CHAPTER 7

General conclusions

Varroa destructor and *Tropilaelaps mercedesae* are parasitic brood mites infesting both *Apis cerana* and *Apis dorsata* the adapted host and *Apis mellifera*, the non-adapted host and are the most serious problems to commercial beekeeping in Thailand. Knowledge of the prevalence and fecundity of both mites species related to seasonality will benefit beekeeping and honey bee management throughout Southeast Asia.

Traditional Thai beekeeping before the later part of the 20th century, utilized *A. cerana*, the eastern hive bee. In addition to beekeeping, defined as the management of honey bee colonies, the native giant honey bee (*A. dorsata*) and indigenous dwarf honey bee species (*A. florea* and *A. andreniformis*) have been historically 'hunted' throughout their Asian biogeographical ranges. Beginning in the early 1980s numerous introductions of the western honey bee (*A. mellifera*) into Thailand began with a major objective of the development of a beekeeping industry based on this exotic species. These multi-agency efforts have proven commercially successful. Most *A. mellifera* beekeeping in Thailand is based in the Northern provinces, largely due to the production of several tropical fruit crops (especially longan and lychee) in the region. The introduction of *A. mellifera* into Southeast Asia meant that this honey bee species is now sympatric with two indigenous honey bee species, *A. dorsata* and *A. cerana*, and their associated brood parasites. Both brood mite genera (*Tropilaelaps* spp. and *Varroa* spp.) have been able to utilize *A. mellifera* as a competent host species.

Most past research on *Tropilaelaps* parasitism has focused on the mite utilizing the non-adapted host, *A. mellifera*. Another fruitful research approach is to investigate the parasite/host relationship looking at the adapted host, *i.e.*, the giant honey bee *A. dorsata*. It is known that when parasitizing both *A. mellifera* and *A. dorsata*, *Tropilaelaps* will infest both host brood genders (worker and drone b). I asked the question that when parasitizing its adapted host (*A. dorsata*), does *Tropilaelaps* exhibit a gender preference? The research findings (Buawangpong et al., 2013) demonstrate that there is no host gender preference and when infesting worker brood, the parasite does show a higher prevalence rate and a higher fecundity than in drone brood of *A. dorsata*.

Giant honey bee species are unique in that worker brood and drone brood are reared in the same sized cell. I initiated a study to examine the brood cell size for *A. dorsata* and the proportion of comb that is used to rear brood (Buawangpong et al., in press). This study found that the majority of the comb area is used for brood rearing (82.7%) with the remaining area used for food storage (honey and pollen). It was also shown that while brood cells are generally uniform in volume and diameter, the cell diameters range from 5.1-6.1 mm (average 5.54 mm) which is in agreement with previous findings. One report (Tan, 2007) hypothesizes that there is a demonstrable difference between the cells' diameters used to rear workers *vs*. drones. My work does not dispute that finding, but suggests that because there is a range of 19.6% between the smallest cells and largest brood cell diameters, cells larger than 5.6 mm are used to produce drones, but that workers are reared in cells throughout the size range. Comb cells used for honey storage are consistently wider than brood cells 6.25 mm *vs*. 5.54 mm), with the depth of honey storage cells displaying great variability.

I studied the seasonal fluctuations in the population dynamics of both *V. destructor* and *T. mercedesae* in *A. mellifera* colonies in Chiang Mai, Thailand in September 2011to September 2012. The overall results show similar phenological pattern of prevalence for both mite species. My study found *T. mercedesae* to exhibit a higher prevalence rate overall (76%) compared to *V. destructor* (24%) for the year. However, based on the data from individual months, the infestation rates for both mite species were not significantly different in January, February, April, May, June, July and August. For the months of September (2011 and 2012), October, November and December (2011) *T. mercedesae* infestations were statistically higher than those of *V. destructor*. The highest infestations for both mite species were found on September 2012. *V. destructor* prevalence never exceeded 5% in any month of observation. *T. mercedesae* prevalence exceeded 5% only in September (2011 and 2012) and October

(2011). A correlation between brood area (cm^2) and mite infestations was observed. There was a significant negative correlation (r = -0.248; P=0.0007) between brood area (cm^2) and *Tropilaelaps* infestation. However, no correlation between brood area (cm^2) and *Varroa* infestation was detected.

Concerning fecundity, both mite species produced similar numbers of progeny per infested host brood (*T. mercedesae* = 1.48 ± 0.05; *V. destructor* = 1.69 ± 0.14 progeny per foundress). There was however, a marked difference between species in the proportion of reproductive vs. non-reproductive foundress mites. About 70% of foundress *T. mercedesae* mites successfully reproduced as compared to 50% of *V. destructor* foundresses when infesting *A. mellifera* worker brood hosts. Thus, the overall population increase of *T. mercedesae* in *A. mellifera* worker brood will be greater than that for *V. destructor,* which adds further evidence as to why *T. mercedesae* populations most often surpass *V. destructor* when utilizing the non-adapted host, *A. mellifera*.

From a sample of 506 *A. mellifera* drone brood, it was observed that *V. destructor* prevalence was higher than *T. mercedesae*. Previous research has shown *V. destructor* to display a preference for drone brood (Issa and Goncalves, 1984). In contrast, *T. mercedesae* does not exhibit a brood gender preference when infesting *A. dorsata*, its adapted host species. Therefore, my observation that *V. destructor* is the more commonly encountered mite species when infested *A. mellifera* drone hosts does not detract from my observations of *T. mercedesae* dominance when infesting worker brood.

The concurrent infestation of a single worker brood cell by both mite species is very rare (<0.1%) under the natural conditions of this experimentation. And while a rare occurrence, the reproductive success of co-infested *A. mellifera* worker brood cells by *V. destructor* and *T. mercedesae* is an interesting ecological question. To compare the reproductive potential of both mite species when co-infesting the same brood host, a series of *A. mellifera* worker brood were deliberately co-infested *V. destructor* produced significantly more progeny per foundress than *T. mercedesae* under the these conditions. Why such low co-infestations occur *in vivo* is an unresolved question.

In this study, I found only the *V. destructor* K1 haplotype infesting *A. mellifera* worker brood. K1 is the most commonly encountered haplotype on a worldwide basis. From a previous study, Anderson and Trueman (2000), did not find K1 infesting *A. cerana*. My results reveal the K1 haplotype to be reproductively successful when infesting *A. cerana* worker brood, however at a lower prevalence than observed on *A. mellifera* worker brood. My limited data for *Varroa* prevalence for *A. mellifera* and *A. cerana* drone brood, showed that the K1 haplotype is capable of infesting *A. cerana* drone brood at a lower prevalence compare to *A. mellifera* drone brood. Moreover, the *V. jacobsoni* NThai haplotype did not reproduce in *A. mellifera* worker brood but did reproduce on *A. cerana* worker brood however at a reduced prevalence rate

Tropilaelaps spp. and *Varroa* spp., show similar effects to their non-adapted honey bee host, *A. mellifera*. *Tropilaelaps* spp. is presently limited to the natural geographic range in tropical and sub-tropical zones of Asia (with the exception of the Korean peninsula) where this species is responsible for very significant economic losses. As shown in past research with physiological effects of Varroa parasitism on host brood, I examined the parameter of brood weight loss coincident with *T. mercedesae* infestations for *A. mellifera* brood. Results demonstrate a decreasing average weight for *A. mellifera* brood during developmental time. These results show that infested drone brood experiences a 17.6% weight loss relative to uninfested drone brood. Overall, *T. mercedesae* infested *A. mellifera* worker brood also show a significant difference in weight between infested and uninfested bees but not consistent for all stages..

This thesis reveals previously unknown aspects of *V. destructor* and *T. mercedesae* parasitism of the non-adapted honey bee host, *A. mellifera*. My observations will be useful for the development of revised *A. mellifera* management techniques targeting honey bee acarine brood parasites. Beekeeping in Thailand is currently heavily dependent on the use of acaricides as the principal tool to lessen the impacts of brood mite parasitism, often resulting in the development of acaricidal resistance. An ultimate goal for mite management is the reduction of agrochemicals and a move towards increased non-pesticidal techniques.