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RESEARCH FOCUS
INTERNATIONAL SCIENTIFIC JOURNAL

**Vol. 5, Issue 10, 2026**
ISSN 2181-3833 | Uzbekistan
https://refocus.uz/

RESEARCH ARTICLE • PEER-REVIEWED • OPEN ACCESS • SERIES B • HAC/OAK 05.00.00 — TECHNICAL SCIENCES

# Experimental results of ultraviolet treatment of honey bee frames

## Asalari ramkasiga ultrabinafsha nur bilan ishlov berishning eksperimental tadqiqot natijalari

## Результаты экспериментальных исследований ультрафиолетовой обработки пчелиных рамок

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**ARTICLE INFO**

**ARTICLE TYPE**
Research Article

**LANGUAGE OF FULL TEXT**
English (EN)

**SCIENTIFIC FIELD / OAK**
☑ 05.00.00 – Technical Sciences
Texnika fanlari
Series B

**ARTICLE HISTORY**
**Received:** 2026-10-01
**Revised:** 2026-10-13
**Accepted:** 2026-10-18
**Published:** 2026-10-31

**DOI**
https://doi.org/10.66073/researchfocus.v5i10.1002

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**AUTHOR, TITLE AND ABSTRACT METADATA (EN / UZ / RU)**

### ENGLISH

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**Abstract.** The article addresses the reduction of the harmful effects of Varroa mites and various infectious disease pathogens associated with honey bee frames, as well as the stimulation of healthy development of unsealed brood, which is of considerable practical importance for maintaining healthy honey bee colonies. In this regard, the development of a specialized device for ultraviolet (UV) treatment of honey bee frames and the improvement of its operational efficiency are relevant research objectives. The aim of this study is to conduct experimental investigations using a laboratory prototype of a UV treatment device for honey bee frames, evaluate the disinfecting effects of UV irradiation on Varroa mites and infectious disease pathogens, assess its influence on the development of honey bee larvae, and determine the most appropriate irradiation conditions while considering biological safety. The experiments were conducted on a laboratory test stand of the UV treatment device with four replicates, using 30 W germicidal and growth-stimulating lamps operating at wavelengths of 253.7 nm and 300 nm, respectively. Different treatment conditions were compared and analyzed based on the distance between the honey bee frame and the UV radiation source, irradiation duration, and lamp power. The results of the comparative analysis of the investigated treatment conditions are presented.

**Keywords:** honey bee, honey bee colony, honey bee frame, honey bee larva, sealed brood, ultraviolet radiation, irradiation, wavelength, lamp, Varroa mite, infectious disease, laboratory test stand

### O‘ZBEKCHA

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**Annotatsiya.** Maqolada asalari oilalarining sog‘lom rivojlanishini ta’minlashda ramkalarda uchraydigan Varroa kanasi hamda turli infeksion kasalliklar qo‘zg‘atuvchilarining zararli ta’sirini kamaytirish, shuningdek, ochiq lichinkalarning sog‘lom rivojlanishini rag‘batlantirish asalarichilikda muhim amaliy ahamiyatga ega. Shu munosabat bilan asalari ramkalariga ultrabinafsha nur (UBN) bilan ishlov beruvchi maxsus qurilmani ishlab chiqish hamda undan foydalanish samaradorligini oshirish dolzarb masala hisoblanadi. Tadqiqotning maqsadi asalari ramkalariga ultrabinafsha nur bilan ishlov beruvchi qurilmaning laboratoriya nusxasida eksperimental tadqiqotlar o‘tkazish, UBNning Varroa kanasi va infeksion kasalliklar qo‘zg‘atuvchilariga zararsizlantiruvchi ta’sirini hamda asalari lichinkalarining rivojlanishiga ta’sirini baholash, shuningdek, biologik xavfsizlikni hisobga olgan holda nurlantirishning eng ratsional rejimlarini aniqlashdan iborat. Tajribalar UBN qurilmasining laboratoriya stendida to‘rt qaytariliqda, to‘lqin uzunliklari 253,7 nm va 300 nm bo‘lgan 30 Vt quvvatli bakteritsid hamda

**How to cite / Iqtibos keltirish / Как цитировать:** USMONOV, I. I., IBROXIMOV, V. I., ABDURAXIMOV, B. B. (2026). Experimental results of ultraviolet treatment of honey bee frames. Research Focus International Scientific Journal, 5(10), 25–31. https://doi.org/10.66073/researchfocus.v5i10.1002

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**HAC / OAK:** On the HAC list of national scientific publications (Academy of Sciences of the Republic of Uzbekistan) for 06.00.00 Agricultural Sciences and 16.00.00 Veterinary Sciences.
O‘zbekiston Respublikasi FA huzuridagi OAK ro‘yxatida: 06.00.00 – Qishloq xo‘jaligi fanlari; 16.00.00 – Veterinariya fanlari.

avjlantiruvchi lampalarda o‘tkazildi. Asalari ramkasi va nurlatgich orasidagi masofa hamda ishlov berish vaqti hamda lampalar quvvati bo‘yicha turli rejimlar o‘zaro solishtirilib, tahlillar natijalari keltirilgan.

**Kalit so‘zlar:** Asalari, asalari oilasi, asalari ramkasi, asalari lichinkasi, yopilgan lichinkalar, ultrabinafsha nur, nurlash, to‘lqin uzunligi, lampa, varroa kanasi, infeksion kasallik, stend

## РУССКИЙ

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**Аннотация.** В статье рассматриваются вопросы снижения негативного воздействия клеща Varroa и возбудителей различных инфекционных заболеваний, встречающихся в пчелиных рамках, а также стимулирования здорового развития открытого расплода, что имеет важное практическое значение для обеспечения полноценного развития пчелиных семей. В связи с этим разработка специального устройства для обработки пчелиных рамок ультрафиолетовым излучением (УФИ) и повышение эффективности его применения являются актуальными задачами. Целью исследования является проведение экспериментальных исследований на лабораторном образце устройства для ультрафиолетовой обработки пчелиных рамок, оценка обеззараживающего воздействия УФИ на клещей Varroa и возбудителей инфекционных заболеваний, а также его влияния на развитие пчелиных личинок и определение наиболее рациональных режимов облучения с учётом биологической безопасности. Эксперименты проводились на лабораторном стенде устройства УФИ в четырёх повторностях с использованием бактерицидных и стимулирующих ламп мощностью 30 Вт с длинами волн 253,7 и 300 нм. Были сопоставлены различные режимы обработки в зависимости от расстояния между пчелиной рамкой и источником излучения, продолжительности облучения и мощности ламп. Представлены результаты сравнительного анализа исследованных режимов.

**Ключевые слова:** пчела, пчелиная семья, пчелиная рамка, пчелиная личинка, печатный расплод, ультрафиолетовое излучение, облучение, длина волны, лампа, клещ Varroa, инфекционное заболевание, лабораторный стенд

## 1. INTRODUCTION

Improving the economic efficiency of the beekeeping industry, producing high-quality and environmentally safe honey products, and maintaining the stable productivity of honey bee colonies are among the important priorities in Uzbekistan. The productivity of a honey bee colony largely depends on its strength, brood-rearing activity, and healthy development throughout the season. However, Varroa mites, bacterial, fungal, and other infectious diseases affecting honey bee colonies can slow their natural development, cause larval mortality, reduce the number of worker bees, and ultimately decrease colony productivity [1].

In beekeeping practice, various chemical preparations and antibiotics are used to control diseases and pests. Regular or excessive application of these substances may result in the accumulation of chemical residues in honey, beeswax, and other bee products. Furthermore, the development of resistance to antimicrobial agents in certain pathogens and resistance to specific chemical treatments in Varroa mites may limit the long-term effectiveness of chemical control measures. Therefore, investigating alternative physical and electrotechnological treatment methods that contribute to reducing chemical use and ensuring the sanitary and environmental quality of beekeeping products is of considerable scientific and practical importance under the conditions of Uzbekistan [1-3].

One potential approach to addressing this problem is the application of ultraviolet (UV) irradiation as an electrotechnological treatment method for honey bee frames. Certain spectral ranges of UV radiation can affect the biological structures of microorganisms, making it possible to reduce microbial contamination on frame surfaces. At the same time, the appropriate selection of irradiation wavelength, intensity, exposure duration, and the distance between the radiation source and the frame is particularly important. Determining the optimal values of these parameters may improve treatment effectiveness against infectious agents on honey bee frames while also ensuring biological safety when living honey bee larvae are exposed to UV radiation and allowing the assessment of their healthy development indicators [4].

At present, the comprehensive scientific justification of rational technological parameters for UV treatment of honey bee frames remains insufficiently investigated. In particular, the complex geometry of honey bee frames, the depth of wax cells, the distance from the radiation source, and the angle of incidence influence the uniform distribution of UV radiation across the frame surface. Consequently, some areas of the frame may receive an insufficient radiation dose, whereas other areas may be exposed to excessive doses that could adversely affect biological organisms. This highlights the need for scientific justification of the structural and energy-related parameters of an electrotechnological device based on UV irradiation.

Therefore, experimentally evaluating the effects of UV radiation against Varroa mites and bacterial, fungal, and other infectious agents associated with honey bee frames, determining biologically safe treatment limits for frames containing living larvae, and investigating the effects of irradiation on healthy larval development are important scientific objectives. To achieve these goals, it is necessary to develop an electrotechnological device capable of controlling the radiation intensity, exposure duration, distance between the radiation source and the frame, spectral composition, and UV dose delivered to the frame surface.

Taking these considerations into account, 12 honey bee colonies of comparable strength were selected, and laboratory experiments involving UV irradiation were conducted with four replicates.

## 2. METHODS

Experimental investigations of UV irradiation of honey bee frames were carried out using a specially developed irradiation test stand. The experiments were conducted with four replicates [7–11].

## 3. RESULTS

As a result of scientific research conducted in recent years, a UV irradiation test stand was developed for the treatment of honey bee frames. Analysis of the experimental results showed that the experiments were performed at irradiation distances of 10, 20, and 30 cm, with exposure durations of 11, 22, and 33 seconds, using germicidal and UV lamps operating at wavelengths of 253.7 nm and 300 nm, with a total rated power of 180 W. The highest development rate of 95.2% was achieved at a distance of 20 cm between the radiation source and the honey bee frame, with an exposure duration of 22 seconds, using 120 W of lamps operating at a wavelength of 253.7 nm and 60 W of lamps operating at a wavelength of 300 nm (Table 2). Compared with the other UV irradiation parameters and treatment conditions, this combination produced the most favorable results.

The experimental investigations were carried out under 12 different treatment conditions corresponding to the power settings of the UV radiation sources. The results obtained are presented in Tables 1, 2, 3, and 4.For each experimental treatment, the developmental status of honey bee larvae and the subsequent amount of sealed brood were determined using the Pukhta method, and the changes were evaluated relative to the control group. In addition, the occurrence of Varroa and Tropilaelaps mites, foulbrood diseases, wax moth infestations, and other pathological conditions was monitored in the irradiated honey bee frames. Disease incidence was recorded based on the number of cases identified during the experiment rather than as percentage values. The main variable parameters in the electrotechnological treatment of honey bee frames using UV irradiation were the total rated power of the lamps (P), the installation height of the radiation source relative to the frame (h), and the irradiation duration (t).The experiments were conducted at the apiary belonging to the Hotamtoy Shifobaxsh Asal farm.

Figure 1 shows disease-related symptoms observed in a honey bee frame.

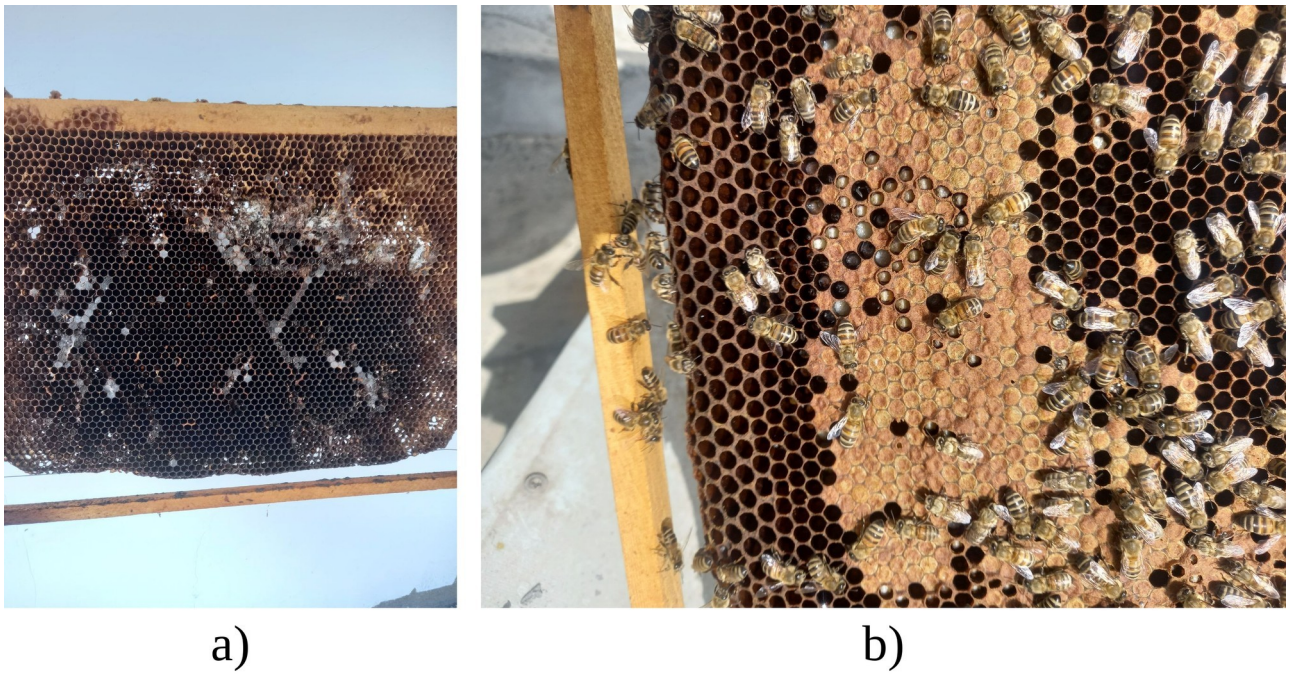



**Fig. 1.** Honey bee frame: (a) a honey bee frame damaged by the wax moth larva; (b) the appearance of diseased larvae in the honey bee frame

Based on the conducted observations and examinations, it was noted that during the long-term use of honey bee frames, various pathogenic microorganisms and parasitic pests may occur on the frame surface and within the wax comb cells. The disease-causing agents and pests that may be found in honey bee frames taxonomically belong to *Paenibacillus larvae* (American foulbrood), *Melissococcus plutonius* (European foulbrood), *Ascosphaera apis* (chalkbrood), *Varroa destructor* (Varroa mite), and *Galleria mellonella* (greater wax moth). In particular, Figure 1a shows a honey bee frame damaged by *Galleria mellonella*, while Figure 1b illustrates honey bee larvae showing disease symptoms and developmental abnormalities. These diseases and pests may negatively affect the physiological condition of honey bee colonies, leading to a reduction in brood area, impaired larval development, and weakening of the colony.

Figure 2 shows the laboratory test stand and the process of irradiating a honey bee frame.




**Fig. 2.** Ultraviolet irradiation test stand for a honey bee frame: (a) front view; (b) internal view

Upon completion of the UV irradiation process, the experimental honey bee frames were placed back into their respective colonies (Figure 3), and their subsequent condition was monitored regularly.




**Fig. 3.** Placement of honey bee frames into the beehive

During the observation period, the incidence of diseases in honey bee colonies, the level of larval development in the frames, the areas of open and sealed brood, and changes in the number of capped larvae were evaluated. From the initial days of the experiment, the general condition of the frames and the dynamics of larval development were recorded. During the subsequent observation periods, a reduction in disease symptoms, healthy larval development, and changes in the amount of sealed brood were identified. The obtained results were compared with those of the control group, and the effect of ultraviolet irradiation on honey bee colony development and the sanitary condition of the frames was assessed.

Figure 4 illustrates that, as a result of the experimental investigations, the degree of larval infection in the honey bee frames decreased, while the area of capped brood cells increased due to the healthy development of the brood.



**Fig. 4.** Experimental results obtained for honey bee frames

As can be seen from Figure 4, in the honey bee frames treated with ultraviolet irradiation (UV), a reduction was observed in the signs associated with various infectious diseases, including foulbrood diseases caused by *Paenibacillus larvae* and *Melissococcus plutonius*, chalkbrood caused by *Ascosphaera apis*, as well as infestations by the *Varroa destructor* mite and the wax moth *Galleria mellonella*. After the experiments, a decrease in the

symptoms of larval infection was recorded, and an expansion of the capped brood cell area was observed.

**Table 1** presents the results of ultraviolet treatment of honey bee frames, including the assessment of disease incidence, larval development, and sealed brood indicators.

**Table 1**

Sealed brood (%) after UV irradiation at λ = 253.7 nm (total lamp power 120–240 W) by distance $H_{UV}$ (cm) and exposure time t (s)

| λ=253.7 nm, P=120 W | | | λ=253.7 nm, P=180 W | | | λ=253.7 nm, P=240 W | | |
|---|---|---|---|---|---|---|---|---|
| $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) |
| 10 | 11 | 76.4 | 10 | 11 | 75.7 | 10 | 11 | 75.3 |
| | 22 | 78.2 | | 22 | 77.8 | | 22 | 77.1 |
| | 33 | 72.1 | | 33 | 72.5 | | 33 | 71.3 |
| 20 | 11 | 77.3 | 20 | 11 | 76.1 | 20 | 11 | 75.8 |
| | 22 | 80.7 | | 22 | 79.5 | | 22 | 78.2 |
| | 33 | 74.8 | | 33 | 73.8 | | 33 | 74.8 |
| 30 | 11 | 73.5 | 30 | 11 | 72.3 | 30 | 11 | 71.5 |
| | 22 | 76.1 | | 22 | 74.7 | | 22 | 74.2 |
| | 33 | 78.2 | | 33 | 75.7 | | 33 | 76.8 |

Table 1 presents the results of experimental investigations conducted using ultraviolet lamps with a wavelength of 253.7 nm and a total rated power ranging from 120 to 240 W. According to the results, the highest development rate of 80.7% was achieved at a lamp power of 120 W, a distance of 20 cm between the irradiation source and the honey bee frames, and an exposure duration of 22 seconds.

**Table 2**

Sealed brood (%) after combined irradiation at λ = 253.7 nm (60–180 W) and λ = 300 nm (60 W) by distance and exposure time

| λ=253.7 nm, P=60 W λ=300 nm, P=60 W | | | λ=253.7 nm, P=120 W λ=300 nm, P=60 W | | | λ=253.7 nm, P=180 W λ=300 nm, P=60 W | | |
|---|---|---|---|---|---|---|---|---|
| $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) |
| 10 | 11 | 90.2 | 10 | 11 | 91.2 | 10 | 11 | 89.5 |
| | 22 | 91.7 | | 22 | 92.3 | | 22 | 91.5 |
| | 33 | 89.4 | | 33 | 90.5 | | 33 | 88.8 |
| 20 | 11 | 91.7 | 20 | 11 | 92.1 | 20 | 11 | 90.3 |
| | 22 | 93.2 | | 22 | 95.2 | | 22 | 91.2 |
| | 33 | 90.3 | | 33 | 91.1 | | 33 | 89.9 |
| 30 | 11 | 89.5 | 30 | 11 | 90.58 | 30 | 11 | 89.2 |
| | 22 | 91.4 | | 22 | 91.9 | | 22 | 90.9 |
| | 33 | 89.1 | | 33 | 89.5 | | 33 | 89.3 |

Table 2 presents the results of experimental investigations conducted using ultraviolet lamps operating at wavelengths of 253.7 nm, with a total rated power ranging from 60 to 180 W, and 300 nm, with a rated power of 60 W. According to the experimental results, the highest development rate of 95.2% was achieved using four 253.7 nm lamps with a combined power of 120 W and two 300 nm lamps with a combined power of 60 W, providing a total rated power of 180 W, at a distance of 20 cm between the irradiation source and the honey bee frames and an exposure duration of 22 seconds.

**Table 3**

Sealed brood (%) after irradiation at λ = 300 nm (120 W), alone and combined with λ = 253.7 nm (60–120 W), by distance and exposure time

| λ=300 nm, P=120 W | | | λ=253.7 nm, P=60 W λ=300 nm, P=120 W | | | λ=253.7 nm, P=120 W λ=300 nm, P=120 W | | |
|---|---|---|---|---|---|---|---|---|
| $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) |
| 10 | 11 | 87.3 | 10 | 11 | 88.9 | 10 | 11 | 88.2 |
| | 22 | 89.5 | | 22 | 90.5 | | 22 | 87.9 |
| | 33 | 86.4 | | 33 | 87.4 | | 33 | 87.3 |
| 20 | 11 | 83.7 | 20 | 11 | 83.9 | 20 | 11 | 82.1 |
| | 22 | 90.5 | | 22 | 91.3 | | 22 | 90.8 |
| | 33 | 84.5 | | 33 | 85.4 | | 33 | 83.7 |
| 30 | 11 | 81.1 | 30 | 11 | 80.1 | 30 | 11 | 79.5 |
| | 22 | 88.5 | | 22 | 89.2 | | 22 | 88.8 |
| | 33 | 83.2 | | 33 | 82.8 | | 33 | 81.1 |

Table 3 presents the results of experimental investigations conducted using ultraviolet lamps operating at wavelengths of 253.7 nm, with a total rated power ranging from 60 to 120 W, and 300 nm, with a rated power of 120 W. According to the

experimental results, the highest development rate of 91.3% was achieved using two 253.7 nm lamps with a combined power of 60 W and four 300 nm lamps with a combined power of 120 W, providing a total rated power of 180 W, at a distance of 20 cm between the irradiation source and the experimental samples and an exposure duration of 22 seconds.

**Table 4**

Sealed brood (%) after UV irradiation at λ = 300 nm (total lamp power 120–240 W) by distance and exposure time

| λ=300 nm, P=120 W | | | λ=300 nm, P=180 W | | | λ=300 nm, P=240 W | | |
|---|---|---|---|---|---|---|---|---|
| $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) | $H_{UV}$ cm | $H_{UV}$ t | Sealed brood (%) |
| 10 | 11 | 75.2 | 10 | 11 | 77.5 | 10 | 11 | 74.9 |
| | 22 | 80.1 | | 22 | 81.1 | | 22 | 79.7 |
| | 33 | 79.2 | | 33 | 79.5 | | 33 | 78.6 |
| 20 | 11 | 72.4 | 20 | 11 | 73.2 | 20 | 11 | 73.4 |
| | 22 | 79.3 | | 22 | 79.5 | | 22 | 79.1 |
| | 33 | 74.7 | | 33 | 75.2 | | 33 | 74.3 |
| 30 | 11 | 74.6 | 30 | 11 | 71.7 | 30 | 11 | 74.2 |
| | 22 | 79.8 | | 22 | 80.8 | | 22 | 79.4 |
| | 33 | 76.1 | | 33 | 77.8 | | 33 | 75.4 |

Table 4 presents the results of experimental investigations conducted using ultraviolet lamps operating at a wavelength of 300 nm, with a total rated power ranging from 120 to 240 W. According to the experimental results, the highest development rate of 81.1% was achieved at a lamp power of 180 W, a distance of 10 cm between the irradiation source and the experimental samples, and an exposure duration of 22 seconds.

## 4. DISCUSSION

The effects of ultraviolet (UV) irradiation on honey bee frames and the larvae within them depend on the irradiation dose, wavelength, and exposure duration. Depending on these parameters, UV radiation may produce positive (growth-stimulating) effects or adverse effects when the exposure exceeds biologically acceptable limits. Ultraviolet radiation at a wavelength of 253.7 nm was applied for its germicidal properties to reduce microbial contamination on frame surfaces under specified exposure conditions, whereas irradiation at a wavelength of 300 nm was used with the aim of stimulating the biological development of honey bee larvae. Accordingly, the combined application of lamps operating at both wavelengths under appropriately selected irradiation conditions may contribute to reducing harmful microbiological factors on honey bee frames while promoting healthy larval development and increasing the amount of sealed brood. In beekeeping practice, controlled ultraviolet treatment of honey bee frames represents a promising electrotechnological approach aimed at reducing the occurrence of Varroa and Tropilaelaps mites and various infectious agents, as well as improving honey bee colony development indicators.

Therefore, the proposed electrotechnological device for ultraviolet treatment of honey bee frames, when operated under rational irradiation conditions, may provide opportunities to reduce the effects of diseases and pests, improve larval development, and support the formation of healthy and strong honey bee colonies.

## 5. CONCLUSION

The experimental investigations demonstrated that electrotechnological treatment of honey bee frames using ultraviolet (UV) irradiation was associated with improved larval development and a reduction in the observed occurrence of diseases and pests. Compared with the control group, frames treated under selected irradiation conditions showed improved larval development and sealed brood formation indicators, along with a decrease in the recorded occurrence of Varroa and Tropilaelaps mites and certain infectious diseases. Ultraviolet treatment of honey bee frames under appropriately selected lamp power, exposure duration, and irradiation source distance represents a promising electrotechnological approach for improving larval development and reducing harmful biological factors associated with honey bee frames.

The experiments included UV lamps operating at a wavelength of 253.7 nm, with total rated power ranging from 60 to 180 W, combined with lamps operating at a wavelength of 300 nm and a total rated power of 60 W. The highest development indicator of 95.2% was obtained using four lamps operating at 253.7 nm with a combined rated power of 120 W and two lamps operating at 300 nm with a combined rated power of 60 W. Under these conditions, the total rated lamp power was 180 W, the distance between the irradiation source and the honey bee frame was 20 cm, and the exposure duration was 22 seconds.

## DECLARATIONS

### Author contributions *CRediT*

Conceptualization; Methodology; Investigation; Data curation; Writing – original draft; Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

### Funding

This research received no external funding.

### Ethics approval

Not applicable. This study did not involve humans, animals or other regulated materials.

### Informed consent

Not applicable.

### Data availability statement

All data supporting the findings of this study are included in the article.

### Conflict of interest

The authors declare no conflict of interest.

### Generative AI disclosure

Not used.

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