

mortality, while prolonged time above the economic mite threshold was associated with increased viral infection and mortality.

3.3 Preparation for major nectar flow periods

Preparing colonies for major nectar flows requires aligning spring population growth with upcoming resource availability rather than maximizing short-term harvest too early. Colonies need abundant pollen and nectar in spring to rebuild food stores, support brood production, and increase population, and their ability to exploit these spring resources helps determine later seasonal success. This timing is environmentally sensitive, because brood rearing in early spring is regulated by both temperature and photoperiod, and mismatches between these cues and floral availability could impair colony growth as seasonal patterns shift (Ulgezen et al., 2025). Preparation for nectar flow also depends on avoiding management decisions that weaken brood production before mass flowering. In intensive farmland systems, favoring honey storage over brood production in spring intensified later pollen shortage effects, and colonies managed this way ultimately produced less honey during the sunflower flow and had lower overwinter survival. Accordingly, avoiding or limiting spring honey harvest can improve later productivity, while colonies established with greater early-season brood resources are more capable of producing honey during the main summer nectar flow (Puškadija et al., 2023).

4 Summer Management Strategies Under High Temperature Conditions

4.1 Temperature regulation and hive microclimate control

Summer management under high temperature conditions begins with maintaining a stable hive microclimate, because brood development depends on narrow thermal limits and colonies experience physiological stress when those limits are exceeded. The brood chamber should be kept near 33 °C-35 °C, while temperatures above 38 °C increase metabolic damage risk, making thermoregulation a central management priority during hot weather. At the colony level, honey bees buffer heat through coordinated behavioral mechanisms, including fanning, evaporative cooling, and adjustments in bee density, but these mechanisms require labor and can divert effort from foraging and brood care. Field evidence shows that external hive conditions strongly influence summer performance. In hotter months, shaded colonies outperformed unshaded colonies because unshaded hives experienced elevated temperature stress that reduced foraging activity, pollen collection, colony growth, and honey production, supporting the practical use of summer shading in hot climates (Taha et al., 2026). Extreme heat can also exceed the effective limits of colony thermoregulation: when maximal shaded air temperatures intermittently exceeded 40 °C, greater within-hive temperature fluctuations were associated with declining colony populations, even though average brood temperatures remained near the optimal range (Chen et al., 2025).

High summer temperatures also threaten queen performance, not just worker activity and brood growth. Queen sperm viability appears safe within an approximate 15 °C-38 °C range, and exposure outside that window can contribute to fertility loss associated with queen failure, which makes temperature control during both field management and queen transport important in hot seasons. More broadly, recent heat-stress synthesis indicates that high temperatures inhibit foraging, fecundity, and normal thermoregulation while also increasing susceptibility to disease and parasites, reinforcing the need to pair microclimate control with broader summer colony support. A practical implication is that summer microclimate management should combine site selection, shading, ventilation, and water availability rather than relying on hive placement alone. Honeybee colonies maintain brood temperature through an interlaced set of physiological and behavioral responses across a wide environmental range, but that resilience is graded rather than unlimited, so management that reduces heat load helps preserve colony labor for nectar collection and brood maintenance. This is especially relevant as temperature is a major determinant of colony behavior, physiology, and performance under fluctuating climatic conditions, making summer microclimate regulation a direct route to sustaining productivity (Taha et al., 2026).

4.2 Nutrition supplementation and colony maintenance

Summer nutrition management is most important during nectar and pollen dearth, when high temperatures and forage scarcity jointly suppress brood rearing and colony growth. Reviews of honeybee nutrition emphasize that seasonal scarcity of bee flora reduces brood rearing, honey production, and overall colony development, and that