5/5 сантиметра), като е извършен сравнителен анализ на получените данни при измерване на посочения показател с програма AutoCAD. Установен е метод за точно определяне на площта на запечатания мед в пчелни пити с използване на програма AutoCAD. Получената разлика между

средната стойност на площта на меда измерена по утвърдения метод с мерителна рамка и с използване на програма AutoCAD е 5,73%.

Ключови думи: медоносни пчели, запечатан мед, AutoCAD

Introduction

The normal development of bee colonies is associated with the presence of food reserves in the hives (nectar, honey and pollen). These signs are monitored by beekeepers during the inspections they perform during the year. In beekeeping well-established methods are used for their determination by using a measuring frame, roughly, by photographing, etc. Well-established methods for determining the amount of honey and honey in the combs require more effort on the part of beekeepers and therefore a large number of samples cannot be processed (Bertrand et al., 2015). When measuring with them the probability of errors is higher (Fitzpatrick et al., 2009; Gonsamo et al., 2014). To avoid a number of inconveniences in these methods new modern methods are used through photography and computerization of the analysis. Computer methods allow automated tracking of measured features and improve data reliability. In recent years, many authors have applied new and modern methods for tracking indicators related to the development of bee colonies (honey, pollen, brood) (Kretzschmar et al., 2016; Alaux et al., 2018; Dubois et al., 2018; Kretzschmar and Frontero, 2017; Rollin and Garibaldi, 2019; Monchanin et al., 2019; Sutter et al., 2019). According to Fresnaye and Lensky (1961) methods with an average error of less than 10% must be considered accurate. With the help of digital photography new modern methods have been developed to automatically determine the surface of the capped brood on photos with Photoshop (Emsen, 2006), ArcView (Meikle, 2008) or ImageJ (Meikle et al., 2016; Yoshiyama et al., 2011; Delaplane et al., 2013) which are applied in modern beekeeping. A new method for determining capped brood and capped honey using Comb-Count software is proposed by Colin et al. (2018).

The objective of this study is to establish a fast and accurate method for determining the

amount of capped honey in honeycombs using AutoCAD.

Materials and methods

A periodic inspection of bee colonies from the local honey bee (*Apis mellifera* L.) of the Training and experimental base of the Beekeeping Department at the Faculty of Agriculture was performed and the surface of capped honey in combs was measured by measuring frame and AutoCAD program. The determination of the surface occupied by capped honey with the AutoCAD program was performed in the Scientific Laboratory of the Beekeeping Section at the Department of Animal Husbandry – Non-ruminants and other animals of the Faculty of Agriculture.

1. Determine the surface of capped honey using a measuring frame.

To determine the surface of capped honey a measuring frame with 5/5 cm squares is placed on the measured honeycomb (fig. 1). The surface of one square of the measuring frame is 25 cm².

To determine the amount of honey (in kilograms) it is assumed that on an surface of 1 dm² (100 cm²) of the comb filled on both sides there is 0.350 kg of honey respectively 0.175 kg on one side (Nenchev and Zhelyazkova, 2010). After counting the occupied squares the surface of the capped honey is determined by the following expression:

$$S_{hf} = n \cdot 25, \text{ cm}^2$$

Where n is the number of squares occupied by honey

The total amount of honey on the side of the comb is calculated (in kilograms) according to the following formula:



Fig. 1. Determining the surface of capped honey with a measuring frame

Фиг. 1. Определяне площта на запечатания мед с мерителна рамка

$$Q_{hf} = \frac{S_{hf} \cdot 0,175}{100}, kg$$

Where Q_{hf} – amount of honey, kg

S_{hf} – surface of capped honey, cm^2

2. Determining the amount of sealed honey by photographing and measuring with AutoCAD.

To determine the amount of capped honey in the combs using the Autocad program first removes the bees from the combs. Then the comb is photographed with a digital camera (Sony DSC-H300- 20.1 mega pixels) – (Fig. 2). A collection of digital photos of each comb is prepared in advance.

Then the photos are placed in AutoCAD program. The dimensions of the photo are updated to the actual internal dimensions of the bee frame: for the Dadan-Blatt system 415/270 mm and for Langstroth-Ruth 415/200 mm. To automatically



Fig. 2. Photographing the combs with scapped honey

Фиг. 2. Фотографиране на питите със запечатан мед



Fig. 3. Determining the surface of capped honey with AutoCAD program

Фиг. 3. Определяне площта на запечатания мед с програма AutoCAD

determine the surface of the honeycomb the areas are fenced with capped honey. After closing the contour of the figure that is formed using the command “Area” the program automatically calculates the surface of honey (fig. 3).

After determining the surface of capped honey with AutoCAD program its quantity in kilograms is determined by the following formula:

$$Q_{ha} = \frac{S_{ha} \cdot 0,175}{100}, kg$$

Where Q_{ha} – amount of capped honey, kg
 S_{ha} – surface of capped honey, cm^2

After obtaining the necessary results from the analyzes statistical processing of the data was performed by one-way analysis ANOVA to

obtain the mean values (Means), standard deviation (SD), standard error (SE), minimum and maximum value (min-max) with software STATISTICA 12, Copyright © Stat Soft Inc. 1984-2014 (StatSoft, 2014).

Results and Discussion

Table 1 presents the results of measuring the honey surfaces of the combs participating in the

Table 1. Results of the studied methods of measuring the sealed honey

Таблица 1. Резултати от изследваните методи за измерване на запечатания мед

Number of comb / Номер на пита	Number of squares / Брой квадратчета	Surface with measurement frame, cm^2 / Площ с рамка, cm^2	Surface with AutoCAD, cm^2 / Площ с AutoCad, cm^2	Amount of honey with measurement frame, kg / Количество мед при измерване с рамка, кг	Amount of honey with AutoCAD, kg / Количество мед при измерване с AutoCad, кг
1	9	225	211.2	0.394	0.370
2	8.5	212.5	186	0.372	0.326
3	2	50	58.6	0.088	0.103
4	9.3	232.5	213.8	0.407	0.374
5	8.6	215	194.7	0.376	0.341
6	8	200	187.8	0.350	0.329
7	7.6	190	173.5	0.333	0.304
8	8	200	178.5	0.350	0.312
9	6.6	165	142.6	0.289	0.250
10	5	125	106.4	0.219	0.186
11	9	225	214.7	0.394	0.376
12	4	100	97.4	0.175	0.170
13	6	150	188.6	0.263	0.330
14	21.6	540	574.4	0.945	1.005
15	9.2	230	206.7	0.403	0.362
16	10	250	236.6	0.438	0.414
17	13.5	337.5	370.8	0.591	0.649
18	8	200	231.7	0.350	0.405
19	9.6	240	262.6	0.420	0.460
20	7	175	172.1	0.306	0.301
21	10	250	276	0.438	0.483
22	10.2	255	266.1	0.446	0.466
23	11	275	281.6	0.481	0.493
24	9	225	206.8	0.394	0.362
25	8.5	212.5	212.3	0.372	0.372
26	9	225	226.5	0.394	0.396

27	2.6	65	63.4	0.114	0.111
28	2.1	52.5	47.4	0.092	0.083
29	1	25	27.9	0.044	0.049
30	1	25	23.1	0.044	0.040
31	1	25	22.2	0.044	0.039
32	12	300	294.9	0.525	0.516
33	12	300	283	0.525	0.495
34	9	225	200.9	0.394	0.352
35	15	375	425.2	0.656	0.744
36	3.5	87.5	69.7	0.153	0.122
37	2	50	47.2	0.088	0.083
38	30	750	822.5	1.313	1.439
39	40	1000	972.2	1.750	1.701
40	16	400	434.6	0.700	0.761
41	10	250	286	0.438	0.501
42	5.5	137.5	160.3	0.241	0.281
43	17	425	467.3	0.744	0.818
44	8	200	196	0.350	0.343
45	6	150	172	0.263	0.301
46	6	150	148.7	0.263	0.260
47	11.5	287.5	273.1	0.503	0.478
48	20	500	520.6	0.875	0.911
49	9	225	248.2	0.394	0.434
50	9	225	230.8	0.394	0.404
51	15	375	339.3	0.656	0.594
52	14	350	393.5	0.613	0.689
53	7.5	187.5	147.3	0.328	0.258
54	9	225	202.9	0.394	0.355
55	9.7	242.5	222.6	0.424	0.390
56	6	150	89.1	0.263	0.156
57	11.3	282.5	259.8	0.494	0.455
58	12.5	312.5	341.5	0.547	0.598

experiment using the methods with the measuring frame and the AutoCAD program.

When determining the surface of the capped honey with the measuring frame the filled squares are counted ocular after which the surface in square centimeters is calculated (Table 1). When measuring the surface of the capped honey with AutoCAD program the values are obtained in square centimeters (Table 1).

Fig. 4 illustrates the results for the measured surface by the two methods for each of the experimental honeycombs. It can be seen (fig.

4) that the profile of the curve obtained when measuring with AutoCad almost coincides with that of the approved method. This finding suggests that the AutoCad method can be applied to calculate the surface of the capped honey. A number of authors apply computer programs in beekeeping due to the established accuracy and speed of work with them (Tofilski, 2004; Abou-Shaara et al., 2011; Mladenovic et al., 2011).

This is confirmed by the absence of statistically proven significant difference between the

results obtained by measuring the two methods ($p = 0.978$) – fig. 5.

Fig. 5 shows the statistically processed results of determining the surface of capped honey by these methods. In the method of measurement with a measuring frame the average value of the

studied indicator $359.24 \pm 121.58 \text{ cm}^2$ was established. The variation in minimum–maximum limits is from 150 to 625 cm^2 . The average value measured by the method with the AutoCAD program is $338.64 \pm 122.26 \text{ cm}^2$. This value is lower than that measured by the method with a mea-

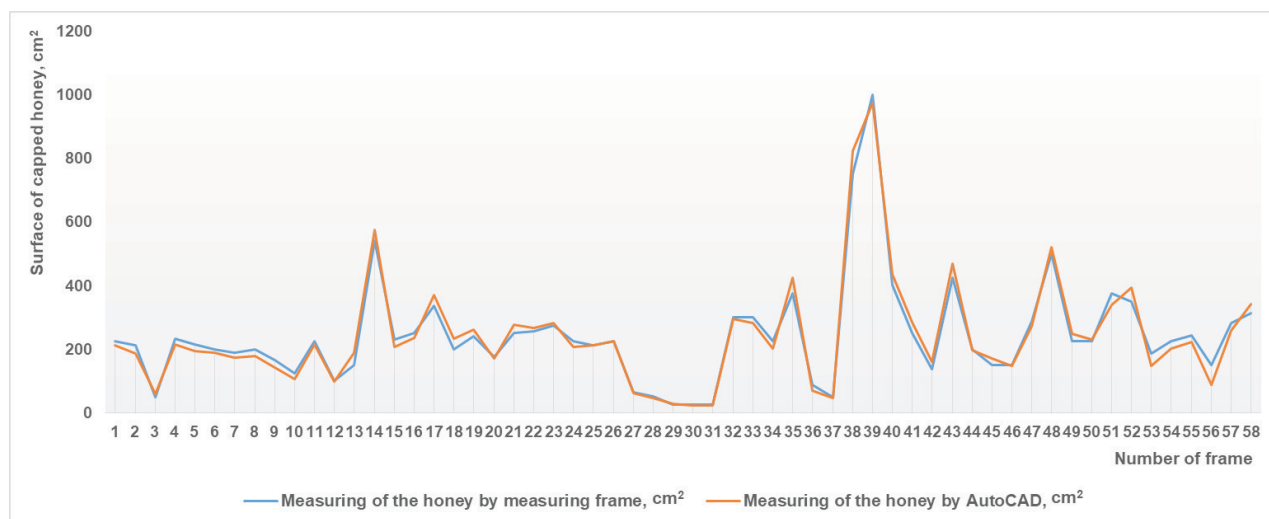


Fig. 4. Results of the studied methods of measuring the surface of capped honey
Фиг. 4. Резултати от изследваните методи за измерване на площта на запечатания мед

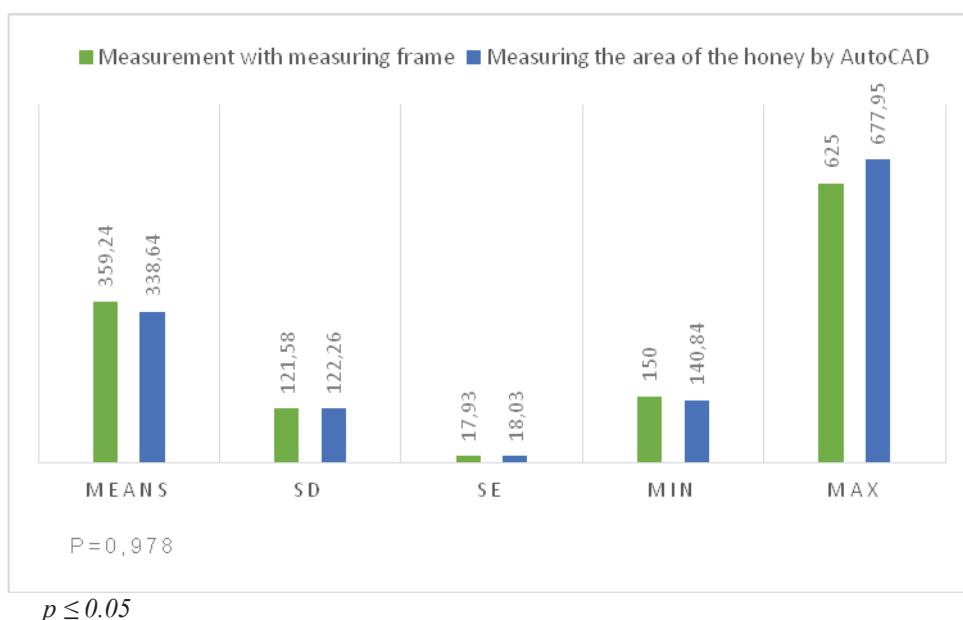


Fig. 5. Results of the studied methods of measuring the surface of capped honey, cm^2 ($p = 0.978$)
Фиг. 5. Резултати от изследваните методи за измерване на площта на запечатания мед, cm^2 ($p = 0.978$)

suring frame of 20.60 cm² or 5.73%. This difference was not statistically confirmed at a significance level $p \leq 0.05$ ($p = 0.978$).

Analogously to Fig. 4 the profile of the curve in fig. 6 for the amount of honey obtained when measured with the AutoCAD program overlaps that when measured with the measuring frame. This gives us reason to believe that determining

the amount of honey with an AutoCAD program can be considered as an alternative method to the established method with a measurement frame.

Figure 7 presents the statistically processed data from the determination of the amount of capped honey (kg) by both methods.

In the well-established method of measurement with a measuring frame it was found that

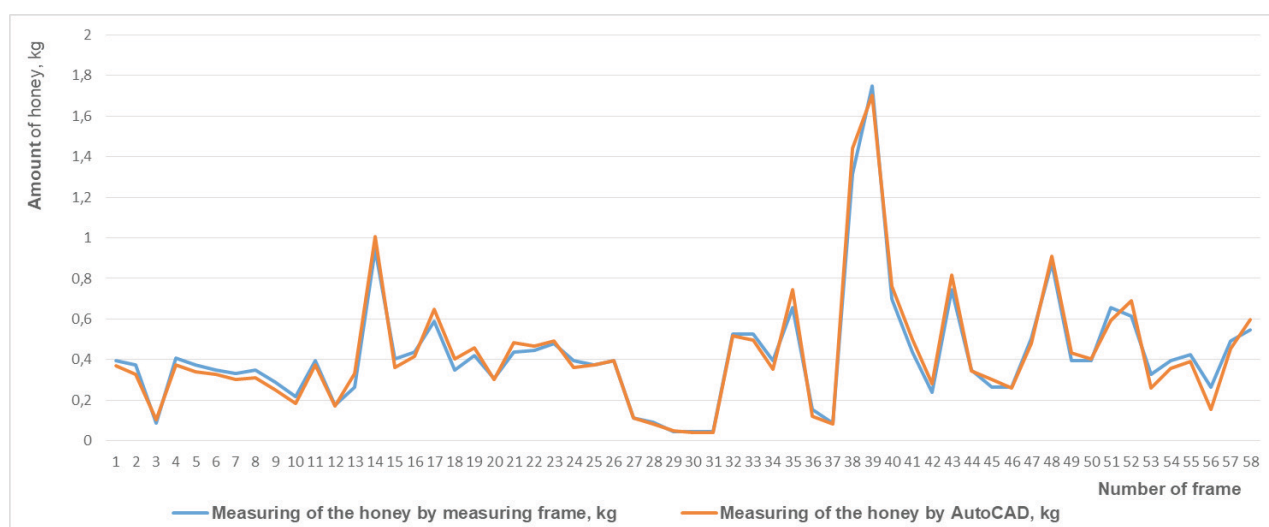
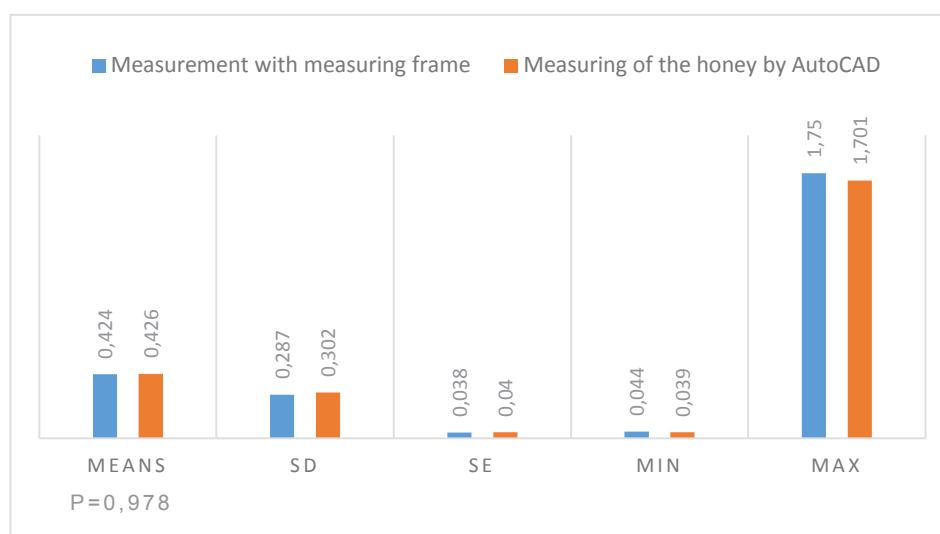


Fig. 6. Results of the studied methods of measuring the amount of capped honey, kg

Фиг. 6. Резултати от изследваните методи за измерване на количеството на запечатания мед, кг



$P \leq 0.05$

Fig. 7. Results of the studied methods of measuring the sealed honey in kg ($p = 0.978$)

Фиг. 7. Резултати от изследваните методи за измерване на запечатания мед в кг ($p = 0.978$)

the average value of the studied indicator is 0.424 ± 0.287 kg. The indicated difference between the mean values of the studied indicator was not statistically confirmed at a significance level $p \leq 0.05$, ($p = 0.978$). The variation in minimum–maximum limits is from 0.044 to 1.750 kg (fig. 7). The mean value measured by the AutoCAD method is 0.426 ± 0.302 kg. This value is higher than that measured by the method with a measuring frame of 0.002 kg which is less than 1% (0.47%). This finding confirms the conclusions of Tofilski (2004) that automatic measurements are fast and accurate and AutoCAD can be successfully applied in beekeeping (Mladenovic et al., 2011). Many authors report the application of accurate and fast semi-automatic computer methods to determine the surface of the capped brood using digital photography (Emsen, 2006; Yoshiyama et al., 2011). Colin et al. (2018) develop the CombCount software with which the surface of the brood and honey can be determined. Other authors report 94.3% accuracy in determining open-cell brood with the HiveAnalyzer program (Höferlin et al., 2013). The free software DeepBee © (Thiago et al., 2020) gives very promising results for determining the area of pile and honey in combs.

Conclusions

The average value of the surface of capped honey obtained by the method of measurement with a measuring frame is 359.24 ± 121.58 cm² and in the method with the AutoCAD program 338.64 ± 122.26 cm². The established difference between the average values of the surface of capped honey measured by the two methods is 5.73%.

When determining the amount of the capped honey in combs by the measuring frame method the average value of 0.424 ± 0.287 kg is established. The value measured by the method with the AutoCAD program is 0.426 ± 0.302 kg. This value is higher than that measured by the method with a measuring frame of 0.002 kg, which is less than 1% (0.47%).

The results of the obtained experimental data give us reason to assume that the measurements with AutoCAD program are accurate and the same can be successfully applied to determine the surface and amount of capped honey in combs.

References

- Abou-Shaara, H. F., Draz, K. A., Al-Aw, M., & Eid, K.** (2011, September). Simple method in measuring honey bee morphological characters. In *Proceedings of 42nd International Apicultural Congress–APIMONDIA in Buenos Aires (Argentina), 21th* (p. 222).
- Alaux, C., Soubeyrand, S., Prado, A., Peruzzi, M., Maisonnasse, A., Vallon, J., Hernandez, J., Jourdan, P., & Le Conte, Y.** (2018). Measuring biological age to assess colony demographics in honeybees. *PLoS ONE*, 13 (12) e0209192, DOI: <https://doi.org/10.1371/journal.pone.0209192>.
- Alves, T. S., Pinto, M. A., Ventura, P., Neves, C. J., Biron, D. G., Junior, A. C., ... & Rodrigues, P. J.** (2020). Automatic detection and classification of honey bee comb cells using deep learning. *Computers and Electronics in Agriculture*, 170, 105244.
- Bertrand, B., Alburaki, M., Legout, H., Moulin, S., Mougél, F., & Garnery, L.** (2015). Mt DNA COI-COII marker and drone congregation area: An efficient method to establish and monitor honeybee (*Apis mellifera* L.) conservation centres. *Molecular Ecology Resources*, 15(3), 673–683. <https://doi.org/10.1111/1755-0998.12339>.
- Colin, T., Bruce, J., Meikle, W. G., & Barron, A. B.** (2018). The development of honey bee colonies assessed using a new semi-automated brood counting method: CombCount. *PLoS One*, 13(10), 1–14. <https://doi.org/10.1371/journal.pone.0205816>.
- Delaplane, K. S., Van der Steen, J., & Guzman-Novoa, E.** (2013). Standard methods for estimating strength parameters of *Apis mellifera* colonies. *Journal of Apicultural Research*, 52 (1), 1–12. Available at: <https://www.tandfonline.com/doi/abs/10.3896/IBRA.1.52.1.03>.
- Dubois, E., Reis, C., Schurr, F., Cougoule, N., & Ribière-Chabert, M.** (2018). Effect of pollen traps on the relapse of chronic bee paralysis virus in honeybee (*Apis mellifera*) colonies. *Apidologie*, 49(2), 235–242. <https://doi.org/10.1007/s13592-017-0547-x>.
- Emsen, B.** (2006). Semi-automated measuring capped brood areas of honey bee colonies. *Journal of animal and Veterinary Advances*, 5, 1229–1232. Available at: <https://agris.fao.org/agris-search/search.do?recordID=DJ2012071745>.

- Fitzpatrick, M. C., Preisser, E. L., Ellison, A. M., & Elkinton, J. S.** (2009). Observer bias and the detection of low-density populations. *Ecological applications*, 19(7), 1673-1679. DOI: <https://doi.org/10.1890/09-0265.1>.
- Fresnaye, J., & Lensky, Y.** (1961). Méthodes d'appréciation des surfaces de couvain dans les colonies d'abeilles. In *Annales de l'Abeille* (Vol. 4, No. 4, pp. 369-376). EDP Sciences. Available at: <https://hal.archives-ouvertes.fr/hal-00890151/document>.
- Gonsamo, A., & D'Odorico, P.** (2014). Citizen science: best practices to remove observer bias in trend analysis. *International journal of biometeorology*, 58(10), 2159-2163. DOI: <https://doi.org/10.1007/s00484-014-0806-8>.
- Höferlin, B., Höferlin, M., Kleinhenz, M., & Bargen, H.** (2013). Automatic analysis of *apis mellifera* comb photos and brood development. In Association of Institutes for Bee Research Report of the 60 th Seminar in Würzburg. *Apidologie*, 44, 19. Retrieved from https://www.springer.com/cda/content/document/cda_downloadaddocument/AGIB-Abstracts.
- Kretzschmar, A., & Frontero, L.** (2017). Factors of honeybee colony performances on sunflower at apiary scale. *Oléagineux, Corps Gras, Lipides*, 24(6), 1-7. D604. DOI: <https://doi.org/10.1051/ocl/2017054>.
- Kretzschmar, A., Maisonnasse, A., Dussaubat, C., Cousin, M., & Vidau, C.** (2016). Performances des colonies vues par les observatoires de ruchers. *Innovations Agronomiques*, 53, 81-93. Available at: <https://hal.archives-ouvertes.fr/hal-01607704>.
- Meikle, W. G., Adamczyk, J. J., Weiss, M., Gregorc, A., Johnson, D. R., Stewart, S. D., Zawislak J., Carroll M. J., & Lorenz, G. M.** (2016). Sublethal effects of imidacloprid on honey bee colony growth and activity at three sites in the US. *PloS one*, 11(12), e0168603. DOI: <https://doi.org/10.1371/journal.pone.0168603>.
- Meikle, W. G., Rector, B. G., Mercadier, G., & Holst, N.** (2008). Within-day variation in continuous hive weight data as a measure of honey bee colony activity. *Apidologie*, 39(6), 694-707.
- Mladenović, M., Pešev, V., Radoš, R., & Rašić, S.** (2011). Morphometric parameters of gray and yellow honey bee from Serbia. *Biotechnology in Animal Husbandry*, 27(3), 1395-1400.
- Monchanin, C., Henry, M., Decourtye, A., Dalmon, A., Fortini, D., Bœuf, E., ... & Fourrier, J.** (2019). Hazard of a neonicotinoid insecticide on the homing flight of the honeybee depends on climatic conditions and Varroa infestation. *Chemosphere*, 224, 360-368. DOI: <https://doi.org/10.1016/j.chemosphere.2019.02.129>.
- Nenchev, P., & Zhelyazkova, I.** (2010). Beekeeping, *Academic Publishing House Trakia University*, Stara Zagora, Bulgaria.
- Rollin, O., & Garibaldi, L. A.** (2019). Impacts of honeybee density on crop yield: A meta-analysis. *Journal of Applied Ecology*, 56(5), 1152-1163. DOI: <https://doi.org/10.1111/1365-2664.13355>.
- Sutter, L., Aebi, A., Buchwalder, G., Caballé, P., Dietemann, V., Girardin, O., Hernandez J., Jacopin-Bucher E., Mayor P., Ménétrier V., Praz C., & Varennes, Y. D.** (2019). Agriculteurs, apiculteurs et chercheurs unis pour la sauvegarde des pollinisateurs. *Rech. Agron. Suisse*, 10, 424-429.
- Tofilski, A.** (2004, September). Automatic determination of honey bee cubital index. In *First European Conference of Apidology. Udine* (pp. 19-23).
- Yoshiyama, M., Kimura, K., Saitoh, K., & Iwata, H.** (2011). Measuring colony development in honey bees by simple digital image analysis. *Journal of Apicultural Research*, 50(2), 170-172. DOI: <https://doi.org/10.3896/IBRA.1.50.2.10>.
- StatSoft, Inc. (2014). STATISTICA (data analysis software system), version 12. Available at: www.statsoft.com.