Infestation of Tracheal Mites (Acari: Tarsonemidae) in Feral and Managed Colonies of Honey Bees (Hymenoptera: Apidae)

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ABSTRACT We tested a population dynamics model that predicts that swarming of honey bees, *Apis mellifera* L., is a regulatory process of tracheal mites, *Acarapis woodi* (Rennie), parasitism. If the model is correct, then feral colonies that are free to swarm should have fewer numbers of infested worker bees, infested workers should have fewer numbers of mites, and fewer feral colonies should be infested than colonies in beeyards that are prevented from swarming by beekeeping techniques. We found that this situation occurred in the Willamette Valley, OR.

KEY WORDS tracheal mite, honey bee, parasitism

TRACHEAL MITES (*Acarapis woodi* [Rennie]) were first detected in the United States in 1984 (Delfinado-Baker 1984), in Oregon in 1985, and have had an important economic effect ever since. Nearly all beekeepers now must contend with this parasite. The mites cause mortality of honey bee (*Apis mellifera* L.) workers (Royce & Rossignol 1990a) and may result in colony loss, especially during winter (Eischen 1987, Eischen et al. 1989, Otis & Scott-Dupree 1992). Royce & Rossignol (1990b) recently reviewed the epidemiology of mite parasitism of honey bees.

A recent theoretical and experimental study of the population dynamics of the host–parasite relationship suggests that swarming plays a dual, albeit contrary, role in the transmission of tracheal mites (Royce et al. 1991). Swarming naturally regulates mite population density within a colony, but along with drift (inadvertent movement of worker bees from colony to colony), it also represents a dispersal mechanism for infested colonies. Interference with this delicate balance by present-day beekeeping, especially the use of the Langstroth movable frame hive in crowded beeyards, may explain the pathology of tracheal mite infestation in managed honey bee colonies in the United States. Typical management involves the reduction of swarming and a potential increase in drift in crowded apiaries.

If premises of the model are correct, then unmanaged feral colonies should have a lower mite load per worker bee (mean number of mites per worker bee) as well as lower intercolony and intracolony prevalence (proportion of infested colonies in a population of colonies and proportion of infected bees within a colony, respectively) compared with managed colonies. Here

we report support for this hypothesis. Our results further implicate modern beekeeping techniques in morbidity associated with tracheal mite parasitism.

Materials and Methods

Wild colonies were located within 50 km of Corvallis, OR. The location of wild colonies does not reflect a difference in densities but rather local cooperation. Managed colonies, both commercial (operations = 2; samples = 19) and "hobbyist" (operations = 6; samples = 15) beekeeping operations, were sampled from the same areas in which wild colonies were found. Hobbyist beekeeping operations usually comprised one or two colonies near a home and generally started from "package" bees obtained from California. Commercial beekeeping operations consisted of several colonies and belonged to beekeepers who pollinate crops within the Willamette Valley and move colonies to California in February each year for almond pollination.

Samples were collected with a sweep net at the colony entrance; the bees were anesthetized with CO_2 and placed on ice for transport to the laboratory, where they were frozen until they could be dissected. A sample size of 100 to 300 bees per colony was used to measure prevalence and load. Honey bees were dissected at $50\times$ magnification, and a subsample of 10 infested bees was taken. For this subsample, we removed the infested thoracic tracheae, teased them open, and counted all the mites within (Royce & Rossignol 1990a). Collections were made from May to September 1990. χ^2 analysis was used to

Table 1. Mite prevalence classes (expressed as percentage of colonies) in managed and feral colonies

Colonies	Intracolony mite prevalence (% of workers infested)			
	<1%	1–10%	11–20%	>20%
Managed	18	52	12	18
Feral	60	19	6	15

compare numbers of mites in wild versus feral colonies.

Results

The prevalence of feral colonies infested with tracheal mites (43%, $n = 52$) in this study was half that in managed colonies (85%, $n = 34$). A hypothesis of equality (on the number of colonies) was therefore rejected ($\chi^2 = 23.1$, df = 1, $P < 0.005$).

We then compared the intracolony mite prevalence of feral and managed colonies as a whole. Within the feral colonies, most colonies had <1% of the workers infested, with the next largest proportion of colonies having between 1 and 10% of the workers infested; few colonies had between 11 and 20% or >20% of the workers infested. Managed colonies overall had higher prevalence (Table 1). The results were again significantly different ($\chi^2 = 27.4$, df = 3, $P < 0.005$).

A similar trend was also noted when we compared the distribution of parasite load on worker bees in feral and managed colonies. Within feral colonies, most colonies had <1 mite per worker (Table 2). Most managed colonies had low (<1) or medium (1–2.9) mite loads. We noted a highly significant difference in mite load between feral and managed colonies ($\chi^2 = 122.3$; df = 3; $P < 0.005$).

Discussion

Our sample of a large number of feral and managed colonies in the Willamette Valley, OR, indicated that feral honey bee colonies have fewer tracheal mites per worker bee than managed colonies. Feral colonies also have fewer infested worker bees within colonies, and fewer feral colonies are infested. We postulate that such low numbers per workers and low intracolony prevalence in feral colonies are the direct result of swarming, as predicted by our model. Low prevalence in the feral colony population is

an indirect consequence of swarming, resulting from a combination of a decreased chance of acquisition caused by drifting, isolation of feral colonies, and an increased chance of recovery. Recovery is defined as loss of mite infestation at the time of swarming (Royce et al. 1991); such recovery is more likely to occur when number of mites per workers is low. It should be noted that recovery is a model postulate (Royce et al. 1991) and has not been demonstrated.

These results provide further support of a model stating that, under natural conditions, tracheal mite parasitism in a colony is largely self-regulatory (Royce et al. 1991). In a previous experiment, infested colonies were split, requeened, and either allowed to resume or delayed in their brood rearing; the last treatments had a lower mite load, but similar prevalence, in worker bees (Royce et al. 1991). Mites require young bees as hosts (Gary et al. 1989); reduction in mite load thus arises because of a 2-wk-long interruption in brood laying that occurs before and after swarming (Winston 1987). Paradoxically, swarming may be the principal method of intercolony transmission of mites, analogous to transovarial transmission in other pathogen–host relationships. The other means of tracheal mite dispersal, drift of bees between colonies, is undoubtedly much lower in feral colonies than in managed colonies, and swarming is of relatively more importance, although the comparative contributions of swarming and particularly drift remain unknown.

The mites have had >5 yr to spread from managed colonies to wild colonies in Oregon. The situation in the Willamette Valley is therefore probably typical, although a test in a different region must eventually be done. Managed colonies in our samples may have been treated with menthol. We were unable to monitor its use, and its impact would in any case make our results conservative.

This study further contributes to the understanding of tracheal mite population dynamics by providing data that fit a theoretical model previously developed. The model demonstrated that intercolony transmission could be stable only if intracolony regulation occurred. Previous experiments using specific hypotheses derived from the model suggested that swarming could be this regulatory mechanism (Royce et al. 1991). This study reached the same conclusion. We consider the model to be an example of the way that theoretical biology can make direct contributions to pest management.

Table 2. Mite load classes (expressed as percentage of colonies) in managed and feral colonies

Colonies	Mite load (mean no. mites per worker)			
	<1	1–2.9	3–4.5	≧5
Managed	53	32	9	6
Feral	79	2	2	17

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