ACARINES, 15: 45-54, 2021

Comparison between morphological characters and ultrastructure of *Varroa* mite from Egypt and Libya

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ABSTRACT

Specimens of Varroa mite, *Varroa destructor* Anderson and Trueman were collected from Egypt and Libya to compare their morphological and morphometric characters. Females were examined using a Scanning Electron Microscope (SEM). Our morphological measurements showed that there were a lot of differences between samples of Egypt and Libya. Only two morphological characters showed significant differences among the two locations specimens' (i.e. anal plate length, anal plate length/ anal plate width (ratio III) and formula of palpal chaetotaxy). These results may be due to geographical locations between Egypt and Libya. We consider samples of Egypt and Libya as morphotypes.

Keywords: Varroa mite, morphology, morphometric characters, Egypt, Libya.

INTRODUCTION

The Varro mite, *Varroa jacobsoni* Oudmans (Acari: Mesostigmata: Varroidae) was first described as an ectoparasite of the Eastern honeybee, *Apis cerana* Fab., in Java, Asia. Varroa mite causes a serious damage by feeding on a hemolymph of larvae, pupae and adults, and by transmitting or activating viral diseases (Martin 2001; Chen et al. 2004). Honey bee keepers consider this mite to be a dangerous pest and the most damaging enemy of the honey bee around the world (Sammataro et al. 2000; Martin et al. 2012; Nazzi et al. 2012). In the last few years Varroa became a subject of concern to bee keepers where the majority of apiaries in the Egyptian Governorates were destroyed (Abd Al-Fattah et al. 1991).

The identity of *Varroa* mites infesting *Apis millifera* L from 32 countries was investigated using mtDNA Co-I gene sequences and morphological characters (Anderson and Trueman 2000). All were found to be *V. destructor*, not *V. jacobsoni* as was assumed. However, only 2 of the six *V. destructor* genotypes which found on *A. cerana* were parasiting *A. mellifera*. The most common was a Korean genotype of *V. destructor*, so-called because its primary host is *A. cerana* in Korea. It was found on *A. mellifera* in Europe, the Middle East, the Americas, Africa and Asia.

Varroa mites have about 15 different haplotypes including (Korean, Chinese, Japanese and Pakistan ones) (Zhou et al. 2004). The Korean haplotype is considered to be the most common one. It is possible to discriminate between Varroa morphotypes using morphological traits (Maggi *et al.* 2009).

In Egypt, Varroa was recorded in 1983 as *V. jacobsoni* (Wienands 1988). It was corrected later to be *V. destructor* according to Anderson and Trueman (2000) (Awad et al. 2011). Awad et al. (2010) observed genetic variability in Varroa belong to different localities in Egypt. Allam et al. (2014) determined the specific Egyptian Varroa morphological Scanning Electromicroscope as a tool to re-describe isolates of *V. destructor* from ten different locations belonging to nine different governorates.

The objective of this research was to compare the morphological and morphometric characters of Varroa mites collected from Egypt and Libya and to characterize and investigate the potential haplotype of Varroa mite.

MATERIALS AND METHODS

Samples of Varroa mite's adult females (1-2 mite/colony) were collected from honeybee, *A. millifera*, Carniolan hybrid colonies at various locations in Egypt and Libya through for two successive years 2019 and 2020. Mites were collected alive from the bodies of workers, drone bees, capped worker broods, or drone brood cells

and preserved in 70% ethanol. To confirm the specific identity, mite morphology was examined using research light microscop and the length and width of each female was measured individually. The measurements in micrometers (μm) were taken for five females, obtained from each region and mounted in Hoyer's medium on glass.

Scanning Electron Microscope (SEM), was used to observe the mite characters. Living specimens of honeybees were put through a served bath of distilled water in an attempt to clean them of debris. Then they were briefly submerged in distilled water near boiling point in order to force prostration of appendages. Specimens were fixed in glutaraldhyde of 3.5% concentration for 6 hours then dehydrated in ethyl alcohol and dried using the critical point procedure. Then, they individually affixed to stubs using double-sided sticky tape, and coated with gold-palladium in a sputter coater, (microscopy was performed with JEOL GM 4200) (Fashing et al, 2000).

Scanning Electron Microscopy was performed at the Applied Centre of Entomonematodes, the Faculty of Agriculture Cairo University, Egypt. They were transferred to the low vacuum chamber of the Electron Microscope, then examined and imaged.

RESULTS AND DISCUSSION

Morphometric characters of *Varroa* mite in Egypt and Libya are summarized in Tables (1 and 2) and Figures (1 and 2). Nomenclature of Delfinado-Baker (1974) and Delfinado-Baker and Agarwal (1987) was used. Results showed no significant differences between samples of Varroa mite collected from Egypt and Libya in all morphometric measurements except anal plate length and ratio III (APL/APW) (Length and width of anal plate).

Table (2) shows twenty characters distinguished and determined in *V. destructor* collected from Egypt and Libya.

Discribtion of *Varroa destructor* in Egypt and Libya

A- Gnathosoma

The gnathosoma is situated anteroventrally and is visible through the dorsum. This character agrees with Allam et al. (2014).

1- **Hyposome**

The surface scan of hypostome determine long striation beside the edges of hypostome and transverse striations nearly the tip of hypostome consist of island of transverse striations in Egyptian smples (Figure1: M, N, P and R) and Libya (Figure 2 G, H, T, K). Three paris on hypostome on one line these character differs from Delfinado-Baker (1974) who found three paris of setae in one row.

2- **Chelicera**

Bidentate (two teeth) on apical half one sharp-tipped and smaller than other blunt tipped tooth (Figure1: O in Egypt and Figure 2: P in Libya), with movable digit only (Figure1: O, Q, W in Egypt and G,T, K in Libya) and fixed digit not found dorsal seta and fissures present. These characters agree with Delfinado and Aggarwal (1987) and Allam et al. (2014).

3- **Palp**

Apotele biforcate have one long forcate and a short one (not equal in length) (Figure1 H, N, R in Egypt) and (Figure 2 K, M, N in Libya). Number of setae on palpal trochanter, femur, genu, tibia, and tarsus 1, 2-3, 2-3, 7-9, 10-12 in Egypt and 1,1-2,2-3,6,10 in Libya, respsctivly (Table 2). This formula of palpal chaetotaxy differs from that of *V. jacobsoni* (Delfinado-Baker 1974), and *V. underwoodi* (Delfinado-Baker and Agarwal 1987) and formula of palpal chaetotaxy of Libya different from in Egypt by Allam et al. (2014).

4- **Deutosternum**

The denticles agree with Delfinado-Baker and Agarwal (1987) whom reported that the deutosternum has denticles in *V. underwoodi* on the other side differes from *V. jacobsoni* (Delfinado-Baker 1974) whom reorted that the deutosternum was smooth and these characters agree with Allam et al. (2014).

B- Ventral shield

All ventral shields extensively developed and sclerotized with surface lightly and finely striate-reticulate this character agrees with Delfinado-Baker and Aggarwal (1987) and Allam et al. (2014).

1- Tritosternum:

The basis of tritosternum is triangule. The basis of triangle contact with sternal shield of Varroa, the triangle extand to the hypostome. Tritosternum bipartite (Figure 1: P in Egypt and Figure 2: G, I, M), membranous, laciniae tapring and separtly serrate (Figure 1 W in Egypt and Figure 2 P). Tthis description of tritosternum agrees with (Delfinado-Baker 1974; Delfinado-Baker and Aggarwal (1987); Allam et al. 2014).

2- Sternal shield:

Sternal shield extending from anterior margin of coxae 2 to coxae 4, occupied the area between coxae 1 and coxa 4 behind tritosternum. from 4 to 8 pairs of setae, 4-6 pairs of lyrifissures in Egyp and 5 pairs of setae, 4–6 pairs of lyrifissures in Libyans. These numbers of setae differe from Delfinado-Baker (1974), whom reported that the number of sternal setae was 5-6 pairs and 4–5 pores in *V. jacobsoni*. Delfinado-Baker and Aggarwal (1987) reprted that *V. underwoodi* has 4 pairs of setae and pores in sternal shield (Figure1 and Figure 2: A, B). between sternal 1 (*st1*) ranged from 71–190 µm in Egypt and in Libya ranged from (75–90). Also between sternal 2 (*st2*) ranged from 192–246 µm in Egypt and in Libya was (196–255). Longitudinal distance between (*st1-st2*) ranged from 76–223 µm in Egypt and in Libya was (87-236). The previos measurments agree with Egypt Allam et al. (2014).

3- Genital shield

Densely covered with simple setae. occupy the area between coxae 4 until anal shield on the posterior region from the venteral shields behind sternal shield, between the suture Y shape which extend laterall with genital (Figure 1 and Figure 2: A and B). In the present work, we found that the width of genital shield ranged from 656–672 µm in the Egyptians but in Libyans ranged from 685–736 and the half number of setae ranged from 40–56 (80–112) in Egyptians but in Libya ranged from 52– 62 (75–118). Also, genital plate wider than long. The anterior porision of genital shield smooth, with no setae. These description agree with Delfinado-Baker and Aggarwal (1987) who stated that genital shield densely covered with setae at posterior 2/3 mostly of uniform length and smooth.

4- Endopodal shield

Endopodal shield well developed, half circuling posterior border of coxa 4. There was suture in Y shape between endopodal plate from one side, metapodal shield on the second side and sternal and genital plat on the third side. **(**Figure 1: A, B, G, K in Egyptian and Figure 2: A, B, D in Libyans). The description of endopodal shield agree with Delfinado-Baker (1974), whom descriped endopodal shield in characters of genus *Varroa*. But the suture in Y shape was not descriped in (Delfinado-Baker 1974; Delfinado-Baker and Aggarwal 1987). Endopodal plat has 8–10 setae on the posterior margin and has a little striation.

5- Metapodal shield

Metapodal shield broadly triangular, densely covered with simple setae (Figure1: A, B, J, K in Egypt and Figure 2: A, B, D in Libyan). Width of metapodal shield ranged from 288–355 µm in Egypt but in Libya was 291–345 µm. The length of metapodal shield ranged from 672–768 µm in Egypt but in Libya was 682–778 µm (Table 1), these description agrees with (Delfinado-Baker 1974; Delfinado-Baker and Agarwal 1987).

6- Anal shield

Width of anal shield ranged from 202 to 223 µm in those of Egypt and in Libyans was 305–346 µm. anal shield triangular, separated from gentil shield, anal plate small bearing 3 setae, paranals situated on each side of anus, with one post anal, anus terminal and has valves. Anal plate has striations and the posterior edge was 8 rows from punctation (Table 1) (Figure1: A,B and Figure 2: A, B, Q, R). This description agrees with (Delfinado-Baker 1974; Delfinado-Baker and Agarwal 1987) that descriped the anal plate small, paranals situated on each side of anus.

C- Peritreme

Visible on ventral view in a lateroventral position between the third and fourth legs. The movable emergment pertrime lies flat along the venter laterad of legs 3 and 4 but can be lowered 90º on the surface of body during respiration (Figure1: S, T). The sclerotized pritremal groove consistes of an ascending and a shorter descending arm forming a hook around the tip of the peritreme. The antrior of the groove and stigmatal atriumare lined with micropapillae (microtrichae). This describtion agree with Bruce et al. (1997) whom reported that the remainder of the peritreme is a sac-like structure that is continuous with the body hemocoel, also agrees with Richard et al. (1990) whom observed that a curved peritreme which continues with a tubular diverticle that connects with the trachea.This mechanism enables the adult female to breathe inside the capped cell where the quantity of oxygen is reduced and liquid is sometimes present.

D- Dorsal shield

Chaetotaxy Surface of dorsal shield covered with numerous finely barbed setae of varying lengths, ornamented with striation and polygonal network of simple line. (Figure 1: C, D, L and Figure 2: C, F).

Number of marginal setae (Lateral setae) ranged from 19-31 in Egypt and in Libya was 13-21. These number disagree with Delfinado-Baker

(1974) whom found the number 21-23 in *V. jacobsoni* and Delfinado-Baker and Agarwal (1987) whom found the number 18-19 in *V. underwoodi* these setae a narrow thickened margin broadened anterio-laterally, dorsally short the tip dagger (Figure 1: A, C, D, E in Egypt and Figure 2: A, B, C, D, E).

E- Legs

Four pairs of robust, squat legs, formed by seven segments: coxa, trochanter, femur, genu, tibia, metatarsus and tarsus (Figure 1: A, B, F, G in Egypt and A, B, E in Libya). with terminal membranous well developed ambulacrum with strong sclerotic, without claw (Figure 1: X, Y & Figure 2: O) the ambulacrum comprises an adherent sucker.

With strong dorsal and ventral setae.

Ambulacrum well developed, membranous, with strong sclerotic, without claws (Figure 1: X, Y and Figure 2: O). These characters agree with Delfinado-Baker and Aggarwal (1987). Length of tarsus IV ranged from 106–192 µm Legs 7 segmented with metatarsi except the first leg did not have metatarsi. Leg chaetotaxy formulas follows: (Figure 1: A, B, F in Egypt Figure 2: A, B, E in Libya) represent coxa, trochanter, femur, genu, tibia, metatarsus and tarsus.

Leg 1: 2, 4, 10, 11-12, 12, 0, 34
Leg 2: 2, 4, 5, 4, 8, 8, 13
Leg 3: 1-2, 4-5, 3-6, 11, 11, 4, 13
Leg 4: 1, 6, 5-7, 9, 10, 4, 12-13

These results agree with Delfinado-Baker (1974) whom found that the numbers of setae was the same number in almost cases and different numbers in few cases.

Formula of chaetotaxy of legs of Libya

Leg 1: 2, 4, 10, 11-12, 12, 0, 34
Leg 2: 2, 4, 5, 4, 8, 8, 13
Leg 3: 1-2, 4-5, 3-6, 11, 11, 4, 13
Leg 4: 1, 6, 5-7, 9, 10, 4, 12-13

CONCLUSION

Our morphological measurements showed that there were differences between samples of Egypt and Libya. Only two morphological characters showed significant differences among the two locations specimens' (i.e. anal plate length, anal plate length/anal plate width (ratio III) and formula of palpal chaetotaxy). These results may be due to geographical locations between Egypt and Libya. We considered these samples of Egypt and Libya to be morphotypes.

Table 1. Means and S.D. of Varroa body characteristics belong to Egypt and Libya.

Characters	Egypt	Libya
Body length (BL)	1.07±0.01a	1.08±0.01a
Body width (BW)	1.55±0.06a	1.59±0.02a
Genital shield length (GSL)	0.50±0.01a	0.48±0.02a
Genital shield width (GSW)	0.66±0.01a	0.63±0.02a
Anal plate length (APL)	0.15±0.01a	0.13±0.01b
Anal plate width (APW)	0.23±0.00a	0.26±0.01a
Lateral plate Length (LPL)	0.65±0.01a	0.64±0.00a
Lateral plate width (LPW)	0.34±0.01a	0.33±0.01a
Ratio I (BL/BW)	0.70±0.03a	0.68±0.00a
Ratio II (GSL/GSW)	0.76±0.02a	0.76±0.04a
Ratio III (APL/APW)	0.63±0.03a	0.49±0.03b
Body size ratio (BW/BL)	1.44±0.05a	1.47±0.01a

In each row, means with the same letter are not significantly different (P> 0.05) according to Duncan's multiple range tests.

Table 2. Morphological characters of *V. destructor* (female) from Egypt and Libya.

Morphological characters	**From Egypt**	**From Libya**
Maximum length	4128* (1152–1728)	1468.1
Maximum width	4992 (1632–1728)	1701.67
Length of chelicera	192	190
Chelicera seta	With	With
Chelicera lyrifissures	With	With
Palpa chaetotaxy	1,2–3,2–3,7–9,10–12	1,1–2,2–3,6,10
Gnathosomal setae	3 in online	3 in online
Deutosternum	With denticles	With denticles
Endopodal plate	6–11 setae	5–12
Sternal setae + lyrifissures	4–8 pairs of setae	5 only
	4–6 pairs of pores	4–6 pairs of pores
Distance between *St1–St1*	114 (71–192)	80 (75–90)
Distance between *St2–St2*	216 (192–246)	233 (196–255)
Longitudinal distance between *St1–St2*	132 (76–223)	149 (87–236)
Genital plate Width	466.67 (656–672)	716.56 (685–736)
Count of ½ of setae on dorsal shield	153–197	158–178
Width of anal shield	214 (202–223)	313 (305–346)
Metapodal plate width	317 (288–355)	301 (291–345)
Metapodal plate length	704 (672–768)	737 (682–778)
Tarsus IV length	160 (106–192)	106 (95–134)
Number of marginal setae (lateral)	19–31 setae	13–20

* Dimensions are in micrometers.

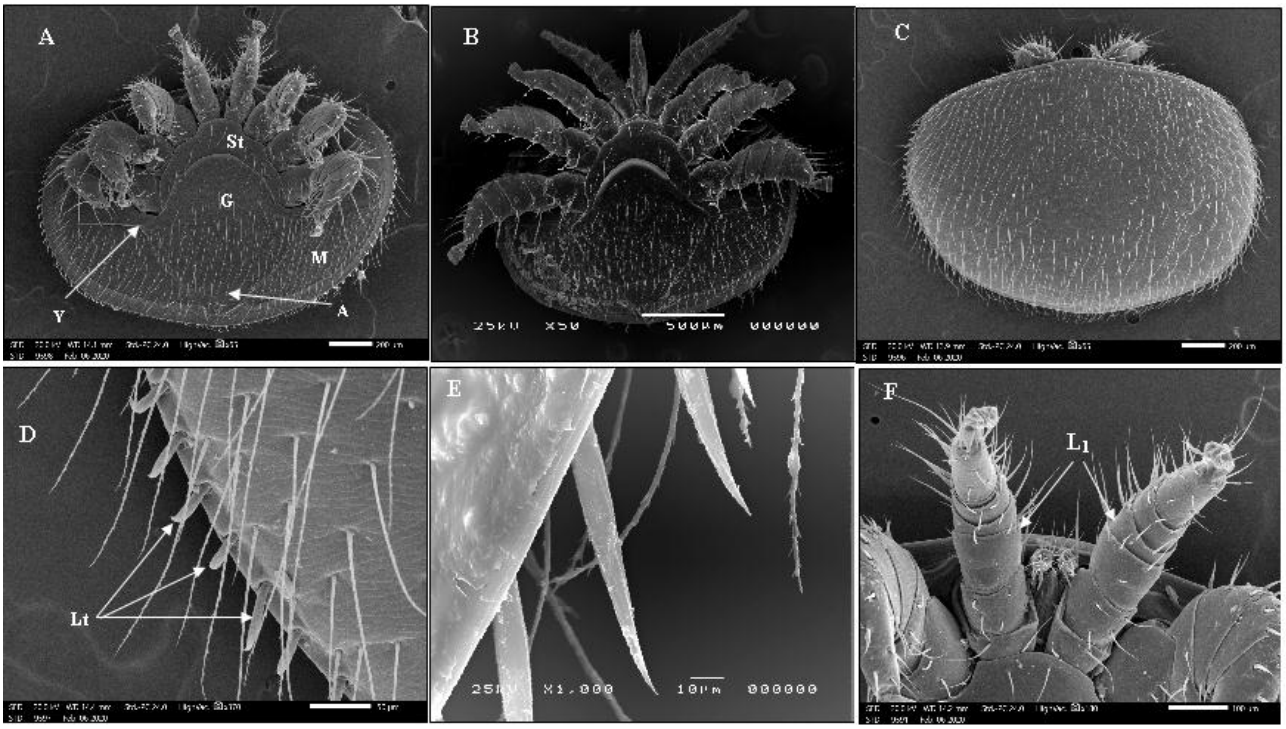

Figure 1. Egypt specimens, A and B: Ventral shape; St: Sternal plate; G: Genital plate; Y suture; M: Metapodal plate; A: Anal plate; C: Doral shape; 3 kinds of setae; D and E: Dorsal shape and Lateral setae ; F: Leg 1

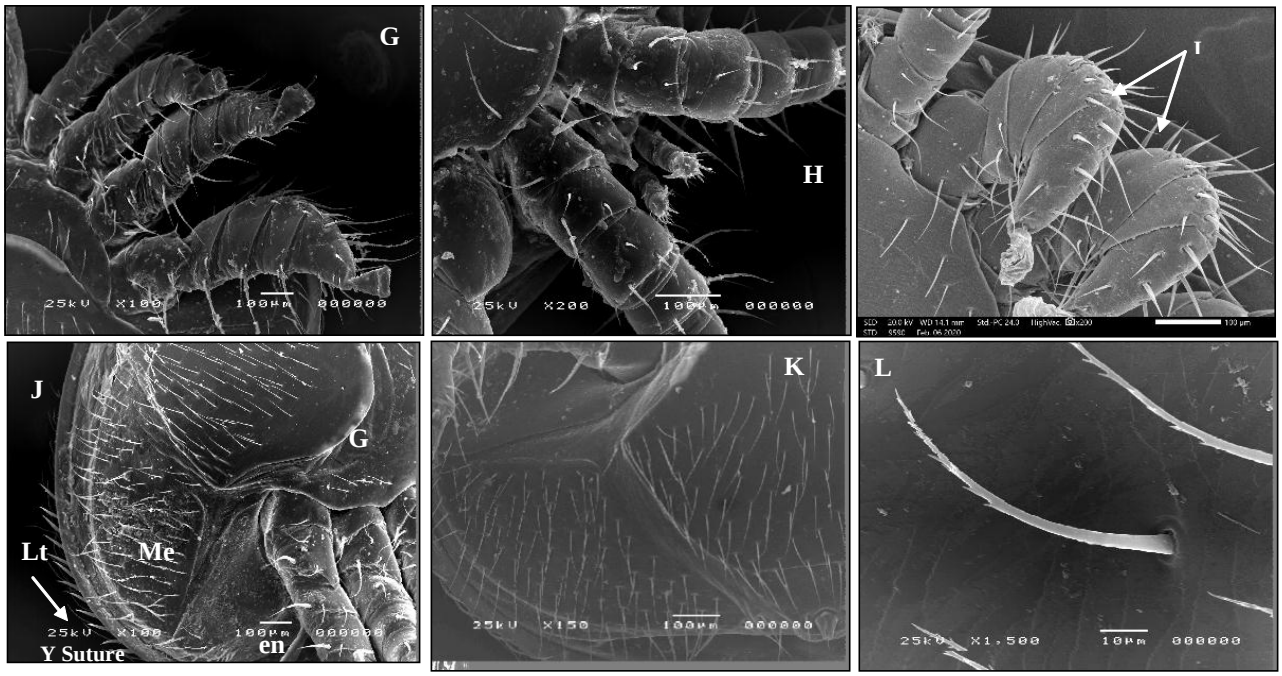

Figure 1. Egypt specimens, G: Legs 1,2,3,4, Amblacrum; **H:** Ventral shape: hypostome, palp, setae on palp tarsus, Leg 1; **I:** Legs 2, 3; **J and K:** Ventral shape: **en:** endopodal plate, **Me:** metapodal plat, Y suture, **Lt:** Lateral seta; **L:** Striation on dorsal shape, setae on dorsal shield

Figure 1. Egypt specimens, M: Ventral shape: surface of hypostome, hypostomal setae; **N:** Ventral shape: 3 setae on hypostome, apotele with bifurcate; **O:** Ventral shape: chlicera with two teeth; **P:** Ventral shape: **Q:** Ventral shape: chelicera with lyrifissure; hypostome, 3 setae on hypostome, chlicera, tritosternum; **R:** Ventral shape: the edges gnathsoma.

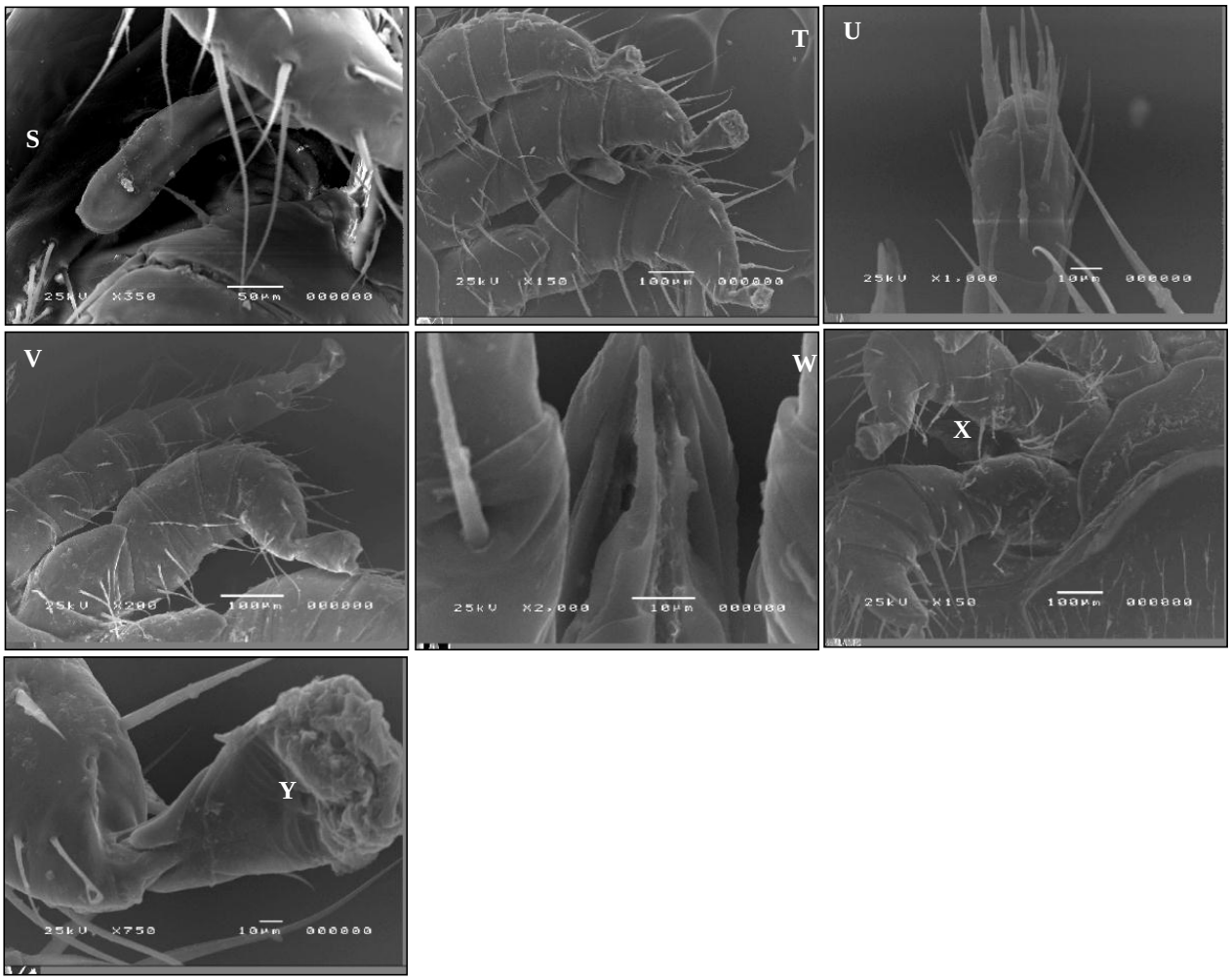

Figure 1. Egypt specimens, S: Ventral shape: pritreme between leg 3 and leg 4; **T:** Ventral shape: pritreme between leg 3 and leg4, Amblacrum; **U:** Edge of hypostome, palp; **V:** leg 1, leg 2, edge of pritreme **; W:** Ventral shape: the edges of hypostome, Chlicear with two teeth; (bidentate) **X:** leg 3, leg 4; **Y:** Amblacrum.

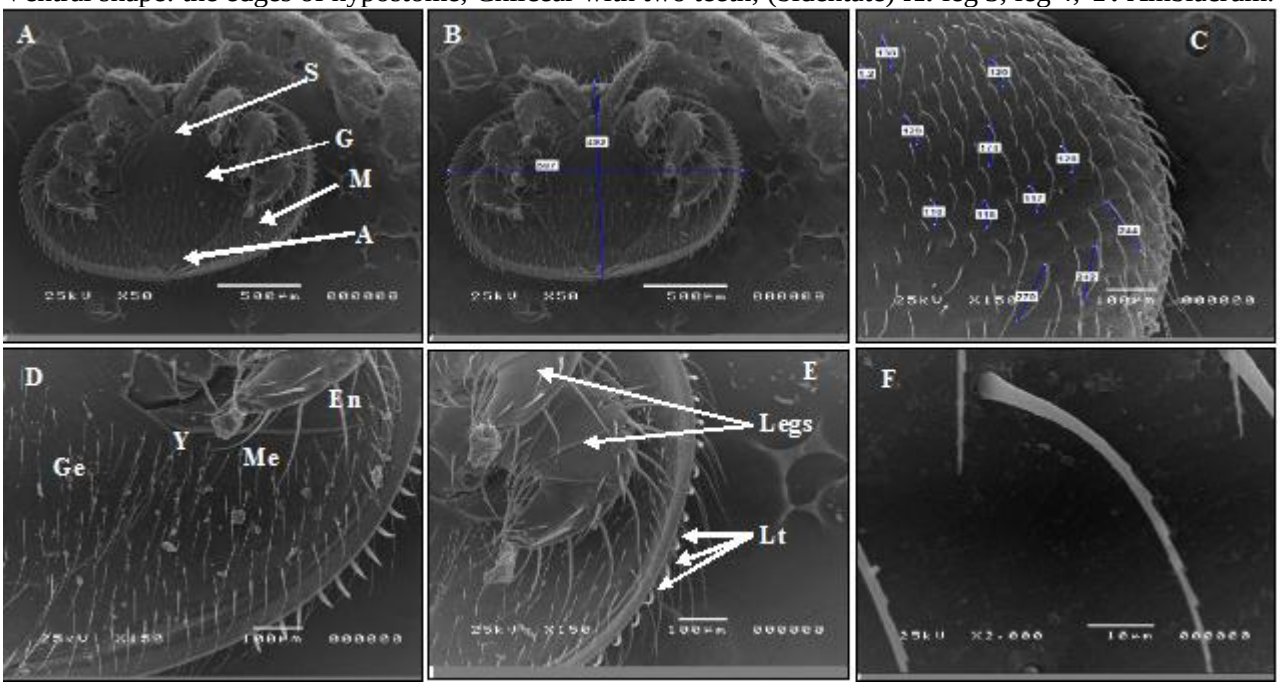

Figure 2. Libya sample, A and B: Ventral shape – St: Sternal plate – G: Genital plate - Y suture – M: Metapodal plate - A: Anal plate; **C:** Doral shape - 3 kinds of setae; **D:** Ventral shape, G: Genital plate - M: Metapodal plate - En: Endopodal plate - Y suture **E:** Lateral setae, Legs 3, 4; **F:** Striation on dorsal shape, setae on dorsal shield.

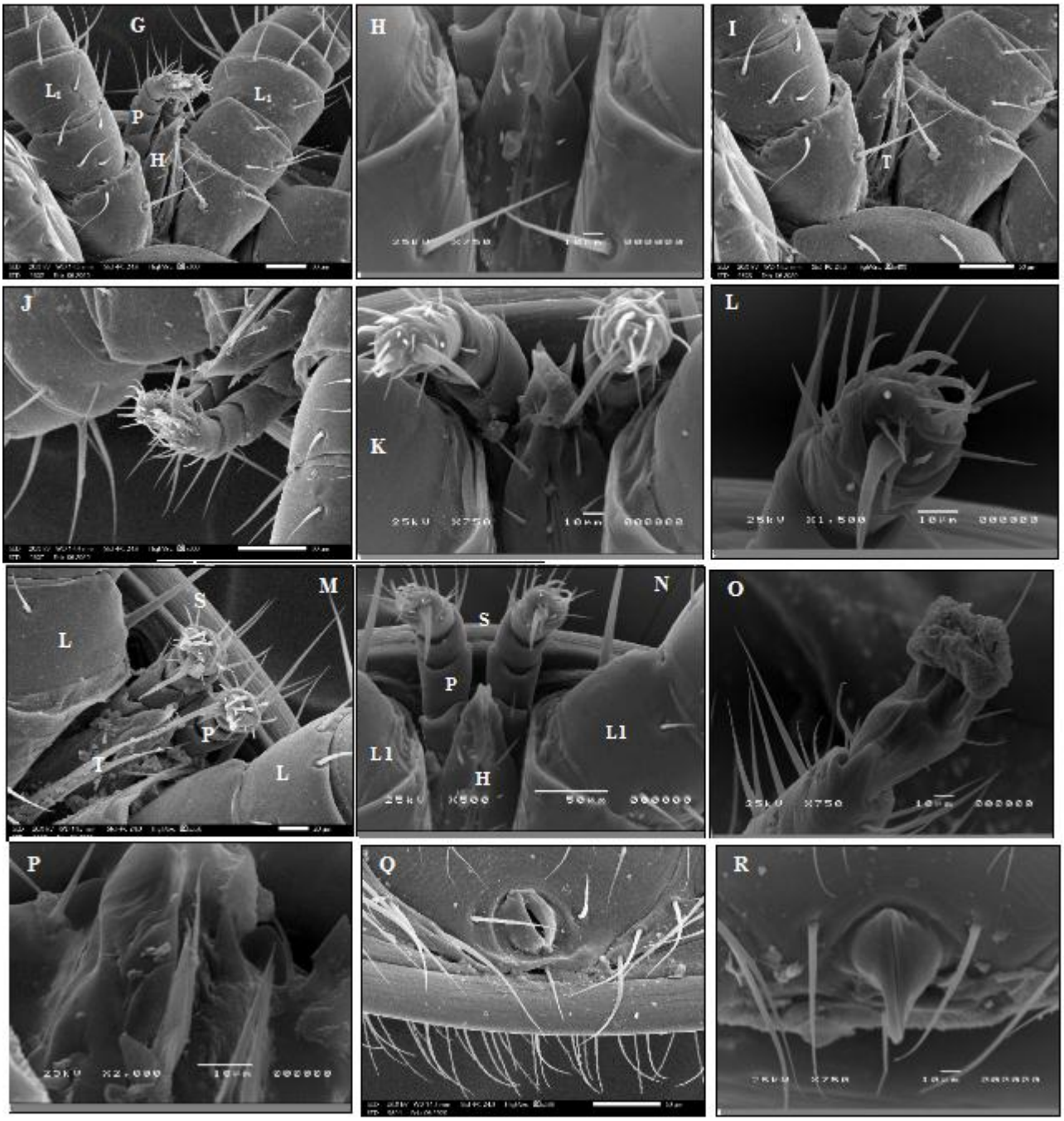

Figure 2. Libya sample, G, H, I, J, K: Ventral shape, L1: Legs 1 with Striation, H: Hypostome with 3 setae, P: Palp with Apotele, T: Tritosternum, Lacinia and para Lacinia, Movable digit to chlicera; **L:** Palp, Ap: Aptele with bifurcate; **M:** Ventral Shape, L1: Legs 1 with Striation, P: Palp with Apotele, S: Striation on dorsal shape, T: Tritosternum; **N:** Ventral Shape, L1: Legs 1 with Striation, Palp with Apotele, H: Hypostome, **O:** Amblacrum with articulation; **P:** Ventral shape, Lacinia and para Lacinia, Movable digit to chelicera with two teeth, Lacinia and para Lacinia; **Q, R:** Ventral shape, An: Anal plate, AnV: Anal valves.

REFERENCES

Abd Al-Fattah MA, Nour ME, El-Shemy AAM. 1991. Efficacy of some chemical compounds to control *Varroa* mite (*Varroa jacobsoni* Oud.) in honeybee colonies in Egypt. *The Egyptian Journal of Applied Sciences*, 6 (12), 139–152.

Abou-Shaara HF, Tabikha RM. 2016. Morphological characterization and a morphometry map for Varroa Mites frome Northwest of Egypt. *Cercetări Agronomice în Moldova*, 4 (168): 75–84. DOI: 10.1515/cerce-2016-0038

Allam SF, Zaki AY, El-Bishlawy SMO. 2014. Scanning electromicroscope as a tool to re-describe isolates of Varroa destructor from nine different Egyptian governorates. *Acarines*: *The Journal of the Egyptian Society of Acarology*, 8(2): 21–29. DOI: 10.21608/AJESA.2014.163836

Anderson DL, Trueman JWH. 2000. *Varroa jacobsoni* is more than one species. *Experimental and Applied* Acarology, 24: 165–189. DOI: 10.1023/A:1006456720416

Awad NS, Allam SFM, Rizk MA, Hassan MF, Zaki, A Y 2010. Fingerprinting and assessment of genetic variability of *Varroa destructor* in Egypt. Journal *of Apicultural Research*, 49: 251–256.

Awad NS, Allam SFM, Rizk MA, Hassan MF Zaki AY. 2011. Identification of Varroa mite (Acari: Varroidae) parasitizing honeybee in Egypt using DNA sequencing, morphometric and SEM analysis. *The Arab Journal of Biothechnology*, 14:41–48.

Bakr EM. 2005. A new software for measuring leaf area, and area damaged by *Tetranychus urticae* Koch. *Journal of Applied Entomology*, 129 (3), 173–175. DOI:10.111/j.1418.2005.00948.x

Bruce WA Delfinado-Baker M Vincent DL. 1997. Comparative morphology of the peritremes of *Varroa* and *EuVarroa* (Varroidae), parasites of honey bees (Apidae). *International Journal of Acarology*, 23(1):13–20. DOI: 10.1080/01647959708684114

Chen Y, Pettis, JS, Evans JD, Kramer M. Feld-laufer MF 2004. Transmission of Kashmir bee virus by the ectoparasitic mite *Varroa destructor*. *Apidologie*, 35:441–448. DOI: 10.1051/apido:2004031

Delfinado MD, Baker EW. 1974. Varroidae, a new family of mites on honeybees (Mesostigmata: Acarina). *Journal of the Washington Academy of Sciences*, 64: 4-9.

Delfinado MD, Baker EW, Aggarwal K. 1987. A new Varroa (Acari: Varroidae) from the nest of *Apis cerana* (Apidae). *International Journal of Acarology*, 13: 233-237. DOI: 10.1080/01647958708683777

Fashing NJ, Oconnor BM, kitching R L. 2000. *Lamingtona carus*, a new, genus of Algophagidae (Acari: Astigmata) from water filled tree holes in Queensland, Australia. *Invertebrate Taxonomy*, 14, 591-606.

Maggi MD, Sardella NH, Ruffinengo SR, Eguaras MJ. 2009. Morphotypes of *Varroa destructor* collected in *Apis mellifera* colonies from different geographic locations of Argentina. *The journal Parasitology Research*, 105:1629-1636. DOI: 10.1007/s00436-009-1605-8

Maggi M, Peralta L, Ruffinengo S, Fuselli S, Eguaras M. 2012. Body size variability of *Varroa destructor* and its role in acaricide tolerance. *The journal Parasitology Research*, 110: 2333–2340. DOI: 10.1007/s00436-011-2768-7

Martin SJ. 2001. The role of *Varroa* and viral pathogens in the collapse of honeybee colonies: A modelling Approach, *Journal of Applied Ecology*, 38: 1082–1093. DOI: 10.1046/j.1365-2664.2001.00662.x

Martin SJ, Highfield AC, Brettell L, Villalobos EM, Budge GC, Powell M, Nikaido S Schroeder DC. 2012. Global honey bee viral landscape altered by a parasitic mite. *Science*, 336: 1304–1306. DOI: 10.1126/science.1220941

Nazzi F, Brown SP, Annoscia D, Del Piccolo F, Di Prisco G, Varricchio P, Della Vevova, G, Cattonaro F, Caprrio E, Pennacchio F. 2012. Synergistic parasite-pathogen interactions mediated by host immunity can drive the

collapse of honey bee colonies. *PLoS Pathogens*, 8(6): e1002735.
DOI: 10.1371/journal.ppat.1002735

Richard D, Colin ME, Lhomme M. 1990. Anatomical organization of the tracheal system of *Varroa jacobsoni*. *Experimental and Applied* Acarology, 9: 63–72.

Sammataro D, Gerson U. Needham G. 2000. Parasitic mites of honey bees: life history, implications and impact. *Annual Review of Entomology*, 45: 519–548.
DOI: 10.1146/annurev.ento.45.1.519

Wienands A. 1988. The Varroa mite has spread over most of the world. *American Bee Journal*, 128 (5): 358–359.

Zhou T, Anderson DL, Huang ZY, Huang S, Yao J, Ken T. Zhang Q 2004. Identification of Varroa mites (Acari: Varroidae) infesting *Apis cerana* and *Apis mellifera* in China. *Apidologie*, 35:645–654.
DOI: 10.1051/apido:2004059