Apidologie 30 (1999) 85–95

Invited review article

Identification and comparison of *Varroa* species infesting honey bees

Lilia I. de Guzman*, Thomas E. Rinderer

ARS, USDA, Honey Bee Breeding, Genetics and Physiology Laboratory, 1157 Ben Hur Road, Baton Rouge, LA 70820, USA

(Received 26 July 1998; accepted 21 February 1999)

Abstract – *Varroa jacobsoni* Oudemans, *V. underwoodi* Delfinado-Baker and Aggarwal and *V. rindereri* de Guzman and Delfinado-Baker are obligatory parasites of honey bees. The key morphological characters, host range and geographic distribution of these three species are reviewed. The occurrence of different genotypes of *V. jacobsoni*, their geographic distribution and virulence on honey bee hosts are discussed. © Inra/DIB/AGIB/Elsevier, Paris

***Varroa jacobsoni* / *Varroa underwoodi* / *Varroa rindereri* / morphology / genotype / host range / distribution**

1. INTRODUCTION

There are three known species of *Varroa* (Acari: Varroidae) parasitizing honey bees (*Apis* spp.), namely: *Varroa jacobsoni* Oudemans 1904, *V. underwoodi* Delfinado-Baker and Aggarwal 1987 and *V. rindereri* de Guzman and Delfinado-Baker 1996. The recent identification of *V. rindereri* from the cavity dwelling honey bee, *Apis koschevnikovi* Buttel-Reepen, in Borneo and the identification of different varieties of *V. jacobsoni* indicate the need for further investigations which may lead to the discovery of still more species of *Varroa*. This review compares the key morphological characters, host range and distribution of the three known *Varroa* species. In addition, the genetic diversity of *V. jacobsoni* and its possible correlation to the virulence of mites on infested hosts are also discussed.

2. *VARROA JACOBSONI*

The general morphology and chaetotaxy of *V. jacobsoni*, *V. rindereri* and *V. underwoodi* are very similar. However, *V. jacob-*

* Correspondence and reprints
E-mail: lguzman@asrr.arsusda.gov

soni and *V. rindereri* are transversely oval as opposed to the ellipsoidal shape of *V. underwoodi. V. jacobsoni* can be distinguished from *V. rindereri* by several characters including small size, short and sharp-looped peritreme, fewer endopodal setae and presence of a seta on the palpal trochanter (*table I*). A more detailed description of characters of the adult female, nymphal stages and adult male of *V. jacobsoni* are described by Oudemans [45] and Delfinado-Baker [26], respectively.

Delfinado-Baker and Houck [28] found some morphological differences between populations of *V. jacobsoni*, especially regarding body size. In general, *V. jacobsoni* that infests *A. cerana* F. is smaller than those infesting *A. mellifera* L. These differences may be due to the existence of at least three genotypes of *V. jacobsoni*: Russian (R), Japanese (J) and Papua New Guinea (PNG) genotypes [4, 14–17]. We use the term 'genotype' to indicate mites having common DNA variations within the native range of *V. jacobsoni*. This definition follows that of King [34]. The R genotype is also referred to as the GER genotype by Anderson and Fuchs [4]. In a previous analysis using random amplification of polymorphic DNA (RAPD), Kraus and Hunt [37] found bands that were shared by German and US *V. jacobsoni* but absent in Malaysian mites. Using the same technique, R and J genotypes were established by using two RAPD primers [15]. In the R genotype, primer OPE-07 produced a 766-bp band which was absent in the J genotype (*figure 1*) [15]. Similarly, using primer OPP-03, the R genotype produced a band at 442 bp not found in the J genotype. The J genotype produced two distinct bands at 675 and 412 bp that were absent in the R genotype.

The PCR amplification and subsequent restriction enzyme digestion of a portion of the mtDNA CO I region [4] was also used to distinguish between the R and J genotypes [16]. When the PCR products were digested with *Sst* I, the fragment amplified from mites with the R genotype did not undergo digestion (producing a single band of 519 bp). *Sst* I digestion of the fragment from the J genotype produced fragments of 236 and

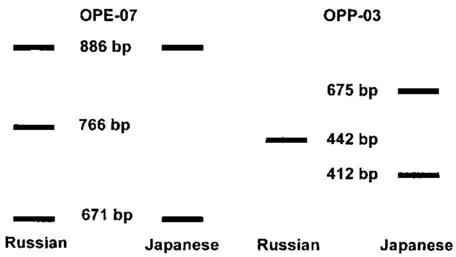

Figure 1. Banding patterns of the Russian and Japanese genotypes of *Varroa jacobsoni* using RAPD primers OPE-07 and OPP-03.

Table I. Comparison of morphological characters between *Varroa jacobsoni* from *Apis cerana* and *Varroa rindereri* from *Apis koschevnikovi* in Borneo, Malaysia (mean ± standard error) (after de Guzman and Delfinado-Baker [12]).

Characters	*Varroa jacobsoni*	*Varroa rindereri*
Body length (μm)	1 077 ± 6	1 180 ± 11
Body width (μm)	1 596 ± 10	1 698 ± 14
Peritreme length (μm)	426 ± 9	582 ± 13
No. of marginal setae	19 ± 0.4	23 ± 0.5
No. of endopodal setae	7 ± 0.3	12 ± 0.5
No. of sternal setae	10 ± 0.3	9 ± 0.3
No. of sternal pores	11 ± 0.4	9 ± 0.4
No. of metapodal setae	22 ± 0.5	23 ± 0.8

338 bp in length, similar to the pattern observed in PNG (*figure 2*). Digestion with *Xho* I did not show any differences between R and J genotypes (fragments of 269 and 300 bp). However, the PNG type lacked the restriction site, producing a single band of 519 bp [4].

2.1. Host range

V. jacobsoni was first discovered infesting *A. cerana* in Java, Indonesia. It has since successfully extended its host range to different honey bee species, including introduced *A. mellifera* in Asia (*table II*). Recently, *V. jacobsoni* was observed in drone brood of *A. nigrocincta* Smith in Sulawesi, Indonesia [32]. Infestation of *V. jacobsoni* has also been reported in colonies of *A. koschevnikovi* in Borneo [29]. However, it is possible that this report may be referring to *V. rindereri* instead of *V. jacobsoni*. *V. jacobsoni* was also found infesting mixed populations of the newly described honey bee species, *A. nuluensis* Tingek, Koeniger and Koeniger and *A. cerana* in Borneo [13]. With this mixed bee species condition, the actual colony source of the *V. jacobsoni* is unclear.

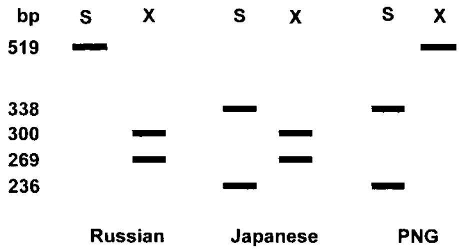

Figure 2. Banding patterns of the Russian, Japanese and PNG genotypes of *Varroa jacobsoni* using *Sst* I and *Xho* I restriction endonucleases.

2.2. Distribution

Since its discovery in 1904 by Oudemans, *V. jacobsoni* has been found throughout the world except Australia, New Zealand, Hawaii and parts of Africa [40]. However, recent genetic studies revealed that the R genotype is actually the predominant genotype of *V. jacobsoni*. The PNG or 'NRP' strain, which is currently found only in Asia, is the type of *V. jacobsoni* that Oudemans described in 1904 [1, 4]. Therefore, the PNG genotype found in Java, Indonesia is not the type that has spread worldwide as originally thought. This was

Table II. Host range and distribution of the three species of *Varroa* mites.

Varroa species	Hosts	Distribution
Varroa jacobsoni	*A. cerana*	Asia
	*A. koschevnikovi**	Borneo
	A. mellifera	Worldwide except Australia, New Zealand, Hawaii and parts of Africa
	A. nigrocincta	Indonesia
	A. nuluensis	Borneo
Varroa underwoodi	*A. cerana*	Borneo**, Indonesia, Korea, Nepal, Papua New Guinea, Vietnam***
	A. mellifera	Papua New Guinea
	A. nigrocincta	Indonesia
	A. nuluensis	Borneo**
Varroa rindereri	*A. koschevnikovi*	Borneo

* The mite may be *V. rindereri*; ** found in mixed population of *A. cerana* and *A. nuluensis*; *** new record.

supported by further DNA analyses, which revealed that the R and J genotypes had a wider distribution than the PNG type [14–17]. The R genotype was the most predominant type being found in much of Europe, Russia, South and North America, Africa, and Asia. The J genotype has been recorded in South and North America, and Asia (*table III*).

2.3. Virulence

V. jacobsoni is known to be the most serious parasite of *A. mellifera* worldwide. It causes abnormalities, reduced weight and longevity of workers and drones, reduced mucus gland and seminal vesicle weights, reduced number of spermatozoa, death of young brood and premature death of adult bees [5, 18, 23, 30, 47, 49]. Enormous losses of managed honey bee colonies in Europe [38, 48] and the United States [33] have been reported. Likewise, the establishment of *V. jacobsoni* in the US resulted in the apparent loss of much of the feral population of honey bees.

Different honey bee species and subspecies of *A. mellifera* vary in response to *V. jacobsoni* parasitism [9, 20, 22, 43, 44, 46, 48]. For instance, in Asia, where the indigenous *A. cerana* and introduced *A. mellifera* are now sympatric, effects of *V. jacobsoni* parasitism on these two honey bee species are quite different. While *A. cerana* regulates *V. jacobsoni* infestations successfully, *A. mellifera* seems to be very susceptible to *V. jacobsoni* infestations. This resistance of *A. cerana* is due to their ability to confine mite reproduction to drone brood, in addition to having good grooming and hygienic behavior [35, 46]. However, reproduction of *V. jacobsoni* has been observed in worker brood of *A. cerana* in Korea and Japan [19, 51]. Whether or not mite genotype influences the ability of *V. jacobsoni* to reproduce in *A. cerana* worker brood is unknown.

The reported global differences in the virulence of *V. jacobsoni* toward *A. mellifera* may suggest that some genotypes of *V. jacobsoni* have reduced virulence. DNA analyses revealed variable genotypes of *V. jacobsoni* infesting *A. mellifera* and *A. cerana* in Asia [4, 14–17] (*table III*). Lack of virulence of the PNG genotype of *V. jacobsoni* has been documented in PNG and Indonesia [1, 4]. This *V. jacobsoni* reproduces in *A. cerana* drone brood, but not in drone and worker brood of *A. mellifera* [4]. Whether or not this characteristic is specific to the PNG genotype has yet to be investigated. The PNG genotype was also recorded in Borneo and the Philippines infesting *A. cerana* colonies (de Guzman, unpublished data).

In contrast, tremendous losses of *A. mellifera* due to *V. jacobsoni* infestations were recorded in the Philippines and Korea [10, 11]. Both countries have the R genotype. The R genotype was a recent introduction into Java, Indonesia [2, 4] but the level of virulence in *A. mellifera* colonies has not been monitored. Both R and J genotypes of *V. jacobsoni* were found in Thailand [15]. However, *Tropilaelaps clareae* which predominates in the colonies could mask the effects of *V. jacobsoni* in *A. mellifera* colonies. *T. clareae* is reported to be a more injurious parasite to *A. mellifera* than *V. jacobsoni* [6, 8]. *V. jacobsoni* is also a major problem for *A. mellifera* beekeeping in Vietnam [31]. In Vietnam, *A. mellifera* colonies have the R genotype, while colonies of *A. cerana* have the J genotype [15]. This observation may explain the differential reproduction of *V. jacobsoni* observed in *A. mellifera* and *A. cerana* colonies in Vietnam [7]. The J genotype was found in both *A. mellifera* and *A. cerana japonica* in Japan [14]. Since the 1970s, no extensive colony mortality has been reported in Japan (T. Yoshida, pers. comm.).

V. jacobsoni also is a serious problem in Europe [38, 48] and the US [33] but not in Brazil where Africanized honey bees are abundant [20, 24]. This disparity in viru-

Table III. Worldwide distribution of different genotypes of *V. jacobsoni*.

Country	*V. jacobsoni* genotype	Host	Country	*V. jacobsoni* genotype	Host
Asia			Africa		
Indonesia	PNG, R	*A. cerana, A. mellifera*	Morocco	R	*A. mellifera*
Japan	J	*A. cerana, A. mellifera*			
Korea	R	*A. mellifera*	N. America		
Malaysia (Borneo)	PNG	*A. cerana*	United States		
PNG	PNG	*A. cerana, A. mellifera*	Arizona	J, R	*A. mellifera*
Philippines	PNG	*A. cerana*	California	J, R	*A. mellifera*
	R	*A. mellifera*	Connecticut	J, R	*A. mellifera*
Thailand	J, R	*A. cerana, A. mellifera*	Florida	J, R	*A. mellifera*
Vietnam	J	*A. cerana,*	Georgia	J, R	*A. mellifera*
	R	*A. mellifera*	Iowa	J, R	*A. mellifera*
Vladivostock, Russia	R	*A. mellifera*	Louisiana	R	*A. mellifera*
			Maryland	R	*A. mellifera*
Europe			Minnesota	R	*A. mellifera*
Denmark	R	*A. mellifera*	Nebraska	J, R	*A. mellifera*
France	R	*A. mellifera*	Ohio	J, R	*A. mellifera*
Germany	R	*A. mellifera*	Oregon	R	*A. mellifera*
Greece	R	*A. mellifera*	Texas	J, R	*A. mellifera*
Italy	R	*A. mellifera*	Virginia	J, R	*A. mellifera*
Moldova	R	*A. mellifera*	Wisconsin	R	*A. mellifera*
Netherlands	R	*A. mellifera*			
Portugal	R	*A. mellifera*	Canada		
Spain	R	*A. mellifera*	B. Columbia	R	*A. mellifera*
Ukraine	R	*A. mellifera*	Nova Scotia	R	*A. mellifera*
United Kingdom	R	*A. mellifera*	Ontario	J, R	*A. mellifera*
Yugoslavia	R	*A. mellifera*			
			Mexico		
S. America			Michoacan	R	*A. mellifera*
Argentina	R	*A. mellifera*	Vera Cruz	R	*A. mellifera*
Brazil	J	*A. mellifera*	Puerto Rico	J	*A. mellifera*

lence may be due to the genotypic differences of the mites rather than the genotypic differences of the honey bees [9, 41] or climatic reasons [25]. European honey bees have survived *V. jacobsoni* infestations without treatment for more than 12 years in Brazil [22] and Puerto Rico (D. Pesante, pers. comm.). Only the R genotype has been found in Europe and this same genotype also predominates in the US. Both Brazil and Puerto Rico have the J genotype of *V. jacobsoni* [14, 16, 17]. The virulence of *V. jacobsoni* in *A. nigrocincta* and *A. nuluensis* colonies has yet to be investigated.

Our knowledge on the genetic diversity of *V. jacobsoni* raises questions regarding the basis of honey bees' resistance to this parasite. It also opens taxonomic issues which need to be carefully examined. Further studies may result in the identification of other species of *Varroa*, and a clarification of genetic differences in *V. jacobsoni* that may explain varied reports of the severity of *V. jacobsoni* infestation. Certainly, as mites continue to be spread about the world, opportunities for mites from different geographic origins to interbreed increase. New combinations of genetic markers may provide evidence of hybridization. However, this is likely to occur very slowly, since *V. jacobsoni* has a life history that only occasionally leads to out-crossing.

3. *VARROA UNDERWOODI*

V. underwoodi can easily be distinguished from *V. jacobsoni* and *V. rindereri* by its small size, ellipsoidal shape and long lateral marginal setae radiating outward. Among populations of *V. underwoodi*, size variation has been reported, although some measurements are well within the range reported by Delfinado-Baker and Aggarwal [27] for the type specimen (*table IV*). The smallest *V. underwoodi* was recorded in PNG from *A. mellifera* colonies [3]. The one specimen collected from Borneo, Malaysia [13] was the largest. This mite from Borneo also has fewer endopodal setae when compared to *V. underwoodi* from Korea.

3.1. Host range and distribution

V. underwoodi was first described in 1987 infesting colonies of *A. cerana* in Nepal [27]. Knowledge of its host range and geographic distribution is rapidly expanding. This parasitic mite has been detected on *A. cerana* in Korea [50], and *A. cerana* and *A. mellifera* in Papua New Guinea [3, 39]. In 1996, *V. underwoodi* or a similar species was observed parasitizing *A. nuluensis* or *A. cerana* in Borneo [13]. The mite was found tightly tucked in between the sternites of *A. nuluensis* collected from

Table IV. Size variation of different populations of *V. underwoodi*.

Country source	Host	Length (μm)	Width (μm)
Indonesia (Irian Jaya)	*A. cerana*	716	1 096
Indonesia (Java)	*A. cerana*	720	1 080*
Indonesia (Sulawesi)	*A. cerana*	780	1 050*
	A. nigrocincta	744	1 160
Korea	*A. cerana*	736	1 199
Malaysia (Borneo)	*A. nuluensis*	820	1 360*
Nepal	*A. cerana*	758	1 162**
Papua New Guinea	*A. cerana*	720	1 105
	A. mellifera	713	1 103

* Measurement from one mite; ** type specimen; sources: [3, 13, 27, 50].

mixed populations of *A. nuluensis* and *A. cerana*. The coincidence of its collection with *A. nuluensis* workers suggested that it likely came from the *A. nuluensis* colony. *V. underwoodi* was also observed in *A. cerana* and on newly recognized *A. nigrocincta* colonies in Indonesia [3]. Recently, *V. underwoodi* was observed in Vietnam in drone brood of *A. cerana* (L. de Guzman, unpublished data), which is the first record on the occurrence of *V. underwoodi* in Vietnam.

Little is known about the biology of this parasite. The mite reproduces on drone brood of *A. cerana* [50] and *A. nigrocincta* [3]. Although *V. underwoodi* has been observed on *A. mellifera*, no reproduction was noted. The potential of this *Varroa* species to become a serious parasite of *A. mellifera* and other *Apis* species needs to be studied.

4. *VARROA RINDERERI*

V. rindereri is a parasite of *A. koschevnikovi*, another cavity nesting honey bee commonly known as the red bee, which is sympatric with *A. cerana* in Borneo, Malaysia [13]. Adult females of *V. rindereri* are similar to *V. jacobsoni* females. However, *V. rindereri* is larger (1 180 × 1 698 μm) than *V. jacobsoni* from Indonesia, mean: 1 065 × 1 575 μm [45]; Europe, mean: 1 117 × 1 677 μm or SW Asia, mean: 1 108 × 1 660 μm [28]. Although *V. rindereri* is larger than *V. jacobsoni* (1 077 × 1 596 μm) from Borneo, the numbers of setae and pores on the sternal shield of *V. rindereri* are fewer (*table I*). Likewise, *V. rindereri* differs from *V. jacobsoni* or *V. underwoodi* by its long and wide-looped peritreme. The trochanter of the palpus lacks a seta. A seta is always present on palpal trochanters of *V. jacobsoni* and *V. underwoodi*.

De Guzman and Delfinado-Baker [13] also showed that *V. rindereri* is genetically different from the *V. jacobsoni* from Borneo. Using RAPD primer OPD-01, *V. rindereri* showed two specific bands that were not present in *V. jacobsoni* while one band present in *V. jacobsoni* was not found in *V. rindereri*. There were two bands shared between the two *Varroa* species.

The biology of *V. rindereri* has not been studied. However, this mite species may be specific to *A. koschevnikovi*. This was supported by the absence of cross infestation between the *A. koschevnikovi* and *A. cerana* colonies in the same apiary. DNA analysis showed that all mites collected from the *A. koschevnikovi* colonies were *V. rindereri* while those mites collected from the *A. cerana* colonies at the same apiary were all *V. jacobsoni*. In addition, differences in the phoretic behavior of the two mite species during the collection were also observed. When pupae were removed from their cells, *V. jacobsoni* tended to hang onto the pupal hosts while *V. rindereri* remained inside the cells [13].

4.1. Host range and distribution

V. rindereri has been only reported in colonies of *A. koschevnikovi* in Borneo, Malaysia.

ACKNOWLEDGEMENTS

We thank numerous colleagues and beekeepers for collecting *Varroa* samples for DNA analyses, and T. Stelzer for his technical help. This manuscript is completed in cooperation with Louisiana Agricultural Experiment Station.

Résumé – Identification et comparaison des espèces de *Varroa*, parasites des abeilles mellifères. Il existe trois espèces de *Varroa* parasitant les abeilles mellifères (*Apis* spp.) : *Varroa jacobsoni* Oudemans 1904, *V. underwoodi* Delfinado-Baker et Aggarwal, 1987 et *V. rindereri* de Guzman et Delfinado-Baker, 1996. *V. jacobsoni* est l'espèce la plus importante du point du vue économique. Ces trois espèces ont une morphologie et une chétotaxie (nomenclature et répartition des soies) semblables. Néanmoins *V. jacobsoni* et *V. rindereri* ont une forme ovale transversale contrairement à la forme elliposoïdale de *V. underwoodi*. *V. jacobsoni* se distingue de *V. rindereri* par sa petite taille, son péritrème court et enroulé à boucles serrées, des soies de l'endopode moins nombreuses et la présence d'une soie sur le trochanter palpal (*tableau I*). *V. jacobsoni* a été signalé comme parasite d'*Apis cerana*, *A. mellifera*, *A. koschevnikovi*, *A. nigrocincta* et *A. nuluensis* [13, 29, 32] (*tableau II*). *V. jacobsoni* est présent dans le monde entier à l'exception de l'Australie, de la Nouvelle-Zélande, d'Hawaï et de certaines régions d'Afrique [40]. Des études génétiques récentes ont montré que l'un des génotypes de *V. jacobsoni* prédominait [4, 14–17]. Parmi les trois génotypes de *V. jacobsoni* connus, le russe (R), le japonais (J) et celui de Papouasie Nouvelle-Guinée (PNG), le génotype R a une répartition plus large que les deux autres [14–17]. Il a été trouvé dans la majeure partie de l'Europe, en Russie, en Amérique du Nord et du Sud, en Afrique et en Asie (*tableau III*). Le génotype J a été signalé en Amérique du Sud et du Nord et en Asie. Le génotype PNG n'est présent actuellement qu'en Asie. Le génotype R est aussi appelé génotype GER par Anderson et Fuchs [4]. Les génotypes R et J ont été déterminés par deux amorces RAPD et l'endonucléase de restriction *Sst I* [15, 16]. Le type PNG a été séquencé par Anderson et Fuchs et correspond vraisemblablement au type de *V. jacobsoni* décrit par Oudemans en 1904 [1, 4]. Le génotype PNG que l'on trouve à Java, Indonésie, n'est donc pas le type répandu sur tout le globe comme on le pensait à l'origine. Notre connaissance de la diversité génétique de *V. jacobsoni* soulève des questions concernant les bases de la résistance des abeilles mellifères à ce parasite. Elle débouche aussi sur des problèmes taxonomiques qui nécessitent d'être étudiés avec soin. De futures études pourraient aboutir à l'identification de nouvelles espèces de *Varroa* et la clarification des différences entre biotypes pourrait conduite à un jugement nuancé sur les conséquences d'une infestation par *V. jacobsoni*.

V. underwoodi se distingue facilement des deux autres espèces par sa petite taille, sa forme ellipsoïdale et par les longues soies latérales rayonnant vers l'extérieur. On a signalé une variation de taille parmi les populations de *V. underwoodi*, bien que certaines mesures entrent bien dans les limites mentionnées par Delfinado-Baker et Aggarwal [27] pour le spécimen type (*tableau IV*). *V. underwoodi* a été décrit pour la première fois en 1987 comme parasite dans des colonies d'*A. cerana* au Népal [27]. Cet acarien parasite a été signalé sur *A. cerana* en Corée [50], sur *A. cerana* et *A. mellifera* en Papouasie Nouvelle-Guinée [3, 39], sur *A. nuluensis* ou *A. cerana* à Bornéo [13] et sur *A. cerana* et *A. nigrocincta* en Indonésie [3]. On a récemment observé *V. underwoodi* dans des cellules de couvain de mâles d'*A. cerana* au Vietnam. C'est la première fois qu'il est signalé au Vietnam. La biologie de ce parasite est peu connue. Il se reproduit sur le couvain de mâles d'*A. cerana* [50] et d'*A. nigrocincta* [3], mais aucune reproduction sur *A. mellifera* n'a été signalée.

V. rindereri parasite *A. koschevnikovi* à Bornéo, Malaisie [12]. Les femelles adultes de *V. rindereri* ressemblent à celles de *V. jacobsoni*. *V. rindereri* est pourtant plus grand et possède moins de soies et de pores sur le bouclier sternal que *V. jacobsoni* (*tableau I*) [28]. *V. rindereri* a un péritrème long et enroulé à boucles lâches, son trochanter palpal est dépourvu de soies. Sur le plan génétique aussi, *V. rindereri* a pu être différentié de *V. jacobsoni* de Bornéo par l'utilisation de l'amorce OPD 01 RAPD [12]. Jusqu'à présent la biologie de *V. rindereri* n'a pas été étudiée. Il n'a été signalé que dans des colonies d'*A. koschevnikovi* à Bornéo, Malaisie.

Varroa jacobsoni / Varroa underwoodi / Varroa rindereri / morphologie / distribution géographique / génotype

Zusammenfassung – Bestimmung und Vergleich der Arten von *Varroa* auf Honigbienen. Von der Gattung *Varroa* sind drei verschiedene auf Honigbienen parasitierende Arten bekannt: *Varroa jacobsoni* Oudemans, *V. underwoodi* Delfinado – Baker and Aggarwal, und *V. rindereri* de Guzman and Delfinado – Baker. Von diesen ist *V. jacobsoni* wirtschaftlich am bedeutendsten. Generell sind diese drei Arten morphologisch und chaetotaxonomisch sehr ähnlich. Jedoch sind *V. jacobsoni* und *V. rindereri* queroval, im Gegensatz zu der elliptischen Form von *V. underwoodi*. *V. jacobsoni* kann von *V. rindereri* durch die geringere Größe, durch kurze und scharfgeschlungene Peritreme, eine geringere Anzahl von endopodalen Borsten und das Fehlen einer der Borsten am palpalen Trochanter unterschieden werden (*Tabelle I*). *V. jacobsoni* wurde parasitierend auf *A. cerana, A. mellifera, A. koschevnikovi, A. nigrocincta und A. nuluensis* gefunden [13, 29, 32] (*Tabelle II*), und ist auf der ganzen Welt verbreitet außer in Australien, Neuseeland, Hawaii und Teilen Afrikas [40]. Neuere Studien belegen, daß hierbei einer der Genotypen von *V. jacobsoni* vorherrschend ist [4, 14–17]. Unter den drei bekannten Genotypen von *V. jacobsoni* [Russisch (R), Japanisch (J) und Papua Neu Guinea (PNG)] hat der Genotyp R eine weitere Verbreitung als J oder PNG [14–17]. Der Genotyp R wurde in den meisten Teilen von Europa, Russland, Süd- und Nordamerika, Afrika und Asien gefunden (*Tabelle III*). Der Genotyp J wurde in Süd- und Nordamerika und in Asien, der Genotyp PNG bislang nur in Asien gefunden. Der Genotyp R wurde von Anderson und Fuchs [4] als Genotyp GER bezeichnet. Die Genotypen R und J wurden durch RAPD Primer (random amplification of polymorphic DNS) und *Sst I* Restriktionsendonucleasen [15, 16] etabliert. Der PNG Typus wurde von Anderson und Fuchs [1] sequenziert und ist aller Voraussicht nach identisch mit dem 1904 von Oudemans beschriebenen Typus von *V. jacobsoni* [4]. Daher ist der auf Java, Indonesien gefundene Genotyp PNG nicht wie ursprünglich angenommen der, welcher sich weltweit verbreitet hat. Unsere Kenntnis der genetischen Vielfalt von *V. jacobsoni* wirft einige Fragen bezüglich der Grundlage der Resistenz von Honigbienen gegen diesen Parasiten auf. Ebenso eröffnet sich ein taxonomisches Feld, das sorgfältig untersucht werden muß. Zukünftige Studien könnten zur Identifikation weiterer Arten von *Varroa* führen, und eine Klärung der Unterschiede zwischen den Biotypen könnte eine differenzierte Beurteilung der Folgen eines Befalls mit *V. jacobsoni* ermöglichen.

V. underwoodi kann durch seine geringere Größe, ellipsoide Form und die langen seitlich ausstrahlenden Borsten von *V. jacobsoni* und *V. rindereri* unterschieden werden. Es wurde über eine Variation der Größe zwischen verschiedenen Populationen von *V. underwoodi* berichtet, obwohl einige der Messungen noch innerhalb des von Delfinado-Baker und Aggrawal [27] für den Holotypus angegebenen Bereichs liegen (*Tabelle IV*). *V. underwoodi* wurde 1987 zuerst aus Völkern von *A. cerana* in Nepal beschrieben [27]. Diese parasitische Milbe wurde bislang in Völkern von *A. cerana* und *A. mellifera* in Papua Neu Guinea [3, 39], *A. nuluensis* und *A. cerana* in Borneo [13], *A. cerana* und *A. nigrocincta* in Indonesien entdeckt [3]. Kürzlich wurde *A. underwoodi* in Drohnenbrutzellen von *A. cerana* in Vietnam beobachtet, dies war der erste Bericht über das Vorkommen von *V. underwoodi* in Vietnam. Über die Biologie dieses Parasiten ist nur wenig bekannt. Die Milbe reproduziert in Drohnenbrut von *A. cerana* und *A. nigrocincta*, eine Fortpflanzung in *A. mellifera* wurde nicht festgestellt.

V. rindereri ist ein Parasit von *A. koschevnikovi* in Borneo, Malaysia [12]. Die adulten Weibchen von *V. rindereri* ähneln denen von *V. jacobsoni*. *V. rindereri* ist allerdings größer und besitzt eine geringere Anzahl von Borsten und Poren auf dem Bauchschild als *V. jacobsoni* (*Tabelle I*) [28]. *V. rindereri* hat lange und weitgeschlungene Peritremen und es fehlt eine der Borsten auf dem Trochanter der Palpen. Bei Benutzung des RAPD Primers OPD 01 kann *V. rindereri* auch genetisch von *V. jacobsoni* von Borneo unterschieden werden [12]. Die Biologie von *V. rindereri* wurde bisher nicht untersucht. Bislang wurde *V. rindereri* nur in Völkern von *A. koschevnikovi* in Borneo gefunden.

***Varroa jacobsoni / Varroa underwoodi / Varroa rindereri* / Morphologie / genotype**

REFERENCES

[1] Anderson D.L., Non-reproduction of *Varroa jacobsoni* in *Apis mellifera* colonies in Papua New Guinea and Indonesia, Apidologie 25 (1994) 412–421.

[2] Anderson D.L., Sukarsih, Changed *Varroa jacobsoni* reproduction in *Apis mellifera* colonies in Java, Apidologie 27 (1996) 461–466.

[3] Anderson D.L., Halliday R.B., Otis G.W., The occurrence of *Varroa underwoodi* (Acarina: Varroidae) in Papua New Guinea and Indonesia, Apidologie 28 (1997) 143–147

[4] Anderson D.L., Fuchs S., Two genetically distinct populations of *Varroa jacobsoni* with contrasting reproductive abilities on *Apis mellifera*, J. Apic. Res. 37 (1998) 69–78.

[5] Akratanakul P., Burgett M., *Varroa jacobsoni*: A prospective pest of honey bees in many parts of the world, Bee World 56 (1975) 119–121.

[6] Atwal A.S., Goyal N.P., Infection of honeybee colonies with *Tropilaelaps* and its control, J. Apic. Res. 10 (1971) 137–142.

[7] Boot W.J., Calis J.N.M., Beetsma J., Hai D.M., Lan N.K., Toan T.V., Trung L.Q., The phenomenon of non-reproduction in worker cells as a *Varroa*-tolerance factor involves natural selection of the mites, Apidologie 27 (1996) 282–283.

[8] Burgett M., Akratanakul P., Morse R.A., *Tropilaelaps clareae*: a parasite of honey bees in Southeast Asia, Bee World 64 (1983) 25–28.

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

[10] Cervancia C.R., Philippines beekeeping status of research and development, in: Beenet Asia: workshop on priorities in R&D on beekeeping in tropical Asia, Kuala Lumpur, Malaysia, 1993, pp. 49–63.

[11] Choi S.Y., Chemical control of *Varroa* mites in Korea, in: Needham G.R., Page R.E., Delfinado-Baker M., Bowman C.E. (Eds.), Africanized Honey Bees and Bee Mites, Ellis Horwood Limited, Chichester, 1988, pp. 413–416.

[12] de Guzman L.I., Delfinado-Baker M., A new species of *Varroa* (Acari: Varroidae) associated with *Apis koschevnikovi* (Apidae: Hymenoptera) in Borneo, Int. J. Acarol. 22 (1996) 23–27.

[13] de Guzman L.I., Rinderer T.E., Whiteside R., Scientific note on the infestation of *Varroa* on *Apis nuluensis*, Apidologie 27 (1996) 429–430.

[14] de Guzman L.I., Rinderer T.E., Stelzer J.A., DNA evidence of the origin of *Varroa jacobsoni* Oudemans in the Americas, Biochem. Genet. 35 (1997) 325–335.

[15] de Guzman L.I., Rinderer T.E., Distribution of the Japanese and Russian genotypes of *Varroa jacobsoni*, Honeybee Sci. 19 (1998) 115–119 (in Japanese).

[16] de Guzman L.I., Rinderer T.E., Stelzer J.A., Anderson D.L., Congruence of RAPD and mitochondrial DNA markers in assessing *Varroa jacobsoni* genotypes, J. Apic. Res. 37 (1998) 49–51.

[17] de Guzman L.I., Rinderer T.E., Stelzer J.A., Occurrence of two genotypes of *Varroa* in North America, Apidologie 30 (1999) 31–36

[18] de Guzman L. I., Rinderer T.E., Lancaster V.A., Delatte G.T., Stelzer J.A., *Varroa* in the mating yard: III. The effects of formic acid gel formulation on drone production, Am. Bee J. (1999) in press.

[19] de Jong D., *Varroa jacobsoni* does reproduce in worker cells of *Apis cerana* in South Korea, Apidologie 19 (1988) 241–244.

[20] de Jong D., Africanized honey bees in Brazil, forty years of adaptation and success, Bee World 77 (1996) 67–70.

[21] de Jong D., Gonçalves L.S., The *Varroa* problem in Brazil, Am. Bee J. 121 (1981) 186–189.

[22] de Jong D., Soares A.E.E., An isolated population of Italian bees that has survived *Varroa jacobsoni* infestation without treatment for over 12 years, Am. Bee J. 137 (1997) 742–747.

[23] de Jong D., Gonçalves L.S., Morse R.A., Weight loss and other damage to developing worker honey bees (*Apis mellifera*) due to the infestation with *Varroa jacobsoni*, J. Apic. Res. 21 (1982) 165–167.

[24] de Jong D., Morse R.A., Eickwort G.C., Mite pests of honey bees, Annu. Rev. Entomol. 27 (1982) 229–252.

[25] de Jong D., Gonçalves L.S., Morse R.A., Dependence on a climate of the virulence of *Varroa jacobsoni*, Bee World 65 (1984) 117–121.

[26] Delfinado-Baker M., The nymphal stages and male of *Varroa jacobsoni* Oudemans, a parasite of honey bees, Int. J. Acarol. 10 (1984) 75–80.

[27] Delfinado-Baker M., Aggarwal K., A new *Varroa* (Acari: Varroidae) from the nest of *Apis cerana* (Apidae), Int. J. Acarol. 13 (1987) 233–237.

[28] Delfinado-Baker M., Houck M., Geographic variation in *Varroa jacobsoni* (Acari, Varroidae): Application of multivariate morphometric techniques, Apidologie 20 (1989) 345–357.

[29] Delfinado-Baker M., Baker E.W., Phoon A.C.G., Mites (Acari) associated with bees (Apidae) in Asia, with description of a new species, Am. Bee J. 129 (1989) 609–610, 612–613.

[30] Engels W., Schatton K., Changes in hemolymph and weight loss in worker bees due to *Varroa* parasitization, *Varroa* Workshop Feldafing (1986) abstract 5.

[31] Ha T.D., Lap P.V., Current status of beekeeping and priorities in research and development on bees and beekeeping in Vietnam, in: Beenet Asia: workshop on priorities in R & D on beekeeping in tropical Asia, Kuala Lumpur, Malaysia, 1993, pp. 15–38.

[32] Hadisoesilo S., Otis G.W., Differences in drone cappings of *Apis cerana* F., 1973 and *Apis nigrocincta* Smith, 1861, J. Apic. Res. 37 (1998) 11–15.

[33] Hoff F.L., Willett L.S., The U.S. Beekeeping Industry, USDA Agric. Economic Report #680, 1994.

[34] King R.C., A Dictionary of Genetics, Oxford University Press, New York, 1974, 375 pp.

[35] Koeniger N., Koeniger G., Wijayagunasekera N.H.P., Observations on the adaption of *Varroa jacobsoni* to its natural host *Apis cerana* in Sri Lanka, Apidologie 12 (1981) 37–40.

[36] Kraus B., Page R., Effect of *Varroa jacobsoni* (Mesostigmata, Varroidae) on feral *Apis mellifera* (Hymenoptera, Apidae) in California, Environ. Entomol. 24 (1995) 1473–1480.

[37] Kraus B., Hunt G., Differentiation of *Varroa jacobsoni* Oud. populations by random amplification of polymorphic DNA (RAPD), Apidologie 26 (1995) 283–290.

[38] Kulincevic J.M., Rinderer T.E., Mladjan V.J., Buco S.M., Five years of bi-directional genetic selection for honey bees resistant and susceptible to *Varroa jacobsoni*, Apidologie 23 (1992) 443–452.

[39] Lee B., Mites, bees, and plagues that are and might be, Partners in Research for Development 8 (1995) 2–9.

[40] Matheson A., World bee health update 1996, Bee World 77 (1996) 45–51.

[41] Moretto G., Gonçalves L.S., de Jong D., Bichuette M.Z., The effects of climate and bee race on *Varroa jacobsoni* Oud. infestations in Brazil, Apidologie 22 (1991) 197–203.

[42] Moretto G., Gonçalves L.S., de Jong D., Africanized bees are more efficient at removing *Varroa jacobsoni*. Preliminary data, Am. Bee J. 131 (1991) 434.

[43] Moritz R.F.A., Heritability of the postcapping stage in *Apis mellifera* and its relation to Varroatosis resistance, J. Hered. 76 (1985) 267–270.

[44] Moritz R.F.A., Hänel H., Restricted development of the parasitic mite *Varroa jacobsoni* Oud. in the cape honey bee *Apis mellifera capensis*, Esch. Z. Angew. Entomol. 97 (1984) 91–95.

[45] Oudemans A.C., On a new genus and species of parasitic Acari, Notes Leyden Mus. 24 (1904) 197–204.

[46] Peng Y.S., Fang Y., Xu S., Ge L., The resistance mechanism of the Asian honey bee, *Apis cerana* Fabr. to an ectoparasite, *Varroa jacobsoni* Oudemans, J. Invertebr. Pathol. 49 (1987) 54–60.

[47] Rinderer, T.E., Guzman, L. I. de, Lancaster V.A., Delatte G.T., Stelzer J. A., *Varroa* in the mating yard: I. The effects of *Varroa jacobsoni* and Apistan on drones, Am. Bee J. 139 (1999) 134–139.

[48] Ritter W., Leclerq E., Koch W., Observations on bee and varroa mite populations in infested honey bee colonies, Apidologie 15 (1984) 389–400.

[49] Sylvester H.A., Watts R., Guzman L.I. de, Stelzer J.A., Rinderer T.E., *Varroa* in the mating yard: II. The effects of *Varroa jacobsoni* and Apistan on the mating ability of drones, Am. Bee J. 139 (1999) 225–227.

[50] Woo K.S., New honeybee mite *Varroa underwoodi* on *Apis cerana* in South Korea, Honeybee Sci. 13 (1992) 173–174 (in Japanese).

[51] Yoshida T., Sasaki M., Yamazaki S., Parasitism and reproduction of varroa mite on the Japanese honey bee, *Apis cerana japonica*, in: Kevan P. (Ed.), The Asiatic Hive Bee: Apiculture, Biology, and Role in Sustainable Development in Tropical and Subtropical Asia, Enviroquest, Ltd., Canada, 1995, pp. 171–175.