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Comparison of Wintering Performance of Honey Bee (Apis mellifera L.) Colonies in Traditional and Mobile Systems in Niğde Province

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Abstract

With a mobile beekeeping system, it is possible to plan operations based on the flowering periods of nectar-producing plants and to utilize foraging areas that maximize the benefits derived from nectar and pollen sources. Recently developed innovative equipment and precision apiculture practices have helped mobile systems evolve from mere means of transport into integrated production platforms. However, for these innovative mobile beekeeping practices to be considered a viable model, they must be applicable not only to the production of bee products but also to other critical periods—such as overwintering—which serve as essential links in a chain. In this study, a total of 20 honeybee colonies of the Anatolian bee breed (Apis mellifera anatoliaca) were examined under the ecological conditions of Niğde province. The study groups consisted of 10 traditional (fixed) hives and 10 mobile multi-shelf hives. The research evaluated the proportional (%) changes in the number of frames covered with bees before and after overwintering, as well as the rates of colony collapse or queen loss (%). The results demonstrated an equal colony survival rate of 80% for both overwintering methods. Among the colonies that successfully completed the overwintering period, the average loss of frames covered with bees per colony was 1.25 ± 1.16 in the traditional overwintering group and 1.00 ± 1.07 in the mobile overwintering group. Statistical analysis revealed that the difference in population loss between the two methods was not statistically significant ($P = 0.701$). Although colonies in the mobile system entered winter with numerically fewer frames compared to traditional hives (5.00 ± 0.93 and 5.88 ± 1.36, respectively), they performed as successfully as the traditional hives during the overwintering period. In conclusion, the mobile beekeeping system presents no disadvantages compared to the traditional method under the winter conditions of Niğde province.

Keywords: *Apis mellifera L., Mobile beekeeping, Innovation, Precision beekeeping, Wintering performance*

Introduction

Migratory beekeeping is based on seasonal changes in the plant flora across different geographical areas (Official Gazette of the Republic of Türkiye, 2011). However, it also involves challenging factors such as the individual loading and unloading of hives, transportation costs, security concerns, and direct exposure to undesirable external environmental conditions (Küçüktekin and Yelboğa, 2022; Erkan and Aşkın, 2021; Tew, 2002; Yeninar et al., 2010).

In modern beekeeping, the development of innovative equipment and the concept of precision apiculture have enabled mobile systems, which have become increasingly utilized in migratory beekeeping in recent years, to evolve beyond being merely a practical means of transportation. This approach encompasses innovative practices such as the implementation of decision support systems for colony transportation, the remote monitoring of biological needs and environmental parameters of bee colonies, the utilization of alternative energy sources such as solar and wind power, and the transition toward autonomous, data-driven colony management (Zacepins et al., 2015).

Modern mobile beekeeping systems—such as multi-rack trailer systems with hydraulic units and climate-controlled mobile platforms, which increasingly drive development in the sector and are considered the heart of this transformation—are equipped with Internet of Things (IoT)-based sensor technologies that monitor temperature, weight, humidity, and vibration, as well as integrated insulation materials (Şirin & Sevin, 2025; Zacepins et al., 2015).

In addition, through artificial intelligence and machine learning, high-accuracy predictions can be made by analyzing the behavior and health status of bee colonies using audio and image processing techniques. Thanks to sensitive sensors, queen bee and disease detection can be achieved with an accuracy of up to 95–99%, providing early warnings against potential adverse conditions (Şirin & Sevin, 2025; De Simone et al., 2024; Iqbal et al., 2024).

Using systems based on image processing and deep learning, valuable data such as the density around the hive entrance and the proportion of forager bees carrying pollen can be monitored in real time (Şirin & Sevin, 2025; Bilik et al., 2024; Rozenbaum et al., 2024).

For these models to be considered beneficial, they must be integrated into all interconnected phases of beekeeping. Without integration across all phases, the fundamental goals of the innovations used in mobile beekeeping—minimizing resource consumption and maximizing bee health and productivity—cannot be fully achieved. The most critical phase demanding these innovative approaches is overwintering, a period when colonies are highly vulnerable to external environmental stress.

Niğde province, with the typical continental climate characteristics of the Central Anatolia Region and its cold, harsh winters, presents a challenging overwintering environment for bee colonies, thus constituting a suitable model for this research. The aim of this study is to quantitatively determine the survival rates and population changes of honeybee colonies overwintered in traditional fixed hives and in mobile multi-rack systems equipped with innovative features under the ecological conditions of Niğde, and to assess the sustainability of mobile systems under harsh winter conditions.

Materials and Methods

The research was conducted under the ecological conditions of Niğde province. A total of 20 healthy honey bee colonies belonging to the Anatolian honey bee subspecies (*Apis mellifera anatoliaca*) with queens of similar age were utilized in the study. Following the completion of colony equalization procedures (brood area, honey reserves, etc.), the colonies were randomly divided into two equal groups.

The first group consisted of colonies housed in standard wooden Langstroth hives, which were secured on bases in an open area using traditional methods. These hives were directly exposed to external weather conditions (wind, rain, etc.). The second group, on the other hand, consisted of colonies managed in accordance with the concept of mobile beekeeping, utilizing a multi-shelf transport platform where the hives were grouped together. In this system, the colonies were not directly exposed to the open air; instead, the hives were elevated off the ground and arranged side by side.

Prior to overwintering, the number of frames covered with bees in both colony groups was determined, and *Varroa* mite control procedures were conducted and standardized. The average number of frames covered with bees upon entering the overwintering period was recorded as 5.88 ± 1.36 in the traditional group and 5.00 ± 0.93 in the mobile group.

During the early spring maintenance conducted after the overwintering period, the viability of the colonies (specifically, checking for colony collapse or queen loss) was evaluated. Population loss was calculated for the colonies that successfully completed the overwintering phase. A statistical analysis of the difference in population loss between the two methods was performed using an independent samples t-test, with the significance level set at $p < 0.05$.

Results And Discussion

The parameters regarding colony viability and changes in the number of frames covered with bees, obtained from the research conducted under the winter conditions of Niğde province, are presented in Table 1.

Performance Parameter	*Traditional*	*Mobile*	*p*
Colony survival (%)	80.0	80.0	-
Queen loss / colony collapse (%)	20.0	20.0	-
Frames covered with bees before overwintering	5.88 ± 1.36	5.00 ± 0.93	-
Average loss of frames covered with bees	1.25 ± 1.16	1.00 ± 1.07	0.701

According to the research findings, the colony survival rate was calculated at 80% for both overwintering methods. In both groups, two colonies experienced either colony collapse or queen loss during the overwintering period. The fact that the survival rate in the mobile system was identical to that of the traditional system, despite the harsh winter conditions of a continental climate, indicates that mobile hive platforms do not introduce any additional stress factors affecting these aspects of colony physiology.

When examining the colonies that successfully completed the overwintering period without queen loss or colony collapse, the average loss of frames covered with bees per colony was calculated as 1.25 ± 1.16 in the traditional group and 1.00 ± 1.07 in the mobile group. Statistical analysis revealed that the difference in population loss was not statistically significant ($p = .701$).

One of the most striking findings of the study is that, although colonies in the mobile system entered the overwintering period with a lower number of frames covered with bees (5.00 ± 0.93), they completed this phase with a lower average population loss (1.00 frame). This success is attributed to the innovative design features of the mobile systems. Compared to traditional methods, the arrangement of hives in a compact block within multi-rack mobile systems is believed to reduce the total surface area exposed to the external environment, thereby minimizing the direct impact of wind.

It is thought that placing the hives adjacent to each other may have allowed the heat radiated from neighboring hives to create a shared thermal mass. Similarly, in their study modeling heat distribution within winter clusters, Eskov and Toboev (2009) reported that thermal stability slows down the food consumption of honey bees, consequently delaying their physiological aging.

It has been emphasized that thermal mass, which is considered a key factor in minimizing temperature fluctuations, proportionally reduces the rate of colony collapse. Kaya (2007) supports this assumption by reporting that colony collapse is most prevalent during February and March, a period characterized by extreme temperature fluctuations.

Conclusion And Recommendations

Through this study, it was observed that in a region like Niğde, which experiences harsh continental climate conditions, the technologically innovative mobile beekeeping system presents no disadvantages compared to the traditional fixed method in terms of colony survival and the number of frames covered with bees during the overwintering period. On the contrary, the shared thermal mass believed to be facilitated by the mobile systems enabled even those colonies that entered the overwintering period with numerically fewer bees to successfully survive until spring.

Mobile systems, which have emerged from efforts to modernize beekeeping and improve efficiency, present an opportunity to ensure a healthy overwintering period with minimal losses by reducing labor and transportation costs and providing stable temperatures inside the hives. In future studies, the effects of precision apiculture innovations on overwintering physiology can be examined in greater detail through the integration of IoT (Internet of Things)-based temperature and humidity sensors into mobile platforms. Furthermore, conducting similar studies in coastal regions—where temperature fluctuations are more pronounced during the overwintering period—is expected to provide valuable additional insights into the subject.

Conflict of Interest

Please declare conflicts of interest or state “The authors declare no conflict of interest.” Authors must identify and declare any personal circumstances or interests that may be perceived as inappropriately influencing the representation or interpretation of reported research results.

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