

# Co-infestation of Honey Bee Colonies with *Tropilaelaps mercedesae* and *Varroa destructor* in the Republic of Kazakhstan

Ulzhan Nuraliyeva<sup>1</sup>, Gaukhar Moldakhmetova<sup>1</sup>, Oleg Krupskiy<sup>1</sup>, Gulim Khalykova<sup>1</sup>, Merej Torehanov<sup>2</sup>, Anna Bakulina<sup>3</sup>, Ekaterina Bessolitsyna<sup>3</sup>, Maxat Toishimanov<sup>4</sup>, Anna Brandorf<sup>3</sup> and Victoria Soroker<sup>5\*</sup>

<sup>1</sup> Kazakh Research Institute of Livestock and Fodder Production, Almaty, Kazakhstan

<sup>2</sup> Institute of Genetics and Physiology, Almaty, Kazakhstan

<sup>3</sup> Federal Agrarian Research Center of the North-East, Kirov, Russia

<sup>4</sup> Kazakh National Agrarian Research University, Almaty, Kazakhstan

<sup>5</sup> The Volcani Center, Agricultural Research Organization, Rishon LeZion, Israel

\*Corresponding Author: [agripro9642@gmail.com](mailto:agripro9642@gmail.com)

**Abstract:** Beekeeping is a well-developed industry in the Republic of Kazakhstan; however, significant winter colony losses necessitate the annual import of thousands of honey bee package colonies from neighboring southern countries. The recent detection of the invasive mite *Tropilaelaps mercedesae* in several of these source countries poses a serious biosecurity threat to Kazakhstani apiculture. This study aimed to identify potentially infested apiaries across Kazakhstan and to evaluate the efficacy of standard diagnostic methods for the concurrent detection of *Varroa destructor* and *Tropilaelaps mercedesae*. A structured questionnaire survey was conducted across 33 farms in seven regions of Kazakhstan. In apiaries suspected of mite infestation, colonies were assessed using three diagnostic methods: sugar shake of adult bees, alcohol wash of bees, and brood uncapping. Survey results revealed that honey bee packages are purchased annually in approximately half of the surveyed apiaries, which, combined with the practice of migratory beekeeping, indicates a high risk of *Tropilaelaps* introduction. All inspected colonies across the surveyed apiaries were found to be infested with *Varroa destructor*. The presence of *Tropilaelaps mercedesae* was confirmed by molecular analysis (PCR) in honey bee colonies across four regions of Kazakhstan: Almaty, East Kazakhstan, Abai, and Turkestan. These findings highlight the urgent need for strengthened biosecurity measures and routine surveillance protocols for *Tropilaelaps* at points of colony importation to prevent further spread within Kazakhstan.

**Keywords:** *Tropilaelaps mercedesae*, *Varroa destructor*, Honey bee, Mite infestation, Biosecurity, Apiculture, Invasive parasites, Kazakhstan

Received: 27-06-2025 | Revised: 05-09-2025 | Accepted: 20-01-2026 | DOI: 10.3844/ojbsci.2026.26.01.003

## Introduction

Kazakhstan possesses a well-developed beekeeping sector, supported by diverse climatic zones that enable both stationary and migratory apiculture. Recent genetic studies have shown that at least six subspecies of *Apis mellifera* are maintained in Kazakhstan, *A. sossimai*, *carpatica*, *mellifera*, *ligustica*, *caucasica*, and *carnica*, with a notable degree of admixture and genetic heterogeneity, as evidenced by mitochondrial haplotypes (C2, C1, M4) and a wide range of alleles

identified using SSR markers [1]. According to recent national statistics, the country maintains over 200,000 managed bee colonies, with key apicultural regions including East Kazakhstan, Almaty, and Turkestan provinces [2-3]. The dominant subspecies in Kazakhstan are *Apis mellifera carnica* and local hybrids, adapted to the region's continental climate. However, the increasing importation of bee packages and the predominance of nomadic beekeeping practices amplify the risk of transboundary spread of honeybee diseases.

Tropilaelapsosis is a serious disease of honeybees caused by mites of the genus *Tropilaelaps*, which parasitize exclusively the brood within a colony. Four species are recognized within this genus: *T. mercedesae*, *T. clareae*, *T. thaii*, and *T. koeniggerum*, all of which are naturally associated with giant Asian honeybees (*Apis dorsata*, *A. breviligula*, and *A. laboriosa*) in Southeast Asia. The first case of *Tropilaelaps* infestation in *Apis mellifera* L. was reported in the Philippines in 1960. Until recently, it was widely believed that these mites could not persist in *A. mellifera* colonies located in northern and northeastern Asia due to their inability to survive extended broodless periods during winter [4]. However, in 2021, *Tropilaelaps mercedesae* was detected in *A. mellifera* colonies in the Russian Federation [5-6]. Subsequently, the same mite species was identified in Uzbekistan in 2023 [7-8], and in Georgia in 2024 [9].

This article addresses a newly emerging threat to honeybees, Tropilaelapsosis. Given that the Republic of Kazakhstan shares borders with countries where the mite *Tropilaelaps mercedesae* has already been detected, the main objective of this study was to monitor Kazakh apiaries for infestation by *Tropilaelaps* mites.

## Materials and Methods

From March to November 2024, a beekeeper survey was conducted using a Google Forms questionnaire, resulting in 48 responses from various regions across Kazakhstan (Table 1). In addition, field investigations were carried out to assess potential mite infestation in 33 suspected apiaries. These inspections were conducted between June and October 2024 in diverse agro-climatic zones across seven regions: 3 apiaries were located in the steppe zone, 4 in the semi-desert zone, 13 in foothill areas, and 18 in mountainous regions. The monitored regions and apiaries (n) included: Abai (n=2), Almaty (n=10), East Kazakhstan (n=1), Zhambyl (n=5), Zhetysu (n=7), West Kazakhstan (n=2), and Turkestan (n=7).

## Data Collection

To evaluate the level of infestation by parasitic mites and determine the most effective diagnostic method, detailed assessments were performed in apiaries where tropilaelapsosis was detected, located in four regions: Abai (n=2), East Kazakhstan (n=1), Almaty (n=1), and Turkestan (n=1). Three techniques targeting both *Varroa destructor* and *Tropilaelaps* spp. were applied according to [10]:

1. **Alcohol wash method** - At least 60-120 live worker bees, collected from brood frames and outer food frames, were placed in a pre-weighed container filled with 95% ethanol, and mites were dislodged for counting.
2. **Sugar shake method** - At least 60-120 live worker bees, collected from brood frames and outer food frames, were weighed and placed in a container with powdered sugar to dislodge mites for detection, allowing the bees to survive.
3. **Brood examination** - Approximately 100 sealed brood cells at the pupal stage were excised, chilled at +4-6 °C for 2-3 hours, then uncapped and examined under a microscope to count mites at all developmental stages.

A comparative analysis of mites' diagnostic methods was conducted on five honey bee colonies, with three replicates for each colony for each method. All diagnostic techniques were applied simultaneously. During the infestation assessment both *Tropilaelaps* and *Varroa* numbers were recorded and calculated as percent infestation of 100 bees/pupae. In the Abay region, the *Tropilaelaps* mites were collected into 96% ethanol for subsequent DNA analysis.

**Table 1: Questions and possible answers in "GooglForm-2024"**

Question	Answer Options
Location of the apiary	Region, locality
Number of bee colonies in your possession	Number
Type of your apiary	Migratory, stationary
Bee breed	<i>A.m.mellifera</i> , <i>A.m.carpatica</i> , <i>A.m.caucasica</i> , <i>A.m. carnica</i> , <i>A.m.sossimai</i> , Buckfast bee, Other
Do you purchase bee packages? If yes, indicate the country of origin	Yes / No
Are there other apiaries located near yours? How many?	Yes / No
Are migratory apiaries located near yours?	Yes / No
Have you observed <i>Tropilaelaps</i> infestation in your apiary?	Yes / No
Which active substances do you use to treat mites (acaroses)?	Formic acid / Oxalic acid / Amitraz / Flumethrin / Fluvinate / Other
What percentage of colonies died during the 2023-2024 wintering period?	Specify the percentage (e.g., 10%)

DNA isolation from *Tropilaelaps* spp. was carried out using the Tissue Strong kit (Sesana, Russia), as well as a guanidine isothiocyanate-based method PCR was performed using primers TCF1 and TCR2 specific to the mitochondrial cytochrome oxidase (CO-I) *Tropilaelaps* spp. [11]. PCR was performed on a programmable thermostat TP4-PCR-01 "Tertsik" (NPO DNA Technology, Russia). The reaction mixture (10 µl) contained 10 ng of DNA, 200 µm dNTPs, 10 pM of each primer, 1.5 mM MgCl<sub>2</sub> 1 x PCR buffer, 3.75 units. Taq polymerases (SibEnzaim, Russia). PCR mode: 1 cycle - 95 ° C 5 min; 35 cycles - 95 ° C 30 sec, 58 ° C 30 sec, 72 ° C 1 min 30 sec; 1 cycle - 72 ° C 10 min. The PCR products were separated by vertical electrophoresis in 6.0% polyacrylamide gel. The resulting amplicons were sequenced using the MegaBACE 1000 DNA Analysis System. Two DNA samples isolated from 10 individuals each were used for sequencing. The similarity of the obtained sequences with the available sequences in Genbank was evaluated using the BLAST service on the National Center of Biotechnology Information portal (ncbi.nih.gov). For identification of *Tropilaelaps* spp., the primers TCF1 (5'-CTATCCTCAATTATTGAAATAGGAAC-3') and TCR2 (5'-TAGCGGCTGTGAAATAGGCTCG-3'), developed by Anderson et al. [11], were employed.

## Data Analysis

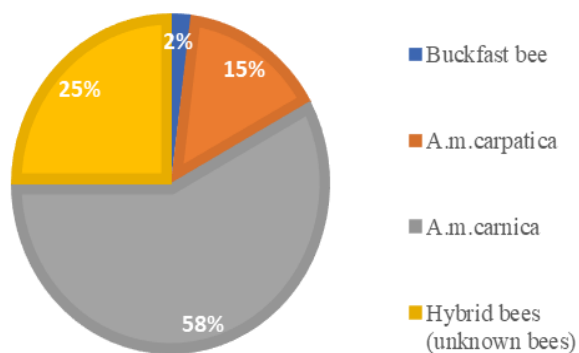
Statistical analysis on the mite infestation was performed using JMP 17.0. We used Anova on proportions following angular transformation in the model replicates nested within the colony while methods were addressed as repeated measures within a colony. Anova was followed by a -posteriori test: LSMeans Student T-test. Pierson correlation test was used to assess correlation between brood infestation by the two mite species.

## Results

### Results of the Beekeepers` Survey

To assess the condition of honeybee colonies and the presence of *Tropilaelaps* infestation, a questionnaire was developed and distributed using the Google Forms platform. The main questions are presented in Table 1.

A total of 48 responses were received from beekeepers. According to the survey results, most apiaries (80%) in Kazakhstan are migratory. Among those, 51% were fully migratory and 29% were mixed (both migratory and stationary).



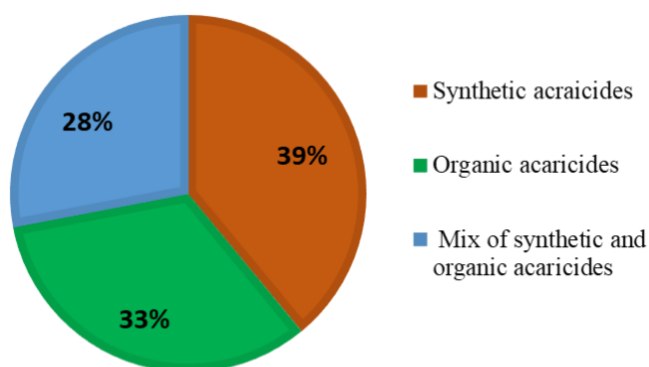
**Fig. 1: Relative representation of honeybee subspecies among the surveyed beekeepers (n = 48). The data are the percentage of surveyed beekeepers**

The most common honeybee subspecies in the surveyed apiaries was *Apis mellifera carnica* (Pollmann) (Figure 1). Approximately one-quarter of beekeepers reported managing colonies of unknown origin or hybrids. Fifteen percent of respondents kept *Apis mellifera carpatica* colonies, while the least common among Kazakhstani apiaries were bees of the Buckfast hybrid line (2%).

Colony losses during the 2023-2024 winter period varied greatly among apiaries, ranging from 10% to 100%. However, 50% of respondents reported losses of around 10%, and only one beekeeper lost all his colonies. About a third of beekeepers (29%) indicated that they purchased bees' packages, and among the latter, winter losses ranged between 10% and 30%.

When asked about the presence of *Tropilaelaps* mites, only 10% of respondents answered positively. All of these beekeepers practiced migratory beekeeping, and more than half of them purchased packaged bees from abroad.

To prevent and treat mite infestations, some beekeepers reported using either organic or synthetic acaricides while about third used both (Fig. 2).



**Fig. 2: Use of different acaricides among surveyed beekeepers/. The data are percent of surveyed beekeepers (n = 48), based in 2024**

Only one-third of respondents (33%) rely entirely on synthetic acaricides to treat honeybee colonies. For the control of acarioses, including *Tropilaelaps*osis, most respondents preferred synthetic treatments, with amitraz-based products being the most used. The remaining beekeepers applied a combination of organic and organic acaricides

### Honeybee Colony Monitoring for Mite Infestation

To assess the spread of *Tropilaelaps*osis, monitoring was conducted at 33 beekeeping operations, the presence of *Tropilaelaps* was tested by uncapping of 100 brood cells. Among the evaluated operations 15 (45%) were stationary. These apiaries were primarily focused on honey production and breeding. The average winter colony loss across all 33 operations

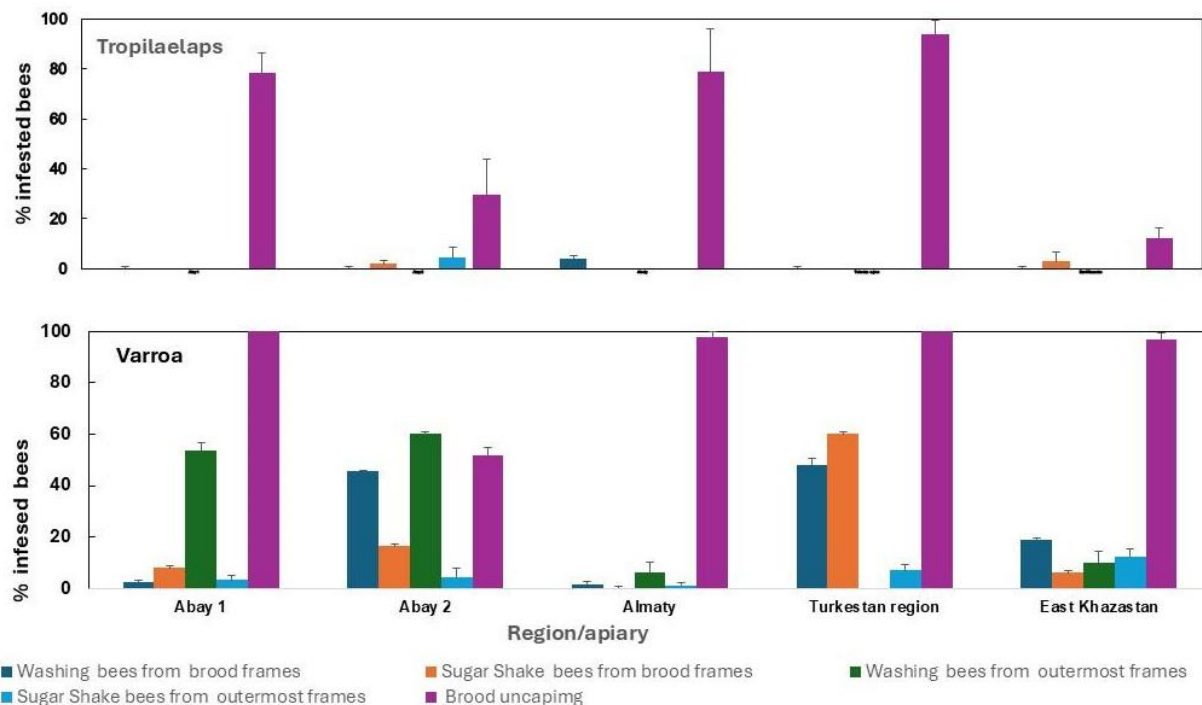
was  $17.8\% \pm 14.12\%$ , with a maximum recorded loss of 60%. In 39% of the surveyed operations, colony mortality exceeded 20%, which represents a substantial reduction in honey bee populations during the winter period in Kazakhstan.



**Fig. 3: Epizootic monitoring map of regions in Kazakhstan (2024); regions where *Tropilaelapsosis* was detected are highlighted in red**

*Tropilaelapsosis* was detected in apiaries located in four regions of Kazakhstan: Turkestan, East Kazakhstan, Abai, and Almaty. Based on direct monitoring of the 33 apiaries, *Tropilaelapsosis* was confirmed in 9 operations, accounting for 27.2%. In contrast, *Varroa destructor* infestation was found in all the colonies surveyed. Among the apiaries affected by *Tropilaelapsosis*, over half of the beekeepers (54%) reported purchasing bee packages annually.

Assessment of infestation in five honey bee colonies across regions of Kazakhstan indicated significant differences in the level of mite infestation (ANOVA,  $F_{4,10}=5.97$ ,  $p=0.01$ ) as well as significant differences between the apiaries. The most infested colony was found in Turkestan region, while the least infested one was found in East Kazakhstan region. The brood examination is the significantly more sensitive diagnostic tool among those implemented for detecting both mite species (*Varroa destructor* and *Tropilaelaps mercedesae*) (Fig. 4) (Anova,  $F_{4,90} = 408.8$ ,  $p<0.0001$ ).



**Fig. 4: Assessment of mite' infestation- *Tropilaelaps*' (above) *Varroa* (below) in honeybee colonies at different regions (x-axis) using different diagnostic methods across various regions /colonies; Infestation data are expressed in percentage (average + SD, n = 3)**

According to the alcohol wash method, *Varroa* infestation levels ranged from 1.75% to 60.0%, while the sugar shake method yielded values between 1.25% and 60.0%.

In the case of *Tropilaelaps* diagnostics, although mites were occasionally observed also on the comb surface, infestation levels detected by both the alcohol wash and sugar shake methods were generally below 1%. Thus infestation levels on adult bees were low, typically between 2% and 4%.

The species identification of the mites collected from the infested apiaries was carried out using polymerase chain reaction (PCR). The analysis by the BLAST service of sequences obtained by amplification with TCF1/TCR2 primers showed that the most homologous sequences are the sequences of the *Tropilaelaps mercedesae* COI gene from Korea (MW725327), Uzbekistan (PQ455194) and China (EF025432). The level of similarity of the sequences of the COI fragment of the samples from Kazakhstan to the sequences of *T. mercedesae* available in Genbank was 99.6-100%. The sequence with the greatest similarity (identity 100%, cover 100%) is entered into Genbank (Access number PX069940).

## Discussion

*Tropilaelaps* infection was confirmed in four regions of Kazakhstan. It is important to note that all the infected regions border with countries where *Tropilaelaps mercedesae* has been recently officially reported: Uzbekistan [8] and the People's Republic of China [12]. According to DNA analysis the mites collected in honey bee colonies in the Abay region of Kazakhstan belong to the species *Tropilaelaps mercedesae*. Although we had not identified the mites molecularly from other regions, based on their morphological features we believe that *Tropilaelaps* detected in other areas also belong to the latter species. This finding clearly indicates that this invasive species continues its spread towards the northern areas of the region. The fact that all infected apiaries were regularly purchasing bee packages further supports the assumption that the source of the *Tropilaelaps* is "external" presumably from the neighboring countries. The fact that colony infestations by *Tropilaelaps* in Kazakhstan were most observed in August-September, suggests that mites were imported from abroad that year and did not overwinter locally. Similarly, the highest incidence of *Tropilaelaps* infestation in honey bee colonies in Russia, was also observed in August-October 2023. According to Brandorf et al. [6], brood infestation in bee colonies increases by September to  $75 \pm 5.7\%$ , with mites actively moving on the combs.

The significance of finding *Tropilaelaps* in Kazakhstan for the local apiculture as it is not yet clear if it is able to establish in this country or at least in those areas where the honey bees experience cold winters with broodless periods. The length of the broodless period is known to vary between the honey bees subspecies and is well known as an important factor in suppressing the population growth of both *Varroa* and *Tropilaelaps* mites.

Most beekeepers in the surveyed operations maintained *Apis mellifera carpatica* and *A. m. carnica*. Only one operation reported keeping *Apis mellifera sossimai*. According to the surveyed beekeepers, the brood less period in their apiaries typically lasts 2-3 months. This relatively short period contributes to high *Varroa* infestation; however, it is yet unclear if *Tropilaelaps* can survive even this relatively short brood break. Therefore, it is recommended that beekeepers conduct regular monitoring of mite infestation levels, especially in preparation for overwintering and during early spring colony buildup, to prevent population growth of both *Varroa* and *Tropilaelaps* as well as following acaricidal treatment. The 100 percent brood infestation by *Varroa* detected in four out of five inspected colonies call for attention and may suggest low efficacy of acaricidal treatment due to application problems or mite resistance as has been recently reported in different countries worldwide [13].

In the selection of monitoring methods, the time and labor costs play an important role often compromising efficacy. Bee washing by ethanol and soapy water and sugar shaking are considered standard methods for *Varroa* monitoring [14]. These methods are obviously much faster and easier under field conditions than brood inspection by uncapping 100 individual cells. However, among the methods tested in this study, the brood inspection method proved to be the most sensitive for diagnosing both *Tropilaelaps* and *Varroa*. This is not surprising as both reproduce within the capped brood cells. Bee washing and shaking were especially not effective for *Tropilaelaps* detection of *Tropilaelaps* on adult bees even on those collected brood frames, even many of the inspected brood cells were infected support earlier findings by Woyke [4], who reported that while mite infestation of adult bees ranged from 0.5% to 6.7%, brood infestation could range from 2% to 54%. Moreover, these findings fit well with the documented biology of the mite, which does not feed on adult bees and have a very short phoretic phase.

Unlike the case with the *Tropilaelaps*, both washing and shaking were still able to detect *Varroa*. This is not surprising as unlike the *Tropilaelaps*, the *Varroa* mite can feed on adult bees and can spend extensive periods of time on the latter [15]. The low sensitivity could be a result of a relatively small number of bees (60-120) tested in our experiment relative to 200-300 honey bees commonly tested by these methods [16]. So, since these methods are fast and somewhat indicative for *Varroa* infestation they can be useful for field comparative studies. However, if high precision monitoring of infestation by both *Varroa* and *Tropilaelaps* is required, the brood uncapping clearly has an advantage.

It is important to note, that all five *Tropilaelaps* infected colonies were also infested with *Varroa* and during the diagnostic examinations of capped brood cells, some (12%) of brood cells were found to be simultaneously infested with both *Varroa destructor* and *Tropilaelaps mercedesae*, with varying ratios between the two mite species. This rate of natural co-infestation was much higher than the one reported previously by Buawangpong et al. [17]. The low negative correlation between the individuals of the two species found in our study suggests some degree of competition between *Varroa* and *Tropilaelaps* mites. In fact, Buawangpong et al. [17] noted potential competitive advantages of *Tropilaelaps* due to its shorter phoretic stage and faster reproductive cycle. Still, when both mite species occupied the same brood cell, they were observed to reproduce concurrently leading to high damages to the honey bee colonies. Further controlled infestation studies will be needed to understand the interaction between these two parasitic mites that just “recently met” on their evolutionary “new” common host.

## Conclusion

*Tropilaelaps mercedesae* has been detected in apiaries in four regions of Kazakhstan, indicating that this invasive mite spread north posing a significant threat to the country’s beekeeping sector. Given the predominantly migratory nature of beekeeping in Kazakhstan and the widespread practice of purchasing bee packages, the risk of further spread of *Tropilaelaps* is high. Intensive monitoring mainly based on brood inspection is required in order ensure timely prevention and treatment of these parasitic mites. Moreover, the high level of *Varroa* infestation recorded across all surveyed apiaries indicates that the current management practices against this pest are not efficient and needs to be revisited.

Co-infestation of honey bee colonies with both *Varroa destructor* and *Tropilaelaps mercedesae* is common but direct competition between these mite species seems to be weak.

## Acknowledgment

We wish to thank the beekeepers participating in a survey and those that enabled us to conduct experiments in their apiaries. Without their collaboration this research would be impossible.

## Funding Information

This work was largely supported by the Ministry of Science and Higher Education of the Republic of Kazakhstan [grant number AP23490810]: The molecular analysis was supported by the RSF grant: <https://rscf.ru/en/project/25-26-00169>.

## Author’s Contributions

Ulzhan Nuraliyeva: Conceptualization, Project administration, Field survey coordination, Funding acquisition, Writing - original draft.

Gaukhar Moldakhmetova: Methodology, Formal analysis, Data curation, reviewing the manuscript

Oleg Krupskiy: Field investigation, Data collection.

Gulim Khalykova: Field investigation, Data collection, and analysis. Reviewing the manuscript

Merej Torehanov: Laboratory diagnostics, Sample preparation.

Victoria Soroker: Supervision, Validation of diagnostic protocols, Writing - review & editing.

Anna Brandorf: Molecular analysis, Supervision of mites monitoring, Writing - review & editing.

Anna Bakulina: Phylogenetic analysis, DNA sequencing.

Ekaterina Bessolitsyna: Lab supervision, Molecular analysis, Data interpretation.

Maxat Toishimanov: Statistical analysis, Final manuscript preparation.

## Ethics

All procedures involving honeybee colonies were conducted in accordance with national guidelines and best practices for the welfare and health of managed bee populations. No harmful or invasive procedures were used beyond standard beekeeping diagnostics. Informed consent was obtained from all participating beekeepers for the collection of survey data and field monitoring.

## References

1. Gritsenko, D., Temirbayeva, K., Taskuzhina, A., Kostyukova, V., Pozharskiy, A., Kolchenko, M., Khusnitdinova, M., Krupskiy, O., Mayer, A., Nuraliyeva, U. and Moldakhmetova, G., 2023. First evaluation of genetic diversity among honeybee populations in Kazakhstan. *Apidologie*, 54(6), p.61. <https://doi.org/10.1007/s13592-023-01034-8>.
2. Nuraliyeva, U. A., Spatay, N. N., Davletova, A. M., Toishimanov, M. R., Moldakhmetova, G. A., Kussainova, Z. A., Khudaiberdiev, A. A., Khrapova, S. N. & Baimukanov, D. A. (2023). The Impact of Environment on the Morphometric Characteristics of Honeybees *Apis mellifera carnica* in South-East Kazakhstan. *Journal of Biological Sciences*, 23(4), 520-527. <https://doi.org/10.3844/ojbsci.2023.520.527>.
3. Moldakhmetova, G., Kurmanov, R., Toishimanov, M., Tajiyev, K., Nuraliyeva, U., Sheralieva, Z., Temirbayeva, K. and Suleimenova, Z., 2023. Palynological, physicochemical, and organoleptic analysis of honey from different climate zones of Kazakhstan. *Caspian Journal of Environmental Sciences*, 21(3), pp.543-553.
4. Woyke, J. (1984). Survival and prophylactic control of *Tropilaelaps clareae* infesting *Apis mellifera* colonies in Afghanistan. *Apidologie*, 15(4), 421-434.
5. Brandorf, A. Z., & Sokhlikov, A. B. (2023). *Tropilaelaps* in bees: A new threat to Russian beekeeping. *Veterinary Sanitation, Hygiene and Ecology*, (2), 217-226. <https://doi.org/10.36871/vet.san.hyg.ecol.202302014>.
6. Brandorf, A. Z., Ivoilova, M. M., Yañez, O., Neumann, P., & Soroker, V. (2024). First report of established mite populations, *Tropilaelaps mercedesae*, in Europe. *Journal of Apicultural Research*.
7. Joharchi, O., & Stolbova, V. V. (2024). The first report on the ectoparasitic genus *Tropilaelaps* Delfinado & Baker (Acari: Mesostigmata: Laelapidae) in Russia. *Persian Journal of Acarology*, 13(3), 513-516. <https://www.biotaxa.org/pja/article/view/85545>.
8. Mohamadzade Namin, S., Joharchi, O., Aryal, S., Thapa, R., Kwon, S.-H., Kakhramanov, B. A., & Jung, C. (2024). Exploring genetic variation and phylogenetic patterns of *Tropilaelaps mercedesae* (Mesostigmata: Laelapidae) populations in Asia. *Frontiers in Ecology and Evolution*, 12, 1275995. <https://doi.org/10.3389/fevo.2024.1275995>.
9. Janashia, I., Uzunov, A., Chen, C., Costa, C., & Cilia, G. (2024). First report on *Tropilaelaps mercedesae* presence in Georgia: The mite is heading westward!. *Journal of Apicultural Science*, 68(2), 183-188. <https://doi.org/10.2478/JAS-2024-0010>.
10. Anderson D.L. & Roberts J.M.K. (2013). Standard methods for *Tropilaelaps* mites research. In: The COLOSS BEEBOOK, Volume II: Standard methods for *Apis mellifera* pest and pathogen research, Dietemann V., Ellis J.D., Neumann P., eds. *J. Apicultural Res.*, 52 (4), <http://dx.doi.org/10.3896/IBRA.1.52.4.21>.
11. Anderson, D. L., & Morgan, M. J. (2007). Genetic and morphological variation of bee-parasitic *Tropilaelaps* mites (Acari: Laelapidae): New and re-defined species. *Experimental and Applied Acarology*, 43(1), 1-24. <https://doi.org/10.1007/s10493-007-9103-0>.
12. Luo, Q. H., Zhou, T., Wang, Q., Zhang, Z., Liu, F., & Li, M. (2011). Identification of *Tropilaelaps* mites (Acari: Laelapidae) infesting *Apis mellifera* in China. *Apidologie*, 42(4), 485-498. <https://doi.org/10.1007/s13592-011-0028-6>.
13. Lester, P. J. (2023). Integrated resistance management for acaricide use on *Varroa destructor*. *Frontiers in Bee Science*, 1: 1297326. <https://doi.org/10.3389/frbee.2023.1297326>
14. Dieteman, V. Nazzi, F., Martin, S. J., Anderson, D. L Locke, B., Delaplane, K. S Wauquiez, Q., Tannahill, C., Frey, E., Ziegelmann, B. Rosenkranz P. & Ellis J. D. (2013) Standard m D. Ellis, and Peter Neumann, editors. *The COLOSS BEEBOOK, Volume II: Standard Methods for Apis mellifera Pest and Pathogen Research*. International Bee Research Association.
15. Jeyapriya, G., Sumathi, E., Saminathan, V.R. et al. Parasitic Mites of Honey Bees (*Apis* Spp.): A Detailed Review of *Varroa destructor* in Parasitism, Pathogen Transmission and its Management. *Acta Parasit.* 70, 184 (2025). <https://doi.org/10.1007/s11686-025-01124-w>.
16. Bava, R.; Castagna, F.; Carresi, C.; Cardamone, A.; Federico, G.; Roncada, P.; Palma, E.; Musella, V.; Britti, D. Comparison of Two Diagnostic Techniques for the *Apis mellifera* Varroaosis: Strengths, Weaknesses and Impact on the Honeybee Health. *Vet. Sci.* 2022, 9, 354. <https://doi.org/10.3390/vetsci9070354>
17. Buawangpong, N., de Guzman, L. I., Khongphinitbunjong, K., & Rinderer, T. E. (2015). Prevalence and reproduction of *Tropilaelaps mercedesae* and *Varroa destructor* in concurrently infested *Apis mellifera* colonies. *Apidologie*, 46(6), 779-786.