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8.6 BIODIVERSITY OF PARASITIC MITES OF HONEY BEES IN SOUTHEAST ASIA

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Biodiversity considers three levels of biological organization: species, genetic and ecological diversity. Southeast Asia is a biologically rich region (Thailand, Burma, Cambodia, Vietnam, Malaysia, and Indonesia) with many species of bee mites. Many more species are known to occasionally invade a bee colony or attach to a honey bee (Eickwort 1988, Delfinado-Baker and Rath 1992) but they will not be considered here. This paper surveys only those parasitic mites that are known to form significant associations with the six species of *Apis* in Southeast Asia (Table 1). Most of the parasitic mites of five native Asian honey bees are more specific to their own hosts than they are to the European honey bee, *Apis mellifera*. The association among species and populations of Asian honey bees and European honey bees of different genetic backgrounds with the 'new' parasites *Varroa jacobsoni* and *Tropilaelaps clareae* promises to provide new insights into 'coevolution'. This paper will review the diverse group of mites parasitic on Asian honey bees. *Varroa jacobsoni* and *T. clareae* are the most familiar species of mites, while *Euvarroa sinhai* and *E. wongsirii* are important on their hosts (Eickwort 1988, Lekprayoon and Tangkanasing 1991, 1993).

DISCUSSION

Euvarroa wongsirii and *E. sinhai*

Both species are mesostigmatids in the family Varroidae, (Table 1) and were first found in southeast Asia (Delfinado and Baker 1974, Delfinado-Baker 1984). Morphology and biological characters confirm that *E. wongsirii* is a separate species found on the small dwarf honey bee, *A. andreniformis* (Lekprayoon and Tangkanasing 1991, 1993, Morin and Otis 1993). The general morphology and chaetotaxy of *E. wongsirii* are very similar to *E. sinhai* but some characters are different. The characters that readily distinguish the female of *E. wongsirii* from *E. sinhai* are a broadly triangular-shaped body, wider, posteriorly, bearing 47-54 slender, long, lanceolate setae. The female of *E. sinhai* has a pear-shaped body, bearing 39-40 very long,

lanceolate setae. *E. wongsirii* is restricted to its original host, *A. andreniformis* and is limited to Southeast Asia, and was discovered in Thailand where its host is native. *E. sinhai* has been reported from *A. mellifera* in India (Kapil and Aggarwal 1985) and *A. andreniformis* in Malaysia (Morin and Otis 1993), and is easily found on drone brood of its native host, *A. florea*, in Thailand. *E. wongsirii* is not a common species since its host, *A. andreniformis*, is rare, at least in Thailand. Both *Euvarroa* species are brood mites parasitizing their respective host species, but they can live phoretically in bee colonies both with and without drones. Koeniger *et al.* (1993) and Lekprayoon *et al.* (1994) reported that *A. florea* and *A. andreniformis* show aggressive cleaning behavior toward foreign mites and kill them (see Table 2). These observations are the basis of our knowledge of their ecology and nature. The relationship between mites and bees can be used to evaluate the hypothesis of a coevolutionary relationship among mite taxa specific to their own hosts (O'Connor 1988).

Varroa jacobsoni and *Tropilaelaps clareae*

Of the many extraordinary mites associated with honey bees, the brood mites *V. jacobsoni* and *T. clareae* are the most important and familiar haemophagous parasites. These two species of mesostigmatid mites evolved in southeast Asia as obligatory parasites of *Apis*. *V. jacobsoni* was originally associated with *A. cerana* and *T. clareae* with *A. dorsata* (De Jong *et al.* 1982, Woyke 1984, Eickwort 1988). Delfinado-Baker's (1982) record for *T. clareae* from *A. cerana* established that the mite is a parasite of *A. cerana* (Wongsiri and Tangkanasing 1989). The original host of *T. clareae* and *T. koenigerum* is *A. dorsata*, but *T. koenigerum* remains restricted to *A. dorsata* in Sri Lanka only, not in Southeast Asia (Delfinado-Baker and Baker 1982). When beekeepers brought *A. mellifera* to Southeast Asia, *V. jacobsoni* and *T. clareae* became devastating pests (Eickwort 1988, Wongsiri *et al.* (1987).

Nymphal and adult female mites feed on the hemolymph of bee larvae and pupae. From a world

Table 1. Taxon and ecological diversity of honey bees (*Apis*) and their parasitic mites in Southeast Asia

Hosts	Mites (Taxon)	Family	Ecology	Range
Parasitiformes - Mesostigmata				
<i>Apis andreniformis</i>	<i>Euvarroa wongsirii</i>	Varroidae	obligatory, parasitic	Southeast Asia
	<i>E. sinhai</i>	Varroidae	incidental, parasitic?	Southeast Asia
<i>Apis florea</i>	<i>E. sinhai</i>	Varroidae	obligatory, parasitic	Asia
	<i>Varroa jacobsoni</i>	Varroidae	incidental, phoretic, parasitic?	Asia
	<i>Tropilaelaps clareae</i>	Laelapidae	incidental, phoretic, parasitic?	Asia
<i>Apis dorsata</i>	<i>T. clareae</i>	Laelapidae	obligatory, parasitic	Asia
	<i>T. koenigerum</i>	Laelapidae	obligatory, parasitic	Sri Lanka
<i>Apis cerana</i>	<i>V. jacobsoni</i>	Varroidae	obligatory, parasitic	Asia
	<i>T. clareae</i>	Laelapidae	incidental, phoretic	Asia
<i>Apis koschevnikovi</i>	<i>V. rinderer</i> *	Varroidae	obligatory, parasitic	Borneo, Indonesia
<i>Apis mellifera</i>	<i>V. jacobsoni</i>	Varroidae	obligatory, parasitic	Asia, Africa, America, Europe
	<i>E. sinhai</i>	Varroidae	incidental, phoretic	Asia
	<i>T. clareae</i>	Laelapidae	obligatory, parasitic	Asia
Acariformes - Astigmata				
<i>Apis mellifera</i>	<i>Acarapis woodi</i>	Tarsonemidae	obligatory, parasitic	almost cosmopolitan, including Asia, but is not yet found in Thailand.
	<i>A. dorsalis</i>	Tarsonemidae	obligatory, parasitic	
	<i>A. externus</i>	Tarsonemidae	obligatory, parasitic	
<i>Apis cerana</i>	<i>A. woodi</i>	Tarsonemidae	obligatory, parasitic	

*de Guzman and Delfinado-Baker, 1996.

standpoint, *V. jacobsoni* is the most destructive and, hence, is of the greatest economic importance to beekeepers. However, *T. clareae* has come to be a more serious pest of *A. mellifera* than *V. jacobsoni* in Southeast Asia. When the two species are found in the same *A. mellifera* colony, *T. clareae* outnumber *V. jacobsoni* by several times (Burget *et al.* 1983, Wongsiri 1989). That appears to be explained by the rate of reproduction of *T. clareae*, which is much more rapid than that of *V. jacobsoni*. Adult females of *V. jacobsoni* feed on the hemolymph of their adult phoretic hosts and can survive low brood periods

during the rainy season and then increase reproduction again when the drone brood is present. In contrast, phoretic *T. clareae* do not feed on the adult host and can survive only 3-4 days without access to brood (Woyke 1984, Rinderer *et al.* 1994). Thus, *T. clareae* spends only short periods of time on adult honey bees. Perhaps a mechanism exists that allows mites to attach to foraging bees and shift to bees from different colonies at foraging sites. There may be physiological responses that permit *T. clareae* to attach to migrating *A. dorsata* and survive over the long periods required to follow such migrations

Table 2. Comparison of survival rates of parasitic mites in cage experiments

Hosts	Survival rates of mites					reference
	<i>A. andreniformis</i>	<i>A. florea</i>	<i>A. dorsata</i>	<i>A. cerana</i>	<i>A. mellifera</i>	
Parasitic Mites on Adult Workers						
<i>E. sinhai</i>		70% (24hrs)		8%	63%	Koeniger <i>et al.</i> 1993
<i>T. clareae</i>	5% (12 hrs)	8% (12 hrs)	80%	31%	69%	Rinderer <i>et al.</i> 1994, Lekprayoon <i>et al.</i> 1994
<i>V. jacobsoni</i>				63%(1 hr)	73%(1 hr)	Wongiri <i>et al.</i> 1993

(Ruttner 1988, Rinderer *et al.* 1994). The survival of mites in our study, whether on *A. mellifera* or *A. dorsata*, is about one day longer than previously reported (Woyke 1984, Rinderer *et al.* 1994). Perhaps still longer periods of survival occur under other conditions. In any event, it is clear that the highly pestiferous *T. clareae* could easily survive even the longest of international airline flights. The recent discovery of the mite in Africa (Kumar *et al.* 1993), suggests that such an event has occurred.

When *V. jacobsoni* and *T. clareae* reproduce on their own original hosts they feed only on drone brood (Wongsiri and Tangkanasing 1989, Rath 1993) and are seldom found in worker brood cells. We found a resistance mechanism in Asian honey bees, *A. cerana* and the giant honey bee, *A. dorsata*, to their ectoparasitic mites (Peng *et al.* 1987, Wongsiri *et al.* 1987, Wongsiri 1988, Wongsiri and Tangkanasing 1989). Trouiller *et al.* (1993) showed that the kairomones from the cuticle of drone larvae were much more attractive to *V. jacobsoni* than kairomones of worker larvae. This could explain the preference of these mites for only the drone brood. The fact that neither of these mites are significant pests of their own native hosts may be an evolved mutualism and coevolution (OConnor 1988), that results in the mites killing the drones but not the workers. This may even be advantageous, since the tropical climates of Southeast Asia lack the cold temperature that kill drones. Drones are killed in the *A. mellifera* colonies in temperate climates by cold weather.

We also observed the cleaning behavior of *A. mellifera*, *A. cerana*, *A. dorsata*, *A. florea* and *A. andreniformis* toward different kinds of mites (Table 2) (Wongsiri and Tangkanasing 1989, Koeniger *et al.* 1993, Rinderer *et al.* 1994, Lekprayoon *et al.* 1994). These reports show that most mites are restricted to their own hosts except for *A. mellifera*, which is susceptible to *V. jacobsoni* and *T. clareae*. Perhaps the kairomones from

foreign bees are more attractive than their own species. However, *A. mellifera* also has a much lower frequency of cleaning behavior against mites than the other bees.

Population genetic analysis and subspecific hybridization between populations of *A. mellifera* have been reported by Rinderer and Oldroyd (1993). DNA analysis of *A. cerana* (Sylvester and Wongsiri 1993) and *A. florea* (Oldroyd *et al.* 1994) but no analysis of genetic variation in most of the parasitic bee mites has been reported. Transposable elements in *Drosophila* genes transferred by the mite *Proctolaelaps regalis* has been studied by Houck *et al.* (1991). Such transfer might be a long-term solution to the control of external parasitic mites in *A. mellifera*. The most promising avenue is the transfer of the behavioral and physiological resistance adaptations of Asian honey bees to *A. mellifera*. There are two major obstacles to such a transfer. First, we have no knowledge of the genetic basis in Asian honey bees of mite resistance. Obtaining such understanding will be labor intensive. Second, the technology to transfer these traits in honey bees is not yet available.

SUMMARY

The biodiversity of parasitic honey bee mites in Southeast Asia is an undervalued and neglected resource, both from a biologic and economic view, especially as it is related to honey bees as pollinators. On a global scale, the rate of species loss due to human disturbance is at least 1,000 times greater than the natural background rate. Southeast Asia's commercial forests were once of great economic importance, and would not now be depleted if we knew enough about the million or more wild bee colonies lost due to fire and the timber industry. All *A. andreniformis*, *A. florea*, *A. dorsata*, *A. cerana* and *A. koschevnikovi* live in the forest. Due to a lack of proper knowledge, the

alarmingly high losses of *A. andreniformis* due to human disturbance, and of biodiversity at all levels make it imperative to study these bees.

Southeast Asia is the center of honey bee-mite diversity. All six of their host species in the genus *Apis* are found here. Curiously, the most studied and economically exploited honey bee, *A. mellifera*, is an "exotic" species recently imported to Southeast Asia. The ranges for *A. cerana*, *A. dorsata*, *A. florea*, *A. andreniformis* and *A. koschevnikovi* are only partially known. A long evolutionary history of honey bees in Southeast Asia favor conditions for the evolution of the diverse set of diseases, pests, and parasitic mites of honey bees. Thus, Southeast Asia is an ideal place for studies of the biodiversity and control of these problems under conditions that existed before their appearance elsewhere in the world.

In conclusion, the association between parasitic mites and honey bees offers great opportunities for evolutionary studies. Many of the examples cited as mechanisms

of resistance demonstrate the scientific rewards to be gained through the collaborative study by acarologists with bee scientists. These observations form the basis for our knowledge of the ecology and nature of the relationship between mites and bees. Similarly, taxonomists should be encouraged to discover the new species of bee mites and formulate hypotheses of evolutionary relationships among mite taxa and bees.

ACKNOWLEDGMENTS

We thank the Research Affairs Division, Chulalongkorn University for funding this research. Sincere thanks are extended to Prof. Dr. Pensri Tangkanasing of the Bee Biology Research Unit, Chulalongkorn University and Dr. Mercedes Delfinado-Baker, Systematic Entomology Laboratory, ARS-USDA, Beltsville, Maryland for reviewing and discussing this manuscript.

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