

GENERAL ARTICLE***Tropilaelaps mercedesae*: An Emerging Global Threat to Honey Bees****Gaurav Vinod Rao Sadafale¹ and Sujal Suhas Munj²**¹Department of Agricultural Entomology, College of Agriculture, Vishweshwaraiah Canal Farm, Mandya, University of Agricultural Sciences, Bangalore, Karnataka-571 405, India²Department of Agricultural Entomology, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka-580 005, India*gauravsadafaleuasb@gmail.com (ORCID - 0009-0006-2648-1158)**Abstract**

The ectoparasitic mite *Tropilaelaps mercedesae* has emerged as a significant global threat to the Western honey bee (*Apis mellifera*), a species critical to global agriculture and food security. First described in association with Asian giant honey bees, this parasite has now adapted successfully to *A. mellifera*, where it feeds on brood, shortens adult bee lifespans, and transmits viral pathogens including Deformed Wing Virus. Unlike *Varroa destructor*, which has dominated global discourse on honey bee health, *T. mercedesae* reproduces faster, remains largely hidden within brood cells, and can disperse via phoresy on adult bees, enhancing its spread potential. New diagnostic tools such as rapid brood decapping have recently been developed to improve detection. The establishment of stable populations in Europe underscores the urgency of coordinated action. This article synthesizes recent advances in knowledge on the biology, spread, impacts, detection, management, and policy implications of *T. mercedesae*, highlighting research gaps and emphasizing the need for global vigilance to prevent a crisis greater than that caused by *V. destructor*.

Keywords: *Tropilaelaps mercedesae*, *Apis mellifera*, honey bee health, brood parasite, emerging pest, diagnostics, biosecurity, pollination services.

Introduction

Honey bees play an essential role in pollinating crops and maintaining biodiversity. As key contributors to global food security, pollinators support agriculture, ecosystem functioning, and sustainable crop production. Among them, the Western honey bee (*Apis mellifera*) is the most economically significant managed pollinator, providing vital pollination services for hundreds of crops worldwide (Klein et al., 2007). However, over recent decades, honey bee populations have experienced substantial declines due to multiple interacting stressors, including habitat fragmentation, pesticide exposure, nutritional

deficiencies, climate change, and numerous pathogens and invertebrate pests (Goulson et al., 2015). Of these threats, parasitic mites remain among the most destructive agents affecting global apiculture.

The mite, *Varroa destructor* is widely regarded as the most devastating ectoparasite of honey bees, having spread from Asia to nearly every beekeeping region worldwide. Its invasion has resulted in severe colony losses, diminished pollination services, and the widespread adoption of expensive and complex management strategies (Rosenkranz et al., 2010). Yet emerging evidence increasingly suggests that *Varroa* may not

remain the most damaging mite threat. Growing scientific concern now centers on *T. mercedesae*, a lesser-known but potentially more aggressive brood parasite capable of surpassing *Varroa* in reproductive capacity and colony-level damage under suitable conditions.

Unlike *Varroa*, which has an extended phoretic period on adult bees, *T. mercedesae* remains almost entirely within brood cells. This brood-focused lifestyle enables exceptionally rapid population growth whenever ample brood is available, making the mite particularly challenging to manage in regions lacking natural brood breaks (Sammataro et al., 2000). Comparative studies have long documented that *Varroa destructor* and *Tropilaelaps* have co-infested *A. mellifera* colonies for about fifty years across Asia (Delfinado, 1963). In regions such as Thailand, Afghanistan, and Vietnam, infestations of *T. clareae* now largely synonymous with *T. mercedesae* were often higher than those of *V. jacobsoni* (now *V. destructor*) (Burgett et al., 1983; Woyke, 1987a, 1989). Seasonal shifts have been observed as well; for example, in the Philippines, colonies with higher *T. clareae* levels in April later showed higher *Varroa* loads by September (Fajardo & Cervancia, 2004). In Northern Thailand, *T. clareae* infestations were similarly dominant in both Thai *A. mellifera* and Russian honey bees (Kavinseksan et al., 2003).

The reproductive dynamics of these mites further shape their competitive interactions. Although both *Tropilaelaps* and *Varroa* produce similar numbers of progeny on average, a significantly higher proportion of *Tropilaelaps* females (=70%) successfully produce at least one progeny compared with *Varroa* females (=50%). Even minimal reproductive success per cycle allows *Tropilaelaps* populations to expand more rapidly, contributing to their dominance in

suitable environments. Host brood preferences also differ markedly. *Varroa* preferentially infests drone brood at rates three to eight times higher than worker brood (Fuchs & Langenbach, 1989), meaning its population growth can be limited when drone brood is scarce. In contrast, *T. clareae* infests worker brood approximately 1.5 times more than drone brood (Woyke, 1987), while *T. mercedesae* shows no significant brood-sex preference when parasitizing its indigenous host *Apis dorsata*, infesting worker and drone brood at similar rates (Buawangpong et al., 2013). Notably, co-infestation of individual brood cells or the same hosts by *Tropilaelaps* and *Varroa* is rare—a pattern also observed by Ritter & Schneider-Ritter (1988) and Burgett et al. (1989) in studies on the *Acarapis* species complex—suggesting potential competitive exclusion or differing host exploitation strategies.

Originally a parasite of Asian giant honey bees such as *Apis dorsata*, *T. mercedesae* has successfully shifted to managed *A. mellifera* colonies, where it inflicts substantial brood damage, accelerates viral transmission, and reproduces more rapidly than *Varroa* (Dong et al., 2017; Ling et al., 2023). While traditional *Varroa* monitoring tools rely on detecting mites on adult bees, the brood-centric nature of *Tropilaelaps* makes field detection more difficult. Recent findings show that *T. mercedesae* can disperse long distances by hitchhiking on adult foragers (Tokach et al., 2025), further increasing its invasive potential.

The first confirmed establishment of *T. mercedesae* outside Asia occurred in western Russia and Georgia, where overwintering colonies were found infested (Brandorf et al., 2024; Uzunov et al., 2025). These incursions highlight the mite's capacity to survive in temperate climates and raise serious concerns for Europe, the Middle East, and other vulnerable regions. Given the global

reliance on pollination for food security, apiculture now faces a critical decision—either implement proactive surveillance and integrated management strategies or risk widespread impact from delayed intervention.

In India, the closely related mite *Tropilaelaps clareae* is primarily associated with the indigenous hive bee *Apis cerana*. First described by Delfinado and Baker (1961), *T. clareae* is a major pest of beekeeping in several Indian states (Abrol & Putatunda, 1995; Koeniger et al., 1983). Its impact is particularly severe in Haryana and Punjab (Putatunda, 1996), and it has also been reported from Jammu & Kashmir (Abrol & Putatunda, 1995). Only isolated exceptions exist; Anderson and Morgan (2007) reported a single *T. mercedesae* female parasitizing *A. cerana* brood in Thailand, concluding that this was likely an anomalous event because *T. mercedesae* rarely infests or reproduces within *A. cerana* colonies.

Apis mellifera, though not native to India, is globally valued for its role in crop pollination, biodiversity maintenance, and the production of economically important hive products such as honey, beeswax, propolis, pollen, and royal jelly. It has been widely introduced due to its economic importance and is one of the most extensively studied bee species (Free, 1993; Seeley, 2011). Honey bees are threatened by a broad array of pathogens and parasites, including bacteria, viruses, fungi, microsporidia, and acarine mites (Genersch et al., 2010). Mites (Acari) inhabit diverse ecological niches; parasitic species feed on host haemolymph or fat body tissue, causing direct damage while also acting as vectors of pathogens (Walter & Proctor, 2013).

The developmental cycle of *Tropilaelaps* is broadly similar to that of *Varroa*, with one crucial

difference: *Tropilaelaps* mites infest both worker and drone brood simultaneously, enabling rapid and sustained population expansion (Kapil & Aggarwal, 1987, 1989). Gravid females enter brood cells shortly before capping, feed on larval haemolymph for up to two days, and lay three to four eggs in a typical cycle. Offspring develop rapidly, with adults emerging in 6–7 days. Female mites exit the cell with the newly emerged bee and quickly reinfest new brood cells. During broodless periods, adult mites survive in a phoretic stage on adult bee sclerites until brood becomes available (Koeniger & Muzaffar, 1988; Rinderer et al., 1994; Wilde, 2000).

Identification of *Tropilaelaps* mites relies on both morphological and molecular diagnostic tools. Visual inspection of hive debris or brood combs can reveal characteristic signs, including irregular brood patterns, dead or deformed pupae, crawling bees with deformed wings, and the presence of fast-moving, reddish-brown, elongated mites on the comb surface (Anderson & Morgan, 2007).

Biology and Life Cycle of *T. mercedesae*

T. mercedesae was first described by Delfinado and Baker (1961) from the Philippines. Belonging to the Laelapidae family, it is morphologically distinct from *Varroa*: elongated, smaller, and highly mobile. These mites are adapted for parasitism, with piercing mouthparts optimized for feeding on developing brood. Genomic sequencing reveals streamlined sensory genes but expanded detoxification repertoires, reflecting its specialized parasitic life history and potential resilience to chemical controls (Dong et al., 2017).

The mite's reproductive cycle is rapid. Females invade brood cells shortly before capping, laying eggs that hatch within hours. Development

from egg to adult takes less than a week, enabling explosive population growth under favorable conditions (De Guzman et al., 2017). Unlike *Varroa*, which can spend extended periods on adults, *T. mercedesae* depends heavily on brood availability, starving quickly when brood is absent (Anderson & Roberts, 2013). However, evidence now shows the mite can survive on adult bees for short periods, facilitating dispersal (Rinderer et al., 1994).

Recent breakthroughs confirm that *T. mercedesae* engages in phoresy on *A. mellifera* foragers exiting colonies, demonstrating a capacity for spread greater than previously assumed (Tokach et al., 2025). Feeding on larvae and pupae causes mortality, reduced weight of surviving bees, shorter adult lifespans, and impaired cognitive function (Gao et al., 2021). Infested bees also show disrupted gut microbiota. Combined with virus transmission, these effects severely compromise colony viability.

Geographic Spread and Pathways of Transmission

For decades, *T. mercedesae* remained largely restricted to Asia, reported in Thailand, China, and Papua New Guinea (Burgett et al., 1990; De Guzman et al., 2017). Its spread has accelerated due to globalization of apiculture and trade in hive products. Khongphinitbunjong et al. (2019) demonstrated that mites can survive in wax and pollen shipments for days, posing biosecurity risks. Migratory beekeeping further amplifies dispersal potential (Edwards & Smith, 2021).

The paradigm shifted in 2024 with the detection of established populations in Krasnodar, Russia (Brandorf et al., 2024). Shortly thereafter, infestations were confirmed in Georgia, including overwintering populations (Janashia et al., 2024; Uzunov et al., 2025). These findings demonstrate the mite's capacity to adapt to temperate climates,

Table 1. Schematic Comparison of *Varroa* vs. *Tropilaelaps* Life Cycles

Feature	<i>Varroa destructor</i>	<i>Tropilaelaps</i> spp.
Primary Host Stage	Brood (larvae and pupae)	Brood (larvae and pupae)
Reproductive Phase	Performed inside a capped brood cell	Performed inside a capped brood cell
Phoretic Phase	Extended; can survive on adult bees for months by feeding on fat bodies	Abbreviated; can only survive on adult bees for 1-3 days
Adult Feeding	Capable of feeding on adult bee fat bodies during the phoretic phase	Mouthparts not suitable for feeding on adult bees
Cell Invasion	Enters brood cell shortly before capping (approx. 60 hours prior)	Enters brood cell just before capping (approx. 10 hours prior)
Egg Laying Rate	Slower; approx. every 30 hours	Faster; approx. every 24 hours
Reproductive Rate	Lower than <i>Tropilaelaps</i>	Higher than <i>Varroa</i>
Feeding Site	Establishes one feeding site shared by offspring	Uses multiple feeding sites on one host
Brood Preference	Prefers drone brood over worker brood	Does not show a preference for drone or worker brood

contradicting earlier assumptions that cold winters would prevent establishment. Climate modeling further suggests that large portions of Europe, North America, and Africa could support the mite's survival (Tsvetkov et al., 2022; Liao & Chen, 2023). With phoretic dispersal on foragers now established (Tokach et al., 2025), the potential for global expansion mirrors and may exceed that of *Varroa*.

Impacts on Honey Bee Health and Colony Survival

The consequences of *T. mercedesae* infestations are multifaceted. At the brood level, feeding results in direct mortality, developmental deformities, and reduced weight of emerging adults (Ling et al., 2023). Survivors often exhibit reduced longevity, impaired navigation, and weakened foraging performance (Gao et al., 2021). At the colony level, infestations destabilize brood patterns, weaken adult populations, and accelerate collapse. A particularly alarming feature is the mite's role as a viral vector. *T. mercedesae* transmits Deformed Wing Virus (DWV) and other pathogens, amplifying their prevalence and pathogenicity (Dainat et al., 2009). The synergy between mite parasitism and viral spread mirrors the *Varroa*-DWV complex but may progress more rapidly given *T. mercedesae*'s shorter reproductive cycle. Colony losses in Papua New Guinea, Thailand, and now Russia and Georgia have been directly attributed to this parasite (Roberts et al., 2020; Brandorf et al., 2024). Beyond apiculture, risks to wild bee populations remain poorly studied but are cause for concern (Jaffe & Pires, 2020).

Detection and Diagnostics

Detecting *T. mercedesae* is challenging due to its cryptic behavior. Methods used for *Varroa*, such as sugar shakes, underestimate infestation levels

because they target mites on adult bees. Direct brood inspection is essential but labor-intensive.

Recent innovations have improved detection. Rapid brood decapping, validated in European field trials, provides a sensitive, practical method for assessing brood infestations (Uzunov et al., 2025). Molecular tools such as qPCR and DNA barcoding also allow for precise identification (Luo et al., 2011; Nielsen & Williams, 2021). Gill et al. (2024) compared field and laboratory diagnostic methods, highlighting the value of integrated approaches. Early detection is critical, as eradication is only feasible in the initial stages of incursion (Ciobanu et al., 2023). International initiatives such as COLOSS are working to harmonize surveillance protocols across regions (Neumann & Yañez, 2022).

Control and Management Strategies

Controlling *T. mercedesae* is particularly challenging due to its rapid reproductive cycle, short phoretic phase, and strict dependence on brood for survival, which limits the effectiveness of adult-bee-based interventions. Chemical control options remain limited; commonly used acaricides such as amitraz have shown poor efficacy against *Tropilaelaps* because the mites spend minimal time on adult bees, reducing exposure (Roberts et al., 2020). In contrast, formic acid—capable of penetrating capped brood cells has demonstrated greater promise as a practical treatment, although its effectiveness varies with temperature and colony strength (Pettis et al., 2017). Reliance on chemical interventions also raises concerns about resistance development, residue accumulation, and impacts on colony health (Simões & Oliveira, 2021).

Given these constraints, alternative strategies are drawing increasing attention. Biotechnological approaches such as RNA interference (RNAi) targeting essential mite genes,

Table 2. Comparison of Diagnostic Methods for *T. mercedesae* Detection

Diagnostic Method	Target Stage	Sensitivity	Advantages	Limitations	Key References
Sugar Shake / Powdered Sugar Roll	Adult bees (phoretic mites)	Low for <i>T. mercedesae</i>	Non-destructive, easy to perform, widely used for <i>Varroa</i> monitoring	Ineffective because <i>Tropilaelaps</i> spend very little time on adult bees; severe underestimation	Uzunov et al. (2025); Gill et al. (2024)
Alcohol Wash	Adult bees	Low-Moderate (higher than sugar shake but still underestimates)	Good for <i>Varroa</i> ; kills mites and bees, improving dislodgement	Still misses most <i>T. mercedesae</i> due to minimal phoretic phase	Neumann & Yañez, 2022
Direct Brood Inspection (uncapping & examining brood cells)	Brood (larvae/pupae)	High	Gold standard for detecting brood-cell parasites; identifies presence, reproductive status	Labor-intensive, time-consuming; requires significant brood sampling	Anderson & Morgan (2007); Kapil & Aggarwal (1987)
Rapid Brood Decapping Method	Brood	Very High	Fast, scalable, validated in field trials; more sensitive than standard uncapping	Requires trained personnel and consistent sampling	Neumann & Yañez, 2022
Sticky Boards / Hive Debris Analysis	Fallen mites / debris	Moderate	Non-intrusive, easy to deploy, captures natural mite drop	Drop rates vary widely; early infestations often missed	Sammataro et al. (2000)
Molecular Diagnostics (qPCR, DNA barcoding)	All life stages; Environmental DNA	Very High	Highly sensitive and specific; detects low-level or early-stage infestations; differentiates species	Requires lab facilities, costlier, slower turnaround in field settings	Luo et al. (2011); Nielsen & Williams (2021)
Integrated Diagnostic Panels (Field + Molecular)	Combined	Very High	Best accuracy; compensates weaknesses of single methods	Requires coordination of sampling and lab analysis	Neumann & Yañez, 2022

fungal biocontrol agents, and pheromone-based disruption of host-parasite interactions represent promising future tools. However, these methods remain largely experimental and require rigorous field validation, optimization of delivery systems,

and cost-effective formulations before they can be integrated into beekeeping practice. An integrated pest management framework that combines chemical, biotechnological, and cultural strategies such as brood interruption, selective breeding for

hygienic behavior, and improved colony monitoring will be essential for sustainable long-term control of *T. mercedesae* (Roberts et al., 2020; Ling et al., 2023).

Policy, Trade, and Biosecurity Challenges

The global spread of *T. mercedesae* underscores significant weaknesses in international and national biosecurity frameworks. Although the World Organisation for Animal Health (WOAH) lists *Tropilaelaps* as a notifiable pest, enforcement of these regulations is often inconsistent, particularly in regions with limited monitoring infrastructure. International trade in hive products- including honey, wax, pollen, and bee packages as well as migratory beekeeping practices, represent key pathways for unintentional dispersal of the mite (Khongphinitbunjong et al., 2019; Edwards & Smith, 2021). Recent incursions into Europe demonstrate that even countries with strong veterinary and apicultural systems are not immune to establishment, highlighting the need for proactive rather than reactive strategies.

Preventing further spread requires a multi-layered approach. Strict import controls on live bees and hive products, coupled with targeted surveillance at ports of entry, are essential first lines of defense. Rapid response contingency plans, including quarantine, colony destruction if necessary, and localized chemical or biological interventions, can significantly reduce the risk of establishment (Maiolo et al., 2022). Economic analyses suggest that early detection and intervention are far more cost-effective than prolonged management or mitigation of established infestations (Reed & Baxter, 2021).

International collaboration is critical to strengthen biosecurity and prevent global escalation. Networks such as COLOSS (Prevention of

Honey Bee Colony Losses) provide frameworks for sharing surveillance data, coordinating diagnostic efforts, and harmonizing response protocols across borders (Neumann & Yañez, 2022). In addition, regional cooperation among neighboring countries can limit cross-border spread, particularly in areas with intensive migratory beekeeping or high-volume trade in hive products. Without coordinated, proactive action, *T. mercedesae* has the potential to replicate and possibly exceed the catastrophic impacts of *Varroa destructor*, threatening global apiculture, pollination-dependent agriculture, and food security.

Research Gaps and Future Directions

Despite substantial progress in understanding *T. mercedesae*, significant knowledge gaps remain, hindering the development of effective management strategies. Comprehensive epidemiological modeling is urgently needed to predict the mite's potential global spread under varying climate, land-use, and trade scenarios (Liao & Chen, 2023). Such models should integrate factors such as brood availability, colony density, seasonal patterns, and international hive product movements to improve risk assessment and inform targeted interventions. The role of *T. mercedesae* in virus transmission and pathogen amplification remains poorly understood. While *Varroa* is a well-known vector for several honey bee viruses, limited research exists on virus-*Tropilaelaps* interactions. Understanding the dynamics of viral transmission, including co-infection scenarios with *Varroa* and other pathogens, is critical to assess the broader impacts on colony health, pollination efficiency, and agricultural productivity.

Early detection is a cornerstone of effective management, yet current diagnostic tools are often insufficient, particularly in resource-limited

settings. Improved, cost-effective molecular, immunological, and rapid field-based diagnostic methods are needed to detect low-level infestations before widespread establishment (Gill et al., 2024). Additionally, monitoring programs should incorporate standardized protocols for both managed and wild bee populations to provide early warnings and track infestation trends over time.

Control strategies require rigorous validation across diverse climates, beekeeping systems, and apicultural contexts. Chemical, mechanical, and biological interventions need to be assessed not only for efficacy but also for their sustainability, cost, and environmental impacts. Parallel efforts in selective breeding programs should focus on identifying and propagating honey bee strains with natural resistance or tolerance to *Tropilaelaps* infestation, including behavioral, physiological, or immunological traits that limit mite reproduction.

Socioeconomic research is equally critical. The direct and indirect costs of *T. mercedesae* spread including colony losses, reduced pollination services, and increased management expenditures are likely substantial but remain poorly quantified. Detailed cost-benefit analyses can guide policymakers and stakeholders in allocating resources effectively and prioritizing preventative measures (Finlayson & Zayed, 2020).

The potential impact of *T. mercedesae* on wild pollinator species is an urgent and largely unexplored area. Spillover effects from managed honey bees to wild pollinators could exacerbate declines in native bee populations, disrupt ecosystem services, and reduce agricultural yields. Long-term ecological studies are needed to assess these risks and develop mitigation strategies. Addressing these research gaps

requires strong global collaboration, sustained and well-coordinated funding, and the integration of molecular, ecological, behavioral, and policy-oriented research. Collaborative networks and data-sharing platforms can facilitate cross-border monitoring, accelerate discovery, and inform harmonized biosecurity measures. Only through a multidisciplinary and proactive approach can the apicultural sector prepare for, and ideally prevent, the potentially devastating consequences of *T. mercedesae* expansion.

Conclusion

T. mercedesae is no longer a regional anomaly but an accelerating global threat to apiculture. Its rapid reproductive cycle, short phoretic phase, and severe disruption of brood development position it as a potentially more destructive parasite than *Varroa destructor*. The recent establishment of stable populations in parts of Europe highlights its expanding geographic reach, driven by global trade, colony movement, and gaps in early-warning systems. Advances in diagnostic tools—such as refined brood decapping methods, improved phoresy detection, and molecular confirmation have expanded scientific understanding of this mite's biology, revealing that current risk assessments may significantly underestimate its invasion potential. Yet, effective management options remain limited, fragmented, and insufficiently validated. To prevent repeating the costly lessons of *Varroa*'s global spread, urgent and coordinated action is essential. At the policy level, harmonized international surveillance protocols, strengthened biosecurity standards, and clear regional contingency plans must be prioritized. Governments should invest in developing novel miticides, RNAi-based tools, brood-targeted technologies, and mite-resistant bee lineages. Equally important is supporting beekeepers through incentives and extension

programs that promote adoption of integrated pest management practices. Cooperative international networks and open data-sharing platforms must be expanded to ensure timely information flow and synchronized responses across borders.

Future research should deepen understanding of reproductive biology, host-parasite interactions, climate-driven spread potential, and diagnostic innovations, alongside long-term studies quantifying ecological and economic impacts. Protecting global apiculture now depends on immediate, unified, and science-driven policies that address *T. mercedesae* before its spread becomes irreversible.

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