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Pest and Disease of Honeybee and their Control Strategies: A Review

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Apiculture is an intergral part of agricultural activity practiced to produces hive products such as honey and beeswax. The honeybees are the best pollinator which enhace crop productivity. Common pest and disease that affect honeybee with their controlling mechanism was the main objective of this review. The bees are susceptible to a number of insect pest's types that will adversely affect the productivity of the bee colony to a significant level. *Varroa destructor, Nosema ceranae*, *Nocema Apis, Acarapis woodi*, small wax moths, Bee lice, Ants and Wax moth are the most economically important honeybee pest and disease types. To control pest and diseae different controlling mechanism are are used at different areas of the country. Nonchemical approaches in integrated pest management (IPM), traditional method and biological control are the prevention strategies. This overview forms the basis to realize the importance of pest management in bee husbandry practices, thus affecting the resilience and productivity of honeybee populations.

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1. INTRODUCTION

Beekeeping plays a vital role in agriculture and biodiversity through the production of honey, beeswax, royal jelly and other hive products, as well as by facilitating pollination of many crops. Honeybees, particularly the species *Apis mellifera*, are essential pollinators (Greenleaf and Kremen, 2006;Garibaldi et al*.,* 2013;Blaauw and Isaacs, 2014;Lowenstein et al*.,* 2015;Bosch and Kemp, 2002;Bosch et al*.,* 2006;Artz and Nault, 2011;Park *et al.,* 2016), for a wide range of plants, making them critical for both natural ecosystems (Losey and Vaughn, 2006;Klein et al*.,* 2007, Gallai et al*.,* 2009, Winfree et al*.,* 2011;Calderone 2012;Lautenbach *et al.,* 2012) and commercial agriculture. However, beekeeping is increasingly threatened by various insect pests that infest colonies, leading to weakened hives, reduced honey production and colony collapse. Managing these pests is essential for ensuring the sustainability of beekeeping operations. Asia has at least eight native species of honey bees, although diversity has been found to be the highest in the tropics (Crane, 1999; Akratanakul, 1990; Fries, 2010; Rosenkranz et al*.,* 2010;Khongphinitbunjong et al*.,* 2012;Chaimanee et al*.,* 2010;Kavinseksan et al*.,* 2003;Wanjai et al*.,* 2012;Sanpa et al*.,* 2015;Stanley et al*.,* 2015). “Multicomb-making cavity-nesting species, *Apis cerana, Apis koschevnikovi, Apis nigrocincta* and *Apis nuluensis* are highly abundant as a group and have been classified into the group of medium-sized bees” (Ruttner 1988; Otis 1996; Tingek et al*.,* 1996; Hepburn et al*.,* 2001; Radloff et al*.,* 2005a,b; Hepburn and Hepburn 2006; Takahashi et al*.,* 2007; Tan et al*.,* 2008; Radloff et al*.,* 2010).

Single comb-making open-air-nesting honeybees include dwarf (*Apis florea* and *Apis andreniformis*) and giant (*Apis dorsata* and *Apis laboriosa*) honeybees (Sakagami et al*.,* 1980; Otis, 1996; Oldroyd and Wongsiri, 2006; Hepburn and Radloff, 2011). This group is confined to subtropical and tropical regions presumably because the species are naturally susceptible to the environment by virtue of their open nesting habits (Hepburn et al*.,* 2005; Hepburn and Hepburn, 2005; Oldroyd and Wongsiri, 2006). “Besides the native *Apis* species, the alien *Apis mellifera* also appears to be widely distributed in the region” (Wongsiri and Tangkanasing, 1987; Crane, 1999; Oldroyd and Wongsiri, 2006).

This review focuses on the major insect pests that affect honeybee, their life cycles and the management strategies used to protect honeybee colonies.

2. MAJOR INSECT PESTS OF BEEKEEPING

Honey bee production systems focus on optimizing honey, wax, and other bee products through efficient hive management and sustainable practices. The most commonly used hive type is the *Langstroth hive*, favored for its modular design and ease of inspection, though others like *Top-Bar hives* and *Warre hives* are also popular in certain regions. Effective management practices include maintaining strong, healthy colonies through regular inspections to monitor pests and diseases such as varroa mites, nosema and foulbrood. Proper seasonal management is critical, such as providing supplemental feeding during dearth periods, ensuring adequate ventilation, and controlling swarming through strategic splitting of colonies or requeening. Beekeepers must also ensure colonies have access to diverse floral resources for nectar and pollen, ideally in pesticide-free environments, to support productivity and bee health. Integrated pest management (IPM) techniques, such as using screened bottom boards or biological controls, help mitigate pest infestations while minimizing chemical interventions. Regularly replacing old comb, maintaining clean equipment, and practicing migratory beekeeping when necessary to follow bloom patterns can further enhance honey yield and colony sustainability.

2.1 Varroa Mite (*Varroa* spp.)

Within the genus Varroa, four mite species are described: *Varroa jacobsoni* (Oudemans 1904), *Varroa underwoodi* (Delfinado-Baker and Aggarwal 1987), *Varroa rindereri* (de Guzman and Delfinado-Baker 1996) and *Varroa destructor* (Anderson and Trueman 2000), all of them parasites from honeybees. *V. jacobsoni* is the first species that was recognized, infesting *A. cerana* in Java (Oudemans, 1904). “In the following researches in the region were reported also further species. Parasitism of *V. underwoodi* was detected from *A. cerana* in Nepal and *V. rindereri* from *A. koschevnikovi* from Borneo, respectively” (Delfinado-Baker and Aggarwal 1987; de Guzman and Delfinado-Baker, 1996).

V. jacobsoni was reevaluated, and it emerged that another species, *V. destructor*, infects *A. mellifera* (Anderson and Trueman, 2000). "The varroa mite is the most serious pest of honeybees worldwide. This external parasitic mite feeds on the hemolymph of adult bees and brood, weakening individuals and spreading viral diseases such as deformed wing virus (DWV) and acute bee paralysis virus (ABPV). Infestations by *Varroa destructor* can cause colony collapse if not managed effectively. The mites reproduce in the capped brood cells of honeybees, which makes them difficult to control. The sympatric occurrence of many species of honeybees and associated parasitic mites in Asia could facilitate the transfer of parasites among them and simultaneous infestations by several species of mites, both at colony or individual level" (Anderson, 1994; Anderson and Trueman, 2000; Buawangpong et al*.,* 2015). At present, 24 haplogroups, 15 for *V. jacobsoni* and 9 for V. destructor, exist (de Guzman and Rinderer 1998, 1999; de Guzman et al*.,* 1997, 1998, 1999; Anderson and Trueman, 2000; Fuchs et al*.,* 2000; Zhou et al. 2004; Solignac et al*.,* 2005; Warrit et al*.,* 2006; Navajas et al*.,* 2010), the Korean (K) and Japanese (J) haplotypes of *V. destructor* being the most successful parasites of *A. mellifera* (Rosenkranz et al*.,* 2010).

2.1.1 *Tropilaelaps* spp.

Tropilaelaps mites, like varroa mites, are parasitic mites that feed on the brood of honeybees. These mites are smaller than varroa mites but reproduce more rapidly, leading to quick infestations. *Tropilaelaps clareae* is mainly found in parts of Asia, but its spread to other regions poses a significant threat to global beekeeping. Infested hives suffer from brood mortality, deformed adults, and eventually colony collapse. Because *Tropilaelaps* mites primarily affect brood, they are difficult to detect until infestations are advanced. There are four species in the mite family Laelapidae identified as *Tropilaelaps*. The first species, *Tropilaelaps clareae,* was collected from dead *A. mellifera* bees and field rats near beehives in the Philippines (Delfinado and Baker, 1961). Twenty years later, *Tropilaelaps koenigerum* was seen as a parasite of *A. dorsata* in Sri Lanka (Delfinado-Baker and Baker, 1982). Anderson and Morgan (2007) described two species, Tropilaelaps mercedesae and Tropilaelaps thaii that parasitize *A. dorsata* and *A. mellifera* in mainland Asia and *A. laboriosa* in the Himalayas, respectively. As in the redescription of *V. jacobsoni* and *V. destructor* (Anderson and Trueman, 2000), *T. mercedesae* was first described as *T. clareae* (Anderson and Morgan, 2007). *Tropilaelaps* mites are thought to be natural parasitoids of the giant honeybees, *A. dorsata, A. laboriosa* and *A. breviligula* (Laigo and Morse, 1968; Delfinado-Baker et al*.,* 1985; Anderson and Morgan, 2007). *T. clareae* was first documented parasitizing A. mellifera in the Philippines and recently found parasitizing A. breviligula in the Philippines and Sulawesi Island in Indonesia (Anderson and Morgan 2007). Earlier works that reclassified *T. mercedesae* as *T. clareae* (Delfinado-Baker, 1982; Kapil and Aggarwal, 1987; Delfinado-Baker et al*.,* 1989; Wongsiri et al*.,* 1989; Abrol and Putatunda, 1995; Koeniger et al*.,* 2002) need to be reviewed.

Reproductive activities of *T. koenigerum* on *A. cerana* brood were observed There are only two other records of this species, those being from India (Abrol and Putatunda 1995) and by a single adult *T. mercedesae* in Thailand (Anderson and Morgan 2007).

"All species are able to parasitize successfully cavity-nesting honeybees. V. jacobsoni infests five honeybee species, including *A. cerana, A. koschevnikovi, A. mellifera, A. nigrocincta* and *A. nuluensis"* (Woyke et al*.,* 1987a; Delfinado-Baker et al*.,* 1989; Koeniger et al*.,* 2002; Otis and Kralj, 2001; de Guzman et al*.,* 1996). *V. destructor*, on the other hand, has been reported only in *A. cerana* and *A. mellifera* colonies (Anderson and Trueman, 2000). *V. underwoodi* is restricted to *A. cerana, A. nigrocincta* and *A. nuluensis*. While its conspecifics appear to be generalist parasites, *V. rindereri* appears to be a host-specific one. It reportedly infects *A. koschevnikovi* successfully, but this species was collected as a debris in *A. dorsata* in Borneo in association with *V. jacobsoni* (Koeniger et al*.,* 2002). "The biomolecular bases for resistance or susceptibility to most recently, approved acaricides have been described; notably resistance to the pyrethroid tau-fluvalinate is associated with a specific site point mutation on the gene encoding the varroa voltage-gated sodium channel" (Millan-Leiva et al*.,* 2021), whereas the resistance linked to coumaphos. The loss-of-function mutations in varroa cytochrome-P450 genes (Vlogiannitis et al*.,* 2021) and the target molecule of amitraz leading to its differential toxicity to varroa and honey bees seems to be the octopamine receptor (Guo et al*.,* 2021). Oxalic acid may be used conveniently and effectively where periods of lack of bees are extended (Al Toufailia et al*.,* 2015; Jack et al*.,* 2021). Apparently, temperature and humidity factors reduce the effectiveness of acaricidal activity of oxalic acid (Patricia et al*.,* 2013). For example, studies on the intensification of dosing with oxalic acid (Jack et al*.,* 2021), the synthesis of long-period releasing oxalic acid preparations (Maggi et al*.,* 2016; Rodríguez Dehaibes et al*.,* 2020) or repeated oxalic acid acute treatments (Berry et al*.,* 2022) were conducted. "Left uncontrolled, *Varroa* and *Tropilaelaps* alone can cause the rapid deterioration in health of A. mellifera colonies in Asia" (Wongsiri and Tangkanasing, 1987;Buawangpong et al*.,* 2015). Many of the acaricides used against *V. destructor* would be expected to control Tropilaelaps as well, including tau-fluvalinate, amitraz, formic acid and thymol, for *T. clareae* on *A. mellifera* in Thailand (Wongsiri and Tangkanasing, 1987; Burgett and Kitprasert, 1990), Vietnam (Woyke, 1987a) and Pakistan (Raffique et al*.,* 2012), respectively.

2.1.2 *Euvarroa* spp.

"Thus, as of now, two species from the genus Euvarroa are thought to be associated with five honeybee species in Asia, *i.e.,* the openair nesters. *A. andreniformis, A. florea, A. dorsata*, as well as the cavity nesters *A. cerana* and *A. mellifera. Euvarroa sinhai* was first noticed from *A. florea* specimens collected in 1971 in India" (Delfinado and Baker, 1974) and *Euvarroa wongsirii* was first noticed in *A. andreniformis* in Thailand (Lekprayoon and Tangkanasing 1991). *E. sinhai* is pear-shaped with 39–40 marginal setae, whereas *E. wongsirii* is triangular or wider posteriorly with 47–54 long setae (Delfinado and Baker, 1974; Lekprayoon and Tangkanasing 1991). *E. sinhai* has been reported in *A. florea* in India, Iran, Sri Lanka, and Thailand (Delfinado and Baker 1974; Koeniger et al*.,* 1983; Mossadegh 1991) and *A. andreniformis* in Thailand (Delfinado-Baker et al*.,* 1989). E. sinhai has been reported in *A. flavescens florea* in India, Iran, Sri Lanka, and Thailand (Delfinado and Baker, 1974; Koeniger et al*.,* 1983; Mossadegh, 1991) and *A. andreniformis* in Thailand (Delfinado-Baker et al*.,* 1989). "Drone reproduction is also seasonal and swarming further reduces *Euvarroa* populations within colonies by disrupting bee brood and hence mite reproduction" (Kitprasert, 1995).

2.1.3 *Acarapis* spp.

There are three described species of mite in the genus *Acarapis*; all these are parasites of adult honeybees. First described was *Acarapis woodi* early in the 1900 on the Isle of Wight, England by Rennie (1921); then came *Acarapis dorsalis* and *Acarapis externus* on several continents from Morgenthaler (1934). All three species parasitize honeybees in Asia. The first record of *A. woodi* parasitizing honeybees in the region came from India (Michael, 1957; Milne, 1957). The species has since been observed parasitizing *A. mellifera* in Egypt, Iran, Israel, Jordan, Kuwait, Lebanon, Palestine and Syria (Matheson, 1993; Rashad et al*.,* 1985; Gerson et al*.,* 1994; Mossadegh and Bahreini, 1994; Amr et al*.,* 1998; OIE 2004) and *A. indica* in India, Pakistan, Bangladesh and China (Delfinado and Baker, 1982). Recently, *A. woodi* was isolated from dead bees of dying colonies of *A. cerana japonica* in Japan (Kojima et al*.,* 2011). Although all the three species of *Acarapis* are hemolymph feeders of bees, only *A. woodi* is considered economically important, as many of the high-infested colonies have died too (Ibay, 1989; de Guzman et al*.,* 2001).

2.2 Small Hive Beetle

"Aethina tumida has recently emerged as a pest of Asian honeybees because it was first recorded in the Asia region in the Philippines in 2014" (Brion, 2015). "The small hive beetle (SHB) is a destructive pest of honeybee colonies, particularly in tropical and subtropical regions" (Meikle and Diaz, 2012). Parasite pressure is a strong environmental factor rather intensely in the case of SHB Signature. The lifecycles of SHB have larvae that under ground in the soil, pupating their population growth is apparently restricted by the suitability of the environment to this pupating step (Ellis et al*.,* 2004; Meikle and Diaz, 2012). Adult beetles invade hives, where they lay eggs in the brood comb. The larvae of the beetle feed on bee larvae, pollen, and honey, causing fermentation of the honey and destruction of the comb structure. Infested hives may abscond or collapse if left untreated. The SHB is particularly damaging to weak colonies, but even strong colonies can suffer from severe infestations if left unmanaged.

These cultural and mechanical controls are, more than often, enough to avert the SHB outbreak has more severe conditions (Cuthbertson et al*.,* 2013). "Perhaps one of the most commonly applied biotechnology-based control measures include the use of EPNs that target pupa stages of SHB deep into the soil" (Cabanillas and Elzen, 2006; Sanchez et al*.,* 2021). "EPNs are one of the frontline parasite agricultural control practices and thus have been moderately successful among beekeepers but could be constrained in their application if colonies are moved frequently, large populations of adult SHBs already exist in the landscape, live delivery cannot be guaranteed by a supplier through their sales channels (beekeepers might need to have a suitable quality microscope to check EPNs upon purchase are alive), or if investment is significant with beekeepers raising their own EPNs. There is an obvious open niche in parasite control in beekeeping: insecticides safe for bees, to control other insect parasites such as SHBs, as so many of the options currently available are precluded for use on live colonies and are used instead on stored frames" (Farone, 2021) or to be used external to colonies as a soil-drench. The beetle is an opportunistic scavenger (Neumann and Elzen 2004). Mild climates of southern Asia offer a superb living condition for *A. tumida*; high temperature reduces the developmental time of the beetle, de Guzman and Frake, 2007, constant food supply throughout the year Brood, pollen, and honey from different species of honeybees increase fecundity de Guzman et al*.,* 2015.

2.3 Wax Moths

"Wax moths, particularly the greater wax moth (*Galleria mellonella*) and the lesser wax moth (*Achroia grisella*), are pests that cause significant damage to honeycombs" (Akratanakul, 1990). "These moths lay eggs in weak or poorly maintained hives, and the larvae feed on wax, pollen, and bee brood, creating tunnels and webs in the comb. Wax moths are a pest for unused or stored combs" (Pernal and Clay, 2013). "This weakens the structural integrity of the hive, reduces honey production, and can lead to the death of bee brood. Although strong colonies can often defend themselves against wax moths, weakened hives are especially vulnerable. Wax moths are the most serious pest of *A. cerana* in Southeast Asia, causing them to abscond" (Akratanakul, 1990;Fries, 2010; Rosenkranz et al*.,* 2010;Khongphinitbunjong et al*.,* 2012; Chaimanee et al*.,* 2010;Kavinseksan et al*.,* 2003;Wanjai et al*.,* 2012;Sanpa et al*.,* 2015;Stanley et al*.,* 2015).

2.4 Ants

"A great many ant species are known to create problems in commercial beekeeping. The most common species recorded of those causing problems to beekeeping operations are weaver ant, *Oecophylla smaragdina*), black ants, *Monomorium* spp.), fire ants, *Solenopsis* spp.) and *Formica* spp." (Akratanakul, 1990). "Ants, including fire ants (*Solenopsis invicta*) and other species, can invade beehives to steal honey, brood, and wax. These pests are especially problematic in warm climates and can cause colonies to abscond if infestations are severe. Ants usually target weak colonies but can overwhelm strong ones if their nests are close to the hives. The constant disturbance from ants can also weaken colonies over time" (Akratanakul, 1990).

2.5 Bee-Eating Birds

"Bee-eating birds are a pest to *A. mellifera*, as well; they include the little green bee eater - *Merops orientalis* The chestnut headed bee eater-*Merops leschenaulti*, Swifts - *Crypsiurus balasiensis, Chaetura* spp, Whitevented needletail - *Hirundapus cochinchinesis*, the Wood peckers - Picus spp, Honeyguides - Indicatoridae and black drongo (*Dicrurus macrocercus*), the ashy drongo (*Dicrurus leucophaeus*), and the greater racket-tailed drongo (*Dicrurus paradiseus*)" (Akratanakul, 1990; Cervancia, 1993; Wongsiri et al*.,* 2005). Some beekeepers will utilize net-trapping to deter predation by birds or to relocate colonies.

2.6 Wasp

Vespa spp. are among the major predators of honeybees in Asia (Matsuura, 1988). The hives of honeybees were often attacked, and one wasp was reported to catch seven bees in one attack (Cervancia, 1993). To avoid predation*, A. cerana, A. nuluensis* and *A. dorsata* perform body shaking as a form of defense (Koeniger et al*.,* 1996; Kastberger et al*.,* 1998; Tan et al*.,* 2010; Khongphinitbunjong et al*.,* 2012) and *A. cerana* and *A. mellifera* formed tight balls where the body heat kills the wasp intruders (Ono et al*.,* 1987; Tan et al*.,* 2005). Sometimes, beekeepers install wasp traps or lower the hive entrance and murder wasps by banging them with slippers, pieces of wood, or badminton rackets (Cervancia, 1993). In addition, toxic baits can be used to poison nest mates.

2.7 Bee Lice

"Braula coeca wingless flies are not considered to be an important pest of honeybees" (Pernal and Clay, 2013). "Larvae feed on wax, pollen and

honey and tunnel through the combs. Adults feed on nectar and pollen and also rob food from the mouths of bees. Control measures used against parasitic mites also prove effective against *Braula coeca"* (Kulincevic et al*.,* 1991).

3. INTEGRATED PEST MANAGEMENT (IPM) (Dwarka et al*.,* 2024)

3.1 Biological Control

Biological control methods aim to harness natural predators, pathogens, or parasites to reduce pest populations. While biological control in beekeeping is still an emerging field, some promising approaches include:

3.1.1 Entomopathogenic fungi

These fungi, such as *Metarhizium anisopliae* and *Beauveria bassiana*, have been tested for their potential to control varroa mites by infecting and killing the mites without harming the bees.

3.1.2 Predatory mites

Research is ongoing to identify predatory mites that could naturally control varroa mite populations within hives.

Despite the potential of biological control, these methods are not yet widely adopted due to limited availability, varying effectiveness, and challenges in application.

3.2 Cultural and Mechanical Control

Cultural and mechanical practices are essential components of pest management in beekeeping. These practices aim to maintain strong, healthy colonies and reduce the chances of infestation:

3.2.1 Hygienic beekeeping

Regular hive inspections and cleaning help detect and remove pests early. Maintaining strong colonies through good nutrition and disease management also makes hives more resistant to pests.

3.2.2 Screened bottom boards

These can help reduce varroa mite populations by allowing mites that fall off bees to drop through the screen, preventing them from climbing back onto bees.

3.2.3 Trapping and exclusion

For pests like small hive beetles and ants, mechanical traps and physical barriers can reduce infestations. Hive stands and moats can prevent ants from entering the hive, while beetle traps placed inside the hive can capture adult beetles.

3.2.4 Freezing comb

Freezing empty combs can kill wax moth eggs and larvae, preventing infestations in stored combs.

3.3 Chemical Control

Chemical treatments are widely used to manage insect pests in beekeeping, particularly for mites like *Varroa destructor* and *Tropilaelaps clareae*. Common chemical treatments include:

3.3.1 Miticides

Synthetic miticides such as amitraz, fluvalinate and coumaphos are used to control varroa mite populations. While effective, overuse of these chemicals can lead to the development of resistance in mite populations and contamination of hive products.

3.3.2 Organic acids

Formic acid and oxalic acid (20 to 30 ml per chamber) are natural miticides that are less likely to lead to resistance and are effective in controlling varroa mites when applied at the correct dosage.

3.3.3 Essential oils

Thymol (5g of thymol crystal into a gauze bag and kep on the top bars for two weeks) (Dwarka et al*.,* 2024), derived from thyme, and other plant-based oils have shown efficacy in controlling mites. These are considered safer alternatives to synthetic chemicals but require precise application.

While chemical control is necessary in some cases, its overuse can have negative impacts on bee health and contribute to pesticide resistance. Additionally, chemical residues can contaminate honey and wax, posing risks to human health.

4. CONCLUSION

Beekeeping faces significant challenges from a range of insect pests, particularly varroa mites, small hive beetles, and wax moths. While chemical control remains the primary management strategy, Integrated Pest Management (IPM) approaches that incorporate biological, cultural, and mechanical methods offer more sustainable solutions. Future research should focus on developing new biological control agents, improving pest. *A. mellifera* could be at higher risk for further pests and parasites from domesticated honeybees, as was already shown by the infestation through *V. destructor* and *A. cerana*. A number of research works have proved that the indigenous Asian honeybee could also effectively cope with the same parasites presently killing the *A. mellifera* through behavioral and immunological defense mechanisms of its host. The migratory nature of several species of native Asian honeybees may also be able to influence susceptibility of infection or infestation. Besides, promotion in standards and research on biomedical properties of bee products, such as honey and propolis, should be encouraged in view of promoting beekeeping in Asia. The risks related to pesticide exposure would be highly posed to honeybees, and in a recent study, it has been observed that organophosphates are highly toxic to *A. cerana* and *A. mellifera*.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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