FORTIFICATION OF ECOLOGICAL SECURITY OF BEEKEEPING IN THE REPUBLIC OF MOLDOVA

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Abstract

The purpose of this paper was to develop measures to adjust conventional to organic beekeeping, to increase the productivity of bee families and the harvest of entomophilous agricultural crops, for the production of organic beekeeping and agricultural products in the Republic of Moldova, according to EU rules. The scientific researches were carried out during 2011-2019 in the Beekeeping Laboratory of the Institute of Zoology of the Academy of Sciences of Moldova. Scientific research has shown that, in order to ensure the compliance of the environment with the requirements of organic beekeeping, it is necessary to test honey flowers, or pollen collected by bees, on the content of the most common and most dangerous pollutants, such as heavy metals (Pb, Cd) and pesticides (Organochlorine insecticides - Fipronil, Spirodiclofen; Organophosphorus insecticides - Azoxystrobin, Carbendazim, Dimethoate, Chlorpyrifos; Neonicotinoid insecticides - Imidacloprid, Thiacloprid, Thiamethoxam, Clotianidin; Pyrethroid insecticides - Tau-fluvalinate, Deltamethrin, Cypermethrin, Pyrethrin; Triazole fungicides - Bitertanol, Fenhexamide, Diphenoconazole, Mepanipyrim, Cyproconazol; Dicarbosimide fungicides - Cyprodininyl; Acaricides - Amitraza; Herbicides - Glyphosate, Sulfosulfurol, Amidosulfuron, Amitrol, Petoxamide, Pendimetalin). The fortification of the power of bee families and their productive capacity for organic beekeeping is ensured by innovative methods of organic feeding in the periods of poor harvesting in nature with nutritional supplements of organic origin. The conversion of traditional beekeeping into organic beekeeping requires the adjustment of the apiary's logistical infrastructure to the requirements of EU rules, according to EC regulations and directives: no. 1881/2006, no. 834/2007, no. 889/2008, no. 834/2009, nr. 271/2010 and no. 392/2013, as well as the Law of the Republic of Moldova no. 115 of 2005 on organic agri-food production and the Technical Regulation "Organic agri-food production and labeling of organic agri-food products", approved by Government Decision no. 1078 of 2008. Bee families in organic apiaries are complemented by healthy and vigorous queens, raised directly by organic selection methods, based on strengthening immunity and disease resistance, increasing queen prolificacy and the colony's ability to accumulate bee production in the nest. Organic beekeeping has a positive impact not only on obtaining organic bee products, but also on significantly increasing the harvest of entomophilous agricultural crops, as well as the production of organic agricultural products.

Key words: bees, organic beekeeping, fortification measures, evaluation, environment

INTRODUCTION

Beekeeping, in the Republic of Moldova, presents a branch of the livestock sector with a special importance for the national economy, due to the value and quality of products offered by it, the creation of jobs among vulnerable sections of the population in rural areas, considerable increase in crop yields entomophiles, as well as for maintaining by pollination the homeostasis and biodiversity of nature's ecosystems.

In total, there are about 180 thousand bee families in the country, from which about 4.5 - 5.0 thousand tons of honey are obtained annually, of which about 4000 tons are exported to different countries, including the EU. From bees are obtained other bee products, quite important, such as: wax, pollen, propolis, royal jelly, venom, which are used in different areas of the national economy (food industry, medicine, pharmaceuticals, cosmetics, fine arts etc).

One of the most important benefits brought to man by bees is the additional product obtained from increasing the productivity of entomophilous plants in

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cultivated and spontaneous flora, as a result of their pollination, thus ensuring the perpetuation of nature's biodiversity.

In the Republic of Moldova, bees pollinate about 600 thousand ha of land with agricultural crops, from which an additional 20-30% of the annual value of over 3.6 - 4.0 billion lei is obtained. Unfortunately, some agricultural producers (agricultural crop growers, agronomists) largely ignore the fact that bees are the main pollinator of entomophilous agricultural crops and can serve as a decisive factor in increasing their harvest, production of organic agricultural and bee products, ensuring the economic efficiency and sustainable development of the respective branches in the country.

The analysis of the beekeeping situation in recent years shows that the traditional technology of breeding and exploitation of bee families does not ensure the production of organic and harmless bee products, of competitive quality, which could be marketed at advantageous prices [55].

According to a report by the Moldovan Investment and Export Promotion Organization (MIEPO), the purchase price of organic (ecological) honey is currently 90% higher than that of regular honey [46]. This is why beekeepers want to practice the BIO beekeeping system en masse, but, unaware of the conditions and legislation of organic farming, they apply the outdated technologies they know, activating in the traditional beekeeping system and thus the production obtained not it is recognized as BIO, and its harvest decreases significantly. Therefore, the specific technologies of the organic beekeeping system imperatively require deep study to be used. It is necessary to know the anthropogenic impact caused by industrialization and intensification of agriculture, the most common pollutants, their distribution areas and the degree of pollution with residues (their concentration in environmental resources), which can affect both honeybees and main entomophilous pollinator, as well as the production obtained from them.

In the beekeeping production exported from the Republic of Moldova are sometimes detected by EU certification and control bodies [27, 47], harmful substances and polluting residues, which leads to its temporary embargo and compromising the competitiveness of the branch and national image internationally [2, 3, 5]. In the EU, organic beekeeping is regulated by a series of European Commission (EC) regulations, the most important of which are: EC Regulation no. 834/2007 on organic production and labeling of organic products [47], EC Regulation no. 834/2009 [28], EC Regulation no. 271/2010 [27] and EC Regulation no. 392/2013 [48], which provide for the accreditation and certification, by European international bodies, of apiaries and bee products in the conventional category, in the bio (organic) category, according to unique criteria and standards.

In our country, both agricultural producers and beekeepers, so far, have not realized that ignorance of EU environmental legislation and uncontrolled use of pesticides in the treatment of agricultural crops and honey bees has an unbalanced impact on the homeostasis of natural ecosystems, with final consequences of diminished human health security.

The main pollutants of the environment, in which the honey bee carries out its vital activity, are pesticides and some heavy metals, which accumulate in the inflorescence of honey plants, soil and water. From the environment, pollutants enter the food of bees, causing an impact both on the health and vitality of bees and on the quality and safety of bee products, affecting the balance of ecological factors necessary for organic beekeeping. Some heavy metals (Pb, Cd, Hg), being in the components of the biosphere above the maximum permissible concentration (CMA), are toxic for environmental biocenoses, including animals and humans. The harmful impact of hyperconcentration of heavy metals on humans and animals is expressed by disturbing the balance of vital activity, increasing the incidence of neurological, cardiovascular and oncological diseases, decreasing their reproduction and productivity. Heavy metals in polluting concentrations in air, soil and water subsequently accumulate in the flora and fauna of terrestrial and aquatic ecosystems, producing the respective impact [70]. The monitoring and regulation of GM emissions and emissions into the environment is provided by the Arhus Convention (1998) and the European GM Monitoring and Evaluation Program [31]. In this context, the knowledge

of the situation regarding the concentrations of heavy metals in the components of the environment and the beekeeping, would allow the improvement of its management for the development of organic beekeeping.

Of particular concern, both in Europe and around the world, has recently been the main concern of systemic pesticides, which are used in agriculture to treat seeds and spray crops to control pests and weeds. According to "Beyond Pesticides" [37], neonicotinoid pesticides have neurotoxic, reproductive and mutagenic effects on insects, birds, fish, freshwater snails, earthworms, dragonflies, mosquitoes, and vertebrates, noting that "*neonicotinoids could represent the new contemporary ecological disaster, being a threat to nature*." The World Health Organization (WHO) and the International Agency for Research on Carcinogens announced in March 2015 that some herbicides (Glyphosate) are carcinogenic with a harmful impact on the endocrine system [38]. Residues of these herbicides can be found in the urine and blood of animals as well as humans [39]. The harmful effects of systemic pesticides are confirmed by a number of renowned researchers in the field [2, 30, 33 - 35, 44, 45, 52, 54, 68, 71].

According to other sources of information [34], some pesticides (such as the organochlorine insecticide Fipronil) are the main chemical factors that spread the collapse disorders of bee colonies. A 2013 EFSA (European Food Safety Authority) report identified Fipronil used for seed treatment as an acute risk to bees, so at the proposal of this authority, the European Union voted on 16 July 2013 to ban this pesticide in the treatment of seed bees. corn and sunflower. At the same time, in some countries, this pesticide continues to be used with derogations from EU legislation [32].

Several researchers have shown that there is a synergism of additive action when pesticides are applied in combination. For example, some research shows that the neonicotinoid Tiacloprid, becomes about twice as toxic to honey bees when used in combination with the fungicide Propiconazole, and three times more toxic - in combination with Trifumizole [35]. Other research has shown that there is a significant synergy between fungicides, neonicotinoid and pyrethroid insecticides, as well as the acaricides Flumetrin, Cumafos and Fluvalinat [44]. Along with the interactions of different pesticides, insecticides also show a synergism with other stressors, such as parasite infestations. For example, honey bee mortality was higher in those infested with the Nozema parasite and a synergistic interaction of factors was found, which reduce the enzymatic activity related to the sterilization of colony food [1, 45].

The adjustment (conversion) of the beekeeping of the Republic of Moldova to the organic category requires the precedence of an in-depth study of compliance of its main components, such as: bee families, environment, beekeeping and care infrastructure, feeding and nutrition methods. of bees during poor harvesting periods in nature, beekeeping logistics (tools, equipment, machinery) for collection, primary processing and storage of bee products, quality and safety of bee products.

A special problem is the feeding of bees during poor harvesting periods in nature. To compensate for the lack of nutrients in the diet of bees during poor harvesting periods in nature, most beekeepers feed bee families with sugar syrup, which, in addition to carbohydrates, lacks a significant number of biologically active substances. In these circumstances, the strengthening of their power and vigor by balanced dietary methods with nutritional supplements enriched with biologically active substances is of major importance. In this context, the biomass of some microalgae has attracted the attention of several researchers [10 - 12, 69].

According to our research [22, 23, 25, 61-63], the biomass of some aquatic microalgae has a rich content of biologically active substances, especially proteins, carbohydrates, lipids, essential amino acids, micro-macro-elements, antioxidants (beta - carotene), which plays a catalytic role in the metabolism of nitrogenous substances in worker bees, participates in the synthesis of enzymes, improves the vital activity of bees, with direct influences on their flight intensity, activating the collection functions of nectar and pollen, and the secretory functions of the cerebral glands, stimulate the functions of the queen's reproductive system, activating ovogenesis and spawning.

All this largely determines the activation of the physiological processes of the body of all members of the bee colony, starting with the queen - founder of the social community (colony) and ending with working bees, on whose vitality depends the strength of bee families, their ability to accumulate beekeepers (nectar, pollen) and their overall productive potential.

The problem of the influence of biologically active substances, in particular, of the rare microelements in the coordinating organic compounds, on the activity of honey bees, presents an insufficiently researched scientific problem. Coordinating organic compounds are more accessible due to the simpler and less expensive technology of obtaining them. Due to the chemical structure and constituent bioelements (complex and bipolar ions with variable valences, organic ligands of different origin), as well as the molar ratio of their combination, coordinating organic compounds possess a wide range of bioactive properties [29]. They are used in various biotechnologies for the synthesis and production of a number of pharmaceutical preparations, such as: vitamin B12 and hemoglobin [4], preparations with antidote and detoxifying properties [72], antibacterial [59] and antifungal [53].

According to our previous research [12, 18, 19], biologically active substances, especially some rare microelements (Cr, Mo, Co, Bi), from nutritional supplements enriched with some coordinating organic compounds, being catalysts of important physiological processes in the body of working queens and bees, contributes to the quantitative development of bee families, strengthening the immunity of bees and increasing resistance to disease, and, finally, to significantly increase the nesting capacity of bee production (honey, pasture, wax).

Based on the above-mentioned approaches, the research of environmental pollutant residues and the identification of their impact on honey bees and bee products, the study of compliance of national beekeeping with organic requirements in different native anthropogenic ecosystems, revealing the most common pesticides and heavy metals. produce residues in honey flora and bee products, highlighting polluting sites and relatively clean areas of pollutant residues that can ensure organic beekeeping, organic nutrition of bees during poor harvesting periods in nature, strengthening the power of bee families for their use in pollination of crops entomophiles, are particularly current problems.

In this context, the purpose of this paper was to develop measures to adjust conventional beekeeping to organic beekeeping, increase the productivity of bee families and harvest entomophilous crops, for the production of organic bee and agricultural products in the Republic of Moldova, according to EU rules.

MATERIALS AND METHODS

The elaboration of measures to strengthen the ecological security of beekeeping, to increase the productivity of bee families and the harvest of agricultural crops through bee-directed pollination, was carried out on the basis of multiannual scientific research conducted in 2011-2018 in the Apiculture Laboratory of the Institute of Beekeeping. Zoology of the Academy of Sciences of Moldova.

The assessment of the conformity of the environment for organic beekeeping was performed by researching pollutant residues (heavy metals and pesticides) in the samples of honey plants, taken from different sites with different anthropogenic impact, according to the rules in force [42]. The determination of the concentrations of the most widespread and dangerous heavy metals (*Pb, Cd*) in the samples of environmental components and honey bee was performed in the accredited laboratory "Geolab", by the method of atomic absorption spectrometry with thermal atomization of elements in graphite atomizer (GFAAS) , according to ISO standard methods: SM SR EN 11047-2006 [56], SM SR EN 14084-2006 [57] and SM SR EN 14083-2006 [58].

Pesticide residues in flower samples of honey plants, as well as in bee components were determined in the Accredited Laboratory of the State Enterprise "National Center for Verification and Certification of Plant and Soil Production", by gas-chromatography - mass spectrometric methods (GC- MS) and liquid chromatography - mass spectrometry (LC-MS), described by Lazari I. (2000) in Collections of standard MS methods [40].

The data obtained, regarding the concentrations of heavy metals and the content of pesticide residues in the investigated samples, were compared with the rules of maximum permissible limits (AML), according to the Sanitary Regulation on maximum permissible residue limits of plant protection products in / or food and food of plant and animal origin for animals, approved by Government Decision of the Republic of Moldova no. 1191 of 23.12.2010 [49], adjusted to EU norms.

A series of nutrient mixtures enriched with biologically active supplements, derivatives of *Spirulina platensis* grown on remedies of coordinating organic compounds, of aquatic microalgae (*Scenedesmus cuadricauda, Scenedesmus apiculatus, Oocystis borgei Snow*) and new generation coordinating organic compounds (*Cobalt (III) tris-thiosemicemicazazate sulphate) • [1,2-diaminocyclohexanthetra bismuth (III) acetate hexahydrate] - [Co (thios)$_3$] [Bi (edta)] SO_4 • $6H_2O$ and [Tetraoxo ethylenediaminetetraacetate dimolibden (V)] bis- (tetrafenylphosphonium) di-semihydrate - $(PPh_4)_2$ [Mo_2O_4 (edta)] • $2,5H_2O$*). Similar batches with bee families were formed in all test experiments, including the control group and the experimentals batches.

The evaluation of the degree of development of the morpho-productive characters of the bee families was performed, according to the methods elaborated by us [6] for the Zootechnical Norm regarding the crediting of bee families, breeding and certification of beekeeping breeding material, approved by Government Decision no. 306 of 28.04.2011 [43].

Innovative methods developed by us have been applied to the breeding of breeding queens [26, 14], which ensure the increased efficiency of directed growth of healthy and well-developed queens.

To increase the yield of entomophilous agricultural crops, efficient methods and procedures of bee-directed pollination have been tested and applied, developed by us as a result of special research [20, 21, 24].

The measures for ensuring the logistic infrastructure of the apiary to the requirements of organic beekeeping were developed based on the study of the profile literature in the field [2, 5, 55], as well as in accordance with the provisions of EU normative acts [27, 28, 47, 48, 50] and of the national legislation in the field: Law no. 115 of 2005 on organic agri-food production [41] and Government Decision no. 1078 of 2008 on the approval of the Technical Regulation "Organic agri-food production and labeling of organic agri-food products" [36].

The data obtained as a result of research at all scientific stages were compared between the respective variables, and their differences were statistically processed using computer software "STATISTICS - 12" and assessed their certainty, according to variational biometric statistics, according to the methods of Плохинский Н.А., 1989 [73].

RESULTS AND DISCUSSIONS

Research results have shown that the adjustment of local beekeeping technology to EU rules on organic beekeeping requires the transfer of scientific achievements and the implementation of measures to ensure compliance with the environment, organic feeding of bees during periods of inadequate harvesting and infrastructure. logistics of the apiary to the requirements of organic beekeeping, according to EU rules, directed breeding of breeding queens with their mating in special nuclei and directed bee pollination of entomophilous agricultural crops. The implementation of these innovative measures contributes to the strengthening of ecological security and the development of beekeeping and agricultural branches in the country. The measures developed shall include detailed methods and procedures for the implementation of scientific achievements in research results, as follows.

1. **Ensuring conformity with the environment.**

In order to ensure the compliance of the environment, measures have been developed that propose to beekeepers, first of all, before placing the apiaries both stationary and pastoral, to investigate the environment to the content of heavy metals and pesticides by one of the following methods (procedures).

1.1. **Testing of honey flowers** in the flight area of bees for the content of residues of the most widespread and dangerous heavy metals

(Pb, Cd) and pesticides, which are often detected in the local environment, such as:

-organochlorine insecticides (*Fipronil, Spirodiclofen*);

-organophosphorus insecticides (*Azoxystrobin, Carbendazim, Dimethoate, Chlorpyrifos*);

- neonicotinoid insecticides (*Imidacloprid, Tiacloprid, Tiametoxam, Clotianidin*);

- pyrethroid insecticides *(Tau-fluvalinate, Deltamethrin, Cypermethrin, Pyrethrin)*;

- triazole fungicides (*Bitertanol, Fenhexamide, Diphenoconazole, Mepanipyrim, Cyproconazol)*;

- dicarbosimide fungicides (*Cyprodynil*);

- acaricides (*Amitraza*);

- herbicides (*Glyphosate, Sulfosulfurol, Amidosulfuron, Amitrol, Petoxamide*).

In total, it is proposed to monitor the residue content of 26 pesticides. For comparison, in the Laboratorio Ambiente in Tuscany, Italy, bee products are tested for 261 pesticides, and in the Laboratoire Famille Michaud Apiculteurs Since 1920, in Versailles, France, honey is tested for 302 pesticide names.

The content of harmful residues in honey flowers largely reflects the compliance of the environment in general. Our scientific research has shown that there are close, quite significant correlations between the content of residues in flowers and that in the soil.

At the beginning of the flowering period of the honey plants, the mixed flower samples are taken (in plastic bags) from the main honey plants, located in the site where the apiary is expected to be harvested. From the flight area of the bees are taken 5-7 samples of flowers from different places, at different distances from the place intended for the location of the apiary. Each sample must weigh at least 100g of flowers. The sampling of flowers is carried out in the morning, so that until late, they (samples) are transported to the accredited laboratory for the analysis of the detection of heavy metals and pesticides. In order to obtain the most credible results, it is desirable that laboratory tests be performed on the same day.

The results of the laboratory analyzes are examined by comparing the data obtained with the maximum admissible limits, according to the national and EU norms approved by Government Decision no. 1191 of 23.12.2010 [49]. If the concentrations of residues in the flower samples do not exceed the maximum permissible limits, then the environment is considered unpolluted and suitable for the practice of organic beekeeping.

1.2. **Testing of pollen** collected by bees from the flight area. This method (procedure) is more objective and advantageous, because it is apimonitoring the environment through a bioindicator food bee product, which adequately reflects the degree of environmental pollution, substantially simplifies the assessment methods and minimizes their cost, provides an objective scale of heavy pollution of heavy metals and pesticides, a correct comparison of their content in the bioindicator bee product with the maximum permissible concentrations, according to European Union (EU) standards, adjusted to the rules of the World Health Organization (WHO) and the Food and Agriculture Organization and Agriculture (FAO) [49].

The essence of the process consists in determining, in an accredited laboratory, the content of heavy metals (Pb, Cd) and pesticides (26 pesticides mentioned above) in the pollen collected by bees. The results of the laboratory analyzes are compared with a scale of environmental pollution grading, previously developed taking into account the exceeding of the maximum permissible concentrations (LMA) of EU standards, in the following categories: unpolluted (pollutant content does not reach LMA), poorly polluted pollutants exceed the LMA by up to 20%), medium polluted (pollutant content exceeds the LMA by 20 to 50%) and heavily polluted (pollutant content exceeds the LMA by more than 50%).

In field conditions, this procedure is performed as follows. At the beginning of flowering honey plants in the area expected for the location of the apiary and assessment of the degree of environmental pollution with heavy metals and pesticides are placed 3-5 control hives with bee families, around which the quality of the environment is assessed within a radius of 3 km - productive flight radius of bees. The day after the location, when the bees have become accustomed to the environment and have a good flight activity, at 900 - 1000 hours, a pollen collector is attached to the hive of each hive,

through which the collecting bees pass and leave the collected pollen in bundles. Every 2-3 hours, the amount of pollen accumulated in the collector is visually checked, and if this is enough, 3 samples of 100g of fresh pollen are taken from each bee family. The pollen is packed in a polyethylene bag, and transported, as soon as possible (so that it does not lose its natural moisture), to the accredited laboratory for the analysis of the respective pollutants. Laboratory tests are performed operatively on the same day. The results of determining the content of heavy metals and pesticides in fresh pollen are compared with the scale of gradation of the level of environmental pollution, previously developed. For example, we present the gradation scale of the level of environmental pollution with heavy metals and pesticides according to their content in the fresh pollen collected by bees (Tab. 1).

The effect of the process of assessing the degree of environmental pollution is caused by the fact that fresh pollen, taken from the collector installed in the hive, is the best beekeeping product bioindicator of cumulative heavy metal and pesticide pollutants, and very effective. From the moment the bees collect the pollen from the flowers of the honey plants, until it is brought to the hive, a relatively short time expires (15-20 min). For the accumulation in the collector of a sufficient amount of pollen to take the sample necessary for the laboratory analysis takes no more than 2-3 hours.

During this period, the pollen keeps its fresh state and reflects quite objectively the concentrations of pollutants in nature. The content of pollutants in fresh pollen is closely correlated with their content in the inflorescence of honey plants and other components of the environment (soil, water).

Table 1 Gradation scale of the level of environmental pollution with heavy metals and pesticides by their content in fresh pollen collected by bees

Name of the pollutant	Maximum permissible limit in pollen (LMA) (EU and MD Standard), mg/kg	Level of environmental pollution, according to the concentration of heavy metals and pesticides in pollen, mg/kg			
		Not polluted (<LMA)	Slightly polluted (up to 20%)	Polluted medium (from 20 to 50%)	Heavily polluted (over 50%)
Heavy metals					
Plumbum (Pb)	3.00	< 3.00	3.00 – 3.60	3.61 – 4.50	> 4.5
Cadmium (Cd)	1.00	< 1.00	1.00 – 1.20	1.21 – 1.50	> 1.5
Pesticides					
Tau-fluvalinate	0.01	< 0.01	0.01 – 0.012	0.013 – 0.015	> 0.015
Chlorpyrifos	0.01	< 0.01	0.01 – 0.012	0.013 – 0.015	> 0.015
Imidacloprid	0.05	< 0.05	0.05 – 0.06	0.061 – 0.075	> 0.075
Difenoconazole	0.01	< 0.01	0.01 – 0.012	0.013 – 0.015	> 0.015
Cyprodinil	0.05	< 0.05	0.05 – 0.06	0.061 – 0.075	> 0.075
and so on. . .					

2. Ensuring the organic feeding of bees during poor harvesting periods in nature.

Beekeepers face annually, at the end of winter (February) and early spring (March-April), the problem of depletion of natural food reserves in the nest of the bee family, when in the body of bees there is a shortage of bioactive nutrients, in especially, of carbohydrates, proteins, microelements, vitamins, which have a decisive role in the physiological processes of vital activity of the bee organism, determining the reproductive capacity and further development of the bee family as a whole.

To compensate for the lack of nutrients in the diet of bees during poor harvesting in nature, most beekeepers feed bee families with sugar syrup, which, with the exception of carbohydrates, lacks a significant number of biologically active substances.

Under these conditions, we have developed a series of processes for feeding bee families with carbohydrate nutritional supplements, enriched with biologically active substances of different organic origin, which we propose to beekeepers.

2.1. Processes for feeding bee families with nutritional supplements enriched with biologically active substances from the biomass extract of the cyanobacterium *Spirulina platensis*.

These processes are described by us in the patents: MD 475 Z 2012.09.30 [64], MD 476 Z 2012.09.30.17 [65], MD 477 Z 2012.09.30 [66].

The essence of the process consists in feeding the bee families over a day, during 2 weeks, with 100 ml (at each interval of honeycombs populated with bee) of nutritional supplement of 50% sugar syrup, enriched with biologically active substances from the extract of the biomass of the cyanobacterium *Spirulina platensis*, cultivated in the presence of coordinating organic compounds, such as: *Zn (II) monochloroacetate - Zn tetrahydrate* $(CH_2ClCOO)_2 \cdot 4H_2O$; *Cr and K alum - KCr* $(SO_4)_2 \cdot 12H_2O$ *and Fe (III) selenite hexahydrate - FeSeO*$_3 \cdot 6H_2O$. The extract of the biomass *Spirulina platensis* is added to the nutrient mixture in the form of an aqueous solution with a concentration of 1 mg in an amount of 2 ml per 1 L of syrup.

Our research [10, 11, 12] has shown that feeding bee families during poor harvesting in nature with a nutritious mixture of sugar syrup enriched with bioactive supplements obtained from the biomass extract of cyanobacterium Spirulina platensis, grown in the presence of organic compounds above-nominated coordinators, contributes to increasing the prolificacy of queens and the amount of captive brood by 32.6-74.4%; family power by 18.1-25.3%; flight intensity of bees by 19.7-23.1%; disease resistance by 13.4-18.5%; viability of the young by 14.2-17.7%; the amount of wax raised in the nest by 41.0-48.0%; the amount of pasture by 52.5-106.7% and the amount of honey accumulated in the nest by 53.1 - 90.0%.

The result obtained is determined by the presence in the nutritional supplements of biologically active substances, such as: amino acids, essential lipid acids, peptides, vitamins (especially B_{12} and B_6), antioxidant pigments and trace elements (especially *Zn, Cr, Fe, Se*) in necessary quantities, being catalysts of important functions of regeneration of the cells of the ovarian tissues of queens, as well as of the lactogenic and ceriferous glands of working bees, with stimulating, immunomodulatory and antioxidant properties, being part of some hormones and enzymes in the hemolymph. contributes to improving the penetrability of organic tissue cells, participates in the process of regeneration of hemocytes and strengthening the body's immune system that ultimately determines the quality and level of permanent feeding of queens and brood larvae in the early days, family development and increase productivity.

2.2. Processes for feeding bee families with nutritional supplements enriched with biologically active substances from the biomass of aquatic microalgae.

The processes are described by us in the patents: MD 1061 Y 2016.08.31 [61]; MD 1062 Y 2016.08.31 [62]; MD 1079 Y 2016.10.31 [63].

The essence of the processes consists in feeding the bee families at the end of winter, in the deficient period of harvesting in nature, when the atmospheric temperatures are low, with nutritious paste prepared from a mixture of sugar powder with honey in proportion of 7: 3, enriched with biological supplements. active from the biomass of aquatic single-cell microalgae *Scenedesmus quadricauda, Scenedesmus apiculatus* and *Oocystis borgei Snow*, which are mixed with the paste in the amount of 10 ml of 2% suspension per 1 kg of paste mixture. The feeding of the bee families with the enriched nutritious paste is carried out by distributing it in the form of cakes placed in the nest above the frames of the frames. A cake is placed on each frame with bees, each weighing 200 g.

Our research [22, 23, 25] has shown that feeding bee families during the poor harvesting period in nature (late winter - February and early spring - March) with nutritious powdered sugar + honey in relation to 7 : 3, enriched with biologically active supplements from the biomass of aquatic microalgae *Scenedesmus quadricauda, Scenedesmus apiculatus* and *Oocystis borgei*, contributes to the increase of queen prolificacy - by 7.8-10.3%, the amount of captive brood - by 7.7-9.3 %, the strength of the bee family - by 7.1- 9.3%, the resistance of the families to diseases - by 1.8-3.8%, the viability of the brood in the nest - by 1.2-1.7%, the amount of pasture accumulated in

the nest - by 15.5-27.6%, the amount of wax raised on honeycombs - by 13.3-36.7% and the amount of honey accumulated in the nest - by 28.0-38.9%.

The result is due to the increased digestibility and accessibility of biomass nutrients, given that the microalgae *Scenedesmus quadricauda, Scenedesmus apiculatus* and *Oocystis borgei* are covered with a thin protective film and the biomass is rich in biologically active substances, in particular, of proteins, carbohydrates, lipids, essential amino acids, micro-macro-elements, antioxidants (beta-carotene), which have a catalytic role in the metabolism of nitrogenous substances in worker bees, participate in the synthesis of enzymes, improve the vital activity of bees, with influences direct on their flight intensity, activating the harvesting functions of nectar and pollen, as well as the secretory functions of the cerebral glands, stimulating the functions of the queen's reproductive system, activating ovogenesis and spawning. All this largely determines the activation of the physiological processes of the body of all members of the bee colony, starting with the queen - founder of the social community (nest) and ending with worker bees, on whose vitality depends the strength of bee families, their ability to accumulate beekeepers (nectar, pollen) and their overall productive potential.

2.3. Processes for feeding bee families with nutritional supplements enriched with biologically active substances of coordinating organic compounds.

The processes are described by us in the patents: MD 850 Z 2015.08.31 [67] and MD 4438 B1 2016.10.31 [60].

The essence of the processes consists in feeding the bee families in spring, during the deficient harvesting period in nature, with a nutritious mixture of 50% sugar syrup enriched with biologically active supplements, of the coordinating organic compounds heteronuclear (*Sulfate of [(tris-thiososemicarbazidate of cob (III)] • [1,2-diaminocyclohexantetraacetate of bismuth (III)] hexahydrate, with the chemical formula - [Co (thios)$_3$] [Bi (cdta)] SO_4 • 6H_2O and (tetrafenylphosphonium) di-semihydrate, of chemical formula - [P (C_6H_5)$_4$]$_2$ [Mo_2O_4 ($C_{10}H_{12}N_2O_8$)] • 4H_2O)*, in the form of an aqueous solution with a concentration of 1 mg%, mixed with sugar syrup in a ratio of 2: 100 , being administered in the feed of bees in the amount of 200 ml of mixture at each interval of frames populated with bees, every 2 days, for two weeks.

Our research [19, 18] has shown that feeding bee families during poor harvesting in the wild with nutrient supplements enriched with biologically active substances of the above-mentioned coordinating organic compounds contributes to increasing the prolificacy of queens and the amount of captive brood. by 9.7-10.5%, family strength - by 9.7-11.9%, disease resistance of the colony - by 4.3-5.0%, viability of the young - by 2.2-2.6 %, the amount of pasture accumulated in the nest - by 21.8-23.3%, the amount of wax raised on honeycombs - by 38.5-39.3% and the amount of honey accumulated in the nest - by 20.0–25, 4%.

The beneficial influence of nutritional supplements enriched with coordinating organic compounds on the vital functions of bee families is explained not only by the action of rare microelements, which have a catalytic role in the physiological processes of substance exchange in the bee body, but also by the complex action of all biologically active substances in their complicated molecular structure with their very close and stable structural bonds, including complex ligand ions, metal ions and radicals with modified valence, and with increased penetrability properties of cell membranes in living tissues of organisms on whom they influence. The biologically active substances of the coordinating organic compounds contribute, in particular, to strengthening the immunity of the insect organism and, as a whole, to increasing the productivity of bee families.

3. Ensuring the logistical infrastructure of the apiary to the requirements of organic beekeeping, according to EU norms.

The location of the apiary, the provision of technological production processes and its logistical infrastructure for conversion to organic beekeeping are carried out in accordance with EC directives and regulations (834/2007 [47], 889/2008 [51],

834/2009 [28], 271 / 2010 [27], 392/2013 [48]), as well as with the national legislation in the field (Law No. 115 of 2005 on organic agri-food production [41], Government Decision No. 1078 of 2008 on the approval of the Regulation "Organic agri-food production and labeling of organic agri-food products" [36]).

The main principles of ecological requirements refer to the location of the apiary, ensuring ecological hives, equipping them with ecological combs, providing ecological machinery, supports and tools, ecological feeding of bees, processing, packaging and certification of production, prophylaxis and control of apiary diseases.

Location of the apiary. The hive must be located in sites where bee families within 3 km will have enough food collected from organic (unpolluted) honey plants. In order to ensure this condition, we proposed the assessment of the conformity of the environment, according to point 1. The hearth of the apiary must be at a distance of not more than 1 km from industrial sources of pollution (factories, plants, car bases, highways and roads, etc.). The hearth of the apiary is desirable to be fenced with ecological fence (from shrubs, natural bush, lotion, wicker, willow, sea buckthorn, etc.).

Ecological hives must be made of natural wood (preferred fir), according to current standards. For weather protection, the hives can be painted with linseed oil, or with special ecological paints. Our previous research [8] has shown that vertical hives have comfort advantages for bees compared to horizontal ones. The maintenance of bee families in vertical hives ensures an increase in queen prolificacy - by 3.5%, family strength - by 6.0% and honey production by 19.1%. The exploitation of bee families in vertical hives ensures an economic efficiency of at least 23.8 euros per bee family. The frames of the hive must also be made of natural wood, and the wires for fixing the honeycombs must be made of stainless steel.

Honeycombs. During the conversion period, for 1 year all old honeycombs are replaced with new honeycombs made of ecological wax. Organic wax honeycombs can be purchased from specialized commercial units, which provide an ecological certificate for the honeycombs sold, or they can be made in your own apiary with the help of the special ecological wax machine accumulated from the opening of honey cells. This wax is considered organic if all its processing rules are followed and, if in the hive, no banned substances have been used in the treatment of antivirus, antinozema, antimolia, etc.

The machine and tools. All equipment (honey extractor, wax melter, release valve, pollen collector, venom collector, vessels, storage and packaging containers for honey and other bee products), tools (chisel, release knife, fork) and tools (perforator, drills), which come into contact with frame, honey, wax, pollen, and other bee products must be made of stainless steel, glass or special plastic, with a certificate of use for food.

Organic feeding of bees. Artificial feeding of bees during poor harvest periods, as well as pollination of orchards, is carried out with honey, or certified organic sugar, or with their mixture. The addition of various nutritional supplements of natural or organic origin, described in point 2, is permitted.

Prophylaxis and control of diseases. In the apiary in conversion for organic beekeeping, special attention is paid, first of all, to disease prevention and disease control through non-polluting methods.

Disease prophylaxis is achieved by:

- selection of winter-resistant bee families with high hygienic instinct (disease resistance), according to the methods proposed by us [6, 7, 9, 13 - 17];
- annual change of at least 40-50% of queens, in particular those with signs of some disease, low prolificacy and exceeding 2 active laying seasons, with young, robust, healthy breeding queens of pedigree distinct, bred in breeding apiaries by guided methods, described in point 4;
- avoiding favorable factors and ways of contamination of bee colonies;
- ensuring the conditions of total peace of the wintering of bee colonies;
- non-admission of the use of contaminated equipment;
- non-admission of the exchange of infected materials between apiaries;

- avoid feeding bees with contaminated honey and pollen;
- non-admission of poaching, a phenomenon by which bees transfer a large amount of germs from sick and weak families to healthy ones;
- keeping bee families active and vigorous;
- passive (visual, phonendoscopic) and active (clinical, pathological and laboratory examinations) surveillance of the young;
- the periodic removal during the year (winter, spring, summer, autumn) of dead bees and residues from the bottom and mirror of the hives, from the entire hearth of the apiary, and their destruction by burning;
- ensuring adequate ventilation in the hive to reduce humidity;
- mandatory annual reform of at least 1/3 of old honeycombs with diarrhea stains;
- non-admission to supplement the food reserves for the winter period with manna honey;
- the addition to the drinking water of the apiary drinker of 3-5 g / L of table salt so that the bees, on the first cleaning flight, get used to the slightly salty water in the drinker and do not accept other sources of non-potable drinking possibly infected . For this, the drinker with slightly salty drinking water must not be absent during the entire flight period of the bees, including pastoral;
- disinfection of the hands of the beekeeper (staff) handling the bee families and the beekeeping inventory after use at the end of the day, or disinfection of them and the place after handling each contaminated hive, with the application of permitted ecological means: potassium and sodium soap, hot water and steam, lime milk, quicklime, sodium hypochlorite, caustic soda, hydrogen peroxide, natural plant essences, citric acid, peracetic acid, formic acid, lactic acid, oxalic acid, acetic acid, ethyl alcohol, essential oils or combinations of them.

The fighting of diseases in bees is determined by their etiology and is achieved through the following measures.

In the case of *bacterial diseases*, including *American and European*, as well as fungal and viral diseases, the fighting measures consist of:

- destruction by burning of the bee family and of all the combs in the affected hive;
- hive bodies and empty frames are flamed with the burner;
- the beekeeping inventory (tools, devices) as well as the beekeeping equipment are rigorously disinfected, using the above-mentioned permitted disinfectants;
- any attempt at antibiotic treatment of any disease in bees is prohibited.

In *Nosemoza* and *Amibiosis*, fighting is achieved by treatment with sugar syrup soaked in medicinal products of natural origin of the Protofil type (hydroalcoholic extracts of medicinal plants, essential oils, organic acids), which contain a number of biologically active substances (cyclic hydrocarbons and aliphatic, sesquiterpenes, triterpenes, phenolic and flavonic compounds, oleanolic acid, trace elements and vitamins) that stimulate the digestive enzymatic secretion of bees and larvae, strengthen the immunity of bees, inhibit the intestinal pathogenic flora, penetrate the sporadic membranes of their protozoa and prevent.

In Varroza, Acarapioza, Brauloza, Triungulinosa and other parasitosis, the fighting is carried out by treatments with organic acids, in particular oxalic acid, formic acid, acetic acid, lactic acid, citric acid, as well as in combination with some essential oils and extracts from medicinal herbs. For Varroa, the treatment period is important, the optimal one being August-October and early spring (February-March). For organic beekeeping, the treatment of these parasitic diseases with preparations containing the pesticides Amitraza and Fluvalinat is not allowed, because it contravenes EU norms. These pesticides pollute bee products (honey, wax, pollen) and pose a harmful danger to human health.

Bee *intoxication* is treated by administering warm sugar syrup (37oC) with the addition of natural medicines based on herbal extracts (Protofil) mixed with natural squeezed lemon juice.

Galeriasis (butterfly) is combated with non-polluting means, by: using light traps, glue and attractants to attract adults and capture them; the use of anti-insect electrical appliances, which act through ultraviolet light and electric shock; removing heavily attacked combs and subjecting them to melting at high temperatures; at less attacked combs, the galleries of the house are opened with a sharp tool, the larvae, the cloths and the donuts of the parasite are destroyed and removed

manually (with tweezers) to allow the bees to clean and restore the damaged cereal cells. In the case of deposits with attacked combs: the attacked combs are removed and the rest of the combs are disinfected with glacial acetic acid in a hermetically sealed space; heat treatment of the combs by freezing for 3 hours to destroy the larvae and eggs; treatment of honeycombs with sulfur dioxide in a hermetically sealed space, repeated every 2-3 weeks.

Ants are fought by: raising and maintaining hives at a height of at least 40 cm from the ground; mowing the grass around the hive to prevent ants from climbing the grass and entering the hive; the use of wormwood or parsley leaves placed next to the hive supports, which have a formicido-fugue effect; the use of motorized petroleum jelly or petroleum products placed in tin containers (cans or other containers) placed under the hive supports during the activity of the ants.

The *wasps and the bee wolf* are fought by: using specific traps; detection and destruction by burning of their nests. It is forbidden to use any chemicals to fought wasps.

Insectivorous birds (*Merops apiaster, Picidae, Hirundo rustica, Paridae* et al.) are combated by: removal with the help of the sounds emitted by their predators in the form of sound recording; the use of ultrasound emitting devices that remove the respective birds from their area of location; use of rodent traps; dressing the hive in winter in a protective mesh cage with a mesh section of 1 cm, spaced from the outside of the hive board on all sides at 10 cm.

Mice (Mus musculus, Mus aparius, Mus silvestricus) and rats (Ratus sp.) Are combated by: installing anti-mouse grids at the urdiniș during the autumn, when the family activity decreases, when it is recommended to reduce the urdiniș; installation of rodent traps; dressing the hive in a protective wire mesh cage with an eye section of 1 cm.

4. **The directed growth of breeding queens.**

For the practice of organic beekeeping it is necessary that each bee family be completed with a breeding queen of known origin, robust, of high prolificacy. When raising brood queens, it is important to apply effective methods that ensure healthy and developed queens. To this end, new methods have been developed and proposed by us, which ensure the increased efficiency of directed growth of queens [14, 26].

The essence of these methods consists in the specific way of organizing the starter family for initiating the growth of larvae in pot holders and of specific formation of the mating nuclei of the queens. For the organization of starter families, healthy, strong families with a lot of young bees are chosen. From these are removed the queens (they are orphaned) with 1-2 honeycombs with brood and bees cover, making a special swarm. The rest of the combs, from each separate family, are shaken by the bee in separate bodies of the hive, in which the starter family is formed. For each family, the amount of bee per frame interval (including bottle holders) is in these hive bodies at least double and constitutes for the Dadant frame not less than 500 g. In at least 3 hours, 2 hives are introduced in these hives. honeycombs with food (honey and pasture), 2 honeycombs with captive brood and a protbotce frame with transferred larvae. 55-65 translucent larvae are introduced on a bottle holder frame. The growth period of the larvae on the bottle holder in the starter family is 24 hours, after which it (the bottle holder) is removed and exchanged in the finisher breeding family.

Scientific research has shown that applying the proposed method to the formation of the starter family for the directed growth of queens, contributes to the obvious increase, compared to families formed in the first traditional way, the degree of larval acceptance 2.5 times (t_d = 25.5; P <0.001) and the queen yield 2.9 times (td = 28.6; P <0.001).

The mating nuclei of queens that have been raised under control are populated with young worker bees (up to 10 days). This allows to increase the acceptance rate of queens by 27.3% and the rate of successful return from their nuptial flight by 32.6%.

5. **Bee pollination of entomophilous agricultural crops.**

Numerous researches in the field of pollination of agricultural crops have shown that the free (cross-pollination) of fruit crops with the participation of insects, contributes

20–150% to the total production. In sunflower this contribution can reach 300-500% [21]. In addition, the quality of fruits and seeds resulting from entomophilic pollinated flowers is at least 10-20% higher than those produced from insect-free pollinated flowers. Trees with flowers poorly pollinated by insects, produce fruits with an affected shape, less sweet and with few seeds. According to some reports, in the US 33% of the food consumed in this country comes from plants pollinated by insects, of which 75-90% bees, and the total value of crops and goods to which bees contribute by pollination amounts to about 19 billions of dollars.

In this context, as a result of our research, we developed and proposed for beekeepers and agricultural cultivators several techniques (methods) for bee-directed pollination of plum and apple fruit crops [20], as well as sunflower [21, 24].

3.1. **When pollinating plum and apple trees.**

For saturated pollination of plum and apple orchards, the load with bees must be at least 3 families / ha. Each family must have at least 7 ranges of bee frames. The hives with the bee families are placed inside the orchard between the rows of trees, in a row, at a distance of 100 m from each other and over every 7th row of trees. In all sectors of the orchard, hives with bee families are placed at the beginning of the flowering period of the trees and retained for at least 6 days, after the day of placement. To speed up the process of accustoming bees to the scent of tree flowers and to increase the intensity of flight, all bee families placed at pollination are fed daily throughout the pollination period, with 50% sugar syrup, mixed with flower infusion, freshly collected from the respective trees, in the amount of 50 g of flowers per 1 liter of syrup. The mixture is administered 50 ml at each interval with bee frames.

It was found that bee-directed pollination of plum and apple orchards by the proposed technique (method) ensures a significant increase, compared to the traditional method of pollination, the frequency of visit of bees to flowers - 2.3-2.4 times, the intensity of bees with pollen clumps - by 23.1 - 24.5%, of the amount of pollen collected - by 46.2-57.4%, of the degree of fertilization of flowers - by 2.1-2.2 times and, as a result, a significant increase in fruit harvest at least 1.5-2.0 times.

3.2. **When pollinating the sunflower.**

For directed pollination of sunflower, the load of bees must be at least 4 families / ha. Each family must have at least 7 ranges of bee frames. The hives with the bee families are placed in a row around the chain on all four sides, at a proportional distance from each other. The distance between the hives is calculated by dividing the total length of the perimeter around the hive by the number of hives placed. Our research [21, 24] has shown that bee-directed pollination of sunflower culture according to the proposed method ensures an increase in the total mass of seeds (harvest) by 21.3-36.3% - compared to the traditional method and, of 3 , 6-8.4 times - compared to isolated pollination.

CONCLUSIONS

1. In order to ensure the compliance of the environment with the requirements of organic beekeeping, it is necessary to test honey flowers, or pollen collected by bees, on the content of the most common and most dangerous pollutants, such as heavy metals (*Pb, Cd*) and pesticides (I. Ocl. - *Fipronil, Spirodiclofen*; I.Of. - *Azoxystrobin, Carbendazim, Dimetoate, Chlorpyrifos*; IN - *Imidacloprid, Thiacloprid, Tiametoxam, Clotianidin*; IP - *Tau-fluvalnat, Deltametrin, Cipermetrin, Piretrin*; FT- *Biten; Mepanipyrim, Cyproconazol*; F.Dcb. - *Cyprodinyl*; Ac. - *Amitraza*; Herb. - *Glyphosate, Sulfosulfurol, Amidosulfuron, Amitrol, Petoxamide, Pendimethalin*).

2. Fortification of the power of bee families and their productive capacity for organic beekeeping shall be ensured by innovative methods of organic feeding during the deficient periods of harvesting in nature with nutritional supplements of organic origin.

3. The conversion of traditional to organic beekeeping requires the adjustment of the logistics infrastructure of the apiary to the requirements of EU rules, according to EC regulations and directives: no. 1881/2006, no. 834/2007, no. 889/2008, no.

834/2009, nr. 271/2010 and no. 392/2013, as well as the Law of the Republic of Moldova no. 115 of 2005 on organic agri-food production and the Technical Regulation „Organic agri-food production and labeling of organic agri-food products", approved by Government Decision no. 1078 of 2008.

4. Bee families in organic apiaries are complemented by healthy and vigorous queens, raised by organic selection methods, based on fortificating immunity and disease resistance, increasing queen prolificacy and the colony's ability to accumulate bee production in the nest.

5. Organic beekeeping has a positive impact not only on the production of organic bee products, but also on the significant increase in the harvest of entomophilous agricultural crops, as well as the production of organic agricultural products.

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