Russian Honey Bee (Hymenoptera: Apidae) Colonies: *Acarapis woodi* (Acari: Tarsonemidae) Infestations and Overwintering Survival

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ABSTRACT Honey bee, *Apis mellifera* L. (Hymenoptera: Apidae), colonies infested by parasitic mites are more prone to suffer from a variety of stresses, including cold temperature. We evaluated the overwintering ability of candidate breeder lines of Russian honey bees, most of which are resistant to both *Varroa destructor* Anderson & Trueman and *Acarapis woodi* (Rennie), during 1999–2001. Our results indicate that Russian honey bee colonies (headed by original and supersedure queens) can successfully overwinter in the north, even during adverse weather conditions, owing to their frugal use of food stores and their resistance to tracheal mite infestations. In contrast, colonies of Italian honey bees consumed more food, had more mites, and lost more adult bees than Russian honey bees, even during unusually mild winter conditions.

KEY WORDS Russian honey bees, Italian honey bees, overwinter, *Acarapis woodi*, tracheal mites

TRACHEAL MITES, *Acarapis woodi* (Rennie), remain a serious problem for the U.S. beekeeping industry because of their catastrophic effects on overwintering honey bee colonies. In the Pacific Northwest, bee colony losses of ≈31% were observed during winter 1988 and early spring 1989 because of high levels of tracheal mites (Burgett and Stringer 1989). Similar results were observed in Pennsylvania in 1989 (Frazier et al. 1994). A higher winter mortality of 25–85% was observed in the northeastern United States during the 1995–1996 season (Finley et al. 1996). The authors claimed that this increase in colony losses was caused by varroa and tracheal mites and also by secondary infections as a consequence of feeding by the parasitic mites.

Tracheal mites can harm honey bees in mild climates. For years, parasitism by tracheal mites has been thought to have minimal consequences to honey bee colonies in regions where winter is mild. However, de Guzman et al. (2001a) showed that susceptible stocks can suffer harmful effects of tracheal mites in the mild winter conditions of southern Louisiana. The authors observed serious losses (≥50%) of overwintering Italian honey bee colonies. Surviving Italian colonies were too small to be able to build up in spring to sizes that could be divided (de Guzman et al. 2001a). In contrast, tracheal mite-resistant Russian honey bee colonies that were maintained in the same locations suffered only minor mortality and developed into sufficiently large colonies in spring that could be divided. Importantly, their study underlines the importance of genotype in affecting the abundance of tracheal mites in honey bee colonies.

Environment does play a role in determining the growth of tracheal mite populations in honey bee colonies. Previous studies showed that colonies of Italian stock (from the same source and bought at the same time), which suffered from a strong growth of tracheal mite populations in Iowa and Louisiana during the summer were not subjected to any growth of tracheal mite populations in Mississippi (de Guzman et al. 2001b). These observations suggest that environmental as well as genetic factors affect the abundance of tracheal mites in honey bee colonies. The exact environmental conditions in Mississippi that prevented the development of tracheal mite populations are not known.

Synergistic interaction between varroa and tracheal mites had been reported by Downey and Winston (2001). Hence, resistance to both parasites may be a key factor to effectively minimize losses of bee colonies especially where winter can be harsh. Russian honey bees are known to have significant resistance to tracheal mites (de Guzman et al. 2001a, b, 2002) and to varroa mites (Rinderer et al. 2000, 2001). To address a growing concern of beekeepers about the difficulty of overwintering bees in cooler parts of the United States because of parasitic mites, we evaluated various lines of Russian honey bees for different characteristics such as food consumption, bee population, and tracheal mite infestations as well as their winter survival.

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Materials and Methods

Colony Setup. *Winter 1999–2000.* The overwintering ability of Russian honey bees was compared with Italian honey bee colonies commercially available in the United States. Established queen-right colonies of both Russian and Italian honey bee stocks from the 1999 stock evaluation trial (Rinderer et al. 2001) near Cresco, IA, were used in this experiment. The colonies were divided between two sites. There were 13 Russian and 16 Italian colonies in site 1 and 13 Russian and 17 Italian colonies in site 2. Of these, 18 Russian colonies (nine colonies for each site) and 19 Italian (10 for site 1 and nine for site 2) were placed individually onto weighing scales (load cells) to monitor colony weight change from November 1999 to April 2000. For each site, individual scales were connected to a centralized switchboard with 24 channels. Colonies were equalized for the amount of honey available for each colony. In September 1999, all colonies were fed with ≈1 gal. of 95% high fructose corn syrup (Type 55, Mann Lake Ltd., Hackensack, MN). Thereafter, no additional food was provided. In November 1999, each colony was packed for winter by using cardboard winter wrap cartons with styrofoam on top of the inner cover. An upper entrance hole was provided for each colony. All colonies were treated with antibiotics (Tetra-B, Dadant and Sons, Inc., Hamilton, IL), Fumidil-B (Medivet, Highriver, Alberta, Canada), and one strip of Apistan (Wellmark International, Schaumburg, IL) to control varroa mites in November 1999. A bag of rat poison (Enforcer Products, Inc., Cartersville, GA) also was placed under each hive.

Colony weight change was estimated by subtracting the final weight of each colony recorded on 17 April 2000 from its initial weight on 10 November 1999. Adult bee populations were estimated as described by Burgett and Burikam (1985), which visually estimated the percentage of adult bees occupying a comb.

Winter 2000–2001. A total of 176 queen-right colonies from the 2000 multistate evaluation of 10 different Russian queen lines (Rinderer et al. 2001) were used in this study. (Only some of these lines were retained in the Russian honey bee breeding program. Others were discarded because they displayed some tracheal mite susceptibility in this and other tests.) In Cresco, 63 colonies were divided between two sites, three sites were used for 57 colonies in Henderson, LA, and three sites were used for 56 colonies in Webb, MS. Colonies in Iowa and Louisiana were on individual bottom boards, whereas colonies in Mississippi were on pallets. Test colonies were either headed by original Russian (OR) or supersedure Russian (SR) queens.

Colonies in Iowa and Mississippi received no chemical treatment. In Louisiana, CheckMite+ (Bayer Corporation, Kansas City, MO) treatment was used in August 2000 because of high varroa mite infestations. These colonies started as highly infested divisions in April 2000 for varroa mite research (Rinderer et al. 2001). Iowa colonies were fed with diluted high fructose corn syrup and then packed using black cardboard boxes as described above. Colonies in Mississippi and Louisiana were not packed for the winter.

In Iowa, 40 colonies were positioned individually onto load cells to monitor colony weights. However, colony weight measurements were halted because of apiary inaccessibility caused by heavy snowfall. Initial adult bee population was estimated as described by Burgett and Burikam (1985), which visually estimated the percentage of adult bees occupying a comb. The amount of brood was estimated using the method of Rogers et al. (1983), which visually estimated the percentage of the total comb area covered by capped brood. Because of cold weather, cluster size was estimated by counting the number of frames covered by adult bees in March 2001. The numbers of frames with brood and covered by adult bees were recorded in May 2001. At the end of the experiment, all broodless colonies with two frames or less of adult bees with or without queens were considered dead.

Tracheal Mite Dissection. *A. woodi* prevalence (proportion of adult workers infested) and mite intensity (number of mites per infested bee) were determined by dissecting 30 bees per colony subsampled from 300 to 500 bees. Examination of bees was done using thoracic dissection (Lorenzen and Gary 1986). Infested tracheae were pulled and placed on a glass slide with double-sided tape. The tracheae were then dissected and individual tracheal mites were counted.

For winter 1999–2000, tracheal mite infestations were recorded from September to November 1999 before the colonies were packed for the winter and from March to April 2000 when temperature permitted the sampling of colonies. For 2000–2001, sampling was done in August and November 2000 and in March and May 2001. All surviving colonies from Iowa and Mississippi were sampled at the end of the experiment. In Louisiana, a total of 25 colonies were randomly sampled (7–10 colonies per site) at the end of the experiment.

Weather Data. Weather information was obtained from the Weather Underground Web site (http://weatherunderground.com); the Decorah station for Iowa, the Lafayette station for Louisiana, and the Greenwood station for Mississippi.

Data Analyses. Analysis of variance (ANOVA) for repeated measures using PROC MIXED (SAS Institute 2001) evaluated the effects of honey bee type and sampling month on the prevalence and intensity of tracheal mites. A two-way factorial ANOVA was used regarding data on colony weight change (final − initial weight), and bee population with bee type and site modeled as fixed effects and colony within type by site as random effects. Before analyses, data for mite prevalence were transformed using arcsine transformation, and square-root transformation was used to transform data on mite intensity, colony weight change, and numbers of brood and adult frames. Degrees of freedom were estimated using the Kenward–Roger method (SAS Institute 2001).

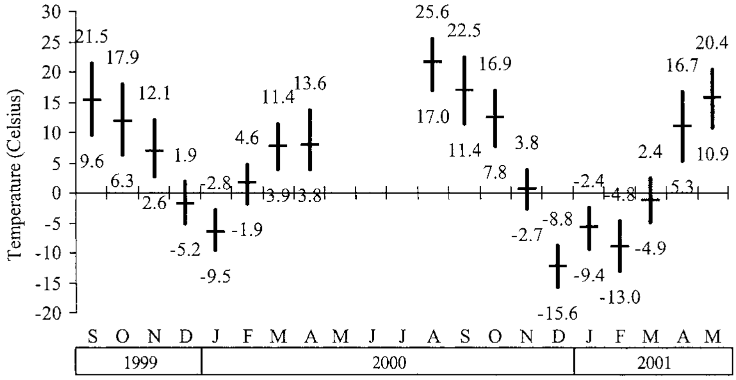

Fig. 1. Monthly maximum, mean, and minimum temperatures (°C) for Decorah, IA (≈20 miles away from the apiary sites) from September 1999 to May 2001.

Results

Winter 1999–2000. Winter in Iowa was relatively mild and short in 1999–2000 (Fig. 1).

Tracheal Mite Infestation. *Prevalence.* The proportion of bees infested was monitored from September 1999 to April 2000. No significant interaction between bee type and sampling month ($F = 1.12$; df = 4, 52.6; $P = 0.358$) was detected (Table 1). However, tracheal mite infestations were significantly ($F = 5.98$; df = 4, 52.6; $P = 0.0005$) different among the sampling months. The highest infestation was observed in April 2000, and the lowest infestations were recorded from September to November 1999. The Russian bees had significantly ($F = 6.5$; df = 1, 57.7; $P = 0.014$) lower infestation than the Italian colonies. Overall, an increase in infestation [(final infestation − initial infestation)/initial infestation] was observed in both stocks. However, no differences ($F = 0.01$; df = 1, 48; $P = 0.921$) were found, with the Russian bees having a 2.5 ± 1.34-fold-increase compared with 3.17 ± 1.3-fold-increase in the Italian colonies.

Table 1. Mean infestation levels (mean ± SE) of tracheal mites in Italian and Russian honey bee colonies during winter 1999–2000 in Iowa

Date	Honey bee type		Mean
	Domestic	Russian	
Prevalence			
Sept. 1999	25.42 ± 4.04	8.46 ± 4.39	16.94 ± 2.99c
Oct. 1999	24.06 ± 3.55	9.21 ± 3.86	16.64 ± 2.62c
Nov. 1999	24.30 ± 3.77	10.0 ± 4.09	17.15 ± 2.78c
Mar. 2000	27.71 ± 4.53	13.29 ± 4.89	20.50 ± 3.33b
April 2000	36.82 ± 5.06	15.07 ± 5.44	25.94 ± 3.71a
Mean	27.66 ± 4.0a	11.21 ± 4.35b	
Intensity			
Sept. 1999	11.23 ± 1.55	6.30 ± 1.68	8.77 ± 1.14c
Oct. 1999	17.74 ± 2.39	15.81 ± 2.59	16.77 ± 1.76a
Nov. 1999	15.55 ± 2.16	10.87 ± 2.35	13.21 ± 1.60b
Mar. 2000	11.84 ± 1.76	10.18 ± 1.83	11.01 ± 1.27b
April 2000	13.94 ± 1.76	10.84 ± 1.82	12.39 ± 1.27b
Mean[a]	14.06 ± 1.39	10.80 ± 1.50	

Numbers within a column and row followed by the same letters are not significantly different ($P > 0.05$).

[a] Not significant ($P > 0.05$).

Mite Intensity. No significant interaction between bee type and sampling month ($F = 0.57$; df = 4, 54.8; $P = 0.682$) was detected (Table 1). However, significant ($F = 4.95$; df = 4, 54.8; $P = 0.002$) differences among sampling months were observed with the highest mite intensity recorded in October 1999. The lowest mite load was observed in September 1999. Both stocks had similar ($F = 1.82$; df = 1, 56.6; $P = 0.183$) numbers of mites per infested bee. Likewise, an increase in mite intensity was noted. However, both stocks supported comparable ($F = 0.01$; df = 1, 45; $P = 0.919$) fold-increase in mite load with a mean increase of 2.96 ± 1.13 and 3.24 ± 1.18 for the Italian and Russian bees, respectively.

Colony Weight Change. No significant interaction between bee type and site was observed ($F = 0.00$; df = 1, 36; $P = 0.980$). Colonies in both sites also showed no significant ($F = 2.35$; df = 1, 36; $P = 0.134$) differences in weight change, with an average loss of 5.01 ± 0.34 and 5.75 ± 0.34 kg for colonies located in sites 1 and 2, respectively. However, significant ($F = 38.08$; df = 1, 36; $P < 0.0001$) differences between stocks were detected. After 21 wk, the Italian colonies lost ≈6.82 ± 0.34 kg, whereas the Russian colonies lost only an average of 3.93 ± 0.34 kg.

Bee Population. Analysis on the number of adult bees in September 1999, showed no significant interaction between stock and site ($F = 0.55$; df = 1, 33; $P = 0.465$). No site effect ($F = 0.62$; df = 1, 33; $P = 0.437$) was detected, with a mean of 14,363 ± 1,246 and 15,406 ± 946 bees for sites 1 and 2, respectively. However, the Italian bee colonies (18,215 ± 759 bees) were significantly ($F = 13.64$; df = 1, 33; $P = 0.0008$) bigger than the Russian bee colonies (11,078 ± 683 bees) at the beginning of the experiment. In April 2000, no interaction between stock and site ($F = 0.01$; df = 1, 30; $P = 0.940$) was observed regarding the number of adult bees in the colonies. Likewise, colonies in site 1 (6,455 ± 517 bees) had similar ($F = 0.00$; df = 1, 30; $P = 0.960$) numbers of bees as those colonies located in site 2 (6,278 ± 453 bees). Both stocks had comparable ($F = 0.24$; df = 1, 30; $P = 0.628$) numbers of adult bees with the Italian bees having a mean of 6,986 ± 477 bees and the Russian colonies an average of 5,805 ± 445 bees. Despite having equal colony strength at the end of the experiment, the Italian colonies significantly (t-test, df = 32, $P < 0.0001$) lost ≈66% of their initial population compared with 45% in the Russian colonies.

Winter Mortality. Colony mortality was very similar (Fisher's exact test, n = 61, P = 0.363) between the two stocks. Only five colonies (one Russian [4%] and four Italian [12%] colonies) died between March and April 2000. Tracheal mite infestations of these colonies before their death were very high (one Russian, 43%; four Italian, 60, 77, 77, and 100%). Approximately 50% (14 of 29) of the surviving Italian colonies had >20% (23–83%) tracheal mite infestations, whereas only 19% (five of 27) of the Russian colonies had high (27–60%) levels of infestation.

Winter 2000–2001. Winter was unusually cold and long during 2000–2001. Heavy snow started falling early (November 2000) and frequent snowstorms occurred for ≈4 mo in Iowa (Fig. 1).

Iowa. Sixty-three colonies (42 OR and 21 SR) were evaluated throughout the winter. No significant interaction between site and stock was detected for both the number of adult bees (F = 0.00; df = 1, 50; P = 0.999) and amount of brood (F = 1.02; df = 1, 50; P = 0.316) in August 2000. Initially, OR and SR colonies had similar (F = 0.00; df = 1, 50; P = 0.996) adult bee population with a mean of 33,721 ± 1,450 and 26,411 ± 2,551 bees, respectively. The amount of brood for OR (45,570 ± 2,481 cells) and SR (39,414 ± 3,951 cells) bees was also similar (F = 3.22; df = 1, 50; P = 0.079) during this month. Likewise, no significant differences between the two sites were detected for both the number of bees (F = 0.00; df = 1, 50; P = 0.9995) and the amount of brood (F = 0.08; df = 1, 50; P = 0.779) in August 2000. Colonies in site 1 had an average of 29,053 ± 1,595 bees and 42,733 ± 3153 brood cells, whereas site 2 had 31,080 ± 2,288 bees and 42,252 ± 3,444 brood cells.

In March 2001, the analysis on cluster size also showed no interaction between site and stock (F = 2.38; df = 1, 57; P = 0.128). No stock differences (F = 0.18; df = 1, 57; P = 0.671) were detected, with an average of 4.3 ± 0.26 and 4.6 ± 0.39 frames for OR and SR, respectively. However, there were significant (F = 41.61; df = 1, 57; $P < 0.0001$) differences between the two sites, with site 2 colonies (5.99 ± 0.33 frames) having bigger cluster sizes than those colonies located in site 1 (2.99 ± 0.33 frames). At the end of the experiment in May 2001, no interaction between site and stock (F = 1.36; df = 1, 42; P = 0.25) and no site effect (F = 0.73; df = 1, 42; P = 0.397) were detected regarding the number of brood frames. However, SR colonies had significantly (F = 4.52; df = 1, 42; P = 0.04) more frames of brood (5.53 ± 0.49 frames) than OR (4.28 ± 0.34 frames) colonies. For the number of frames covered by adult bees, no site by stock interaction (F = 0.24; df = 1, 42; P = 0.625) was detected as well as no site (F = 1.51; df = 1, 42; P = 0.227) and stock (F = 1.90; df = 1, 42; P = 0.175) effects. OR and SR bees had similar number of frames covered by adult bees with an average of 6.69 ± 0.56 and 8.06 ± 0.49 frames, respectively.

Table 2. Mean infestation levels (mean ± SE) of tracheal mites in colonies of Russian honey bees located in Cresco, IA, during winter 2000–2001

Date	Honey bee type: Original Russian	Honey bee type: Supersedure Russian	Mean
Prevalence			
Aug. 2000	6.81 ± 2.04	7.49 ± 2.96	7.15 ± 1.8b
Nov. 2000	7.76 ± 2.28	8.91 ± 3.22	8.33 ± 1.97b
Mar. 2001	14.55 ± 3.22	12.76 ± 4.65	13.65 ± 2.83a
May 2001	5.64 ± 1.42	6.14 ± 2.04	5.89 ± 1.24b
Mean[a]	8.69 ± 2.03	8.82 ± 2.90	
Intensity			
Aug. 2000	7.80 ± 1.97	11.87 ± 2.92	9.83 ± 1.76a
Nov. 2000	3.69 ± 0.90	4.69 ± 1.28	4.18 ± 0.78b
Mar. 2001	7.11 ± 1.11	6.64 ± 1.67	6.87 ± 1.0ab
May 2001	10.38 ± 2.29	9.52 ± 3.30	9.95 ± 2.01a
Mean[a]	7.13 ± 0.95	8.18 ± 1.44	

Numbers within a column followed by the same letters are not significantly different ($P > 0.05$).
[a] Not significant ($P > 0.05$).

For the mite prevalence, our results showed no interaction between honey bee type and sampling month (F = 0.07; df = 3, 52.9; P = 0.976) (Table 2). However, significant (F = 6.20; df = 3, 52.9; P = 0.001) differences among the sampling months were detected, with a peak infestation observed in March 2001. The lowest infestations were observed in August and November 2000 and May 2001. OR and SR colonies showed similar (F = 0.01; df = 1, 58.7; P = 0.914) infestations of tracheal mites.

A similar trend was observed with the number of tracheal mites per infested bee (mite intensity) (Table 2). There was no stock by sampling month interaction (F = 0.28; df = 3, 51.8; P = 0.840) and no stock (F = 0.23; df = 1, 58.1; P = 0.633) effect was observed. However, significant (F = 6.24; df = 3, 51.8; P = 0.001) differences among sampling months were recorded. The highest mite intensity was observed in August 2000 and May 2001, whereas the lowest mite load was observed in November 2000, but it was comparable with the mite load observed in March 2001.

There were no differences (Fisher's exact test, n = 63, P = 1.0) in colony mortality between colonies headed by OR and SR queens. A total of 18 colonies (12 OR and six SR) died between November 2000 and May 2001 (Table 3). Among the 18 dead colonies, 10 colonies were mite-free, four colonies had 3–7% tracheal mite infestations, and four colonies had infestations >25% when the colonies were packed in November 2000. By March 2001, all of the 42 OR colonies were still alive, although 10 colonies had infestations ranging from 27 to 83%. Three of these highly infested OR colonies died between March and April with infestations of 53, 77, and 83%, although they had adequate food stores. Another nine OR colonies died in May 2001, despite having low (0–7%) levels of infestation and good cluster sizes in March 2001. Nineteen SR colonies also were alive in March; four had 20–47% infestation and 15 colonies had 0–17%. Five of the six

Table 3. Numbers of colony survivors and divisions made from colonies overwintered in different locations in 2000–2001

Location	Original Russian	Supersedure Russian	Total	No. divisions[a]
Iowa				
Initial	42	21	63	
Final	30	15	45	77
Dead[b]	12 (29%)	6 (29%)	18 (29%)	
Louisiana				
Initial	49	8	57	
Final	48	8	56	137[c]
Dead	1 (2%)	0	1 (2%)	
Mississippi				
Initial	30	26	56	
Final	25	25	50	104
Dead[b]	5 (17%)	1 (4%)	6 (11%)	

[a] Includes divisions from colonies headed by unidentified queens of Russian origin

[b] Not significant ($P > 0.05$).

[c] Includes 11 3-lb packages.

SR colonies that died between November 2000 and May 2001 had low infestations (0–17%), and one colony had 47% infestation. At the end of the experiment, 93% (28 of 30) of the surviving OR and 87% (13 of 15) of the SR colonies had 0–10% mite infestations. Only two OR colonies (20 and 23%) and two SR (23 and 27%) had infestations above the economic thresholds. Between the two sites, there were significantly (Fisher's exact test, $n = 63$, $P = 0.025$) more (41 versus 14% colonies) dead colonies in site 1 than in site 2.

Forty-five colonies survived the winter. In May 2001, ≈77 divisions were made from all the surviving colonies, including eight colonies of unknown origin (queens were not seen either at the beginning or at the end of the experiment but known to be of Russian origin). Each new colony consisted of three deep brood frames and two frames of honey (plus five empty frames) and enough bees to at least cover five frames.

Louisiana. Among the 57 colonies at the beginning of winter, 49 were headed by OR and eight by SR queens (Table 3). Initially, tracheal mite infestations were very low (≈1% on average). Only four of 25 colonies (three OR and one SR) sampled were infested with 3–13% at the end of the experiment. All colonies were alive in February 2001. However, in late March, one OR colony was queenless and too weak to be given a queen. This was the only colony death. Approximately 137 divisions (three deep brood frames, two frames of honey, enough adult bees to cover at least five frames and four empty frames) were made in March. An additional 11 3-lb packages also were obtained from the surviving colonies. Some of the divisions/packages also were made from 17 colonies with queens (of Russian origin), which were not seen either at the beginning or at the end of the experiment. The lowest temperature of 2.9°C was recorded in December 2000.

Mississippi. Among the 56 colonies that survived the winter, 30 were headed by OR and 26 by SR queens (Table 3). All colonies were nearly mite-free throughout the experiment. At the end of the experiment, only one OR colony (queenless with laying workers) was infested with tracheal mites at 3%. No differences (Fisher's exact test, $n = 56$, $P = 0.200$) in colony mortality between OR and SR were detected. Of the 56 colonies, six colonies (11%) died; five OR colonies and one queenless SR colony. Of the five OR colonies, one colony had the lid blown off, and three colonies had either a virgin queen or were queenless and were considered dead because they were too weak to receive new queens. There were 104 divisions made, which consisted of two deep frames of brood, three frames of food, enough bees to cover five frames, and four empty frames. However, the number of divisions also included divisions made from 14 colonies with queens of Russian origin but were not verified as to whether they were original or supersedure Russian queens. The lowest temperature of −2.7°C was recorded in December 2000.

Discussion

Substantial differences in overwintering characteristics between Russian and Italian honey bees were observed in 1999–2000, despite that season's mild winter. One important difference was that Russian colonies lost less weight. This observation corroborates observations of Tubbs et al. (2003) who reported frugal use of stores by Russian honey bees. However, although differential food consumption contributed to the differential weight loss by the Russian and the Italian colonies, the differential loss of adult bees also played a role. The Italian colonies started as significantly bigger (18,000 versus 11,000 bees) colonies, but the two stocks had similar strength at the end of the experiment. The Italian colonies lost ≈66% of their adult bees, whereas Russian colonies lost ≈45%. Hence, Italian colonies lost more weight in part because they lost more adult bees. This worker bee loss was at least partially because of tracheal mite infestations. Italian colonies had infestation rates that were above the economic threshold (Eischen 1987, Otis and Scott-Dupree 1992) throughout the winter and rose as winter proceeded. Because infested bees die sooner than uninfested bees (Bailey 1958, 1961; Adam 1968; Eischen 1987), it is clear that tracheal mite infestations led to a disproportional early death of worker bees in the Italian colonies, even during unusually mild winter. These observations suggest that greater loss of Italian bees may occur during harsh winter because of an increased death of infested adult bees and also from starvation. Thus, chemical treatment to control mites and feeding of colonies during winter must be used to increase winter survival of these Italian bees.

Colonies with high tracheal mite infestations generally are expected to die during winter. The five colonies that did die in the 1999–2000 study were all highly (43–100%) infested. Fifty percent of the surviving Italian colonies had infestations of >20%. These results are generally consistent with previous studies (de Guzman et al. 2001a, b, 2002) where tracheal mite infestations in Iowa, Louisiana, and Mississippi were always higher in Italian colonies compared with Russian colonies. The survival of these colonies can be attributed to the mildness of the winter because cold temperature stress accelerates colony deaths because of tracheal mites (Maki et al. 1988).

These same overwintering traits were shown by colonies with Russian and Russian supersedure queens the following year during an unusually harsh winter. Colony survival was excellent in Louisiana and Mississippi. Some colony deaths in Iowa were clearly the result of tracheal mite infestations in lines that proved susceptible to tracheal mites in harsh conditions and also because of starvation (isolation of clusters from food supply). However, most lines displayed good tracheal mite resistance. Hence, in this study the same lines gave somewhat different results in the three states. In Louisiana, no colonies were troubled by tracheal mites although mites were present at very low levels in the colonies. In Mississippi, once again the majority of colonies had no tracheal mites as observed in previous studies (de Guzman et al. 2001b). Only colonies that were severely stressed for other reasons had low infestations. In Iowa, tracheal mite pressure was the greatest. Iowa conditions were necessary to provide a good evaluation of Russian honey bee tracheal mite resistance. However, the mild winters of Louisiana are sufficiently cold to have resulted in tracheal mites killing ≥50% of highly susceptible Italian colonies (de Guzman et al. 2001a).

Our results also showed higher mortality (41 versus 14% colonies) of colonies located in the more exposed apiary than the apiary located on top of a slope and surrounded by trees in Iowa. Hence, it is important to use apiaries that are protected from chilly winds when overwintering colonies, especially under northern weather conditions.

This study supports the conclusion that Russian honey bees, which are known for their varroa and tracheal mite resistance, have the ability to overwinter successfully in the north, even under harsh conditions. Several traits that enhance the overwintering ability of this stock are frugal food use and good clustering ability, characteristics that also were observed by Tubbs et al. (2003). However, without tracheal mite resistance these traits are insufficient to assure successful overwintering.

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