



Prevalence of honeybee pathogens in South Korea: A five-year nationwide surveillance (2020-2024)

Juhaeng Heo^{1,4}, Yongrae Kim¹, Dae-Sung Yoo², Doo-Sung Cheon³, Dae-Yong Kim⁴

1. Korea Apicultural Agriculture Cooperative, Seoul, Republic of Korea
2. Department of Veterinary Epidemiology, College of Veterinary Medicine, Chonnam National University, Gwangju, Republic of Korea
3. POSTBIO, Gyeonggi, Republic of Korea
4. Department of Veterinary Pathology, College of Veterinary Medicine, Seoul National University, Seoul, Republic of Korea



Introduction

- Since the winter of 2021, South Korea has experienced increasing honeybee colony losses, often associated with colony collapse disorder (CCD).
- Multiple stressors such as climate variability, pesticides, and floral resource decline contribute to this trend.
- However, the role of pathogens remains under-characterized at the national level.
- Objective: Conduct a 5-year nationwide molecular surveillance of 12 major honeybee pathogens in managed *Apis mellifera* colonies.

Methodology

- **Study period:** 2020–2024
- **Sample size:** 1,825 colonies from 4,953 apiaries
- **Region division:** Northern, Central, Southern
- **Diagnostic method:** qPCR and RT-qPCR for virus, bacteria, fungi
- **Data analysis:** Prevalence by year, season, region; co-infection network

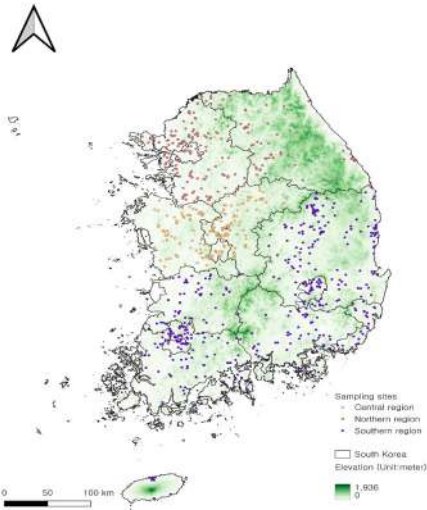


Fig. 1. Sampling sites across South Korea (2020-2024), categorized into northern, central, and southern regions considering mean annual temperature and beekeeping practices. Dot colors indicate regional classification.

Results

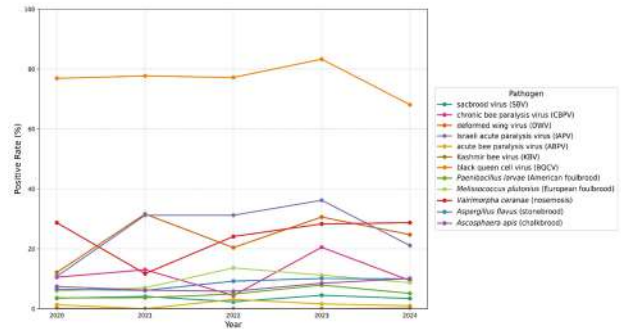


Fig. 2. Annual prevalence of 12 major honeybee pathogens in South Korea (2020–2024). Viral pathogens, particularly BQCV, IAPV, and DWV, showed the highest prevalence, whereas *Vairimorpha ceranae* was the most common fungal pathogen.

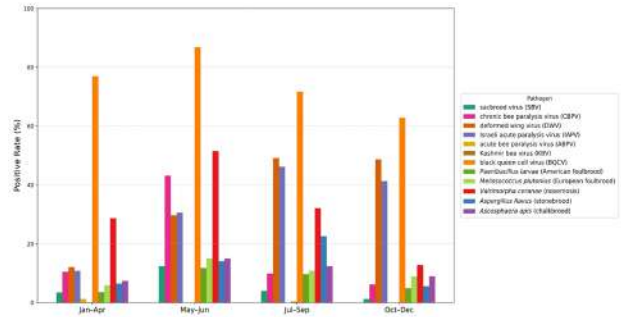


Fig. 3. Seasonal prevalence of 12 honeybee pathogens across four seasonal periods (Jan-Apr, May-Jun, Jul-Sep, Oct-Dec) during 2020–2024. BQCV maintained high prevalence year-round, while DWV, IAPV, and *Vairimorpha ceranae* exhibited marked seasonal variation.

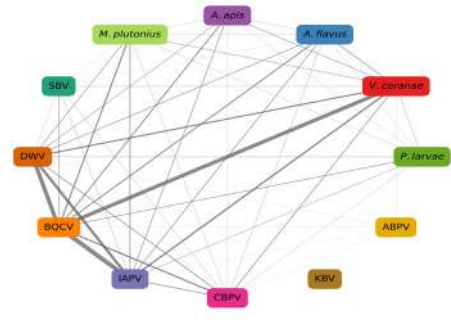


Fig. 4. Co-infection network of 12 honeybee pathogens detected from 1,825 colonies in South Korea (2020–2024). Edge thickness indicates the frequency of co-infection between each pathogen; thicker lines represent higher co-infection rates. BQCV formed the central hub, frequently co-occurring with DWV, IAPV, and *Vairimorpha ceranae*.

Conclusion

- Nationwide surveillance revealed consistently high prevalence of viral pathogens, particularly BQCV, IAPV, and DWV, as the major contributors to colony health deterioration during 2020–2024.
- The fungal pathogen *Vairimorpha ceranae* remained consistently prevalent, especially in spring and summer.
- Seasonal peaks in DWV and IAPV prevalence underscore the need for season-specific diagnostic and control strategies.
- High frequency of co-infections, especially combinations involving BQCV, highlight the importance of multiplex detection and integrated management.
- These results provide a scientific basis for establishing a national honeybee pathogen monitoring and surveillance system in South Korea.

Juhaeng Heo¹, Yongrae Kim¹, Dae-Sung Yoo², Doo-Sung Cheon³, Dae-Yong Kim⁴

¹Korea Apicultural Agriculture Cooperative, Seoul, Republic of Korea

²Department of Veterinary Epidemiology, College of Veterinary Medicine, Chonnam National University, Gwangju, Republic of Korea

³POSTBIO, Gyeonggi, Republic of Korea

⁴Department of Veterinary Pathology, College of Veterinary Medicine, Seoul National University, Seoul, Republic of Korea

Since the winter of 2021, the colony collapse disorder (CCD) phenomenon has caused significant damage to honeybee (*Apis mellifera*) populations in South Korea. The potential causes of CCD include abnormal climate conditions, pesticide use, declining floral resources, and the increasing prevalence of honeybee pathogens. To investigate the role of pathogens in honeybee health, we conducted a nationwide surveillance study over five years (2020–2024). A total of 1,825 honeybee colonies from 4,953 apiaries were extensively sampled across South Korea, and the prevalence of 12 major honeybee pathogens was analyzed using quantitative real-time PCR (qPCR) and reverse-transcription qPCR (RT-qPCR). The results indicate that viral pathogens exhibited the highest prevalence among all honeybee diseases. Black queen cell virus (BQCV) had the highest overall infection rate (68.1%) over the five-year period, and particularly in 2023, it showed an exceptionally high prevalence of 83.3%. Additionally, deformed wing virus (DWV, 24.7%) and Israeli acute paralysis virus (IAPV, 21.1%) were frequently detected, with peak infection rates occurring in the winter season. Among fungal pathogens, *Vairimorpha* (*Nosema*) *ceranae* had the highest prevalence (28.7%) and was most frequently detected in spring and summer. These findings highlight the increasing burden of viral infections on South Korean honeybee colonies, particularly the widespread and persistent occurrence of BQCV. The seasonal variations in DWV, IAPV, and *V.ceranae* suggest the need for targeted, season-specific disease management strategies. This study provides epidemiological data on honeybee pathogens in South Korea, which is expected to contribute to the establishment of long-term surveillance and disease control strategies for honeybee health management.