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Morphometric identification of the predominant species of *Varroa* (Parasitiformes: Varroidae) in bee colonies in Hopelchén, Campeche

Identificación morfométrica de la especie predomínate de *Varroa* (Parasitiformes: Varroidae) en colonias de abejas en Hopelchén, Campeche

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ABSTRACT

Worldwide, varroasis continues to be the main sanitary problem in beekeeping production systems, causing great economic losses; currently in the Yucatan Peninsula the presence of *Varroa* has been reported, however, it is unknown which of the 4 species parasitize *Apis mellifera* bees in Campeche State. The aim of this research was to identify morphometrically the predominant species of *Varroa* (Parasitiformes: Varroidae) in bee colonies in Hopelchén, Campeche; for this purpose, 61 hives were evaluated from 5 apiaries, 200 to 300 bees were collected from each one; for the morphometric analysis, 244 mites were placed in 50% lactic acid for 2 hours at 100ºC, and then the segments were measured in an ocular micrometer. The results indicated that 100% of the mites evaluated belonged to the *Varroa destructor* species, the mean K clusters indicated intraspecific differences ($P< 0.05$), observing 5 morphotypes of *V. destructor*, the variables that presented greater variability were width of the anal shield ($P=0.001$) and width of the genital shield ($P=0.001$). It is concluded that although 100% of the mites belonged to *V. destructor*, they showed intraspecific morphometric differences.
Keywords: haplotype, varroasis, infestation, Apis.

RESUMEN

A nivel mundial, la varroasis continúa siendo el principal problema sanitario en los sistemas de producción apícola, causando grandes pérdidas económicas; actualmente en la península de Yucatán se ha reportado la presencia de *Varroa*, sin embargo, se desconoce cuál de las 4 especies parasitan a las abejas *Apis mellifera* en el Estado de Campeche. El objetivo de esta investigación fue identificar morfométricamente la especie predominante de *Varroa* (Parasitiformes: Varroidae) en colonias de abejas en Hopelchén, Campeche*;* para ello de 5 apiarios se evaluaron 61 colmenas, de cada una se colectaron de 200 a 300 abejas; para el análisis morfométrico, 244 ácaros fueron colocados en ácido láctico al 50% durante 2 horas a 100ºC, y posteriormente se midieron los segmentos en un micrómetro ocular. Los resultados indicaron que el 100% de los ácaros evaluados pertenecen a la especie de *Varroa destructor*, los conglomerados K medias indicaron diferencias intraespecíficas (P< 0.05) observándose 5 morfotipos de *V. destructor*, las variables que presentaron mayor variabilidad fueron ancho del escudo anal (P=0.001) y ancho del escudo genital (P=0.001). Se concluye que a pesar de que el 100% de los ácaros pertenecieron a *V. destructor* estos presentaron diferencias morfométricas intraespecíficas.

Palabras clave: haplotipo, varroasis, infestación, Apis.

INTRODUCTION

Varroasis is a disease caused by the *Varroa* mite, an obligate ectoparasite of honey bees (Rosenkranz *et al*., 2010). To date, four species of the genus *Varroa* are known, including *Varroa jacobsoni* and *Varroa underwoodi*, mites that parasitize *Apis cerana* bees and they are distributed throughout Asia, *Varroa rindereri* described in *Apis koschevnikovi* bees and distributed in Borneo, and *Varroa destructor* described in both *Apis cerana* and *Apis mellifera* bees. The presence of *V. destructor* was first recorded in the Americas in 1987 and recently through morphometric studies it has been identified in countries such as Mexico and Argentina (De Guzman & Delfinado, 1996; De Guzman & Rinderer, 1999; Anderson & Trueman, 2000; Anderson, 2000a; Maggi *et al*., 2009; Loeza-Concha *et al*., 2018).

Despite the existence of four species of the genus *Varroa* only *V. destructor* is considered of economic importance, since untreated colonies can collapse due to the presence of this mite after 3 to 4 years of the initial infestation (BüChler, 1994). Mites are harmful because they generally lodge in the thorax and abdomen of drones and worker bees, besides feeding mainly on fat bodies of adult bees and the hemolymph of larvae (Ramsey *et al*., 2019), which causes serious damage to the health of bees affecting the immune system, reduces the growth and development of colonies (Moreira *et al*., 2017). In this sense, it has been observed that worker bees have a reduced lifespan, have a lower learning ability and lower rate of return to the colony (Amdam *et al*., 2004; Kralj *et al*., 2007). In addition, *V. destructor* is considered a vector of several honeybee viruses (Chen & Siede, 2007) because viruses have been considered a problem for honeybee health since their emergence (Yue & Genersch, 2005).

Recent studies have shown that bee size correlates with mite size, whereby *V. jacobsoni* affects *Apis cerana*, being smaller than *V. destructor* and *A. mellifera* (Anderson & Trueman, 2000), to test this hypothesis morphometric discrimination techniques have been used by measuring body segments, which mainly use concepts of size and shape in order to know the morphological adaptations (Delfinado & Houck, 1989). In this sense authors such as De Guzman & Delfinado-Baker (1996), Anderson & Trueman (2000), Maggi *et al*., (2009), Loeza-Concha *et al*., (2018) have studied the morphometric variations of different populations of *Varroa* mites where different morphotypes have been established in different regions of the world. In this region until now it was unknown which of the four species affects the different populations of *A. mellifera* and if there are morphological variations in Varroa populations that affect the different populations of *A. mellifera*. The objective of this research was to identify morphometrically the predominant species of *Varroa* (Parasitiformes: Varroidae) in bee colonies in Hopelchén, Campeche.

MATERIAL AND METHODS

Experimental area location

The research was carried out in the apiaries of the Higher Technological Institute of Hopelchén, Campeche, located at 19°76′41″ north latitude and 89°86′68″ west longitude at 100 m a.s.l. Two types of climates predominate in the area: warm sub-humid (awo) (w), with summer rainfall of less than 5.0 mm and warm sub-humid (aw1), with winter rainfall and precipitation between 5 and 10.2 mm. The average annual precipitation is 1,050 mm, with rainfall from May to October. The annual temperature varies between 19.5 °C and 32.5 °C, with an average of 26 °C (Weather Spark, 2021).

Sample obtaining

The research was carried out in 5 apiaries in Hopelchén municipality where 61 hives were studied with the following characteristics: five brood frames in all stages of development and 4 frames with honey and pollen. In these hives, 200 to 300 bees were collected from the third and fourth frames of the brood chamber. Bees were placed in containers with absolute alcohol until use (Loeza-Concha *et al*., 2018).

Varroa specimen collection

Varroa specimens were obtained using the methodology described by De Jong *et al*., (1982) with modifications (Loeza-Concha *et al.,* 2020), which consisted of shaking plastic containers containing between 200 and 300 bees for 10 min at 60 rpm. The contents of containers were placed in a conical container with a 3 mm mesh which was filled with absolute alcohol until the bees were completely covered, then, with a glass rod the samples were shaken to detach mites from bees, so that by gravity the mites were deposited at the bottom of the cone, finally, the solution was decanted through a white cloth and mites obtained from each of the hives were stored and labeled separately in microtubes of 1. 5 ml microtubes and kept refrigerated (4 °C) until use.

Mite processing

To determine the predominant Varroa species and morphometric variability, 244 female *Varroa* specimens were analyzed and placed in 50% lactic acid for 2 h at 100 °C; subsequently, mites were stored in 50% v/v alcohol until observation. Morphometric characters were measured using a stereo microscope with an ocular micrometer at 20X (Maggi *et al*., 2009; Loeza-Concha *et al*., 2018).

Morphometry

For morphometric identification of the predominant *Varroa* specimens, six variables were measured on each specimen: dorsal shield width (AED), dorsal shield length (LED), genital shield width (AEG), genital shield length (LEG), anal shield width (AEA) and anal shield length (LEA) (Figure 1) (Maggi *et al*., 2009; Loeza-Concha *et al*., 2018).

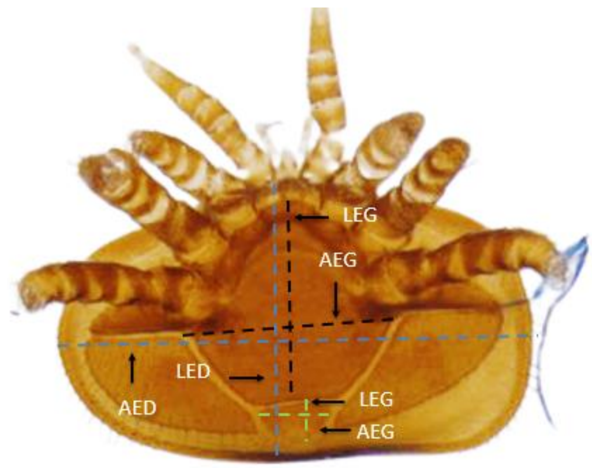

Figura 1. *Varroa* measured variables: dorsal shield width (DSW), dorsal shield length (DSL), genital shield width (GSW), genital shield length (GSL), anal shield width (ASW), and anal shield length (ASL)

Statistical analysis

To determine the morphometric differences of *Varroa* between apiaries, a comparison of means was performed with a one-factor ANOVA test; the variables that had significant differences were subjected to a second *post hoc* multiple comparison analysis using a Tukey's comparison of means (P<0.001). To determine the morphotypes, a K-means cluster analysis was performed using the *Statistical Package for the Social Sciences* (SPSS) version 20.0 (IBM, 2011).

RESULTS

It was determined that 100% of the specimens evaluated in this study area belonged to the species *V. destructor*, only the variables GSW and ASW showed differences among the apiaries evaluated (Table 1).

Table 1. Mean of the studied variables (µm) belonging to the *V. destructor* populations of five evaluated apiaries

Apiarie	DSW	DSL	GSW	GSL	ASW	ASL
1	1685[a]	1159[a]	688[a]	733[a]	248[abc]	199[a]
2	1688[a]	1153[a]	707[ab]	734[a]	261[c]	198[a]
3	1691[a]	1151[a]	719[b]	761[a]	238[ab]	197[a]
4	1689[a]	1154[a]	711[ab]	741[a]	254[bc]	206[a]
5	1684[a]	1146[a]	708[ab]	755[a]	233[a]	201[a]
Mean	1687	1553	703	742	248	200
SEM	3.36	2.38	2.89	3.77	2.36	1.87

Dorsal shield width (DSW), dorsal shield length (DSL), genital shield width (GSW), genital shield length (GSL), anal shield width (ASW) and anal shield length (ASL). Standard error of the mean (SEM). Different literals per column indicate Tukey statistical difference with p<0.001

According to the analysis of hierarchical clusters K means, it could be observed that all the variables presented discrimination for the formation of clusters among the Varroa populations analyzed in the five apiaries. In this sense, 5 morphotypes of *V. destructor*, which allowed us to observe that morphotypes A and E were the most widely distributed; these were differentiated because morphotype A presented smaller DSW size and larger DSL size compared to morphotype E. It was observed that morphotype B was the least distributed, presenting a larger DSW and smaller DSL compared to morphotypes A and E (Table 2).

According to the cluster analysis, it was observed that there is a morphometric variability of the mites in the 5 apiaries evaluated. In this sense, of the 5 morphotypes found, morphotypes A and E were the most widely distributed since they were found in hives of the 5 apiaries. Morphotype B was the least distributed since it was only found in hives of apiaries 1 and 5; morphotype C in hives of apiaries 1, 3, 4 and 5, morphotype A in hives of apiaries 1, 2, 4 and 5 (Table 3).

Table 2. Mean of the studied variables (µm) belonging to the 5 morphotypes of *V. destructor*

Morphotype	DSW	DSL	DSW	GSL	ASW	ASL
A	1681	1165	675	754	239	184
B	1706	1144	712	837	237	215
C	1652	1149	709	736	230	205
D	1684	1144	693	712	256	197
E	1707	1159	717	752	255	204
p<	0.0001	0.02	0.0001	0.0001	0.0001	0.002

Dorsal shield width (DSW), dorsal shield length (DSL), genital shield width (GSW), genital shield length (GSL), anal shield width (ASW) and anal shield length (ASL)

Table 1. Number of colonies belonging to each morphotype per apiary

Morphotype	A	B	C	D	E
Apiary	Number of hives colmenas /Apiary				
1	4	1	4	7	3
2	2	--	--	5	5
3	1	--	2	--	4
4	1	--	2	2	8
5	1	1	3	1	4
Total	**9**	**2**	**11**	**15**	**24**

According to the data obtained, when plotting the similarities between the morphotypes, a grouping in three nodes is observed, isolating morphotype B with higher values of LEG and LEA, but lower number of colonies (Figure 2, Table 2).

DISCUSSION

The results obtained indicate that the predominant species of *Varroa* in the 5 apiaries analyzed is *V. destructor* since according to Abou-Shaara & Tabikha, (2016). The proportion of body size is equal or greater than 1140 µm, confirming that the existing species is *V. destructor.* Our results agree with those obtained in Argentina by Maggi *et al*. (2009) where they reported 3 mite morphotypes, with a range of DSW 1696 µm to 1757 µm and DSL from 1128 µm to 1178 µm. For the case of Mexico, Loeza-Concha *et al*. (2018) found 8 morphotypes of *V. destructor* species with DSW ranges from 1582 µm to 1700 µm and DSL from 1042 µm to 1147 µm. In Japan, Thailand and Vietnam, Anderson & Trueman, (2000) reported the presence of *V. destructor* with a DSW of 1708 µm and a DSL of 1167 µm. In New Zealand, Zhang, (2000) reported that the DSL ranges of *V. destructor* were from 1132 µm to 1185 µm and the DSW 1642 µm to 1757 µm. In Poland where they studied the cell size effect so it could be demonstrated that the mite of *V. destructor* significantly reduced its size when the DSW of *V. destructor* was reduced when the *V. destructor* DSW was 1132 µm to 1757 µm. *V. destructor* mite significantly reduced its size when it was housed in small cell sizes. In this sense, Borsuk *et al*. (2012)

reported DSW and DSL of 1665 µm and 1121 µm respectively in small cell sizes and 1716 µm and 1142 µm respectively in standard cell sizes. We can mention several similar reports in Benin, Nigeria, Tunisia, Iran and Egypt (Table 4) (Rahmani *et al*., 2006; Akinwande *et al*., 2013; Abou-Shaara & Tabikha, 2016; Kelomey *et al*., 2016; Yevstafieva & Nasarenko, 2018), according to the above mentioned, *V. destructor* is distributed in most of the world. This mite presents variations in size and shape within the same mite population in the different bee species it parasitizes (Akimov *et al*., 2004). In this sense, we consider that the morphometric variability observed in this mite can be defined as an adaptation adjustment to the environment, which allows maintaining the individual fitness of the mite and the subsistence of the species (Pigliucci, 2005; Nussey *et al*., 2007).

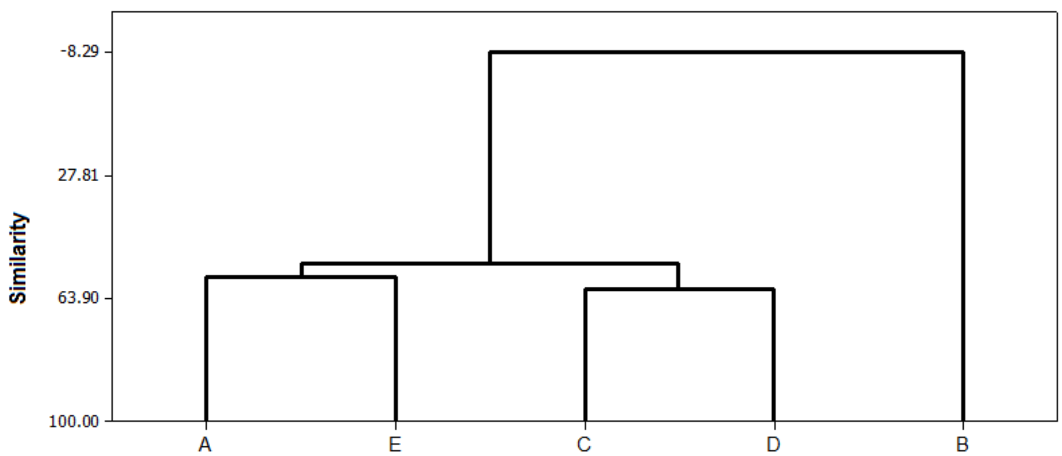

Figura 2. Grouping of morphotypes by similarity considering morphometric variables (morphotypes A, B, C, D and E)

According to the above, we consider that the variations of *Varroa* morphotypes found in the study area are mainly due to the interaction between the mite and bee species it parasitizes. Thus, we agree with Giménez *et al.* (2017) and George *et al.* (2004), who indicate that parasites tend to vary their morphotype according to their host, i.e. morphometric variability depends on the lineage of *Apis mellifera* that the mite parasitizes. The results obtained with the analysis of hierarchical clusters K means (Table 2) it could be observed that there is morphometric variability between closely related populations (Figure 1). Loeza-Concha *et al*. (2018) found 8 morphotypes in Tepic, Nayarit, Mexico, likewise, Maggi *et al*. (2009) found 7 morphotypes of *V. destructor* in colonies located in different geographical areas of Argentina, similarly, Akimov *et al*. (2004) and Dadgostar & Nozari (2018) have reported morphometric and gyiographic differences of *Varroa* mites in Iran and Ukraine. According to the aforementioned we differ with Rosenkranz *et al.* (2010) quienes who indicated that *Varroa* mites from different populations are physically the same; as well as with Dadgostar & Nozari (2018) indicated that geographical variations are causes of *Varroa* morphological variations. In this sense, we consider that if there are physical and morphometric differences between different *Varroa* populations since it not only depends on geographical variation but also on colony migration, morphometric correlations between coexisting *V. destructor* populations and bee species it parasitizes and the mutations that the mite may present (Akimov *et al.*, 2004; Loeza-Concha *et al.*, 2018). These morphometric differences in arthropods and insects has been reported previously (Mozaffarian *et al.*, 2007; Lashkari *et al.*, 2015).

Table 4. Body size measurements in micrometers of *Varroa* females in the world

Taxonomic group (species)	DSL (µm)	DSW (µm)	Origin	Author
V. rindereri	1180	1698	Malaysia	De Guzman & Delfinado (1996)
V. destructor	1167	1708	Japan /Thailand/ Vietnam	Anderson & Trueman (2000)
V. Jacobsoni	1063	1506	Java	Anderson (2000b)
V. destructor	1159	1700		
V. destructor	1167	1708	New Zealand	Zhang (2000)
V. Jacobsoni	1063	1506		
V. destructor	1205	1738	North Tunisia	
V. destructor	1165	1711	Central Tunisia	Boudagga *et al*. (2003)
V. destructor	1197	1756	South Tunisia	
V. destructor	1149	1692	Ukraine	Akimov *et al*. (2004)
V. destructor	1197	1775	Iran Colonies less than 1000 m of altitude	
V. destructor	1199	1781	Iran Colonies between 1000-1500 m altitude	Rahmani, *et al*. (2006)
V. destructor	1200	1789	Iran Colonies at more than 1500 m altitude	
V. destructor	1135	1696		
V. destructor	1128	1711	Argentina	Maggi *et al*. (2009)
V. destructor	1178	1757		
V. destructor	1121	1665	Poland	Borsuk *et al*. (2012)
V. destructor	1142	1716		
V. destructor	1177	1718	Nigeria	Akinwande *et al*. (2013)
V. destructor	1115	1639	Benin	Kelomey *et al*. (2016)
V. destructor	1160	1710	Egypt	Abou-Shaara & Tabikha (2016)
V. destructor	1128	1688	Nayarit, Mexico	Loeza-Concha *et al*. (2018)
V. destructor	1090	1630	Ukraine	Yevstafieva & Nasarenko (2018)

Width of dorsal shield (DSW); length of dorsal shield (DSL)

Finally and according to the morphometric data obtained in this research we agree with Akimov *et al.* (2004) y Abou-Shaara & Tabikha (2016), since we consider that according to the body characteristics of *V. destructor* specimens obtained in Mexico. It is suggested that they are of the Korean haplotype, especially because the mean values of the length and width of the dorsal shield are similar to those found in this research (1149 µm and 1692 µm). Besides that the Korean haplotype is the most common worldwide since records of its presence are found in Europe, Middle East, Africa, Asia, North America and South America (Zhang, 2000; Muñoz *et al*., 2008; Akinwande *et al*., 2012). The present investigation takes on greater relevance if we consider that the Japanese *Varroa* haplotype has a more restricted distribution. It is considered less virulent compared to the Korean haplotype which reproduces more easily (De Guzman & Rinderer 1999), because of this Carneiro *et al.* (2007) indicate that the reproduction rate of *V. destructor* females in young worker cells of Africanized honeybees in Brazil is currently almost double compared to the reproduction rate of twenty years ago. It is considered that *Varroa* populations of the Japanese haplotype have been replaced by the Korean haplotype, causing an increase in infestation levels in South America (Strapazzon *et al.,* 2009), which could lead to a greater loss of hives in America.

CONCLUSION

The present study confirmed that although 100% of mites belonged to *V. destructor*, they showed intraspecific morphometric differences.

CITED LITERATURE

ABOU-SHAARA H, Tabikha R. 2016. Morphological characterization and a morphometry map for Varroa mites from northwest of Egypt. *Cercetari Agronomice in Moldova.* 49(4):75-84. ISSN: 2067-1865. https://doi.org/10.1515/cerce-2016-0038

AKIMOV I, Benedyk S, Zaloznaya L. 2004. Complex analysis of morphological characters of Gamasid mite *Varroa destructor* (Parasitiformes, Varroidae). *Vestnik Zoologii*. 38(5): 57-66. ISSN: 00845604, 20732333.
http://dspace.nbuv.gov.ua/handle/123456789/3366

AKINWANDE K, Badejo M, Ogbogu S. 2013. Morphometrics and parasitic load of Varroa mites (Acari: Varroidae) on colonies of *Apis mellifera* adansonii (Hymenoptera: Apidae) in South Western, *Nigeria. Acarina.* 21(1):17-26. ISSN: 01328077, 22215115 https://acarina.utmn.ru/upload/iblock/b39/Akinwande2013.pdf

AKINWANDE KL, Badejo MA, Ogbogu SS. 2012. Incidence of the Korean haplotype of *Varroa destructor* in southwest Nigeria. *Journal of apicultural research*. 51(4):369-370. ISSN: 0021-8839. https://doi.org/10.3896/IBRA.1.51.4.15

AMDAM GV, Hartfelder K, Norberg K, Hagen A, Omholt SW. 2004. Altered physiology in worker honey bees (Hymenoptera: Apidae) infested with the mite *Varroa destructor* (Acari: Varroidae): a factor in colony loss during overwintering?. *Journal of economic entomology*. 97(3):741-747. ISSN 1938-291X. https://doi.org/10.1093/jee/97.3.741

ANDERSON D, Trueman J. 2000a. *Varroa jacobsoni* (Acari: Varroidae) is more than one species. *Experimental and applied acarology*. 24(3):165-189. ISSN: 1572-9702. https://link.springer.com/content/pdf/10.1023/A:1006456720416.pdf

ANDERSON D. 2000b. Variation in the parasitic bee mite *Varroa jacobsoni* Oud. *Apidologie.* 31(2):281-292. ISSN: 0044-8435. https://agris.fao.org/agris-search/search.do?recordID=FR2000003100

BORSUK G, Olszewski K, Strachecka A, Paleolog J, Kasperek K. 2012. Genetic and morphometric variation of the *Varroa destructor* developing in standard and small comb cells. *Veterinary Medical Science and Practice (Medycyna Weterynaryjna)*. 68:599-602. http://www.medycynawet.edu.pl/images/stories/pdf/pdf2012/102012/201210599602.pdf

BOUDAGGA H, Barbouche N, Laârif A, Hamouda MH. 2003. Morphological identification of the *Varroa* species (Acari: Varroidae) colonizing Tunisian apiaries. *Systematic and Applied Acarology.* 8(1):97-100. ISSN: 13621971. https://doi.org/10.11158/saa.8.1.12v

BÜCHLER R. 1994. *Varroa* tolerance in honey bees—occurrence, characters and breeding. *Bee World Journal*. 75(2):54-70. ISSN: 0005772X.
https://doi.org/10.1080/0005772X.1994.11099201

CARNEIRO FE, Torres RR, Strapazzon R, Ramírez SA, Guerra Jr, JC, Koling DF, Moretto G. 2007. Alteração do potencial reprodutivo do ácaro *Varroa destructor* (Anderson e Trueman) em colônias de abelhas africanizadas (*Apis mellifera L*.) (Hymenoptera: Apidae) no sul do Brasil. *Entomología Neotropical*. 36(6):949-952. ISSN: 1678-8052.
https://www.scielo.br/j/ne/a/hZQsr7tqBsCs75DV4sWKzFQ/abstract/?lang=en

CHEN Y, Siede R. 2007. Honey bee viruses. *Advances in virus research.* 70:33-80. ISSN: 00653527, 1557839. https://doi.org/10.1016/S0065-3527(07)70002-7

DE GUZMAN L, Delfinado-Baker M. 1996. A new species of *Varroa* (Acari: Varroidae) associated with Apis koschevnikovi (Apidae: Hymenoptera) in Borneo. *International Journal of Acarology.* 22(1):23-27. ISSN: 1647954.
https://doi.org/10.1080/01647959608684077

DE GUZMAN L, Rinderer T. 1999. Identification and comparison of *Varroa* species infesting honey bees. *Apidologie.* 30(2-3):85-95. ISSN: 0044-8435. https://doi.org/10.1051/apido:19990201

DE JONG D, De Jong P, Goncalves L. 1982. Weight Loss and Other Damage to Developing Worker Honeybees from Infestation With *Varroa jacobsoni. Journal of apicultural research.* 21(3):165-167. ISSN: 0021-8839.
https://doi.org/10.1080/00218839.1982.11100535

DELFINADO M, Houck M. 1989. Geographic variation in *Varroa jacobsoni* (Acari, Varroidae): application of multivariate morphometric techniques. *Apidologie*, 20(4):345-358. ISSN: 0044-8435.
https://www.apidologie.org/articles/apido/pdf/1989/04/Apidologie_0044-8435_1989_20_4_ART0007.pdf

DADGOSTAR S, Nozari J. 2018. Classical and geometric morphometric methods reveal differences between specimens of *Varroa destructor* (Mesostigmata: Varroidae) from seven provinces of Iran. *Persian journal of acarology*. 7(1):51-60. ISSN: 2251-8169. https://doi.org/10.22073/pja.v7i1.32063

GIMÉNEZ P, Mendoza Y, Invenizzi C, Fuselli S, Alonso R, Fernandez P, Maggi M. 2017. Morphometric correlation between Apis mellifera morphotypes (Hymenoptera) and Varroa destructor (Acari) from Uruguay. *Journal of Apicultural Research.* 56(2): 122-129. ISSN: 0021-8839. https://doi.org/10.1080/00218839.2017.1287998

GEORGE M, Muñoz G, Marquet P, Poulin R. 2004. Testing the energetic equivalence rule with helminth endoparasites of vertebrates. *Ecology Letters*. 7(7): 527-531. ISSN: 1461-0248. https://doi.org/10.1111/j.1461-0248.2004.00609.x

KELOMEY E, Paraiso A, Azonwade F, Gbemavo C, Goergen, GE, Tamo M, Baba-Moussa L. 2016. Morphometric characterization of parasite *Varroa sp*. of bee *Apis mellifera L*. in *Benin. European Scientific Journal*. 12(33):221-234. ISSN: 1857-7881. http://dx.doi.org/10.19044/esj.2016.v12n33p221

KRALJ J, Brockmann A, Fuchs S, Tautz J. 2007. The parasitic mite *Varroa destructor* affects non-associative learning in honey bee foragers, *Apis mellifera L*. *Journal of Comparative Physiology A.* 193(3):363-370. ISSN: 1432-1351.
http://dx.doi.org/10.1007/s00359-006-0192-8

IBM SPSS. 2011. IBM SPSS statistics for Windows, version 20.0 (p. 440). New York: IBM Corp.

LASHKARI M, Hentz MG, Boykin LM. 2015. Morphometric comparisons of Diaphorina citri (Hemiptera: Liviidae) populations from Iran, USA and Pakistan. *Peer J.* 3, e946. 1-12. ISSN: 2689-7733. https://doi.org/10.7717/peerj.946

LOEZA-Concha H, Salgado-Moreno S, Avila-Ramos F, Escalera-Valente F, Lemus-Flores C, Domínguez-Rebolledo Á, Carmona-Gasca C. (2020). Seasonal variation in the prevalence of Varroa, Nosema and Acarapis in hives from which queen bee mating nuclei are produced. Journal of Apicultural Research. 59(4): 558-563. ISSN: 0021-8839. https://doi.org/10.1080/00218839.2020.1717060

LOEZA-Concha H, Domínguez-Rebolledo A, Escalera-Valente F, Ávila-Ramos F, Carmona-Gasca C. 2018. Identificación morfométrica de *Varroa destructor* y su plasticidad por la exposición a timol. *Abanico veterinario*. 8(2):98-107. ISSN 2448-6132. https://doi.org/10.21929/abavet2018.82.9

MAGGI M, Sardella N, Ruffinengo S, Eguaras M. 2009. Morphotypes of *Varroa destructor* collected in Apis mellifera colonies from different geographic locations of Argentina. *Parasitology research,* 105(6):1629-1636. ISSN: 1432-1955.
https://doi.org/10.1007/s00436-009-1605-8

MOREIRA S, Queiroz G, De Castro H, De Souza E, Pereira D, De Holanda J. 2017. Infestação do ácaro *Varroa destructor* em colônias de abelhas africanizadas (Apis mellifera L.) no Semiárido potiguar, Nordeste do Brasil. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*. 12(1):143-149. ISSN 1981-8203.
http://dx.doi.org/10.18378/rvads.v12i1.4845

MOZAFFARIAN F, Sarafrazi A, Ganbalani GN. 2007. Host plant-associated population variation in the carob moth Ectomyeloisceratoniae in Iran: A geometric morphometric analysis suggests a nutritional basis. *Journal of Insect Science*. 7(1). ISSN 1536-2442. https://doi.org/10.1673/031.007.0201

MUÑOZ I, Garrido-Bailón E, Martín-Hernández R, Meana A, Higes M, De la Rúa P. 2008. Genetic profile of *Varroa destructor* infesting *Apis mellifera* iberiensis colonies. *Journal of apicultural research*. 47(4):310-313. ISSN: 0021-8839. https://doi.org/10.1080/00218839.2008.11101480

NUSSEY D, Wilson A, Brommer J. 2007. The evolutionary ecology of individual phenotypic plasticity in wild populations. Journal of evolutionary biology. 20:831-844. ISSN: 1420-9101. https://doi.org/10.1111/j.1420-9101.2007.01300.x

PIGLIUCCI M. 2005. Evolution of phenotypic plasticity: where are we going now? Trends in Ecology y Evolution. 20:481-486. ISSN: 0169-5347. https://doi.org/10.1016/j.tree.2005.06.001

RAHMANI H, Sabouri A, Nozari J, Kamali K. 2006. Report and survey of morphometric characteristics of *Varroa destructor* (acari: varroidae) collected from honey bees in Tehran province, Iran (Research note). *Journal of Agricultural Science and Technology*. 8(1):351-355.ISSN: 1680-7073. https://www.sid.ir/en/journal/ViewPaper.aspx?id=47578

RAMSEY S. Ochoa R. Bauchan G, Gulbronson C, Mowery J, Cohen A, Ellis J. 2019. *Varroa destructor* feeds primarily on honey bee fat body tissue and not hemolymph. *Proceedings of the National Academy of Sciences.* 116(5):1792-1801. ISSN: 0027-8424. https://doi.org/10.1073/pnas.1818371116

ROSENKRANZ P, Aumeier P, Ziegelmann B. 2010. Biology and control of *Varroa destructor. Journal of invertebrate pathology.* 103:S96-S119. ISSN: 00222011, 10960805. https://doi.org/10.1016/j.jip.2009.07.016

STRAPAZZON R, Carneiro F, Guerra Jr J, Moretto G. 2009. Genetic characterization of the mite *Varroa destructor* (Acari: Varroidae) collected from honey bees *Apis mellifera* (Hymenoptera, Apidae) in the state of Santa Catarina. *Brazil. Genetics and Molecular Research.* 8(3):990-997. ISSN: 00222011, 10960805. https://www.geneticsmr.org/articles/genetic-characterization-of-the-mite-varroa-destructor-acari-varroidae-collected-from-honey-bees-apis-mellifera-hymenopt.pdf

WEATHER Spark 2021. El clima promedio en Hopelchén, Campeche, México. https://es.weatherspark.com/y/12357/Clima-promedio-en-Hopelchen-M%C3%A9xico-durante-todo-el-a%C3%B1o

YEVSTAFIEVA V, Nasarenko O. 2018. Морфометричні ознаки самок *Varroa destructor* Anderson and Trueman, 2000 (Acari, Mesostigmata: Varroidae). *Theoretical and Applied Veterinary Medicine*. 6(1):40-45. ISSN: 2090-3308. https://bulletin-biosafety.com/index.php/journal/article/view/169

YUE C, Genersch E. 2005. RT-PCR analysis of Deformed wing virus in honeybees (*Apis mellifera*) and mites (*Varroa destructor). Journal of General Virology.* 6(12):3419-3424. ISSN: 00221317, 14652099. https://doi.org/10.1099/vir.0.81401-0

ZHANG Z. 2000. Notes on *Varroa destructor* (Acari: Varroidae) parasitic on honeybees in New Zealand. *Systematic and Applied Acarology Special Publications.* 5(1):9-14. ISSN: 13621971. https://doi.org/10.11158/saasp.5.1.2

Errata Erratum

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