

BEEHIVES AND HONEY PRODUCTION - A BRIEF STATISTICS IN THE WORLD AND EUROPEAN UNION 2000-2022 AND HONEY BEES BETWEEN INTERLINKED CRISIS OF BIODIVERSITY, POLLUTION AND CLIMATE CHANGE

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Abstract

The paper analyzed the number of beehives and honey production at the global level and in the European Union as well as the main problems honey bees are facing nowadays and how they could be solved. The statistical data for the period 2000-2022 provided by FAOStat, Knoema, Eurostat and other official data bases have been processed using fixed basis and structural indices, trend regression equations (linear and polynomial), R square, descriptive statistics, regression analysis, correlation coefficient, comparison method. Compared to 58.8 million beehives in the world in the year 2000, in 2022 their number reached 102 million (+76.3%). The share of beehives by continent is: Asia 44.6%, Europe 24.7%, Africa 17.7%, Americas 11.4% and Oceania 1.4%. The highest number of bee hives is in India, China Mainland, Turkey, Iran (Islamic Rep.), Ethiopia, Russian Federation, Argentina, Tanzania (U. Rep.), USA and Mexico. In 2022, the EU had 20.27 million beehives, meaning +19.44% versus 2016. The largest number of bee hives in the EU is in Spain, Romania, Greece, Poland, Italy, France, Hungary, Germany, Bulgaria and Czechia. From 1.25 million tons in the year 2000, the global honey production reached 1.83 million tons in 2022 (+45.8%). The regression equation: $y = 0.0148x + 0.4064$ shows that an increase by one million beehives will determine a growth by 0.0148 million tons of honey at the global level. From the peak of 22.5 kg honey per bee hives in the year 2005, in 2022, it was registered 17.9 kg at the global level. Honey production by continent in 2022 was: Asia 48.2%, Europe 22.8%, Americas 18.5%, Africa 8.5% and Oceania 2%. In 2022, the top 10 honey producing countries at the global level were: China, EU-27, Turkey, Iran (Islamic Rep.), India, Argentina, Russian Federation, Mexico, Ukraine and Brazil, all together representing 73.6% of the world honey production. In 2014, the EU produced 235 thousand tons honey and in 2022 it achieved 286 thousand tons (+21.7%). The top honey producing countries are Germany, France, Romania, Spain, Hungary, Italy, Poland, Greece, Bulgaria and Portugal. A bee hives produces 21 kg honey in average, but there are EU countries with higher yields: Finland, Germany, Belgium, Denmark, Estonia, Austria, Italy, Lithuania, Latvia and France. To solve the crisis of biodiversity, pollution and climate change, specific recommendations are destined to improve the ratio between the managed honey bees and wild bees so that the wild bees to have access to flowering sources, to benefit of a suitable habitat to live and reproduce and biodiversity not to suffer. Special measures have to be taken in the cities so that the balance between honey and wild bees to be preserved and the residents and tourists not to be affected. Severe cleaning and hygiene in the apiary, avoiding bees imports, making treatments based on organic medicines could avoid diseases and pests. Farmers have to avoid the use of Neonicotinoids pesticides to help apiculturists not to have bees losses. Beekeeping technology must be adapted to the local conditions and weather alerts, assuring flowering sources, bees reproduction and food storage, as the bee families to pass easier over the winter. An intensified consultancy service, investments in new technologies, a balanced transhumance, more effective marketing actions could increase honey production and quality and stimulate consumption in the EU.

Key words: beehives, honey production, biodiversity, pollution, climate change

INTRODUCTION

Bees are very important on our Planet playing a special role in assuring human existence by

sustaining agriculture, food security, health and also preserving biodiversity.

Besides the horse and the dog, the bees contributed to the history and civilization of mankind. Beekeeping is one of the oldest activities carried out by people for millennia [3].

Bees are spread on all the continents where the habitats offer them flowering plants which could be pollinated by the bees species. To live they need food, that is nectar rich in energy and pollen as a source of protein.

The habitats should be not only rich in food sources, but also they must offer places for nesting, reproduction and food storage.

The preferred habitats by bees are the ones where the flowering flora is abundant, that is: fruit trees, orchards, technical crops (sunflower, rape, mustard, flax, cotton), vegetables (cabbage, onion, radishes), leguminous seeds (alfalfa, clover), melons, pumpkins, strawberry, blackberry, raspberry, meadows, blueberry, forestlands, gardens, parks etc.



Photo 1. Apis Mellifera Carpatica

The domesticated honey bees produce honey for human consumption all over the world in different habitats [5, 38, 69].

For assuring a balanced development of honey bees, between the number of bee colonies and forage resources should be an optimal relationship [29].

Pollination made by bees is very important both from an economic point of view, because they pollinate an important weight of agricultural crops and fruit trees and also from an ecological point of view because they pollinate wild plants preserving biodiversity.

From the 200,000 species of pollinators, bees represent about 20,000 species and by the pollination service they carry out, they contribute to the maintenance of the balance of the eco-systems [34, 58].

It is officially recognized that 80% of the world plants depend on pollinators and 35% of the world crop production is sustained by the activity of bees and other pollinators [22, 71]. It is estimated that about 98 % of the economic benefice obtained from honey bees is the result of pollination which increases agricultural production, favors plant reproduction and maintains biodiversity, and only the rest of 2% is the value of bee products.

About 264 species of cultivated plants are totally of partially dependent on pollination and production from 75% of the cultivated crops, which assure traded products on the international market, depend on pollination.

In case of over 90 agricultural crops like: cotton, medicinal plants, agricultural crops which produce fruits, vegetables, nuts, seeds, forages for animals, bees could increase production by at least 30%. More than this, about 10% of entomophilous agricultural crops totally depend on pollination made by bees [7].

In Table 1, there are shown the production gains obtained by various plants due to pollination made by bee families.

Table 1. Production gains due to pollination made by bee colonies

Entomophilous plants	No. of bee families per ha	Production gains due to pollination made by honey bees (%)
Fruit trees	2-3	50-60
Alfalfa	8-10	50-60
Clover	4-5	200-300
Sunflower	1-2	30-50
Rape, mustard	4	25-50
Cotton	1-2	25
Cabbage, onion, radishes	3	200-300
Melons, pumpkins	0.6-1	200-400

Source: [38].

A more detailed presentation of the multiple role of bees is provided in Table 2.

Table 2. The role of bees on our Planet

	ROLES
1	Provide natural pollination service of the agricultural crops on 40% of the Earth land and also of other wild plant species, both in warmer areas and cold zones
2	Assure food security offering a large variety of natural and high nutritive value food products such as: honey, pollen, royal jelly
3	Offer important products with medicinal effect used in the treatments of various diseases (pollen, propolis, royal jelly, bee venom etc)
4	Bee products are used in various fields like: nutrition, medicine, cosmetics, food industry etc
5	Sustain human life, health and longevity of billions of people
6	Increase agricultural production
7	Sustain biodiversity assuring a balanced link among pollinators, their abundance and maintenance of other species and the growth of cultivated and wild plants
8	Promote the beauty of the landscapes
9	Offer subject of inspiration for human culture (in art, music, song lyrics, movies, festivals etc
10	Are tools of war to attack the enemies, for fighting against invaders and protecting the ancient citadels
11	Contribute to the creation of jobs, involving pleasant activities in fresh air
12	Empower women and youth as labour
13	Reduce migration
14	Reduce poverty and food insecurity in the developing countries
15	Develop hobbies
16	Develop social relationships between the apiculturists and bee lovers (associations, clubs etc)
17	Create networking among beekeepers
18	Increase household income
19	Contributes to the development of rural areas
20	Support forest conservation
21	Provide information about the environment quality giving signals about the presence of pollutants
22	Create opportunities for export

Source: Own conception adapted based on: [1, 2, 8, 24, 26, 27, 32, 42, 47, 49, 50, 52, 53, 56, 62, 70].

The development of apiculture across the time could be quantified in the increased number of bee hives and honey production which were stimulated by the higher and higher honey demand and measures taken by various states to sustain beekeepers.

An increased number of apiaries, and also a higher and higher apiary size than 100-150 bee hives are compulsory for assuring economic efficiency in beekeeping [40, 41].

In a large-sized apiary, the difference between gross product, representing the value of honey and other bee products obtained in the farm, and variable costs could led to a higher gross margin [43, 46].

From beekeeping, the apiculturists obtain not only honey, but also other products like: pollen, beeswax, propolis, royal jelly, bee venom which could be an important income source. Also the apiarists could get income from selling bee queens, package bees, bee hives etc.

These products could be commercialized both on the internal market, but also in the

international trade. However, the most traded bee product is honey.

The main supplier of honey is China, while the main importer is the EU [44, 45, 55].

The intensive agricultural systems based on high levels of chemicals, especially pesticides have become polluting factors which affect environment quality (soil, water, air) and in addition the global warming has disturbed the balance in agro-eco-systems diminishing the habitats, forage resources and the number of pollinators [36].

These negative aspects confirmed by scientists have led to the need to raise the awareness that without bees and other pollinators life cannot be sustained. Even the quota mis-attributed to Albert Einstein affirmed that "If the bees will disappear off the face of the Earth, man would only have four years left to live", which is not quite true [59].

Many scientists suggested that people dealing with agribusiness and environment protection have to change crop technologies adapting them in such a way to reduce the amount of pesticides which affect environment quality,

high value wild flora and agricultural crops which are forage sources for pollinators, and also diminish the population of pollinators and disturb its density and variety, and by default, will affect food security, biodiversity, health and beauty of our Planet.

Joint efforts are made to internationally cooperate in protecting honey bees [4, 9, 11]. Since 2018, every year it is celebrated the World Bee Day, as established by UN General Assembly, at the proposal of the Republic of Slovenia and with the support of the International Federation of Beekeepers Association-APIMONDIA and on this occasion the big problems of apiculture are discussed [21].

In this context, the paper aimed to analyze the evolution of bee hives and honey production at the global level and in the EU, in the period 2000-2022 in order to establish the main trends, emphasizing the distribution by continent, regions and in the main honey producing countries. In this study, the big problems of bees in relation to intensive agriculture, pollution, diseases and pests and climate change are also approached.

MATERIALS AND METHODS

The paper was set up based on the empirical data provided by FAOStat, Knoema, Eurostat and other official data sources for the period 2000-2022, concerning the number of bee families and honey production worldwide, by continent and regions. Also, a special attention was paid to the European Union as the second honey producer in the world after China and the top importer of honey. The top 10 countries for these two indicators were nominated.

Regarding the methodological aspects, we could mention: fixed and structural indices, descriptive statistics in terms of mean, standard error, standard deviation, kurtosis, skewness, minimum and maximum value. Also, the trend equation suitable to the evolution of each indicators, in terms of linear or polynomial

regression as well as the coefficient of determination, R square, were calculated.

More than this, the correlation coefficient and the regression equation between the dependent variable, Y, honey production and independent variable, X, the number of bee hives were determined and interpreted.

Illustrations in terms of graphics and tables have been used for a better understanding of the analyzed indicators.

Finally, the obtained results were correspondingly interpreted.

RESULTS AND DISCUSSIONS

Number of bee hives

Dynamics of the number of beehives worldwide

In the 1990, at the global level there were 69.2 million beehives. In the year 2000, there were 58.8 million beehives, but across the time it increased so that in the year 2022 it accounted for 102 million, which means a surplus by 73.46% (Fig. 1).

The dynamics reflects an ascending trend with small inflexions, and the determination coefficient confirms the change in number of bee hives across these 23 years.

This growth was stimulated by the increase in human population, requiring higher agricultural production both in vegetal and animal sector, a higher demand for pollination services.

In terms of descriptive statistics, the main results regarding the number of beehives at the global level are shown in Table 3.

On the whole period of 23 years taken into account, the average number of bee hives was 78.58 million with a standard deviation of 13.59. The level of this indicator ranged between the minimum of 58.8 million and the maximum of 102 million.

The coefficient of variation was 17.07 %, reflecting a good result and that the variability of the data is low around the mean, suggesting a high degree of consistency and reliability.

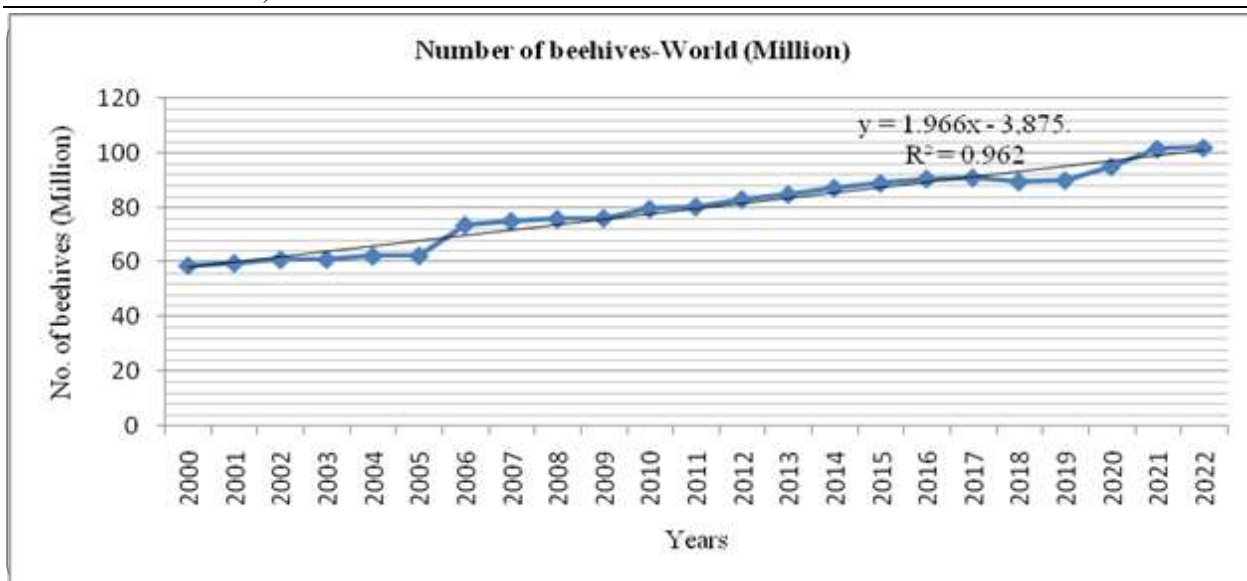


Fig. 1. Dynamics of the world number of bee hives (million)
 Source: Own design and calculation based on the data from: [10, 65].

Table 3. Descriptive statistics for the world number of beehives, 2000-2022

Mean	St. Error	St. Dev.	Kurtosis	Skewness	Min	Max	Coef. of Var. (%)
79.58	2.83	13.59	-1.064	-0.1604	58.8	102	17.07

Source: Own calculation.

Dispersion of the number of bee hives by continent

The distribution of the bee hives at the global level differs from a continent to another and from a country to another.

In 1990, the top position was kept by Asia with 33.4%, followed by Europe with 32.5%, on the 3rd position came Africa (14%) and finally Oceania (1%).

In the year 2021, Asia preserved its leading position with 45.1%, despite that in the period 1990-2000 it registered a decline, but then, it has recorded a growth by 11.7 percentage points versus 1990.

On the 2nd position comes Europe, keeping 24.7% share after a decrease from the year

2000 to 2013, but now the number of bee hives has recovered. In case of Europe, in 2021 versus 1990, the reduction accounts for - 7.8 percentage points.

Africa came the 3rd with 17.9% in the year 2021, but this share is by -1.2 percentage points smaller than 19.1% in 1990.

The Americas are ranked the 4th for 11.4%, recording a continuous lower share in the global number of bee hives across the studied period.

Oceania had a negative trend, in 2021, its number of bee hives being by -0.1 percentage points lower than in 1990 (Table 4).

Table 4. Distribution of the number of bee hives by continent (%)

	1990	2000	2007	2013	2021	2021- 1990 (pp)
Africa	19.1	23.4	21.8	20.4	17.9	-1.2
Americas	14.0	17.4	13.8	14.1	11.4	-2.6
Asia	33.4	28.3	41.5	43.9	45.1	+11.7
Europe	32.5	29.5	21.7	20.7	24.7	-7.8
Oceania	1.0	1.4	1.2	0.9	0.9	-0.1.

Source: Own calculation based on [65].

As mentioned before, the variability of the number of bee hives from a geographical point of view on the world map is very large depending on the continent, region, country and of course on the climate conditions, tradition an experience in beekeeping, apiary

power and apiculturist financial resources and desire to extend its apiary size.

Figure 2 shows the share of the number of bee colonies by continent in the global number in 2021 versus 1990.

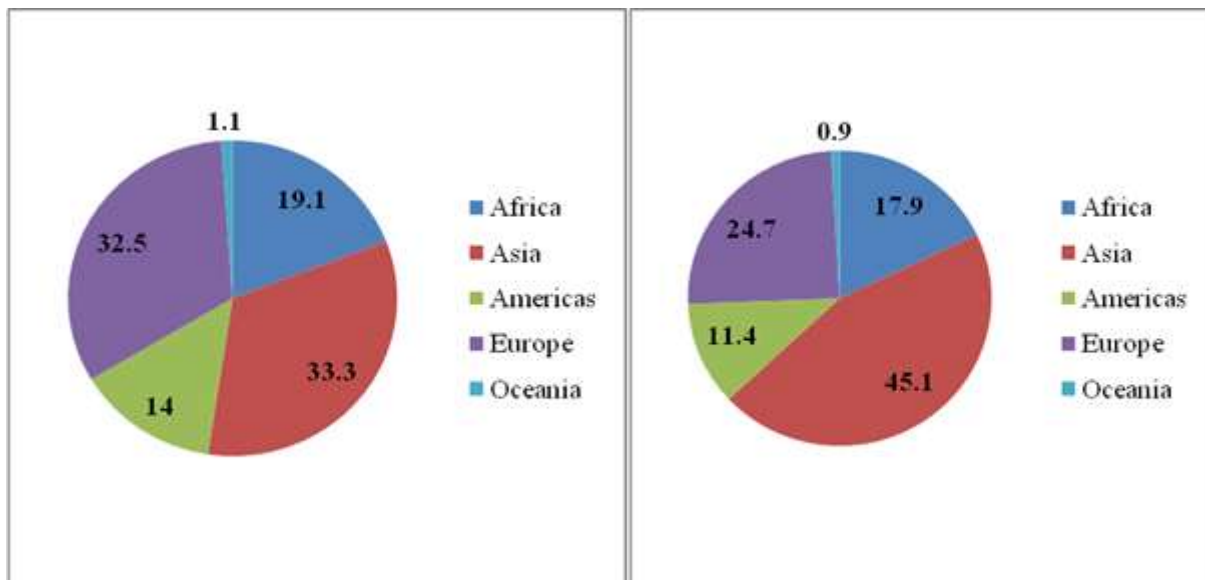


Fig. 2. The share of the number of bee colonies by continent in the global number in 1990 (Left) versus 2021 (Right) (%)

Source: Own design and calculation.

Distribution of beehives by region in each continent

Judging this aspect by region in the year 2021 versus 1990 within each continent, the situation looks as mentioned below.

In Africa, in this interval the number of bee colonies increased by +37.87%. The most numerous bee colonies (12.1 million) are in Eastern Africa, where in these 41 years, their number increased by 51.25%. In Central Africa, the growth was +26.92%, in Western Africa by 300%, in Southern Africa remained at the lowest level (0.1 million) and in Northern Africa declined by -4% (Table 5).

Asia recorded a surplus of 96.10% bee colonies in 2021 versus 1990 and it deserves to specify that in all the regions of this continent the number of bee colonies increased as follows: +89.9% in Southern Asia, +42.16% in Eastern Asia, +300% in South Eastern Asia, +205% in West and +100% in the Central part. The most numerous bee colonies are in the South (20.8 million), East (11.8 million) and West (11.3 million) (Table 5).

In the Americas as a whole, the number of bee colonies increased by 19.58%. while in the Central part it remained at the same level (2.6 million). In the Caribbean area, it increased by 33.3% and in South America went up by 74.3%. In Northern America, the number of bee colonies declined by 8.11%. However, South America comes on the top position with 5.2 million bee colonies, being followed by Northern America (3.4 million) and Central America (2.6 million) (Table 5).

On the European continent, the number of bee colonies raised by 11.55% from 1990 to 2021, but with different growth rates from a region to another. While in the North region, their number became six times higher and in the Southern Europe increased by 23.91%, in Eastern Europe it was noticed a decline by 24.65% and in West part also a decrease but by only 2.86%. In 2021, the highest number of bee colonies is in Eastern Europe (10.7 million) and in Southern Europe (10.3 million) (Table 5).

Oceania doubled its number of bee colonies, which accounted for 1.4 million in the year

2021. All the bee colonies are located in Australia and New Zealand (Table 5).

Table 5. Distribution of bee colonies by geographical region within each continent in 2021 versus 1990 (Million)

Continent	Geographical Region	1990	2021	2021/1990 %
Africa	North	2.5	2.4	96.0
	Central	2.6	3.3	126.9
	East	8.0	12.1	151.2
	West	0.1	0.4	400.0
	South	0.1	0.1	100.0
	AFRICA	13.2	18.2	137.8
Asia	Central	0.5	1.0	200.0
	East	8.3	11.8	142.2
	South	11.0	20.8	189.1
	South-East	0.1	0.4	400.0
	West	3.7	11.3	305.4
	ASIA	23.1	45.3	196.1
America	North	3.7	3.4	91.9
	Central	2.6	2.6	100.0
	Caribbean	0.3	0.4	133.3
	South	3.0	5.2	173.3
	AMERICAS	9.7	11.6	119.6
Europe	West	3.5	3.4	97.1
	North	0.1	0.6	600.0
	East	14.2	10.7	75.3
	South	4.6	10.3	223.9
	EUROPE	22.5	25.1	111.5
Oceania	Australia and New Zealand	0.7	1.4	200.0
	OCEANIA	0.7	1.4	200.0
WORLD	TOTAL	69.2	101.6	146.8

Source: Own calculation based on the data from [10].

Top countries in the world for the number of beehives

In 2019, the main countries with the highest number of bee hives, in the decreasing order,

were: India, China Mainland, Turkey, Iran (Islamic Rep.), Ethiopia, Russian Federation, Argentina, Tanzania (U. Rep.), USA and Mexico (Fig. 3).

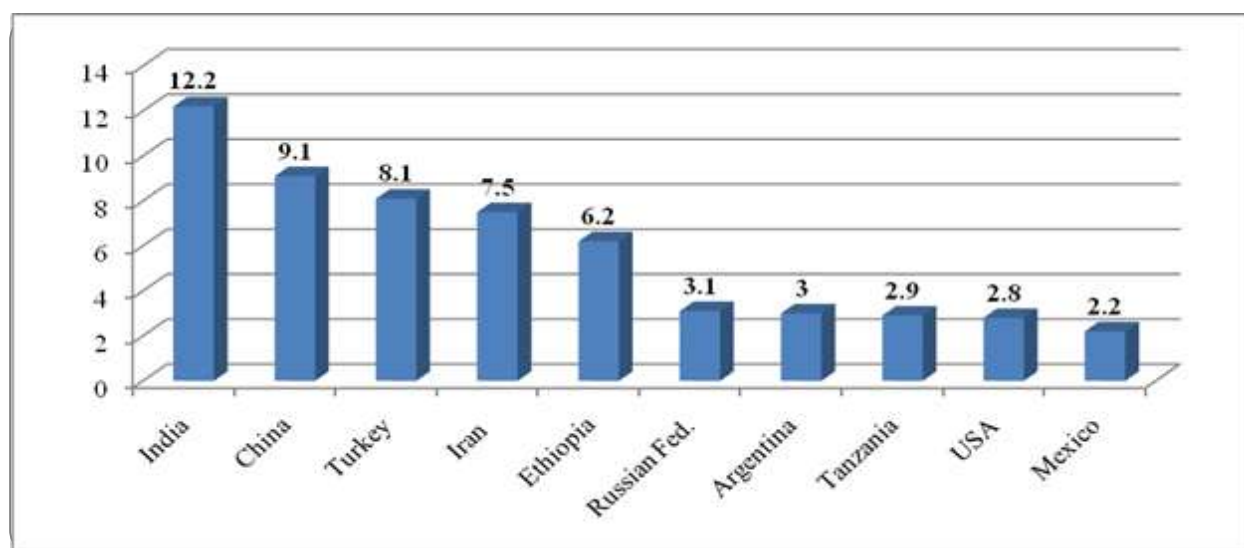


Fig. 3. The top 10 countries in the world with the highest number of beehives in 2019 (Million)

Source: Own design based on the data from [35, 60].

The number of beehives in Europe

According to FAO, 2024, in 1990, Europe had 22.5 million bee hives, but in 2021 it reached 25.1 million (+11.5%).

Beekeeping is practiced in many European countries, but the most numerous are

concentrated in the East part (10.7million) and in the South region (10.3 million). In the Western part, there were only 3.4 million (Table 5 and Figure 4).

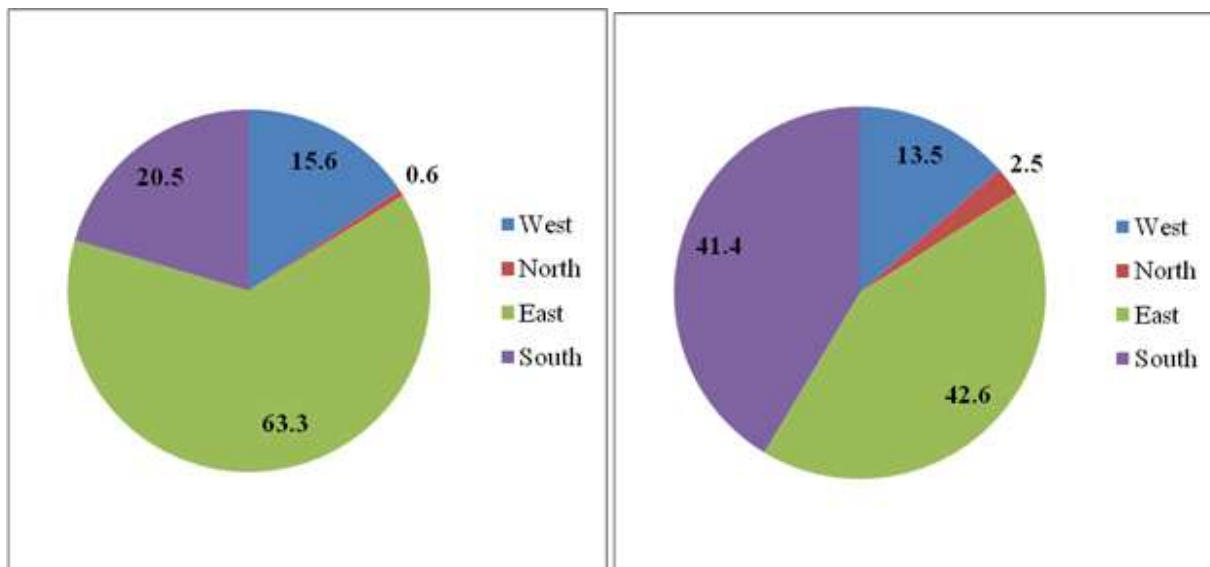


Fig. 4. The distribution of the share of bee hives by geographical region in Europe in 1990 (Left) and 2021 (Right)(%)
 Source: Own design and calculation based on the data from [10].

Dynamics of beehives in the European Union

The EU beekeeping is practiced in almost all the member states, but in different geographical conditions which determine that the abundance and density of the bee colonies to vary from a country to another and a large range of beekeeping practices to be carried out

in apiaries of various sizes with a deep impact on honey yield and production.

At the EU level, beekeeping development was favored by the increased honey consumption. However, the offer is not satisfactory so that the subsidies offered to the apiarists to increase the number of bee hives and apiary size has continuously stimulated apiculture.

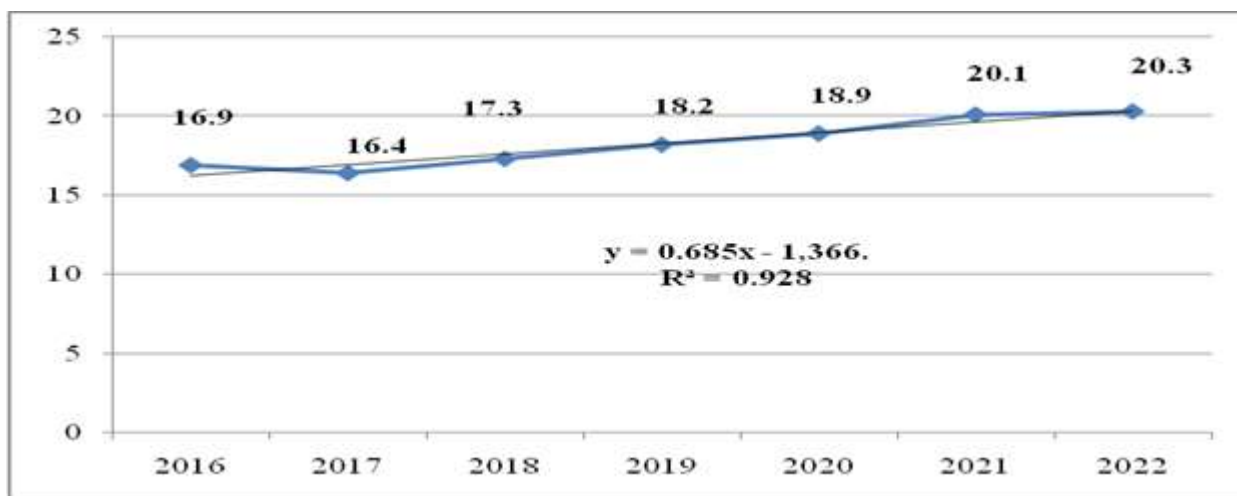


Fig. 5. Dynamics of the number of bee hives in the European Union, 2016-2022 (Million)
 Source: Own design based on the data from: [15, 19].

In 2022, the EU had 20.27 million beehives compared to the year 2016, when it had 16.97 million, meaning an increase by 19.44% (Fig. 5).

The top 10 member states with the largest number of bee hives in the EU are: Spain, Romania, Greece, Poland, Italy, France, Hungary, Germany, Bulgaria and Czechia [51].

This is a consequence of the fact that the number of beekeepers increased in the EU from 635.6 thousands in the year 2010 to 710.8 thousands in the year 2022, meaning by 11.83% more.

The most numerous beekeepers (in thousands) are in the following countries: Germany (149.1), Poland (91), Italy (81.7), Czechia (65), France (61.7), Spain (36.5), Austria (34.4), Romania (31.2), Slovakia (11.9) and Greece (11.7).

Taking into account the levels of the two indicators mentioned above, in the year 2022,

the average number of bee hives per beekeeper in the EU is 29, but there are member states where this figure exceeds the EU mean. It is about: Greece (99), Cyprus (81), Bulgaria (81), Spain (80), Romania (73), Poland (62), Hungary (57), Croatia (50), and Latvia (34).

More than this, in 2022, in many EU countries, the number of beekeepers keeping more than 150 beehives increased. It is about Germany, Poland, Italy, Czechia, France, Spain, Austria, Romania, Slovakia and Greece) [19].

Honey production

Global honey production

In the studied period, 2000-2022, honey production increased at the global level. If in the year 2000, it accounted for only 1.25 million tons, in the year 2022, it reached 1.83 million tons, meaning a surplus of +0.58 million tons, that is +45.8% (Fig. 6).

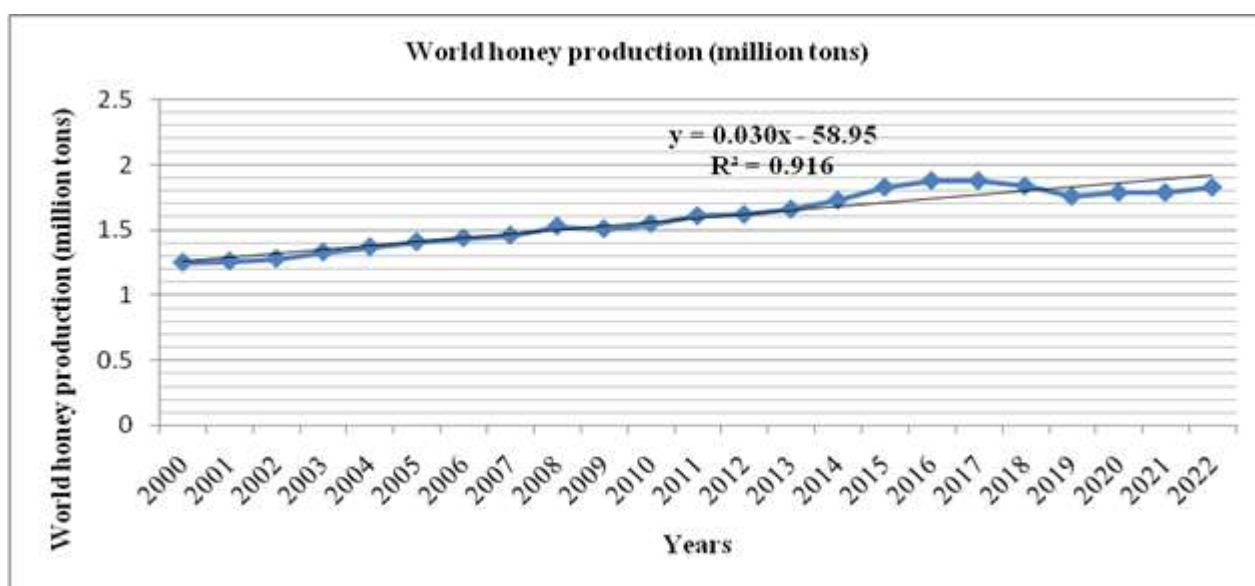


Fig. 6. Dynamic of the world honey production, 2000-2022 (million tons)

Source: Own design based on the data from [28].

In terms of descriptive statistics, the main results regarding the world honey production are shown in Table 6. On the whole interval,

the mean was 1.59 million tons, with variations between 1.25 and 1.88 million tons. The variability is weak around the mean (13.2%).

Table 6. Descriptive statistics for the world honey production, 2000-2022

Mean	St. Error	St. Dev.	Kurtosis	Skewness	Min	Max	Coef. of Var. (%)
1.59	0.04	0.21	-1.359	-0.177	1.25	1.88	13.20

Source: Own calculation.

Regression equation reflecting the determination relationship of global honey

production (y) by the world number of bee hives (x)

The regression equation reflecting the connection between the global honey production, considered Y- the dependent variable, and the number of the bee hives at the world level, considered the independent variable X, is shown in Table 7.

The regression equation shows that an increase by one million beehives will determine an increase by 0.0148 million tons of honey at the global level.

The determination coefficient, R square = 0.901 tells us that 90.1 % of the variation in the global honey production is determined by the variation in the number of bee hives.

The correlation coefficient $r = 0.949$ reflects that between honey production and the number of bee hives it is a positive and very strong link.

Table 7. Regression statistics for Y- raw silk production depending on x- silkworm cocoons production

Variable	Coefficient	St. Error	t - stat	Prob.
Regression analysis for Y- Global honey production; X- Global number of bee hives				
C-constant	0.4064	0.0867	4.682	0.0001
X - Number of bee hives	0.0148	0.0010	13.8457	4.986
R squared	0.901	Mean of dependent var. Y	1.59	
Adjusted R squared	0.8965	St. Dev. of dependent var.	0.21	
St. Error of regression	0.0685			
Sum squared residuals	0.0987			
Regression equation: $y = 0.0148x + 0.4064$				

Source: Own calculation.

Average honey production per bee hive at the global level

Taking into consideration honey production and the number of bee hives, it was easy to determine the dynamics of honey yield per bee hive.

In the analyzed interval, the maximum honey yield per bee hive was 22.5 kg recorded in the year 2005. In fact, in the period 2000-2005, honey production had an ascending trend. In the following five year, 2006-2010, the yield declined and varied between 19.4 kg in 2006 and 2010 and 20.1 kg in 2008.

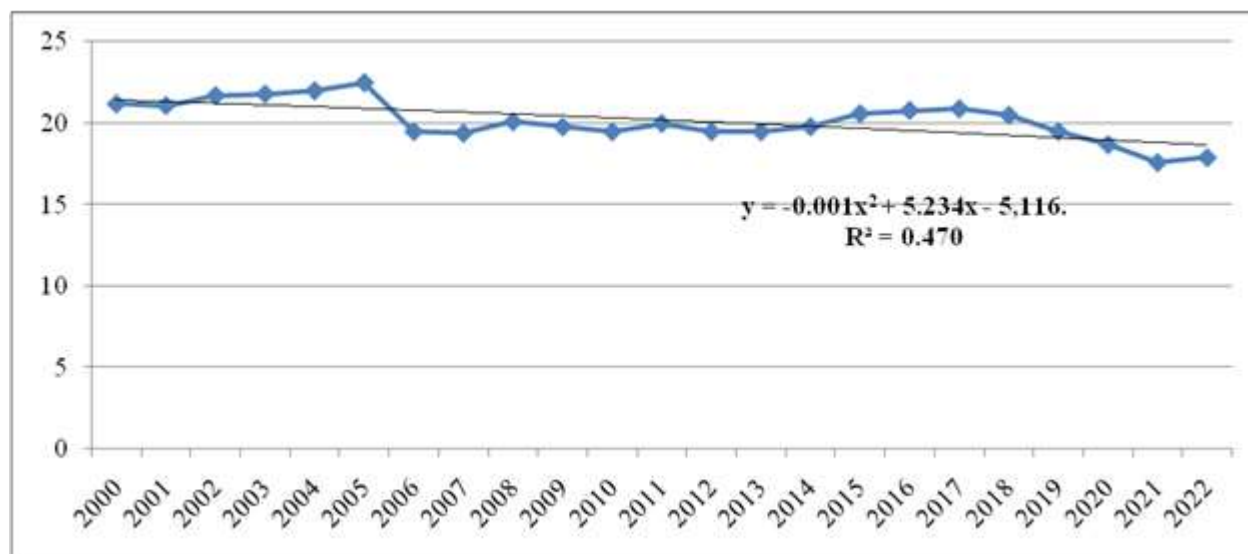


Fig. 7. Honey yield per bee hive at the global level (kg/bee hive)

Source: Own calculation.

This period was a critical one, when the syndrome called "bee colony collapse

disorder" appeared in the United States from various causes such as: the use of pesticides in

agriculture, attack of the parasite varroa and pathogens (mites and viruses), loss of habitat, genetic factors etc. In this case, the bee queen and a few nurse bees were left by the majority of worker bees to raise the immature bees, leading to the death of the colony [66].

A slight recover to 20 kg/bee hive was noticed in the year 2011, but then till 2015, the yield varied between 19.5 and 19.8 kg. In the period 2015-2018, yield increased and varied between 20.6 in 2015 and 20.9 kg in 2017.

Starting from 2019, honey production per bee hives started to decline again reaching the minimum level of 17.6 kg in the year 2021, the smallest in the whole period of 23 years. In 2022, yield increased a little to 17.9 kg per bee hive (Fig. 7).

Distribution of the global honey production by continent

As the number of bee hives varies from a continent to another it is expected as honey production to differ as well.

The major producing continent of honey is Asia, whose share in the global production increased by +12.5 pp, from 35.7% in the year 2000 to 48.2% in the year 2022.

On the second position comes Europe whose share in the world honey production accounted for 22.8% in 2022, but being by -0.3 pp smaller than in the year 2000.

The contribution of the Americas registered a continuous reduction from 27.1% in the year 2000 to 18.5% in 2022 (-8.6 pp). Africa comes on the 4th position with only 8.5% and a continuous declining trend. Finally, Oceania registered a decline accounting for only 2% in the global production of honey (Table 8).

Table 8. Distribution of honey production by continent (%)

	2000	2007	2013	2022	2022- 2000 (pp)
Africa	11.4	11.0	10.1	8.5	-2.9
Americas	27.1	21.5	19.9	18.5	-8.6
Asia	35.7	43.5	45.7	48.2	+12.5
Europe	23.1	22.0	22.3	22.8	-0.3
Oceania	2.7	2.0	2	2	-0.7

Source: Own calculation based on [64].

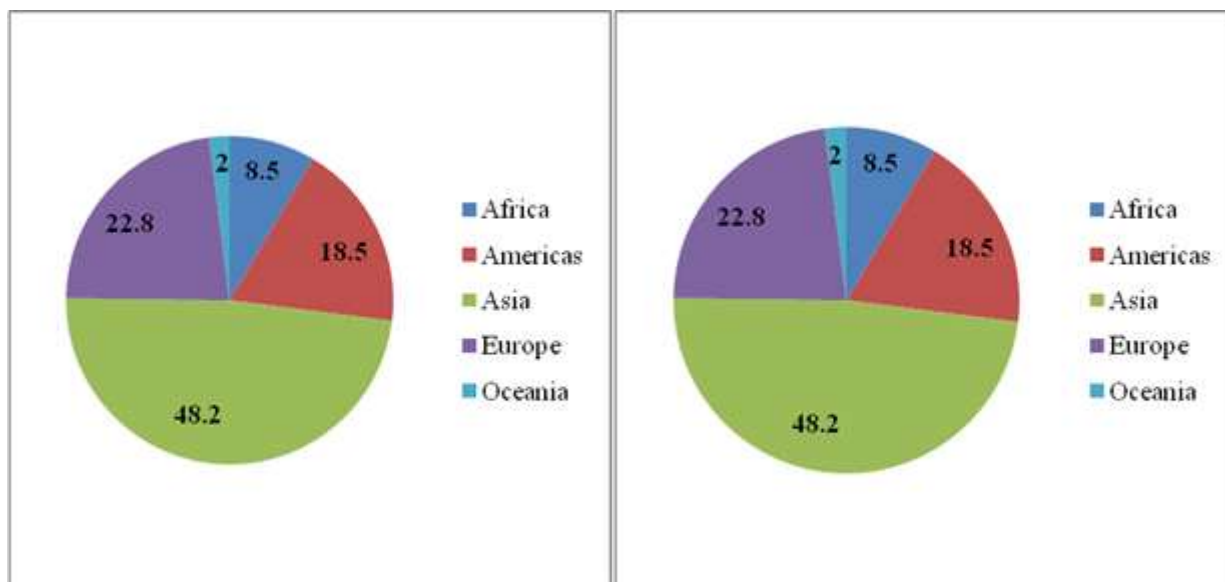


Fig. 8. Share of continents in the global honey production in the year 2000 (Left) versus 2022 (Right) (%)

Source: Own calculation.

The top honey producing countries in the world

In the year 2022, the top 10 honey producing countries at the global level were: China (27.4%), EU-27 (16%), Turkey (6%), Iran

(Islamic Rep.) (4%), India (4%), Argentina (3.8%), Russian Federation (3.4%), Mexico (3%), Ukraine (3%), Brazil (3%), all together carried out 1,357 thousand tons, representing 73.6% of the world honey production [64].

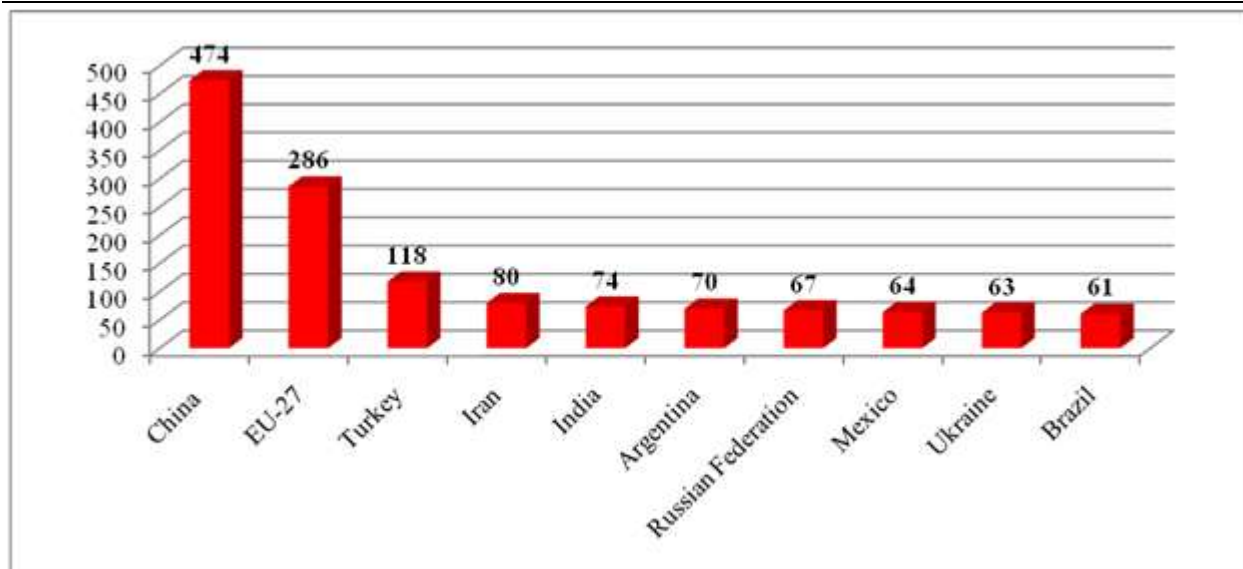


Fig. 9. Honey production in the top 10 producing countries in the world in the year 2022 (Thousand tons)
 Source: Own design based on the data from [64].

In the top producing countries, honey production per bee hive is higher than the world average.

In 2019, in five countries honey yield exceeded 25 kg per bee hive: Canada 56 kg, China 52 kg, Mexico 29 kg, Argentina 29 kg and USA 26 kg [35].

Honey production in Europe

Europe is the 2nd honey production after China. If in the year 2000, Europe produced 289.7 thousand tons honey, in the year 2022, its production accounted for 418.3 thousand tons, representing 22.8% of the world production.

Also, Europe is the largest honey importer, due to the high demand for consumption. Self-sufficiency rate is small which request as more honey to be purchased from other countries.

The main suppliers of honey for Europe are the developing countries.

The most preferred honey by the Europeans is organic honey [68].

Honey production in the European Union

The EU has suitable geographical position, various types of relief, various climate, high potential to produce honey, large utilized agricultural area for a large diversity of crops, wild melliferous flora, various flower sizes, blooming periods, *Apis Mellifica Carpatica*, a bees species with a high potential for producing honey and not only.

All these factors have favored the development of beekeeping, which was also sustained by a constructive policy and strategy in the field.

The number of beekeepers increased, also the number of apiaries, average apiary size, honey yield is over 24 kg per bee hive, and total honey production increased. Organic honey is the most preferred by European consumers and the need for high quality honey is very high.

Therefore, the EU is an important honey producer in the world, coming on the 2nd position after China. But, it is also the main importer of honey for satisfying the consumption demand [14, 16, 18].

Honey production in the EU recorded an ascending trend, but the self-sufficiency rate shows that EU must import honey to cover the requirements on the internal market [54].

However, honey production varied across the years mainly in the period 2014-2022 in closely connection with the number of apiaries and beekeepers, apiary size and other factors whose presence had a negative impact on honey production such as: the Covid-19 pandemic, the relative decline in the number of honey bees caused by diseases, the use of pesticides in agriculture and climate change which brought extreme meteo phenomena: higher temperatures, heat waves, droughts, fires, huge rainfalls, floods etc. In addition inflation rate and energy price have had also a relative negative impact [12, 13].

In 2014, the EU produced 235 thousand tons honey and starting from 2015, production increased to a peak of 275 thousand tons in the year 2018. Then, honey production entered in a deep decline, the lowest level being attained

in 2019 and accounting for 226 thousand tones. In the coming year, it was noticed a slight recover so that in the year 2022, honey production reached 286 thousand tons [68].

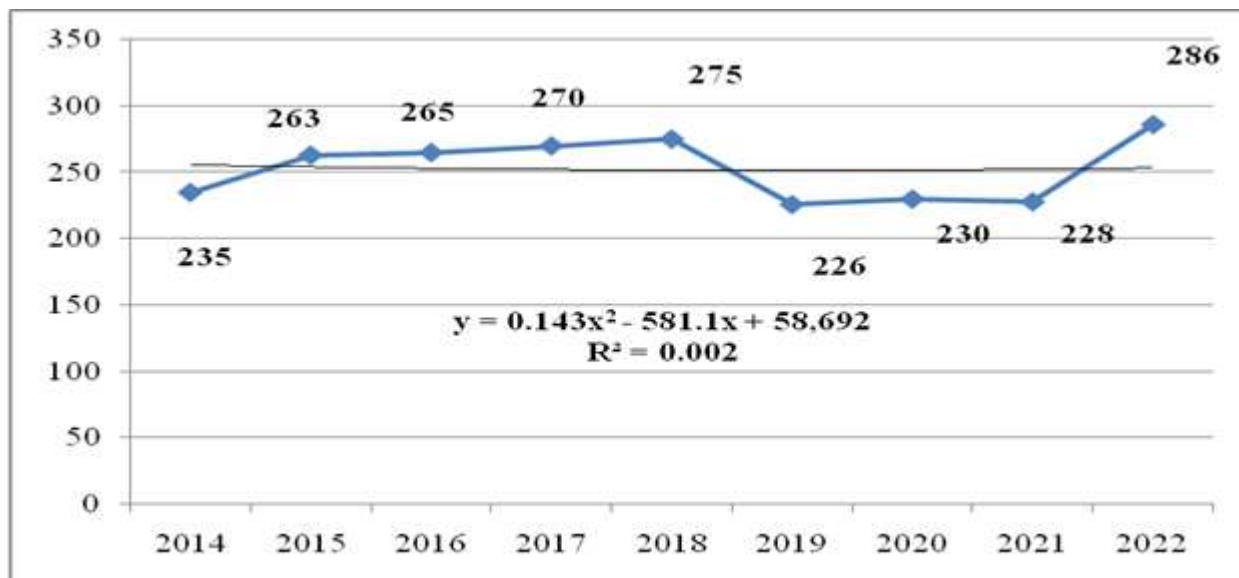


Fig. 10. Dynamics of honey production in the EU, 2014-2022 (Thousand tons)
 Source: Own design based on the data from [19, 13].

In the year 2022, the top honey producing countries were: Germany, France, Romania,

Spain, Hungary, Italy, Poland, Greece, Bulgaria and Portugal (Fig. 11).

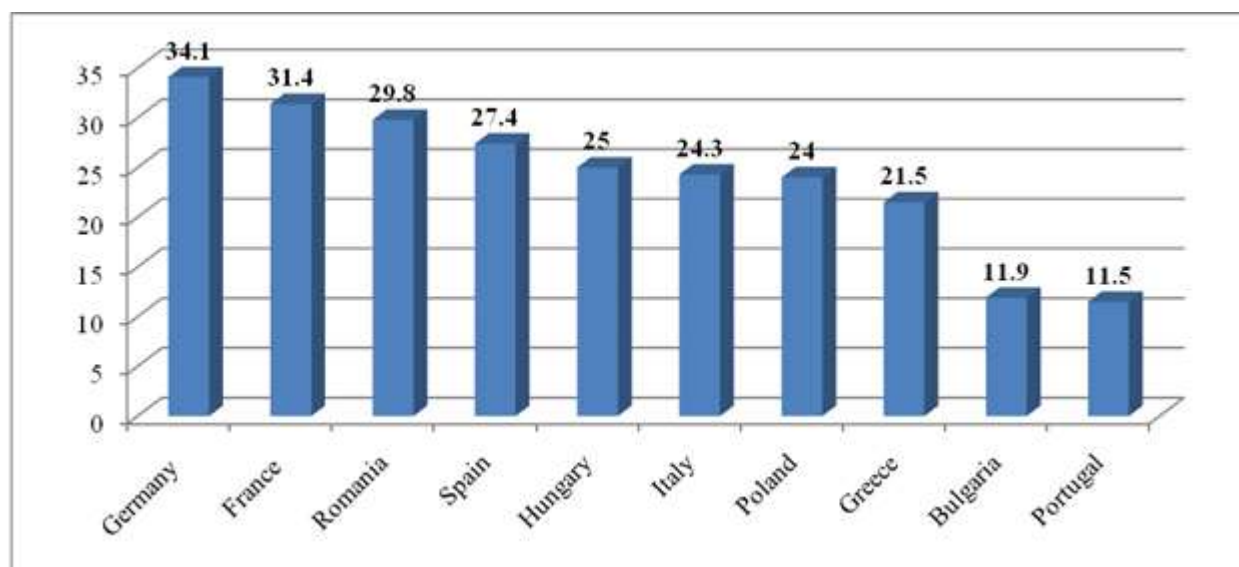


Fig. 11. Honey production in the top 10 EU countries (thousand tons)
 Source: Own design based on the data from [19].

Romania is one of the top honey producing country in the EU, having a long tradition, a large variety of landscapes and floral resources, a important number of beekeepers. The country is situated on the 2nd position in the EU for the number of beehives and on the

3rd position for honey production. Romanian honey is of high quality for which it is highly appreciated for export in the Western European countries [39, 48].

EU honey yield per bee hive

The EU average accounts for 21 kg honey per bee hive, but there are countries with a stronger beekeeping where yield is higher. It is about

Finland, Germany, Belgium, Denmark, Estonia, Austria, Italy, Lithuania, Latvia and France (Fig. 12).

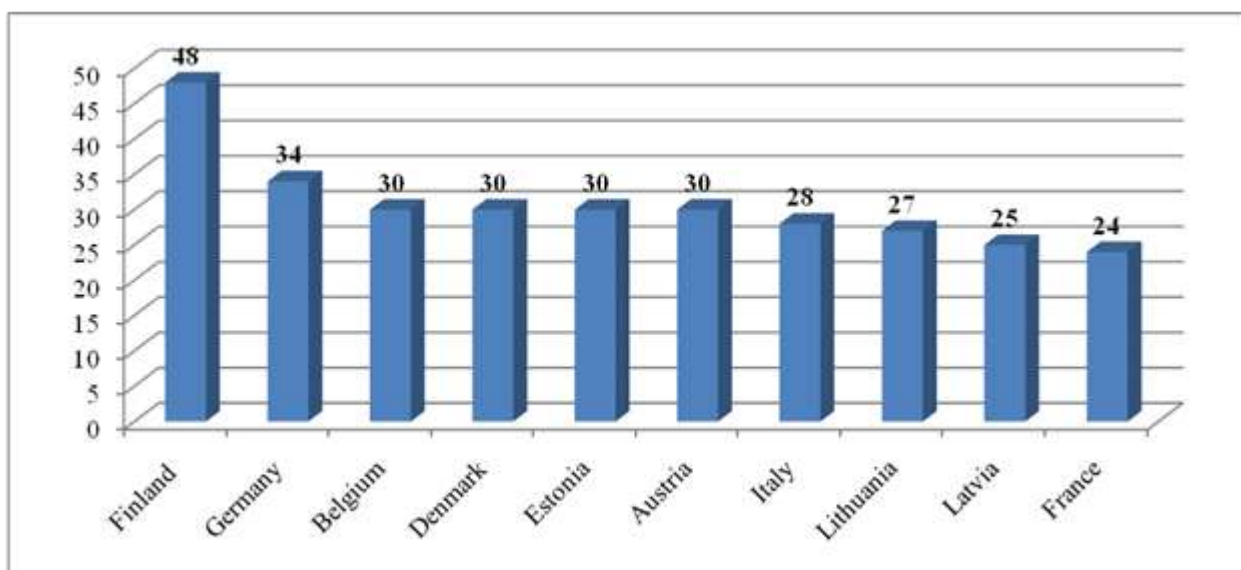


Fig. 12. The top 10 EU countries with the highest honey yield per bee hive (kg/bee hive)
Source: Own design based on the data from [19].

The EU pays a special attention to honey quality, which is severely analyzed in order to detect adulteration with sugar, if it is overheated and if traceability from beekeeper or importer to consumer is assured. Labeling must provide information about honey geographical origin.

Honey bees between interlinked crisis of biodiversity, pollution and climate change *Competition between managed honey bees and wild bees and other pollinators*

The increased number of honey bees has affected the number of wild bees and other pollinators because they compete in finding and using the floral sources of nectar and pollen. In consequence, the wild bees and other pollinators have a lower chance for finding the food they need, and their number is damned to a continuous decline as well as the variability of their species.

This has happened mainly during the last decade when beekeeping has been intensified especially in Europe.

The subsidies allowed by the EU have stimulated beekeeping sector looking for an increased honey production to better satisfy the market requirements. This led to an increased number of apiculturists, apiaries and their size in terms of number of bee hives. In many EU

countries, as mentioned before, there are apiarists keeping more than 150 bee hives to assure a high economic efficiency in their business.

As a result, it was noticed that in the South part of Europe, more exactly in the Mediterranean countries like Greece, Portugal and Spain, the number of managed bee colonies has substantially increased. In this part of the continent, the number of managed bees reached 10.3 million in 2023, being 2.23 times higher than in the year 1990. Also, in the Eastern part of Europe, there are other 10.7 million honey bees, but their number continue to decrease.

Lazaro et. (2021), examining the density of the managed honey bees and the visitation rate in the Aegean archipelago in the period 2005-2015, found a disturbance of biodiversity in 41 sites on 13 Cycladic Islands in the sense that a higher visitation rate of the honey bees had a negative impact on the wild bee species and abundance [31].

Density and abundance of wild bee colonies versus manage honey bee colonies

Without denying the important role of the honey bees whose number increased, Visisk and Ratnieks (2023), studied the density and abundance of wild colonies compared to the

honey bees in 41 locations worldwide and concluded that the number of wild colonies is 2-3 times higher than the number of honey bee

colonies at the world level, except Europe and Asia and suggested that the problem should be deeply approached at a smaller scale (Table 9).

Table 9. Density of bee colonies versus wild colonies by geographical area worldwide (number per km²)

	Wild bee density	Managed honey bee density	Ratio wild colony/Managed colony
Europe	0.3	1.2	0.25/1
N America	1.4	0.3	4.66/1
Latin America	6.7	0.5	13.4/1
Oceania	4.4	0.2	22/1
Africa	6.8	1.0	6.8/1
Asia	No data.	2.2	-

Source: Ratio calculation based on the data from [67].

Also, the same authors noticed that in the larger areas and in the regions with a colder climate, the density is smaller.

Beekeeping in the cities

Patterson (2020) affirmed that the driver of the wild bee decline is the exponential growth of the world honey bee colonies. He studied the honey bees in the cities, especially in United Kingdom where people like to keep bees as a hobby, for producing home honey, for selling honey and getting an additional income and for treating nervous diseases. More than this, the beekeeping lovers like to socialize, developed close friendships and created clubs and associations where to enjoy spending time together.

He noticed that in London, but also in other European cities like Berlin, Brussels, Paris and in the South of France, the honey bees are more numerous than the wild bees, which led to an increased competition for finding food and in consequence to an unbalanced biodiversity, as in the cities there are also wild bee and other insects in the home gardens and parks.

The higher number of bee colonies in the city has also become a disturbing factor for the residents and even for tourists who like to enjoy sitting on the restaurant terraces. To avoid complains, the local authorities have limited the number of apiaries in the urban area.

Actions and measures to avoid the negative impact of honey bees on biodiversity

To preserve biodiversity and ecosystems balance, it is recommended:

- to create natural and semi-natural habitats, a bee friendly area, knowing that bees love wild flowers, grass and weeds;
 - to diversify the flower resources, improving flora structure by including plant species agreed by bees and wild bees; these flowers could be cultivated in pots, at the windows, on the terraces, in the gardens, on the house roofs, in the city flower beds and in the parks.
 - to establish a flower conveyer along all the seasons from early spring to late autumn;
 - the landscapes to be designed in various shapes, colors and bloom times to attract the bees;
 - bees need space where to land and drink water, and this must be in beekeeper's mind all the time;
 - to set nesting habitats for breeding and hibernating of the wild bees; also to provide shelters for rest and reproduction and food storage;
- It was proved that the lack of natural habitats for 1 km distance from fields could reduce the number of pollinators by 255, the fruit production by 16% and crop yield by 9% [5].
- to keep a severe hygiene and cleaning, eliminating the wastes;
 - to limit the number of apiaries and the number of bee hives per apiary in the cities, in order to assure a similar chance for wild bees and honey bees for pickings;
 - do not use chemical-based products, but organic products like vinegar and cayenne pepper for protecting the bees against other insects;

-to plant trees like Acacia and Tilia which could be a good source of nectar and also make great shelters [37].

-In case of farms, the reduced use of chemicals is required to protect both honey bees, wild bees and other pollinators;

-Also, farmers have to avoid monoculture and to pass to policulture with a beneficial biodiversity, strengthening the sources of nectar and pollen and favoring the extent of nesting sites, maintaining the number of pollinators and their health.

-Farmers have to apply environment friendly technologies to protect soil, water and air and maintain the balance in agro-eco-systems.

Diseases and pests are a big problem both for honey bees and for wild bees and other pollinators.

These factors could reduce or kill bee families, reduce honey production and beekeeper's income.

Diseases are caused by pathogens like varroa which can affect a bee family or even an apiary. The viruses could be spread by the imports of queen bees and bee families, and for this reason they have to be avoided.

To prevent varroasis, the mites control has to be done in the fall for having a strong bee family during the winter. Also, treatments with organic formic acid, oxalic acid and botanical oils of thymol could be beneficial.

Environment pollution is another risky factor and a big problem for beekeepers and also for the bee families and wild bees.

Pollution created by intensive agriculture where pesticides are used for sustaining production performance could deeply affect both honey bees and wild bees and other pollinators.

To protect beekeeping of this danger, the EU launched the slogan: "Save bees and farmers" with the goal to diminish soil, water and air pollution, to preserve environment quality and biodiversity [17].

The use of less chemicals is welcome, especially of Neonicotinoids class, which are neuro-active insecticides which could kill the bee families and produce disasters to beekeeping [33, 61].

The use of clothianidin, imidacloprid and thiamethoxam (used as seed treatment or as

granules), has acute and chronic effects on bee colony survival and development (especially on bee larvae and bee behaviour). This is why this risk needs to be quantified [20].

Fauzi and El-Kazafi (2023) affirmed that among the top hazard categories in Rapid Alert System for Food and Feed (RASFF) notifications for honey from 2002 to 2022, there were found: unauthorized residues of veterinary medicinal products, adulteration/fraud, foreign bodies, pesticide residues. This regards especially honey coming from China, Turkey, Ukraine, Argentina and Bulgaria. Also, they found in honey chemicals (chloramphenicol, streptomycin, sulfathiazole, tylosin, sulfadimidine) used by beekeepers to control infectious diseases of bees. Strict restrictions should be imposed to reduce the risk of finding these contaminants in honey [23].

Using less chemicals and intensify the advertising alerts, bee families and other useful insects could be saved, the agro-eco-systems could preserve their balance, for assuring sustainability of food and food security.

Floral resources should be chemically-free and habitats for honey and wild bees to be preserved.

Climate change has disturbed human and animals life during the last decades but also it has affected agriculture, beekeeping, environment and biodiversity.

More and more effects resulting from extreme climate phenomena have become more visible with a deep economic, social and environment impact [25].

Huge rains, floods, storms, winds, high temperatures, hot waves, cold winters, etc have disturbed the habitats, destroyed the hives, have diminished the food resources, made bees more sensitive to pests and diseases and even killed bee colonies and other valuable insects and pollinators [6].

What is worse is the fact that the weather patterns cannot be predicted so well, except in a relative level based on the statistical data for a long period of time regarding temperatures and precipitations, but climate change has led to unpredictable phenomena. Extreme weather events increased their occurrence, localized warming and cooling, long and severe

droughts, aridity, desertification, the gap of the seasons.

Due to this it has appeared a difference between the moments when the plants are in bloom and the bees and other pollinators need food and reproduction. As noticed the last year, the weather became warmer early and the bees and other pollinators emerge early, but the flowering period will appear later. This desynchronization affect the insects and also the effect of pollination.

The long and severe droughts diminish the flower resources, and the bees spend a lot of time and energy visiting the blooms for less nectar. The bee families cannot nourish well and will have a weaker capacity to survive.

In the wetter periods, the bees cannot fly and bring nectar in the hive, therefore, they cannot store enough food to reproduce.

The wet and cold winters could increase mortality during hibernation.

To prevent the damages and losses, beekeepers have to set up their own strategy adapted to the local conditions. The beehive boxes have to be reinforced, the beehives have to be reallocated, food has to be supplemented with new diets, and pests and diseases have to be managed. Beekeepers have to be informed every moment about the climate evolution (temperatures, rains, winds etc), to take the corresponding measures to protect the bee families in order to maintain their health and power to survive, reproduce and produce bee products [30].

Rajagopalan et al (2024) quantified the effect of warmer autumns and winters on honey bee foraging activity, age structure overwinter, spring colony losses, and evaluated indoor cold storage to diminish the negative effect of climate change. They proposed to store in a cold place the bee colony during winter for reducing honey bee colony losses [57].

Important intervention actions provided by the CAP Strategic Plan in the EU

The EU Common Agricultural Policy regarding the development of beekeeping is permanently adapted to the new conditions by issuing intervention measures, among which the most important ones are the following:

-providing consultancy services for apiculturists: technical assistance, training, updated information, facilitating networking;

-sustaining the investments in tangible and non-tangible assets;

-preventing and combating bee diseases and pests attack;

-mitigating the effects of climate change;

-promoting best management practices;

-enhancing the bee breeding to enlarge the colonies using best and selected bee queens and buying packaged bees;

-sustaining the bees transhumance in a rational manner to diminish the related costs;

-promoting the collaboration and cooperation among beekeepers to exchange ideas, to form associative forms, to organize bee honey and other products fairs;

-stimulating the delivery of valuable information to consumers to develop their awareness about the quality of bee products;

- suggesting actions to improve honey quality; in this respect, the EU sustains the laboratories for honey analysis of honey and other bee products to detect toxic substances for bees;

-to continue to control the quality of imported honey in order to protect the EU beekeepers of an unfair competition;

- to diversify marketing solution in valorizing honey, in bottled manner in cans labeled to show the geographical origin;

-to increase value added to get a higher price per sold product and increase beekeeper's income;

-to extend research programmes in beekeeping and apicultural products;

-to develop research networking actions and create bridges between researchers for exchanging ideas and solving problems;

- to intensify the monitoring of marketing actions, emphasizing on communication and promotion;

-helping consumers to become more aware of the nutritive and energetic value of honey and other bee products for increasing consumption;

- sustaining beekeeping by providing financial support for the period 2023-2027 [63].

CONCLUSIONS

The statistics proved a continuous increase in the number of beehives and also regarding honey production. Both the bee hives and

production of honey are concentrated in Asia and Europe, followed by Americas.

If in the year 2000, at the global level there were 58.8 million beehives, after 23 years, that is in the year 2022, their number reached 102 million, meaning a surplus of +76.3%.

The distribution of the beehives by continent is: Asia 44.6%, Europe 24.7%, Africa 17.7%, Americas 11.4% and Oceania 1.4%.

India, China Mainland, Turkey, Iran (Islamic Rep.), Ethiopia, Russian Federation, Argentina, Tanzania (U. Rep.), USA and Mexico are the top 10 countries with the highest number of bee hives at the world level. In 2022, the EU had 20.27 million beehives, a level by 19.44% higher than in the year 2016. Spain, Romania, Greece, Poland, Italy, France, Hungary, Germany, Bulgaria and Czechia are the top 10 countries with the highest number of beehives.

The global honey production reached 1.83 million tons in 2022, being by +45.8% higher than 1.25 million tons in the year 2000.

A correlation coefficient, $r = 0.949$ reflects that between honey production and the number of bee hives it is a positive and very strong connection.

The regression equation: $y = 0.0148x + 0.4064$ showed that an increase by one million beehives will determine a growth by 0.0148 million tons of honey at the global level.

From the peak of 22.5 kg honey per bee hives in the year 2005, in 2022, it was registered 17.9 kg at the global level.

Honey production by continent was distributed as follows in 2022: Asia 48.2%, Europe 22.8%, Americas 18.5%, Africa 8.5% and Oceania 2%.

The top 10 honey producing countries at the global level in the year 2022 were: China, EU-27, Turkey, Iran (Islamic Rep.), India, Argentina, Russian Federation, Mexico, Ukraine and Brazil, all together representing 73.6% of the world honey production.

In the year 2022, Europe produced 418.3 thousand tons honey, representing 22.8% of the global production, for which it is situated on the 2nd position after China.

Europe is also the largest honey importer, due to the high demand for consumption and the

main suppliers of honey are the developing countries.

In 2022, the EU produced 286 thousand tons honey, by 21.7% more compared to 235 thousand tons in the year 2014.

Germany, France, Romania, Spain, Hungary, Italy, Poland, Greece, Bulgaria and Portugal are the top honey producing countries in the EU in 2022.

The average honey yield per bee hive in the EU is 21 kg, but Finland, Germany, Belgium, Denmark, Estonia, Austria, Italy, Lithuania, Latvia and France produce much more honey. The EU pays a special attention to honey quality and traceability from beekeeper or importer to consumer, attested by labeling which offers information about honey geographical origin.

The main problems honey bees between are facing at present are: the crisis of biodiversity, pollution and climate change.

The increased number of managed honey bees has affected the number of wild bees and other pollinators disturbing the balance of the ecosystems and diminishing biodiversity regarding both the structure of pollinators species and flora mainly in Europe (especially in the Southern part in the Mediterranean countries) and in Asia.

Also, as a result of the high number of honey bees in some regions of the world, the density ratio between wild bees and honey bees has decreased. Normally, the wild bees must have a few times higher number than honey bees.

Special recommendations have been specified to be taken into consideration for avoiding this unpleasant aspect in the future.

Also, special suggestion have been made for the presence of honey bees in the cities, so that their number not affect the abundance of wild bees and other pollinators and not to disturb the residents and tourists.

To prevent the appearance of diseases and pests attack, it was suggested as apiculturists to keep a severe cleaning and hygiene in the apiary and to avoid imports of bee queens and package bees. Treatments are compulsory to save the bee hives if it is possible and using medicines based on organic substances.

The use of pesticides from the Neonicotinoids category must be stopped for avoiding the loss of bee colonies.

To diminish the negative effects of climate change on beekeeping, apiculturists must adapt the applied technology to the local conditions, taking measures for assuring flowering sources, reproduction of the bee family, strengthening its power to pass easier over the winter season making food storage.

The EU strategy is focused to enhance beekeepers knowledge and skills by an intensified consultancy service and to offer support for investments in modern beehives, high genetic value bee queens, bee colony breeding, a more balanced transhumance, an increased production and honey quality and to intensify the marketing actions for making consumers more aware of the high nutritive and energetic quality of honey and the bee products.

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