International Journal of Agriculture and Biosciences 2025 xx(x): xx-xx.
https://doi.org/10.47278/journal.ijab/2025.087

RESEARCH ARTICLE
eISSN: 2306-3599; pISSN: 2305-6622

Therapeutic Efficacy of Phytopreparation for the Prevention and Treatment of Varroosis and Nosemosis of Honey Bees in Western Kazakhstan

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ABSTRACT

Bee diseases significantly hinder the development of the beekeeping industry and reduce its profitability. The use of various chemical origin preparations for treating bee diseases ensures that the infestation of bee colonies is kept to a minimum. However, the preparations have a negative impact on the bee body and contaminate bee products. Therefore, this study aimed to investigate the therapeutic efficacy of a new phytopreparation in the conditions of West Kazakhstan region. The phytopreparation was developed using medicinal plants native to the Republic of Kazakhstan. The therapeutic dose of phytopreparation (10 and 15mL/1L of 20% and 50% sugar syrup) was established using the laboratory method of dosed feeding. The research and production experiment demonstrated that the phytopreparation exhibits a pronounced anti-varroosis and anti-nosemosis effect. In the treatment of varroosis, the intensity of invasion is reduced to a safe level when used by the method of feeding at a dose of 10-15mL/1L sugar syrup in the spring period, the therapeutic efficiency is 86-85.7%, when irrigated in the specified doses - 84.3-85%. In the treatment of nosemosis, the preparation's effectiveness reaches 100%. The preparation can also be used for complex treatments and systematic therapeutic and preventive protection of bee colonies, as well as to stimulate the development of healthy bee colonies, an increasing their productivity.

Keywords: Honey bee, Varroosis, Nosemosis, Treatment, Phytopreparation

Article History
Article # 25-215
Received: 23-Apr-25
Revised: 28-May-25
Accepted: 30-May-25
Online First: **01-Jul-25**

INTRODUCTION

The honey bee (*Apis mellifera*) plays a key role in biodiversity conservation and provides several unique products for the food industry and pharmaceuticals. Therefore, beekeeping is an important component of every country's economy.

Despite the annual increase in the number of bee colonies, beekeeping in many countries faces challenges that hinder the industry's growth (Wakgari et al., 2021). In Kazakhstan, as well as worldwide, one such factor is bee diseases, among which the most widespread and dangerous are varroa mites and nosemosis. Currently, these diseases are widespread, affecting between 10 and 100% of bee colonies (Chemurot et al., 2016; Tokarev et al., 2018; Baigazanov et al., 2022; Robi et al., 2023; Bava et al., 2023; Cilia et al., 2023; Farida et al., 2024). They adversely affect the bee organism, causing a decrease in productivity and the death of bee colonies, which results in significant damage to beekeeping.

The Varroa mite is the most significant pest for bee colonies, as it affects them at all stages of development (Noël et al., 2020). Against the background of Varroa infestation, there is a tendency to the growth of infections (ascospherosis, American and European rot), the causative agents of which are transmitted by Varroa mite (Mikhaltsevich & Velichko, 1996; Grobov et al., 2008; Reams & Rangel, 2022; Dequenne et al., 2022).

The negative impact of *Nosema spp.* on bees is also significant. It is known that already 14 days after the development of *N. ceranae* in the middle intestine of bees, the amount of lipids in the fat body of honey bees decreases sharply. Especially strongly (up to 50%) lipid reserves decrease in the fall period (Gilbert et al., 2024).

Cite this Article as: Satybaev B, Valitova N, Kushaliyev K, Nurzhanova F, Kairgalieva G, Bayantassova S, Kozhayeva A and Mendybayeva E, 2025. Therapeutic efficacy of phytopreparation for the prevention and treatment of varroosis and nosemosis of honey bees in Western Kkazakhstan. International Journal of Agriculture and Biosciences xx(x): xx-xx. https://doi.org/10.47278/journal.ijab/2025.087

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Additionally, bees infected with *N. ceranae* are protein deficient due to midgut lesions, resulting in a lower survival rate of the bees (Panek et al., 2018), which can lead to weakening and death of the bee colony (Mayack & Naug, 2009; Bekele, 2015; Ostap-Chec et al., 2024).

Various methods are used to protect bee colonies from disease, but the most effective is the use of medicines. It should be noted that most of the preparations used in beekeeping are products of biological and chemical production (Formato et al., 2011; Vandervalk et al., 2014; Bava et al., 2023; Aurell et al., 2024; Jack et al., 2024). They are often expensive or unavailable to beekeepers (especially in remote areas) and their choice is limited, as they are imported to the Republic of Kazakhstan from other countries. In some countries, the use of these preparations is prohibited or restricted (Chaimanee et al., 2021; Formato et al., 2022).

The uncontrolled and illiterate use of improvised veterinary and medical preparations causes even more damage, as it results in the death of bee colonies, the emergence of resistant species of pathogens, and outbreaks of bee diseases not previously encountered in a particular region. Additionally, it impacts the ecology of bee products that contain by-product compounds (Formato et al., 2011; Guün et al., 2024).

Studies have confirmed that chemical origin preparations negatively affect bees by accumulating in their bodies (Shakarian, 1981; Sotnikov, 1982; Terpin et al., 2019; Ahmad & Elsaiegh, 2022), also affect the exterior traits of honeybees, (Larkina & Lapynina, 2021), accumulate in honeycombs, honey (Er Demirhan & Demirhan, 2022), perga (Lambert et al., 2013; Lozano et al., 2019) and persist in them for a long time (more than 6 months) (Formato et al., 2011). Honey contaminated with veterinary preparation residues may acquire undesirable properties, including allergenicity, carcinogenicity, effects on the reproductive system, and teratogenicity (Rodrigues et al., 2024; Shoaei et al., 2024).

Scientists in many countries worldwide are conducting research on the development of new biologically active, therapeutic, and prophylactic preparations that are safe for both bees and humans (Formato et al., 2011; Kunat-Budzynńska et al., 2022; El-Seedi et al., 2022). Compounds found in plants are gaining attention because they exhibit antimicrobial, antifungal, antiviral and acaricidal activities (Bava et al., 2023). When isolated from plants, these compounds are able to degrade over time when exposed to light, air, and moisture. In addition, plant-based preparations have a balanced chemical composition and have combined and targeted therapeutic and biostimulatory actions. There is evidence from various sources on the use of more than 250 species of medicinal plants for the prevention and treatment of bee diseases (Kerimaliev, 2005; Khan et al., 2019; Pasca et al., 2021; El-Sayed et al., 2024), to stimulate the development and increase the productivity of bee colonies.

Medicinal plants are used in various dosage forms, including extracts, fumigants, and essential oils. Of these, extracts have the greatest therapeutic effect. Different extracts of the same plant inhibit pathogen development, but ethanolic extracts have the best results in most cases (Formato et al., 2022). Plant essential oils are used as impregnated strips on veneer and cardboard, or by spraying them on frames with bees (Rashidet et al., 2020). The efficacy of such treatment under field conditions for nosema can range from 71.21 to 84% (Ozuicli et al., 2023; Bava et al., 2023; Boonmee et al., 2024). For varroosis it can be as high as 97% (Mahmood et al., 2014; Salkova et al., 2024).

Fungi also have the potential to mitigate the negative effects of environmental factors. For use, of which only one contains medicinal plants, three are a combination of a chemical drug with essential oils of plants, and 8 are of chemical origin. Therefore, the purpose of this research is to investigate the therapeutic efficacy of a new phytopreparation for the prevention and treatment of varroosis and nosomosis in honeybees in the Western Kazakhstan region.

MATERIALS & METHODS

Ethical Approval

The experiment plan and handling of bees in the current study were approved by the local Commission on Biological Ethics of «Batys Zoo Vet Service» LLP (Protocol No. 276, dated 30.04.2024). When conducting experiments, we were guided by the recommendations of the Board of the Eurasian Economic Commission (2023), as outlined in the guidelines for working with laboratory (experimental) animals when conducting preclinical (non-clinical) studies.

Place of Study

The study was conducted by the Zhangir Khan West - Kazakhstan Agrarian – Technical University based on the beekeeping farm «Golden Beehive» located in the Michurinsk rural district of Bayterek (Fig. 1). The area of the land plot for the apiary is 5.5 hectares. The farm has about 100 bee colonies of the Carpathian breed, which are kept in wooden Dadan hives. The apiary is mobile; in winter, the hives are kept in wintering houses; in the spring-summer-autumn season, they are placed near the sources of honey collection (crop fields, meadows, forests).

Phytopreparation

To obtain a phytopreparation for the prevention and complex treatment of bee varroosis and nosemosis, the following medicinal plants were taken: yarrow (*Achillea millefolium*), bitter wormwood (*Artemisia absinthium*), common pine (buds) (*Pinus sylvestris*). The finished preparation is a 10% extract of plant material in 70% ethanol (for 1 L of ethanol, take 50g of yarrow, 40g of wormwood, and 10g of pine buds). It is a brown-green liquid with a bitter taste and herbal aroma. All plants used to produce the preparation were collected in the region and identified by specialist N.V. Valitova. All plants for the preparation were collected on the territory of the region by the rules for the use of plant life as approved by order of the Council of the Eurasian Economic Commission (2018) and Acting Minister of Ecology and Natural Resources of the Republic of Kazakhstan (2023) on approval of the Rules of proper practice of cultivation, collection, processing, and storage of initial raw materials of plant origin.

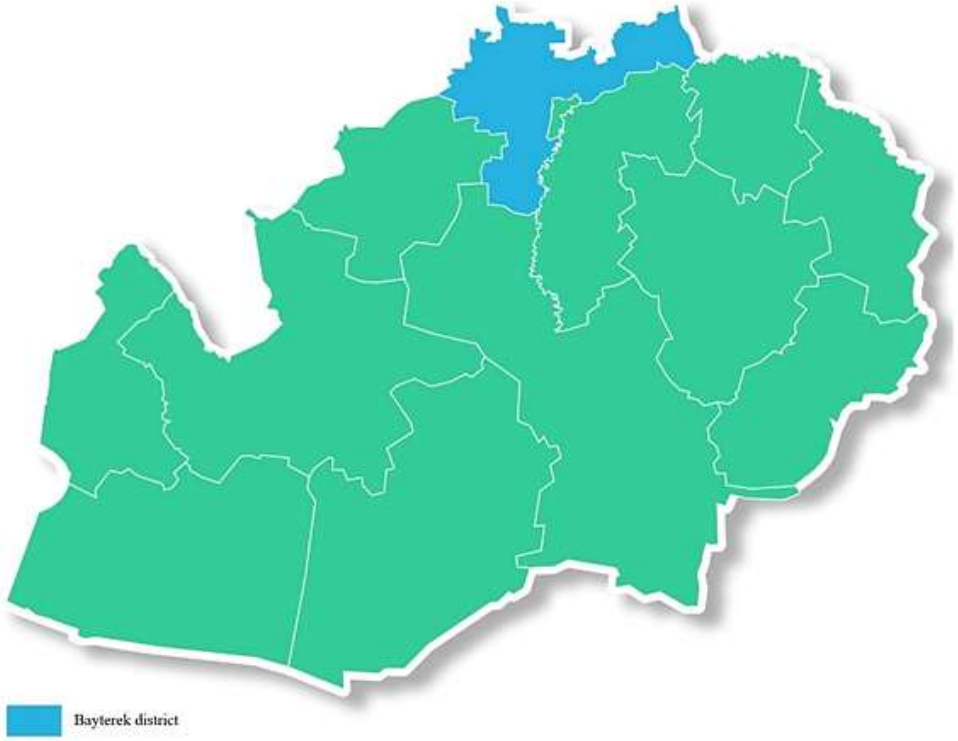

Fig. 1: Surveyed district of West Kazakhstan Region.

Determination of the Therapeutic dose of a Phytopreparation

For the research, we took the methodology for the determination of toxic impurities in flower pollen according to GOST 28887-90 «Flower pollen (beebread). Technical conditions». During the study, this method was adjusted to consider the work's purpose, the materials used, the drug's dosage form and the planned schemes and methods of treating bee colonies.

Approximately 60 bees were taken from one colony, extracted from a honeycomb frame with open brood, and placed in 15x6.5x13cm entomological cages. There were 2 bee cages in each group. The total number of bees in each group was at least 120.

The therapeutic dose of the phytopreparation was determined by administering the phytopreparation to bees in a dose-dependent manner. The experiment scheme included five groups of bees: four experimental and one control group.

For feeding bees in experimental groups, the tested preparation was mixed with 50% sugar syrup in volumes of 10, 15, 20 and 30 mL/1L of syrup. The syrup with the preparation was poured into test tubes. The test tubes for the control group were filled with 50% sugar syrup without preparation. All test tubes were covered with polyethylene film and secured with a rubber band. Small holes were made in the plastic film with a needle to allow the bees to take the food. The syrup tubes were inverted and placed in the cage, allowing the bees to access the food (Fig. 2). Bee cages were placed in a thermostat and kept at 30°C for 12 days (Fig. 3). The number of live and dead bees was counted daily. The average lifespan of bees in experimental and control groups was determined according to formula 1:

$$Po(k) = n1+n2+...+n12 / N \quad (1)$$

where Po(k) is the average lifespan of bees in experimental and control groups;

n1, n2, etc. - is the number of live bees in the cages on the corresponding day of counting;

N - the total number of bees in the group.

The average life expectancy of bees in experimental and control cages was the main criterion for assessing the harmlessness of the phytopreparation for bees. According to the methodology, the indicator in the experimental group should not be less than that in the control group. If the average lifespan of the experimental bees is shorter, the tested preparation or its concentration is considered toxic for bees.

Fig. 2: Bees in an entomological cage.

Fig. 3: Cages with bees in the thermostat.

Experimental Groups and Treatment Schemes for bee Colonies

For the scientific and farming experiment, 5 groups with 3 analog bee colonies in each group were formed during the spring period, specifically in the month of May. Before experimenting, a comprehensive assessment of the condition of bee colonies was carried out according to the following characteristics:

- infestation of bee colonies with varroosis (Varroa infestation is diagnosed based on visual detection of Varroa mites and laboratory data. (Methodological guidelines for the rapid diagnosis of varroosis and determination of the degree of infestation of bee colonies by Varroa mites in apiary conditions following methodological guidelines of the USSR Ministry of Agriculture (1984) - degree of nosemosis disease. To assess the influence of family strength on honey productivity, an indicator such as the relative amount of honey per 1kg of live bee weight is introduced. This indicator characterizes the ability of one kilogram of live bee weight (from the family under consideration) to collect a certain amount of honey. The viability (strength) of the bee colony was assessed before sampling and after treatment in accordance with the Instructions for the assessment (evaluation) of the breeding value and reproduction of bees, approved by order of the Minister of Rural Development of the Republic of Kazakhstan (2014). Moreover, assessed by the number of frames covered with bees on both sides in accordance with the requirements of GOST 20728-2014 Bee colony. Technical conditions.)
- the strength of bee colonies.

The mentioned groups of bee colonies were treated with phytopreparation (phytopreparation in accordance with the recommended doses of preparations with a similar active substance. (Order No. 101 of March 6, 2018. On the approval of rules for conducting preclinical trials of medicinal products for veterinary use, clinical trials of medicinal products for veterinary use, and bioequivalence trials of medicinal products for veterinary use)) and known antivarroosis and antinociceptive preparations (as control) according to the scheme:

1. Phytopreparation method of feeding – 10 mL/1L of 50% sugar syrup 200 mL every other day for 12 days;
2. Phytopreparation method of feeding - 15mL/1L of 50% sugar syrup 200 mL every other day for 12 days;
3. Phytopreparation - irrigation – 10 mL/1L of 20% sugar syrup at the rate of 10-12 mL per 1 bee hive for 12 days every other day;
4. Phytopreparation - irrigation - 15 mL/1L of 20% sugar syrup at the rate of 10-12 mL per 1 bee hive for 12 days every other day;
5. Bipin-T+nosemat - according to instructions for use.

After treatment, the honey productivity of bee colonies was determined in the fall.

Sampling of Bees for Research

Sampling of bees to determine the infestation of bee colonies (intensity of infestation) was done from 15 bee colonies. Adult bees and bee dung collected near the hives were selected for the study. Each sample contained a minimum of 50 individuals for the study. Samples of bees were placed in an air-accessible plastic container and paper bags by shaking. Bee dung was collected separately in paper bags (Antonov, 1987).

Methods of Examination for Nosemosis

Microsporidia infestation of honey bees was analyzed according to «Methodological guidelines for laboratory tests for nosema of honey bees» (Antonov, 1987) using a microscope with an 8MP digital camera, LCD touch screen, and a hemocytometer. The number of spores of *Nosema spp*. was counted in the hemocytometer and used to calculate the average number of spores per bee.

Methods of Diagnosis of Varroosis

The diagnosis of varroosis was made after careful visual inspection of bee colonies and laboratory data. The studies were carried out in accordance with the approved in the territory of the Republic of Kazakhstan «Methodological guidelines for express-diagnosis of varroosis and determination of the degree of damage of bee colonies by varroa mites in apiary conditions».

A Method for Determining the Strength of bee Colonies

The viability (strength) of the bee colony was assessed before sampling and after treatment according to the Instruction on Bonding (Evaluation) of Breeding Value and Reproduction of Bees, approved by the Minister of Rural Development of the Republic of Kazakhstan (2014). Moreover, evaluated by the number of honeycombs sitting on both sides of the bees by the requirements of GOST 20728-2014 «Bee colony. Technical conditions».

Method for Determining Honey Productivity

The honey productivity of the apiary was estimated by the total amount of honey produced. For this purpose, the amount of marketable honey and the amount of forage honey remaining in the hive were counted. The amount of honey in the honeycomb was determined by one of the following methods: weighing the frames by subtracting the weight of the empty honeycomb on a scale, or visually by measuring the area of the honeycomb filled with honey. It was considered that a fully sealed honeycomb frame with a volume of 43.5×30.0cm up to 3kg, and 43.5×23.0cm up to 3kg would be suitable. The amount of sugar fed at the beginning of the season was subtracted from the amount of gross honey (Seriakov, 2021).

Statistical Method

Accumulation, correction, systematization of initial information, statistical processing, and analysis of results were performed using Microsoft Office Excel 2016 spreadsheets. Statistical analysis was also performed using online calculators https://medstatistic.ru (Marapov, 2022).

The results and the difference between treatment options were analyzed using Student's t-test. Data are presented as mean+SE. For this purpose, the following main parameters were calculated: mean, variance, standard deviation, standard error, and significance level. The significance level to determine the statistical significance of the observed differences between treatment options was $P<0.05$.

RESULTS

At the first stage of the study, the infestations of nosema and varroa in bee colonies were assessed. Based on clinical and laboratory tests, nosema (Fig. 4) and varroa (Fig. 5) infestations were identified.

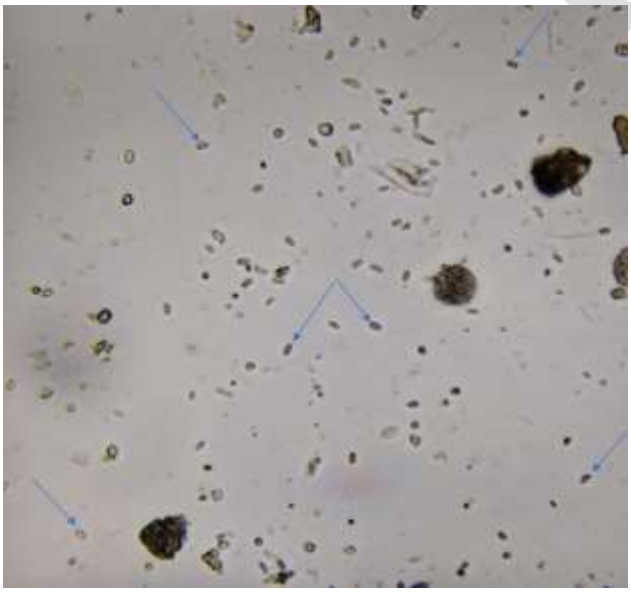

Fig. 4: Nosema spores at 400x magnification.

To study the therapeutic efficacy of phytopreparation, experimental and control groups of bee colonies were formed according to the principle of analog colonies.

Fig. 5: Varroa mite.

Experimenting to Determine the Harmlessness of the Phytopreparation for bees and to Establish its Therapeutic Dose

To establish the therapeutic dose, the phytopreparation was tested by feeding method at the dose of 10, 15, 20 and 30 mL of phytopreparation per 1L of sugar syrup.

The results of the experiment are presented in Table 1.

As can be seen from Table 1, the average life expectancy of bees in the control cage was 10.55 days, according to the results. The average life expectancy of bees receiving phytopreparation in different dilutions differs from each other and the control indicator. When using the phytopreparation in the dose of 10-15mL/1L of sugar syrup, the average life expectancy of bees exceeds the control indicator, and according to the methodology, these doses are harmless to bees. They can be used for testing on bee colonies. Using the phytopreparation in supplementary feeding at dilutions of 20 and 30 mL of the phytopreparation per 1L of sugar syrup causes poisoning and death of bees. Thus, these dilutions can be considered toxic for bees. They are excluded from further experiments. The following doses are recommended for scientific and economic experiments: 10 and 15 mL of the preparation per 1L per second.

Table 1: Average lifespan of bees in control and experimental cages

№	Preparation	Average lifespan of bees, days
1	Control	10.55
2	Phytopreparation 10mL/1L of sugar syrup	11.28
3	Phytopreparation 15mL/1L of sugar syrup	11.62
4	Phytopreparation 20mL/1L liter of sugar syrup	10.54
5	Phytopreparation 30mL/1L of sugar syrup	10.33

Results of a Scientific and Economic Experiment

After spring treatment with the phytopreparation, a general excitement of bees was observed and their cleansing and summer activity was activated.

As shown in Table 2 (Fig. 6), the stickiness of bee colonies before treatment averaged 7.8-8.0% in the groups. As a result of treatments with phytopreparation by feeding

Table 2: Effectiveness of phytopreparation in spring treatment of bee colonies

	Alleyways, pcs.		Frames, quantity		Frames with brood, number		Honey productivity, gross honey, kg	Varroosis incidence, %			Nosema infestation, number of spores per 1 bee		
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment		Before treatment	After treatment	Decrease in lesions, %	Before treatment	After treatment	Decrease in lesions, %
1. Phytopreparation method of feeding – 10 mL/1L of 50% sugar syrup	8	18	16	20	5	14	52	8.1	1.3	84	-	-	-
	7	18	16	19	6	12	45	7.5	0.9	88	-	-	-
	7	18	16	20	5	12	45	7.8	1.1	86	-	-	-
Average	7.3±0.4	18.0±0.0	16±0.0	19.7±0.4	5.3±0.4	12.7±1.2	47.3±2.9	7.8 ±0.2	1.1±0.1	86	-	-	-
2. Phytopreparation method of feeding - 15mL/1L of 50% sugar syrup	8	18	16	20	5	13	45	8.3	1.0	88	12	-	100
	8	18	16	20	5	13	50	7.6	1.1	85	15	-	100
	7	17	15	19	5	12	43	7.4	1.2	84	6	-	100
Average	7.7±0.4	17.7±0.4	15.7±0.4	19.7±0.4	5.0±0.4	12.7±0.4	46.0±2.5	7.7±0.3	1.1±0.16	85.7	11±3.2	-	100
3. Phytopreparation - irrigation – 10 mL/1L of 20% sugar syrup	8	18	16	20	5	12	47	7.6	1.2	84	-	-	-
	7	18	16	20	5	13	49	8.0	1.2	84	-	-	-
	8	18	16	20	6	12	44	7.9	1.2	85	-	-	-
Average	7.7±0.4	18.0±0.0	16.0±0.0	20±0	5.3±0.4	12.3±0.4	46.7±1.8	7.8±0.15	1.2±0.05	84.3	-	-	-
4. Phytopreparation - irrigation - 15 mL/1L of 20% sugar syrup	7	17	16	20	6	13	49	7.9	1.3	83	-	-	-
	8	18	15	20	5	12	42	8.1	1.1	86	-	-	-
Average	7.7±0.4	17.7±0.4	15.7±0.4	20.0±0.0	5.3±0.4	12.3±0.4	45.3±2.5	8.0±0.07	1.2±0.05	85	-	-	-
5. Bipin-T+ nosemat	7	17	16	20	5	12	45	7.5	1.4	81	7	-	100
	8	18	16	19	6	12	44	7.9	1.2	85	13	-	100
	8	18	16	19	5	12	43	8.2	1.2	85	8	-	100
Average	7.7±0.4	17.7±0.4	16.0±0.0	19.3±0.4	5.3±0.4	12.0±0.0	44.0±0.7	7.9±0.23	1.3±0.1	83.5	9.3±2.3	-	100

at doses of 10 and 15 mL/1L of sugar syrup, the stickiness of bee colonies in both groups decreased to 1.1 % or by 86.0 and 85.7%, respectively. At irrigation in the same doses, the therapeutic efficacy of the phytopreparation amounted to 84.3 and 85%. The use of Bipin-T reduced the pecking rate by 83.5%.

In the bee colonies of the second and fifth groups before treatment, a weak degree of nosemosis (ranging from 1 to 15 spores in the microscope field of view) was observed; in the rest, no disease was detected. After treatment, all groups of bee colonies were found to be healthy for nosomosis.

When determining the statistical significance of the observed differences between treatment options, the significance level was above the established level ($P > 0.05$) in all cases and for all considered indicators. Consequently, the phytopreparation corresponds to such preparations as Bipin-T and nosemat in terms of therapeutic efficacy.

Additionally, in the groups treated with phytopreparation, the number of brood frames was slightly higher than in the control group. However, this difference is not significant ($P>0.05$).

DISCUSSION

The use of medicinal plants in beekeeping for the prevention and treatment of bee diseases or as biologically active food additives gives a comprehensive positive effect, manifested in increased survival rate of bees, reduction in the number or complete elimination of the causative agent of the disease, reduction of stress in bees (Sofou et al., 2017; Jovanovic et al., 2023). Plant preparations may not have a significant effect on bee immunity (Glavinic et al., 2024). However, when used, bee mortality is significantly lower than when treated with chemical preparations (Rahimi & Prichrhreh, 2024).

The positive effects of medicinal plants and their preparations are observed when used on sick bee colonies. However, there is an opinion that in healthy bees, some plants and their active substances can cause certain disturbances in the bee organism, reducing their survival rate and immunity (Potrich et al., 2020; Glavinic et al., 2022).

Consequently, when using preparations for disease prevention, it is essential to exercise caution and use only proven remedies and plants with a proven effect on the bee organism.

For this purpose, laboratory tests are conducted to determine the therapeutic dose of herbal preparations, thereby establishing optimal schemes and methods of treatment for bee colonies (Ariana et al., 2002; Sofou et al., 2017; Vilarem et al., 2021). In our study, the laboratory experiment showed that phytopreparation is safe for bees at doses of 10 and 15 mL/1L of sugar syrup.

It should be noted that when using alcoholic extracts of plants, it is necessary to take into account the concentration of alcohol in sugar syrup, as ethanol at a concentration of more than 2.5% in complex with the pathogen can cause a synergistic effect and significantly reduce the viability of

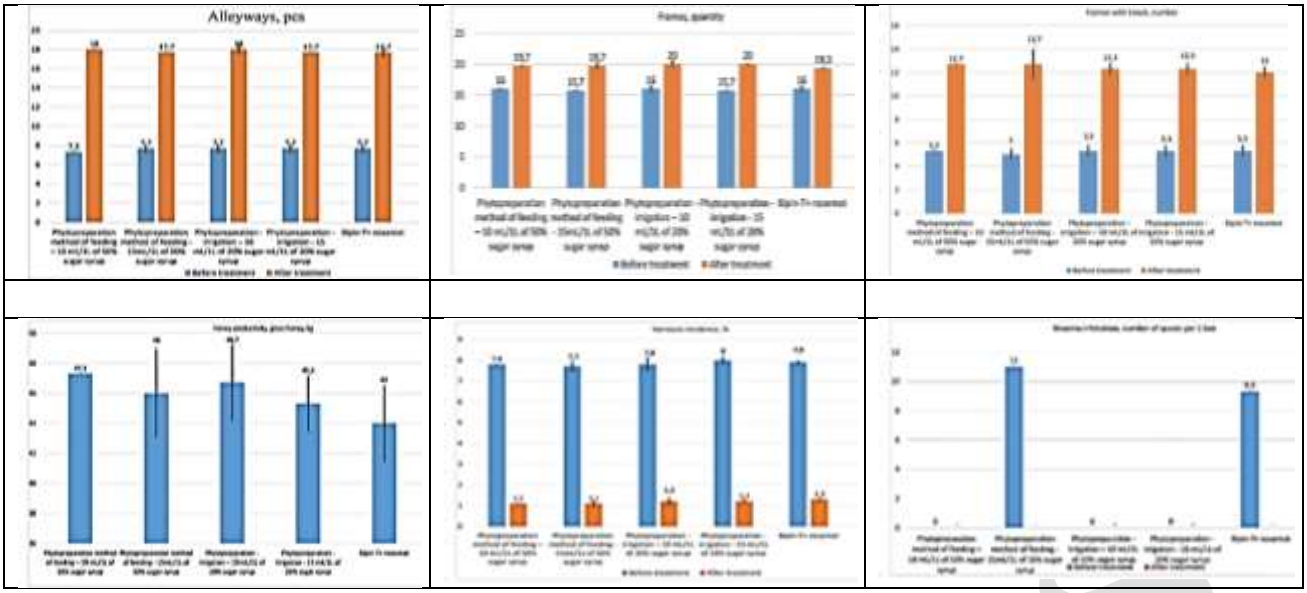

Fig. 6: Effectiveness of phytopreparation in spring treatment of bee colonies.

bees (Ptaszyńska et al., 2013). The dilutions of the phytopreparation (10 and 15 mL/1L of syrup) comply with these requirements and do not exceed the established concentration of ethanol in the working solution.

It is believed that the therapeutic dose of the preparation and its efficacy depend on the route of administration (Ozkırım et al., 2021; Castagna et al., 2022; Bava et al., 2023).

According to available data, one of the most effective ways to use plant preparations is to feed with a 50% sucrose solution containing 0.1-5% plant extract. In this case, their effectiveness is comparable to known chemotherapeutic preparations (Allabergenova et al., 2021).

The acaricidal and insecticidal activity of spraying alcoholic extracts of plants also has a high level of toxicity against mites and is harmless to bees (Damiani et al., 2011). The therapeutic efficacy can reach 100% in some cases (Razaviet al., 2015; Allabergenova et al., 2021).

The results of our studies confirm this. In the treatment of varroosis, the therapeutic efficacy of the phytopreparation at feeding was 86 and 85.7% and at irrigation, 84.3 and 85%. In the control, mite infestation decreased by 83.5%. In the treatment of nosemosis, the efficacy of the phytopreparation and control was 100%.

The results of these studies, as well as the high efficacy of plant alcohol extracts, are confirmed by the studies of other scientists. For example, when studying 90% ethanol extracts of leaves and stem bark of *Swietenia mahogani* and *Swietenia macrophylla*, acaricidal activity reached 100% and 95%, respectively (El Zalabani et al., 2012). The ethanol extract of laurel leaves, after a 30-second exposure, kills 50% of mites within 24 hours after treatment (Damiani et al., 2014). The use of a mixture of extracts from T. thymus and *H. perforatum* in Kazakhstan resulted in a reduction of *Varroa* mite abundance index to 0% (Allabergenova et al., 2021).

In the treatment and prevention of nosemosis, the effectiveness of phytopreparations is also high. In bee colonies that received plant extracts with feeding, fewer dead bees and lower levels of nosema infestation were observed during the winter period (Ptaszyńska et al., 2013). This may be due to the fact that plant extracts at a concentration of 1-2% inhibit the development of *Nosema* spores already on the 5th-9th day after treatment, the number of microsporidium spores decreases 4-6 times within 30 days after treatment and the efficacy is 32.5-100% (Damiani et al., 2014; Chaimanee et al., 2021; El-Sayed et al., 2024). The antimicrobial activity of the plant extract is mainly due to the presence of phenolic compounds and terpenoids (Iorizzo et al., 2022).

The use of phytopreparation, in most cases, also has a bio stimulating effect on bees. In our study, after treatment, the number of brood frames in the experimental groups was slightly higher than in the control group; however, the difference was not significant ($P>0.05$). In all groups treated with phytopreparation, honey production of bee colonies was also higher than in the control. Although the significance level of the observed differences between the treatment variants exceeds the established value ($P>0.05$), this suggests that the studied phytopreparation has not only a therapeutic effect but also favorably affects all economically valuable traits of bee colonies. This may be because the addition of phytopreparation to sugar syrup increases the amount of carbohydrates and protein in the bee body, increases the productivity of bee colonies (Amera et al., 2024) and as a consequence, increases the honey productivity of bee colonies and improves the quality of honey (Mahmood et al., 2014; Vasileva et al., 2024).

Thus, the results of this study enable us to recommend phytopreparation for use in veterinary practice as an effective means of preventing and treating varroosis and nosemosis in bees, thereby increasing the natural resistance of bee colonies to diseases and enhancing their productivity.

Phytopreparation has several advantages: it has a pronounced antivarroosis, antinosemosis, and biostimulating effect. The phytopreparation has no side effects during its use. The components of the phytopreparation are environmentally friendly, readily available in the Republic of Kazakhstan and cost-effective.

The method of phytopreparation manufacturing is labor-intensive and low-cost.

The appearance of highly effective, inexpensive, and non-toxic to bees and humans therapeutic and prophylactic preparations from plant raw materials on the market will improve the epizootic situation in apiaries, allowing for the preservation and increase in the number of bee colonies and the production of high-quality industrial products.

Conclusion

The results of the present study showed that the investigated phytopreparation used in the spring period by the method of feeding at a dose of 10-15 mL/1L of 50% sugar syrup or by irrigation at the same dose in 20% sucrose syrup is a highly effective environmentally friendly preparation that can be successfully used in the practice of beekeeping for the prevention and treatment of varroosis and nosemosis of bees, to increase the natural resistance of bee colonies to diseases, to increase their productivity. The practical use and results of this study demonstrate the feasibility of phytopreparations for preventing and treating varroosis and nosemosis in bees as an effective, safe, and affordable means.

It is essential to continue studying the phyto-preparation on a larger number of experimental bee colonies to determine its effectiveness in the fall treatment of bee colonies, as well as to investigate its impact on the organism and economically valuable characteristics of bees.

DECLARATIONS

Funding: These studies were conducted within the framework of the project on grant financing of scientific and (or) scientific-technical projects for 2024-2026 years (Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan) on the topic «Development of a complex of veterinary and sanitary measures for bee diseases in the conditions of the West Kazakhstan region and technology for obtaining environmentally friendly bee products», Grant No. AP23489173.

Acknowledgement: The authors express their gratitude to the Zhangir Khan West Kazakhstan Agrarian-Technical University for providing material and technical base and to the beekeeping farm "Golden Beehive" for assistance in conducting experimental work.

Conflicts of Interest: The authors declare no conflict of interest.

Data Availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Statement: All procedures involving animals were reviewed and approved by the the local commission on biological ethics of «Batys Zoo Vet Service» LLP (Protocol No. 276 of 30.04.2024). All methods were carried out in accordance with relevant guidelines and regulations.

Author's Contribution: BS, FN, NV, and GK collected data, implemented experiments, conducted experimental work, and analyzed and interpreted data. NV developed the concept and content of the research, as well as writing and designing the article. KK supervised the research, collated the research results, reviewed, and edited the article. SB conducted statistical analysis and interpretation of results. AK and EM prepare literature selection, compilation of bibliographies, and analysis of processed information. AK prepares draft articles, including template frameworks and modifications to the final submitted version. All authors read and approved the final version of the manuscript.

Generative AI Statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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