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Original article

Damaged *Varroa* mites in the debris of honey bee (*Apis mellifera* L) colonies with and without hatching brood

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Summary — The proportion of damaged *Varroa* mites within the debris of honey bee colonies is discussed as a possible tolerance factor of the host. We investigated the rate of damaged *Varroa* females in honey bee colonies with and without hatching brood. Additionally, in some colonies sealed brood combs were treated by the use of heat or formic acid to kill the mites within the brood cells to quantify the behaviour of the bees towards dead mites. In 17 experimental honey bee colonies (*Apis mellifera*) at two different study sites, the debris was checked at 12-h intervals. Nearly 5 000 mites were individually analyzed for three different types of damages. The percentage of damaged mites varied on average from 44 to 63% depending on experimental conditions. No significant differences in the damage rates of 'phoretic mites' and 'brood mites' could be found. Dead mites from the treated brood combs were damaged to a slightly lesser extent. The significance of these results for the use of the parameter 'damaged mites' in selection programs is discussed.

***Varroa jacobsoni* / *Apis mellifera* / damaged mites / resistance**

INTRODUCTION

The tolerance to *Varroa jacobsoni* Oudemans is a major concern in many honey bee breeding programs. Unfortunately, the term '*Varroa* tolerance' describes a multifactorial phenomenon of host adaptations which, additionally, are influenced by environ-

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mental factors. All physiological, behavioural and ecological traits of the host bees that reduce the life span or the reproductive success of the female mites could act as 'tolerance factors' (Fries et al, 1994). Meanwhile, recent discussion of selecting honey bees tolerant to *Varroa* has concentrated on three parameters: i) the control of mite fertility by host factors (Ruttner et al, 1984; Rosenkranz et al, 1993; Rosenkranz and Engels, 1994; Eguaras et al, 1994, 1995; Anderson, 1994); ii) specific hygienic behaviour performed by removal of mites from infested brood cells (Boecking and Drescher 1992); and iii) grooming of parasitized adult bees (Delfinado-Baker et al, 1992; Ruttner and Hänel, 1992). Such adaptations are also described from the original host, *Apis cerana* in Asia and from the Africanized *Apis mellifera* hybrids from South America (Camazine, 1986; Büchler et al, 1992; Boecking et al, 1993; Rosenkranz et al, 1993; Moretto et al, 1993), the only well-documented cases of natural and long-lasting *Varroa* tolerance in *A mellifera*.

The examples of tolerance mentioned are strongly correlated with a reduced *Varroa* fertility in worker brood (Ritter and De Jong, 1984; Camazine, 1986; Rosenkranz et al, 1993; Rosenkranz and Engels, 1994). Nevertheless, mite fertility is rarely used as a selection criteria in honey bee breeding. First, the variance of this factor within European honey bee races is remarkably low and, second, it is difficult to quantify *Varroa* fertility under practical breeding conditions.

It has been demonstrated that honey bees are able to kill and injure *Varroa* females (Ruttner and Hänel, 1992) and a certain proportion of the mites falling from the bees shows typical damage on legs and dorsal shield. The grooming behaviour, expressed as the proportion of damaged *Varroa* females in the colony debris, has been included in performance tests of *A mellifera* breeding strains (Moosbeckhofer, 1992; Büchler, 1993; Wallner, 1994). However, it is still unknown to what degree an enhanced grooming behaviour contributes to a balanced host–parasite relationship (Fries et al, 1996) and how this behaviour can be quantified properly.

It should be clarified what percentage of damaged *Varroa* females found in the debris were injured as vital living mites. Only this proportion will really reduce the number of reproductive female mites, in contrast to damaging dead or 'half dead' mites. It should also be clarified whether there are differences in the rate of damaged mites between 'brood mites' (mites which leave a brood cell after reproduction) and 'phoretic mites' (mites on the body surface of the adult bees). To answer these questions we examined the debris in honey bee colonies where the brood nests were manipulated artificially to establish distinct periods with and without hatching brood.

MATERIAL AND METHODS

The experiments were performed during July 1994 at Erlangen, Germany and during August 1994 on Gotland, a Swedish island in the Baltic sea. *Varroa* infested honey bee colonies were kept in 'Zander' magazine hives (two boxes with 18 to 20 combs in total) with *A m carnica* (Erlangen) and *A m ligustica* (Gotland). In spite of different infestation rates, we observed natural mite downfall of at least four mites per day per colony (see table I). At both apiaries the eight (Erlangen) and nine (Gotland) experimental colonies were divided into three groups. The colonies of the first two groups were kept without hatching brood (phoretic period). In a second step brood combs were added that were untreated (first group) or were previously treated either by heat or by formic acid in the other group (to kill the brood mites). In the third group the colonies remained unmanaged during the first period (control) before treated brood was added. In detail, the groups were prepared as follows.

Table I. Average daily downfall of *Varroa* females into the debris of the experimental colonies at Erlangen (eight colonies) and Gotland (nine colonies) before (phoretic period) and after adding either untreated (group 1) or treated (groups 2 and 3) brood combs.

	Study Site	*No of Colonies*	*Average Mite Downfall per day per colony*	
			*phoretic period**	*brood added*
Group 1	Erlangen	2	12.6	22.5
"untreated brood"	Gotland	3	19.2	36
Group 2	Erlangen	4	3.9	70
"treated brood"	Gotland	3	18.9	79.3
Group 3	Erlangen	2	31.3	180.8
"control"	Gotland	3	37.4	125.3

* Group 3 with unmanaged brood nest during the phoretic period

Group I ('untreated brood')

All queens were caged on 'trapping combs' to restrict egg laying to this single comb. Eighteen days later, 1 day before the recording of mite mortality and mite damage began, all brood except the trapping combs were removed and the queens released. Therefore, the capped brood in these colonies was restricted to a single comb and at the start of the recordings no hatching brood was present. One day later (day 19) we started recording the mites dropping from the bees (see below) at 12-h intervals and, at the same time, we also checked the 'trapping combs' for hatching brood. When the first bees started to hatch the colonies switched from the 'phoretic phase' (no hatching brood) to the 'brood phase' (hatching brood present). After 1.5–4 days (see below) the trapping combs were removed and the colonies switched again to the 'phoretic phase'. Thus, in this group we compared the grooming behaviour of the bees towards phoretic mites and brood mites.

Group 2 ('treated brood')

The same procedure and time schedule as in group 1 (untreated brood) were used except that the trapping combs were treated at day 18 without bees outside the colonies with heat (Erlangen: Engels and Rosenkranz, 1992) or formic acid (Gotland: Fries, 1991), respectively, to kill all mites within the brood cells. From all treated brood combs at least 30 *Varroa* infested brood cells were analyzed for surviving mites. Not a single live mite was discovered after the treatments of the brood combs. Damages to the treated brood could not be detected. After treatment, all colonies received their own brood comb in return. With this setup we wanted to quantify the damage rate of dead brood mites released during the hatching of the young bees.

Group 3 ('control')

In this group the queens were not caged. Otherwise the colonies were treated as described for group 2 (treated brood). Therefore, bees from untreated brood cells hatched over the whole experimental period. Thus, we compared the condition of an unmanaged colony with hatching brood (control) to a situation with a surplus of dead mites within the brood cells.

Recordings of mite mortality and damages

The mites falling from the bees were analyzed at 12-h intervals using full-sized bottom boards with a net screen that prevented any contact between the bees and the mites that dropped. The duration of the collection periods varied in the different experimental groups in order to obtain a sufficient number of mites in the debris for statistical analysis (phoretic phases: 2–7 days; brood phase: 1.5–4 days). The following details of the mites in the debris were analyzed immediately with a stereomicroscope (40-fold magnification):

Table II. Analysis of dead and living *Varroa* females in the debris: the number of mites analyzed per colony at 12-h intervals and percentages of damaged mites during periods with and without hatching brood.

			Dead mites				*Living mites*			
	Study site	*No of Colony*	*No of Mites (phoretic period)*	*% damaged*	*No of Mites (brood with living mites added)*	*% damaged*	*No of Mites (phoretic period)*	*% damaged*	*No of Mites (brood with living mites added)*	*% damaged*
Group 1	Gotland	30	60	55.0	26	53.9	31	12.9	10	20.0
"untreated	Gotland	41	132	56.1	74	51.4	27	7.4	9	33.3
brood"	Gotland	78	28	57.1	8	75.0	6	33.3	4	50.0
	Erlangen	98	77	66.2	20	50.0	19	0	10	20.0
	Erlangen	252	125	56.8	115	53.9	96	16.7	74	23.0
	Sum.		422	58.3	243	56.8	179	14.1	107	29.3
Group 2	Gotland	9	32	59.4	91	44.0	12	8.3	1	0
"treated	Gotland	105	117	50.4	40	27.5	22	4.6	0	0
brood"	Gotland	106	49	65.3	107	43.9	8	12.5	1	0
	Erlangen	366	21	57.1	146	49.3	6	0	1	0
	Erlangen	319	40	65.0	91	56.0	11	27.3	1	0
	Erlangen	243	36	61.1	92	56.5	5	20.0	3	0
	Erlangen	101	27	29.6	125	29.6	6	0	0	0
	Sum.		322	55.4	692	43.8	70	10,4	7	0
Group 3	Gotland	65	141	53.2	146	52.7	17	5.9	3	0
"control"	Gotland	68	78	59.0	123	53.7	12	8.3	2	0
	Gotland	74	174	73.6	107	53.7	16	12.5	4	25.0
	Erlangen	384	20	85.0	174	52.9	10	0.0	3	33.3
	Erlangen	189	510	44.1	468	33.6	455	7.0	120	13.3
	Sum.		923	63.0	1018	49.8	510	6.8	132	14.3

– total number of *Varroa* females (dark and lightly coloured adult mites);

– ratio of dead and live mites (all mites who showed any kind of movement);

– percentage of damaged dead and damaged live mites. Moreover, damaged mites were divided into three classes:
class 1: injury to only one leg;
class 2: injury to several legs but dorsal shield intact;
class 3: injury to the dorsal shield.

Additionally, from the live *Varroa* females in the debris 28 mites were introduced into freshly capped worker brood cells in an additional test colony. This brood comb remained 10 days in the colony and was analyzed afterwards for *Varroa* reproduction.

RESULTS

The average daily number of mites falling from the bees in the experimental colonies ranged between 3.9 and 180.8. The lowest number was recorded when no brood was hatching (range: 3.9–19.2). After introduction of treated brood combs the daily number of fallen *Varroa* reached maximal values between 70 and 180.8 (table I). In all colonies the introduction of a brood comb (treated or untreated) resulted in a significant increase in falling mites ($P < 0.05$, χ^2). This means that after introduction of the brood combs the 'brood mites' represented a large proportion of all *Varroa* mites in the debris.

In total, 3620 dead and 1005 living mites in the debris were analyzed individually. On average, 31% of the analyzed mites in the debris were still alive (only colonies without treated brood). During the phoretic phases, without hatching brood, the damage rates of dead mites ranged from 29.6 to 66.2%, during periods with hatching brood from 33.6 to 85.0%. After addition of treated brood combs (containing dead brood mites only) the rate of damaged mites decreased slightly to values between 29.6 and 56.5% (table II). This demonstrates a considerable variation in the damage rates between individual colonies. There is a significant correlation between the damage rates in different colonies before and after the introduction of brood ($r^2 = 0.26$; $P = 0.04$) indicating individual differences in damaging activities.

The average proportion of damaged dead mites from the different colony conditions are presented in figure 1a. Since there were no statistical differences between the results from Erlangen and Gotland ($P = 0.43$; Wilcoxon rank sum test) the data were pooled. Surprisingly, there were no significant differences in the damage rate of phoretic mites and brood mites. When a surplus of dead brood mites was present in the colonies (group 2 'treated brood' and group 3 'control') a small decrease in the damage rate was detected, but the differences were not significant ($P = 0.4$, χ^2). Thus, the results demonstrate an unexpectedly high proportion of damaged mites in the debris, independent of study site and brood condition of the honey bee colony. Dead mites within brood cells are obviously damaged to a somewhat lesser, but still appreciable, extent.

Mites in the debris that were still alive were damaged to a lesser extent than dead mites (figure 1b, table II) with values ranking from 0 to 50% in individual colonies. From the undamaged living mites we introduced 28 *Varroa* females into freshly sealed worker brood cells. After 10 days, we recovered 17 mites: four of them were dead, six with and seven without offspring. Therefore, living mites that have fallen onto the bottom board are, at least in part, still able to reproduce.

Most damages concerned only the legs of the *Varroa* mites (table III). On average, about 25% of the damaged mites had only one leg injured. This was mostly the first leg, where often only the first section of the leg was lacking. Damaging of legs occurred in more than 75% of all damaged *Varroa* mites; injuries to the body itself were rela-

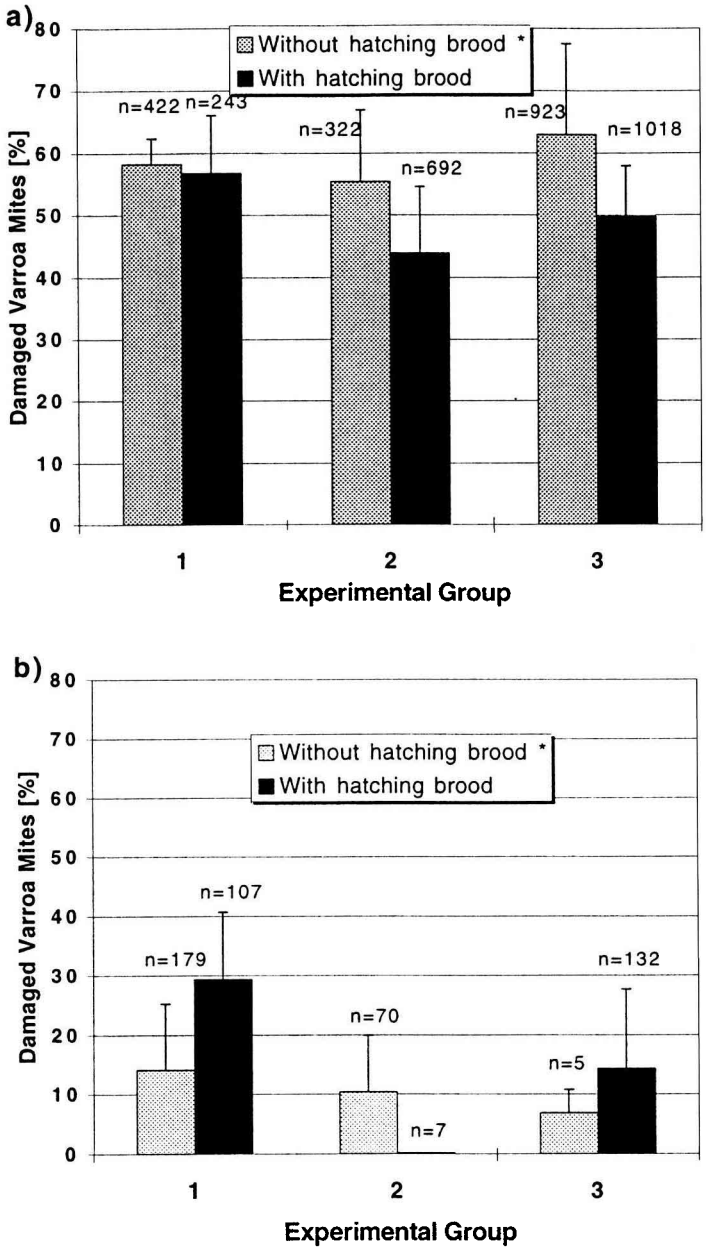

Fig 1. Percentages of damaged dead (a) and living (b) *Varroa* females collected at 12-h intervals from the debris of honey bee colonies. Mites were collected during periods without hatching brood and after either untreated (group 1) or treated (groups 2 and 3) brood combs had been added. In the treated brood combs all *Varroa* mites in the brood cells had been killed by formic acid or heat.
* In group 3 ('control') the brood nest was unmanaged during the first period.

Table III. Distribution of different types of damages to the dead mites collected in the debris. Class 1: Damage to one leg only; class 2: damages to several legs; class 3: damage to the body.

	Study Site	*Colony Condition*	*Dead Damaged Mites [%]* *Class 1*	*Class 2*	*Class 3*
Group 1	Erlangen	phoretic period	17.2	46.7	36.1
"untreated		brood added	15.3	52.8	31.9
brood"	Gotland	phoretic period	43.1	53.7	3.3
		brood added	39	54.2	6.8
Group 2	Erlangen	phoretic period	25	63.2	11.8
"treated		brood added	32.2	53.9	13.9
brood"	Gotland	phoretic period	33.6	64.5	1.8
		brood added	29.6	68.4	3.1
Group 3	Erlangen	control period	26.5	47.4	16.1
"control"		brood added	26.3	53.7	20
	Gotland	control period	25.7	72.7	1.1
		brood added	22.2	76.8	1.0

tively rare. Differences in the distribution of the damage classes in relation to the presence of brood in the bee colony were not visible. In the pattern of damages we could detect some differences depending on study site and/or honey bee race. In the *A m carnica* colonies at Erlangen, the percentage of body damage was remarkably higher than in the *A m ligustica* colonies on Gotland (table III). Within the damaged living mites, in most cases only one leg was cut, and injuries of classes 2 and 3 hardly occurred.

DISCUSSION

A *Varroa* specific grooming behaviour was first described from the tolerant original host *A cerana* (Peng et al, 1987). To a somewhat lesser extent, similar behavioural patterns were also observed in the non-tolerant secondary host, *A mellifera* (Büchler et al, 1992; Boecking et al, 1993; Moretto et al, 1993). Our results confirm that a large proportion of the mites collected from the debris show typical damages obviously caused by the honey bees. Other insects such as ants or waxmoths, which are also capable of injuring *Varroa* mites (Szabo and Walker, 1995) could not be detected in the experimental colonies. Additionally, the short observation intervals of 12 h prevented damage by occasional intruding predators and we could sometimes detect typical imprints of the honey bee mandibles on the mites as described by Ruttner and Hänel (1992). These sharp-edged damages could clearly be distinguished from 'regular dimples' of the dorsal shield, which sometimes occur in living mites and obviously are due to disturbances during the nymphal development (Lodesani et al, 1996).

The proportion of damaged mites was suprisingly high in all experimental colonies. If we consider dead and living mites in the debris, an average of about 45% damaged mites was recorded in the control colonies (group 3 'control'). This value is higher than described by Moosbeckhofer (1992) from observations of more than 100 *A m carnica* colonies and fits in the range of colonies which were 'preselected' for distinctive

hygienic behaviour (Büchler, 1994; Wallner, 1994). Our rates of damaged mites show a considerable variation between individual colonies and between different recordings, although this variation is lower than that described by other authors (Moosbeckhofer, 1992; Boecking and Ritter, 1993; Büchler, 1994). One reason may be that we used in general more than 30 mites that dropped onto the bottom board over a period of several days for the calculation of the damage rates. Additionally, the use of honey bee colonies that were widely standardized in size may have reduced the variation. Another source for variation is the presence and amount of honey bee brood. It is known that the number of mites falling onto the bottom board is highly correlated with the presence of brood (Fries et al, 1991; Liebig, 1994). Obviously, many of the *Varroa* female mites that have reproduced within the brood cells are in a stressed condition and fall down onto the bottom board. Therefore, one would expect a higher damage rate of these brood mites. Surprisingly, we did not detect any significant correlation between the proportion of damaged mites and the presence of hatching infested brood within the colonies. Through our experimental setup we created time periods with and without hatching brood. The increasing number of dropped mites after adding the trapping combs indicates that during the 'period with hatching brood' between 50 and 80% of the collected mites came out of the introduced brood cells. Nevertheless, the average rate of damaged mites remained unchanged. This could mean that the rate of damage is independent of the viability of the *Varroa* females. This hypothesis seems to be confirmed by the results from the introduction of brood combs containing dead mites only. After introduction of combs with a great number of dead mites only a small, and not significant, decrease in the average rate of damages was detectable. This means that only a part of the dead *Varroa* mites removed from the brood cells are visibly damaged by the bees.

The analysis of mites that were still alive in the debris demonstrated that not only weak or already dead mites are damaged. About 30% of all recorded mites showed signs of movements. Comparable proportions were found in short interval records by Boecking and Ritter (1993) in Tunesia. As mites can not survive for long time periods apart from their host, the percentage of living mites may depend mainly on the observation interval. The living mites were, at least in part, able to reproduce, which demonstrates a certain level of viability. Although the proportion of live damaged mites in the debris was significantly lower compared to dead mites, the results confirm that the honey bees are able to injure vital mites.

Probably, the reaction of the bees towards the mites does not depend on the status of the mites. This means that during the cleaning of dead mites out of empty cells and during active removal of mites from sister bees, only a certain proportion of the mites are damaged by the mandibles of the bees. The other mites may drop down because of other movements or disturbance by the bees or because of their own weakness.

What does this mean for the evaluation of a *Varroa* specific 'grooming behaviour'? First, by determining damage rates we do not really measure active grooming behaviour. The 'history' of the mites in the debris still remains unknown and it is virtually impossible to calculate the proportion of active damaged mites.

It is assumed that an effective and specific grooming behaviour contributes to host tolerance (Delfinado-Baker et al, 1992). However, all data that support this hypothesis were obtained in experiments using small observation hives (Peng et al, 1987; Moretto et al, 1993, 1995). Some results have, at least in part, been disproved (Corrêa-Marques and De Jong, 1996; Fries et al,

1996) and long lasting observations in full-sized colonies are still lacking or do not fit the hypothesis. For example, the only well-established example of *Varroa* tolerance in *A mellifera*, described in the Africanized honey bee in Brazil, does not show conspicious damage rates compared to non-tolerant honey bee races (Corrêa-Marques and De Jong, 1996). In Europe attempts have been made to correlate the proportion of damaged mites in the debris and the size of the *Varroa* population (Moosbeckhoofer, 1992). Although a negative correlation has been found, these results require confirmation. We believe that it is premature to include the proportion of damaged mites in breeding programs as a selection criteria (Büchler, 1994) or to use it in commercial offerings of 'selected' queens (Wallner, 1994).

ACKNOWLEDGMENT

The assistance of Joel Fries in determining the damage to numerous *Varroa* mites is appreciated.

Résumé — Les acariens *Varroa* mutilés dans les débris des colonies d'abeilles (*Apis mellifera* L) avec et sans couvain naissant. Un comportement de toilettage dirigé spécifiquement contre l'acarien *Varroa jacobsoni* Oudemans pourrait réduire la population d'acariens dans une colonie d'abeilles et donc agir comme facteur de tolérance de l'hôte. La possibilité de quantifier ce comportement de toilettage par la proportion d'acariens mutilés présents dans les débris de la ruche est controversée. Il est important de savoir si ces acariens étaient encore vivants au moment de leur mutilation. Nous avons donc essayé de quantifier le taux de mutilation de différents types d'acariens.

Nous avons utilisé 17 colonies d'abeilles situées dans des ruchers expérimentaux à Erlangen (Allemagne) et sur l'île de Gotland (Suède). En mettant les reines en cage sur les rayons-piège durant un certain temps nous avons pu créer des périodes successives avec et sans couvain naissant. En outre, dans certaines colonies, des rayons-pièges operculés ont été traités par la chaleur ou à l'acide formique pour tuer les acariens présents dans les cellules de couvain. Les débris ont été vérifiés toutes les 12 h et les mutilations des pattes et du corps de tous les varroas femelles ont été analysés à la loupe binoculaire. Nous avons pu ainsi comparer les taux de mutilation des types d'acariens suivants : acariens sur les abeilles (« acariens phorétiques »), acariens dans les cellules de couvain (« acariens du couvain ») et acariens du couvain déjà morts.

Nous avons analysé 3 620 acariens morts et 1 005 acariens encore vivants dans les débris. La plupart des mutilations ne concernaient que les pattes (> 75 % des acariens mutilés). Nous n'avons pas observé de mutilation spécifique aux différentes classes d'acariens. Les taux de mutilation (toutes mutilations comprises) ont varié grandement d'une colonie à l'autre : de 30 à 66 % pour les acariens phorétiques et de 34 à 85 % pour les acariens du couvain. Dans l'ensemble il n'y a pas de différence significative entre le taux de mutilation des acariens du couvain et celui des acariens phorétiques (fig 1a). Les acariens du couvain tués par le traitement n'étaient mutilés que légèrement moins, ce qui est surprenant (fig 1a). Les acariens encore vivants dans les débris étaient mutilés dans une proportion significativement plus faible (fig 1b). Ils étaient encore, au moins en partie, capables de se reproduire après introduction artificielle dans des cellules de couvain ($n = 28$).

Nous avons pu confirmer que, dans des colonies d'abeilles non sélectionnées, le taux de mutilation pouvait être étonnamment haut (> 50 %) et qu'il de dépendait pas de la présence ou non du couvain. Le taux élevé de

mutilations des acariens morts provenant des cellules du couvain indique que les abeilles ne mutilent pas que les acariens vivants et capables de se reproduire. Il est pratiquement impossible de calculer la proportion d'acariens mutilés actifs et de la corréler avec la taille réelle de la populations de *Varroa*. Il semble donc prématuré d'incorporer cette analyse, coûteuse en temps, dans les programmes de sélection.

***Apis mellifera* / *Varroa jacobsoni* / mutilation / résistance**

Zusammenfassung — Beschädigte Milben im Gemüll von Honigbienenvölkern (*Apis mellifera* L) mit und ohne schlüpfende Bienenbrut. Ein spezifisch gegen *Varroa* gerichtetes Putzverhalten der Bienen könnte die bestehende Milbenpopulation in den Honigbienenvölkern mindern und damit einen Toleranzfaktor des Wirts darstellen. Es wird kontrovers diskutiert, ob ein solches Putzverhalten anhand des Anteils beschädigter Milben im Gemüll quantifiziert werden kann. Hierbei ist eine wichtige Frage, ob die beschädigten Milben zum Zeitpunkt der Beschädigung lebendig und vital waren. Wir haben daher versucht, die Beschädigungsrate unterschiedlicher Milbentypen zu bestimmen.

Wir untersuchten insgesamt 17 Bienenvölker auf Bienenständen in Erlangen (Deutschland) und Gotland (Schweden). Durch zeitweises Sperren der Königinnen auf Bannwaben erstellten wir aufeinanderfolgende Perioden mit und ohne schlüpfende Brut. In einigen der Völker wurden zusätzlich alle Milben in den verdeckelten Zellen durch eine Wabenbehandlung mit Hitze oder mit Ameisensäure abgetötet. Das Gemüll in den Völkern wurde alle 12 h untersucht und alle gefundenen Milben mit einer Stereolupe auf Beschädigungen der Beine und des Körpers untersucht. Hierdurch konnten wir die Beschädigungsraten von Milben von adulten Bienen ('phoretische Milben'), von Milben aus Brutzellen ('Brutmilben'), und von bereits toten Brutmilben bestimmen.

Wir untersuchten insgesamt 3 620 tote Milben und 1 005 Milben, die im Gemüll noch lebend gefunden wurden. Bei über 75% der beschädigten Milben waren nur die Beine verletzt. Die Beschädigungen unterschieden sich nicht zwischen den Milbentypen. Die Beschädigungsraten, bezogen auf alle Beschädigungen, unterschieden sich stark zwischen den verschiedenen Völkern und betrugen 30 bis 66% für Bienenmilben und 34 bis 85% für Brutmilben. Insgesamt waren die Beschädigungsraten der phoretischen Milben und der Brutmilben allerdings nicht signifikant unterschiedlich (Fig 1a). Überraschenderweise waren die Beschädigungsraten der durch eine Behandlung abgetöteten Milben leicht verringert (Fig 1a). Die im Gemüll noch lebend gefundenen Milben waren signifikant weniger oft beschädigt (Fig 1b). Diese Milben waren zumindest teilweise nach künstlichem Einsetzen in Brutzellen noch reproduktionsfähig ($N = 28$).

Wir konnten bestätigen, daß auch in nicht daraufhin selektierten Bienenvölkern die Beschädigungsrate bemerkenswert hoch sein kann (über 50%), und daß diese nicht vom Brutstatus der Kolonien abhängig ist. Die hohe Beschädigungsrate von bereits toten Brutmilben zeigt, daß nicht nur vitale und reproduktionsfähige Milben von den Bienen verletzt werden. Es ist in bislang in keiner Weise möglich, die Beschädigungsraten aktiver Milben zu bestimmen und zur Größe der Varroapopulation in Beziehung zu setzen. Es erscheint daher übereilt, diese zeitaufwendige Prozedur in Zuchtprogramme aufzunehmen.

***Varroa jacobsoni* / *Apis mellifera* / beschädigte Milben / Resistenz**

REFERENCES

Anderson DL (1994) Non reproduction of *Varroa jacobsoni* in *Apis mellifera* colonies in Papua New Guinea and Indonesia. *Apidologie* 25, 412-421

Boecking O, Drescher W (1992) The removal response of *Apis mellifera* colonies to brood in wax and plastic cells after artificial and natural infestation with *Varroa jacobsoni* and to freeze-killed brood. *Exp Appl Acarol* 16, 321-329

Boecking O, Ritter W (1993) Grooming and removal behaviour of *Apis mellifera intermissa* in Tunisia against *Varroa jacobsoni*. *J Apic Res* 32, 127-134

Boecking O, Rath W, Drescher W (1993) Grooming and removal behaviour – Strategies of *Apis mellifera* and *Apis cerana* bees against *Varroa jacobsoni*. *Am Bee J* 133, 117-119

Büchler R (1993) Erfahrungen in der Resistenzzucht – Möglichkeiten und Chancen bei der Carnica. *Bienenvater* 114, 59-65

Büchler R (1994) Entwicklung varroatoleranter Honigbienen. *Schweiz Bienen-Ztg* 117, 449-453

Büchler R, Drescher W, Tornier I (1992) Grooming behaviour of *Apis cerana*, *Apis mellifera* and *Apis dorsata* and its effect on the parasitic mites *Varroa jacobsoni* and *Tropilaelaps clareae*. *Exp Appl Acarol* 16, 313-319

Camazine S (1986) Differential reproduction of the mite *Varroa jacobsoni* (Mesostigmata, Varroidae), on Africanized and European honey bees (*Hymenoptera, Apidae*). *Ann Entomol Soc Am* 79, 801-803

Corrêa-Marques H, De Jong D (1996) Estudo da resistência à Varroatose em abelhas *Apis mellifera* no Brasil. *Proceeding of V. Congresso Latinoamericano de Apicultura, Mercedes, Uruguay*, 146-147

Delfinado-Baker M, Rath W, Boecking O (1992) Phoretic bee mites and honey bee grooming behavior. *Int J Acarol* 18, 315-322

Eguaras M, Marcangeli J, Oppedisano M, Fernández N (1994) Seasonal changes in *Varroa jacobsoni* reproduction in temperate climates of Argentina. *Bee Sci* 3, 120-123

Eguaras M, Marcangeli J, Oppedisano M, Fernández N (1995) Mortality and reproduction of *Varroa jacobsoni* in resistant colonies of honey bees (*Apis mellifera*) in Argentina. *Bee Sci* 4, 174-178

Engels W, Rosenkranz P (1992) Hyperthermie-Erfahrungen bei der Varroatose-Kontrolle. *Apidologie* 23, 379-381

Fries I (1991) Treatment of sealed honey bee brood with formic acid for control of *Varroa jacobsoni*. *Am Bee J* 131, 313-314

Fries I, Aarhus A, Hansen H, Korpela S (1991) Comparison of diagnostic methods for detection of low infestation levels of *Varroa jacobsoni* in honey bee (*Apis mellifera*) colonies. *Exp Appl Acarol* 10, 279-287

Fries I, Camazine S, Sneyd J (1994) Population dynamics of *Varroa jacobsoni*: A model and a review. *Bee World* 75, 5-28

Fries I, Huazhen W, Wei S, Jin CS (1996) Grooming behavior and damaged mites (*Varroa jacobsoni*) in *Apis cerana cerana* and *Apis mellifera ligustica*. *Apidologie* 27, 3-11

Liebig G (1994) Bedeutung des natürlichen Milbenfalls. *Dtsch Bienen J* 2, 14-15

Lodesani M, Vecchi MA, Tommasini S, Bigliardi M (1996) A study on different kinds of damage to *Varroa jacobsoni* in *Apis mellifera* colonies. *J Apic Res* 35, 49-56

Moosbeckhofer R (1992) Beobachtungen zum Auftreten beschädigter *Varroa*-Milben im natürlichen Totenfall bei Völkern von *Apis mellifera carnica*. *Apidologie* 23, 523-531

Moretto G, Gonçalves LS, De Jong D (1993) Heritability of Africanized and European honey bee defensive behavior against the mite *Varroa jacobsoni*. *Rev Brasil Genet* 16, 71-77

Moretto G, Gonçalves LS, De Jong D (1995) Analysis of the F1 generation, descendants of Africanized bee colonies with differing defense abilities against the mite *Varroa jacobsoni*. *Rev Brasil Genet* 18, 177-179

Peng YS, Fang Y, Xu S, Ge L (1987) The resistance mechanism of the Asian honey bee *Apis cerana* to an ectoparasitic mite *Varroa jacobsoni*. *J Invertebr Pathol* 49, 54-60

Ritter W, De Jong, D (1984) Reproduction of Varroa jacobsoni in Europe, the Middle East and tropical South America. *Z Ang Entomol* 98, 55-57

Rosenkranz P, Tewarson NC, Singh A, Engels W (1993) Differential hygienic behaviour towards *Varroa jacobsoni* in capped worker brood of *Apis cerana* depends on alien scent adhering to the mites. *J Apic Res* 32, 89-93

Rosenkranz P, Engels W (1994) Infertility of *Varroa jacobsoni* females after invasion into *Apis mellifera* worker brood as a tolerance factor against varroatosis. *Apidologie* 25, 402-411

Ruttner F, Marx H, Marx G (1984) Beobachtungen über eine mögliche Anpassung von *Varroa jacobsoni* an *Apis mellifera* in Uruguay. *Apidologie* 15, 43-62

Ruttner F, Hänel H (1992) Active defense against Varroa mites in a Carniolan strain of honey bee (*Apis mellifera carnica*). *Apidologie* 23, 173-187

Szabo TI, Walker CRT (1995) Damages to dead *Varroa jacobsoni* caused by the larvae *of Galleria mellonella*. *Am Bee J* 135, 421-422

Wallner A (1994) Der Varroakillerfaktor. *Imkerfreund* 49, 9-10