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MORPHOLOGICAL CHARACTERIZATION AND WING DESCRIPTION OF *VESPA ORIENTALIS ORIENTALIS* QUEENS

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Communication

Abstract: Oriental hornets, *Vespa orientalis*, are dangerous enemy to bee colonies in some countries of the world. There are more than one subspecies of *V. orientalis*. Few studies have investigated the morphological characteristics of these subspecies. Morphological characterization can help in confirming and discriminating between the subspecies, and to follow any changes in their morphology over time. In this study, some body characteristics of *V. orientalis orientalis* queens from Egypt were measured including head width, fore wing length and width, hind wing length and width, femur length, tibia length and approximate stinger length. Also, fore wing characteristics using wing coordinates for 20 landmarks were studied. Computer based techniques were applied to take these measurements. The data of the current study can be utilized for comparisons with other subspecies.

Key Words: hornets, *Vespa*, vespidae, morphology, queens.

Introduction

The oriental hornets (*Vespa orientalis* Linnaeus, 1771; Order: Hymenoptera, Family: Vespidae) occurs in north Africa, south-eastern Europe, Arabian Peninsula, and southwestern Asia (*Archer, 1998*). It was also found in Mexico where it was probably accidentally introduced (*Dvořák, 2006*). Oriental hornets are dangerous pests to bee colonies, especially weak ones. They can be caught with bait traps inside apiaries. In north Egypt (Dakahlia), the queens have been observed to be active from January to May and a few during December and January (*Taha, 2014*). In south Egypt (Assiut), found an increase of *V. orientalis* activity during September and October with no activity during November (*Khodairy and Awad, 2013*). Similar activity trends of *V. orientalis* have been

observed in other countries, in Pakistan hornet numbers greatly increased from August to October and decreased during November (Islam et al., 2015). The activity of *V. orientalis* was significantly correlated with temperature (r=0.137) and humidity (r=0.560) (*Taha, 2014*). In general, *V. orientalis* appears from the spring until the end of autumn and disappear during winter. During autumn, large number of queens can be trapped.

The subspecies of *V. orientalis* are *V. orientalis* variety *aegyptica* André, *V. orientalis zavattarif* Guiglia & Capra, *V. orientalis somalica* Giordani-Soika, *V. orientalis arabica Giordani-Soika*, and *V. orientalis orientalis* (*Archer, 1998*). These subspecies can be identified using body color characteristics. Some studies have considered morphology of *V. orientalis.* The morphology of the sting organ of some hymenopterans including *V. orientalis* has been described (*Zalat et al., 1980*). Also, chemo-receptors of the antenna have been investigated (*Khodairy and Awad, 2013*). The exact measurements (i.e lengths and widths) of different body parts of *V. orientalis,* e.g. heads, wings and legs have not been widely investigated so that there are no available comprehensive databases about morphological characteristics of these subspecies. Another way to characterize or discriminate between species and subspecies is the use of wing coordinate system (geometric morphometric). By identifying the coordinates (X and Y) of specific wing landmarks (points), it is possible to analysis the shape of wings. The geometric morphometric has been used with different hymenopterans including honey bees as reviewed by *Abou-Shaara (2013)*, *Sphex* spp. (*Tüzün, 2009*), and some Vespidae hornets (*Perrarda et al., 2016*). This technique has been able to discriminate between honey bee races (*Tofilski, 2008; Francoy et al., 2008*). The objective of this study is to present a morphological database of *V. orientalis orientalis* for different body parts including heads, wings, legs and stingers, and to use wing point coordinates to present a description to fore wings. This study is likely to contribute in expanding the knowledge about the morphology of this *Vespa* subspecies, and to assist in discriminating this subspecies than others.

Materials and Methods

Fifty six queens of *Vespa orientalis* hornets were collected from traps in a private apiary at Damanhour city, Egypt during autumn 2016. The queens were then identified according to their body color to be *Vespa orientalis orientalis*. The queens were dissected to separate heads, fore wings, hind wings, legs and stingers.

Morphological characterization.

The separated body parts were scanned (Canon Scanner, k10352, CanoScan LiDE 110, Vietnam) at resolution of 1200 dpi to obtain clear images. Subsequently, the images were opened using Photoshop program according to *Abou-Shaara and Al-Ghamdi (2012)* to take the measurements as shown in Fig. 1.

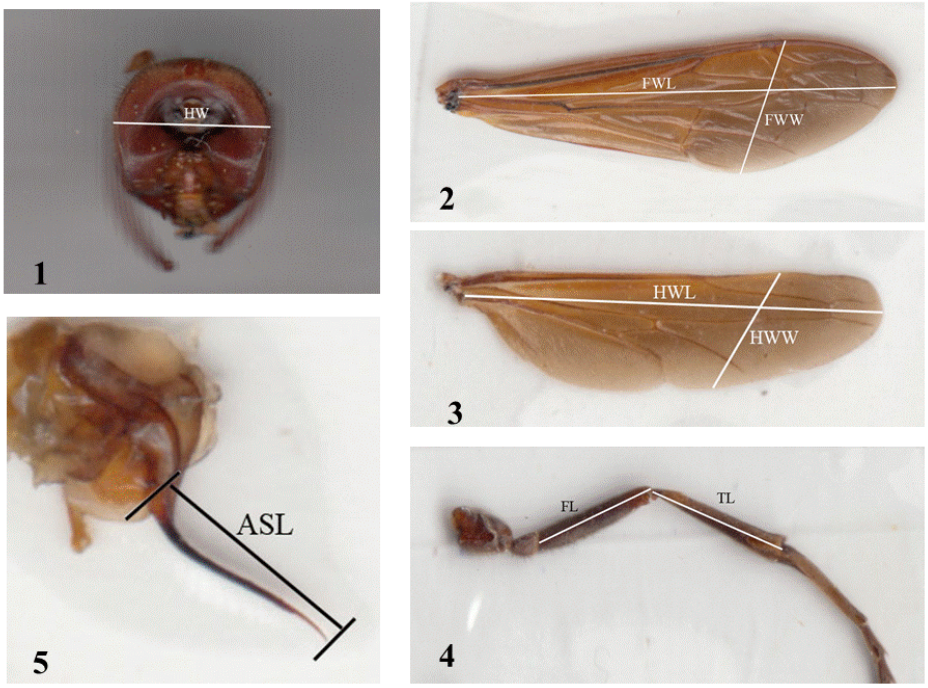

Figure 1: Characteristics measured in this study; 1) Head Width (HW), 2) Fore wing Length (FWL) and Width (FWW), 3) Hind Wing Length (HWL) and width (HWW), 4) Femur and Tibia Length (FL, TL), 5) Approximate Stinger Length (ASL).

Wing description

To present a detailed description to the fore wings, the coordinates of 20 wing landmarks (points) were obtained using ImageJ program, and these coordinates were analyzed using MorphoJ program (*Klingenberg, 2011*) according to *Abou-Shaara and Al-Ghamdi (2012)*. After obtaining the X, Y coordinates for each point for 15 wings using ImageJ, the means of these coordinates were calculated. The means were analyzed using MorphoJ to obtain the transformation grid for the points after principal component analysis (PCA). Addition, procrustes sums of squares, tangent sums of squares and total variance were calculated for the points. Usually, the fore wings of dead hornets are bent (tucked). Thus, the width of bent fore wings was measured as shown in Fig. 3. The width of bent fore wings was compared with width of full fore wings to obtain measurements to fore wings

during full and bent positions. This comparison was performed on 13 fore wings, widths measured firstly for bent wings and then for full wings.

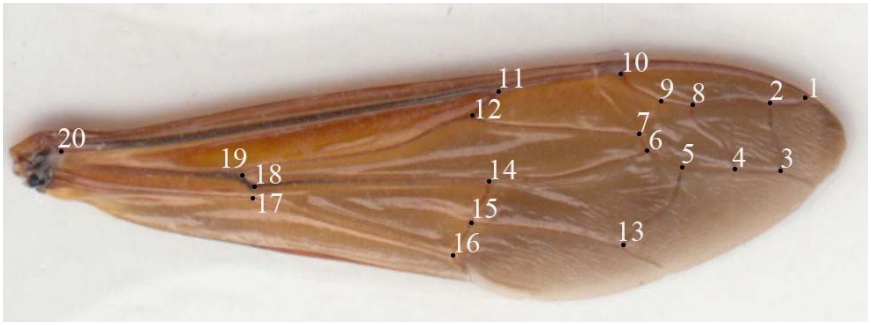

Figure 2: Twenty points of *Vespa orientalis orientalis* fore wings.

Figure 3: Bent fore wing width (BFWW).

Statistical analysis

Means and their standard errors (S.E.) were calculated for studied characteristics. The correlation coefficients (r) were calculated among measured body characteristics at 5% level of significance. The width of bent wings and full wings were compared using t-test at 5% of probability using SAS program (version 9.1.3, 2004).

Results and Discussion

Morphological characterization

The measurements in mm of different body characteristics of *V. orientalis orientalis* queens and the range of each character are listed in Table 1. The differences between minimum value and maximum one were 0.4, 0.7, 0.9, 0.8, 0.5, 0.6, 0.4, and 0.5 mm for head width, fore wing length, fore wing width, hind wing length, hind wing width, femur length, tibia length, and approximate sting length, respectively. The differences were not large and varied from 0.4 to 0.9 mm (less than 1 mm) for measured characteristics. Differences about 0.06 and 0.13 mm were

recorded in head width of emerged *Vespula vulgaris* queens during 1990-91 and 1991-92, respectively (*Harris and Beggs, 1995*). The differences between individuals of the same subspecies are normal and can be attributed to feeding quality and quantity as well as rearing conditions (e.g. cell size and nest temperature) during immature stages. A review by *Abou-Shaara (2013)* and *Abou-Shaara et al. (2013)* on wing and body characteristics of honey bees, *Apis mellifera*, highlighted factors impacting them including environmental factors, temperature and nest conditions. It's better to use body color together with body measurements to confirm the subspecies due to the variations in morphological measurements.

The correlation between all body characteristics was significant and high, with a range from 0.89 to 0.97 (Table 2). This means that body characteristics increased linearly, i.e. the increase in any character means the increase in all other body characters. Unlike honey bees, *A. mellifera*, *Kolmes and Sam (1991)* found that bees with larger overall size, corbiculate or wing measurements showed lack of possession to other morphological characters that showed high correlation in size. Therefore, size related characteristics of honey bees are not linearly correlated. Perhaps these variations are related to the ecological niche of each species; hornets are predators, therefore they need larger body characteristics while honey bees are pollinators, thus they need specific body characteristics to be larger than other characteristics to be able to perform their ecological role.

Table 1: Body characteristics of *Vespa orientalis orientalis* queens (Means ± S.E.).

Characteristics	Means ± S.E. (mm)	Range (mm)
Head width	5.52±0.01	5.4 to 5.8
Fore wing length	19.19±0.03	18.9 to 19.6
Fore wing width	6.11±0.03	5.9 to 6.8
Hind wing length	12.19±0.03	11.9 to 12.7
Hind wing width	3.26±0.02	3.1 to 3.6
Femur length	4.99±0.02	4.8 to 5.4
Tibia length	5.56±0.01	5.4 to 5.8
Sting length	3.42±0.02	3.2 to 3.7

Table 2: Correlations (r values) among body characteristics of *Vespa orientalis orientalis* queens. All correlations are significant (*P*<0.05). HW: head width, FWL: fore wing length, FWW: fore wing width, HWL: hind wing length, HWW: hind wing width, FL: femur length, TL: tibia length, and ASL: approximate stinger length.

Characteristics	HW	FWL	FWW	HWL	HWW	FL	TL	ASL
HW	--	0.94	0.95	0.95	0.96	0.92	0.92	0.92
FWL	0.94	--	0.92	0.97	0.95	0.90	0.90	0.95
FWW	0.95	0.92	--	0.95	0.96	0.95	0.93	0.89
HWL	0.95	0.97	0.95	--	0.95	0.92	0.93	0.93
HWW	0.96	0.95	0.96	0.95	--	0.91	0.91	0.93
FL	0.92	0.90	0.95	0.92	0.91	--	0.92	0.90
TL	0.92	0.90	0.93	0.93	0.91	0.92	--	0.89
ASL	0.92	0.95	0.89	0.93	0.93	0.90	0.89	--

Wing description

The transformation grid for means of the point coordinates of the fore wings obtained after principal component analysis (PCA) is shown in Fig. 4. The values of procrustes sums of squares, tangent sums of squares, and total variance were 0.104, 0.103, and 0.0069, in respect. The shape and values of the 20 fore wing landmarks could help in confirming the subspecies of *V. orientalis* because such characteristics should be unique for each subspecies. However, *Perrard et al. (2016)* did not find wing landmark configurations alone as reliable phylogenetic tools. Also, *Tüzün (2009)* found that geometric morphometric analysis alone was less successful in discriminating three species of *Sphex.* Therefore, using body color, body measurements together with wing landmark analysis is better over using one method alone to identify or discriminate *V. orientalis* subspecies.

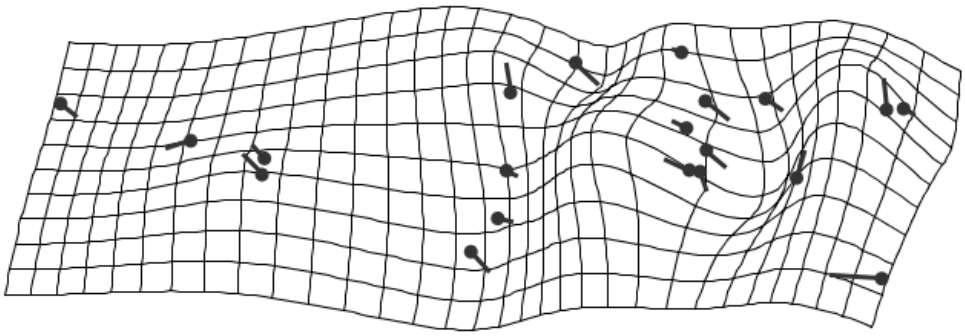

Figure 4: Transformation grid for means of 20 fore wing landmarks of *Vespa orientalis orientalis* queens.

The width average of fore wings was 6.40±0.09 mm and for bent fore wings 2.98±0.05mm of the same wings. The difference between them was about 3.42±0.06 mm, this difference was significant according to t-test (N=13, df=12, t =54.16, *P*<0.05). It seems that fore wings consists of two parts; upper part (Fig. 5, A) has less width with more thick cuticle, while the lower part (Fig. 5, B and C) has larger width with soft cuticle. The second part can be easily bended on the first part. The variation between the two parts is about 0.44 mm. The presence of these two fore wing parts could have a specific role in the flight of *V. orientalis*, especially since these hornets need to attack prey during flight, and to carry it to the nest. This point may worth further investigations to shade more lights on the flying mechanisms of these hornets.

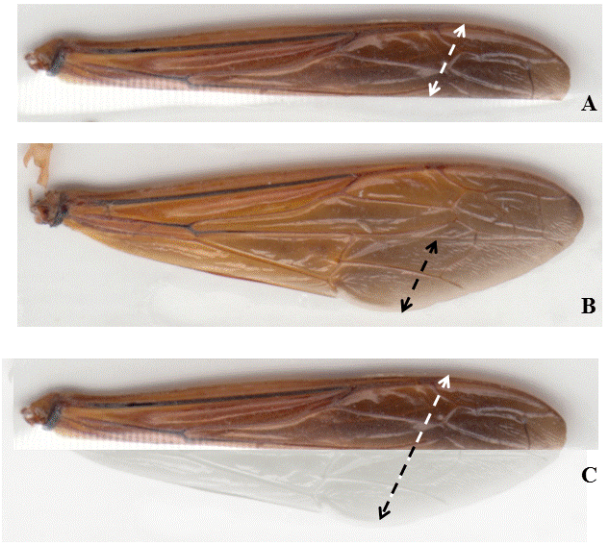

Figure 5: Fore wing at bent position (A), complete position with showing width of lower part (B), and the two positions (C). The black and white arrows show the width.

Conclusion

The study presented database for some body characteristics of *Vespa orientalis orientalis* queens of Egypt. The lengths and widths of body parts of this subspecies have not been well documented. Therefore, the results of this study have specific importance to any future comparisons either with the same subspecies or with other subspecies. Also, the coordinate analysis of 20 fore wing landmarks was done and the transformation grids of the wings were presented beside some statistical values. There was a significant difference between the width of bent wings and full wings; this suggests a special flight mechanism of these hornets. It is recommended to measure body characteristics of all *Vespa orientalis*

subspecies to facility discrimination among them and to prepare database for them. It is also better if these studies can be performed on hornets from various geographical regions to identify the potential ecotypes.

Morfološka karakterizacija i opis krila matica *Vespa orientalis orientalis*

Hossam Abou-Shaara

Rezime

Orijentalni stršljenovi, *Vespa orientalis*, opasni su neprijatelji pčelinjih kolonija u nekim zemljama sveta. Postoji više od jedne podvrste V. *orientalisa*. U nekoliko studija su se ispitivale morfološke karakteristike ovih podvrsta. Morfološka karakterizacija može pomoći u potvrđivanju i diskriminaciji podvrsta, kao i da se prate eventualne promene u njihovoj morfologiji tokom vremena. U ovoj studiji izmerene su neke karakteristike tela matica *V. orientalis orientalis* iz Egipta, uključujući širinu glave, dužinu i širinu prednjih krila, dužinu i širinu zadnjih krila, dužinu femura, dužinu tibije i približnu dužinu žaoke. Takođe, ispitivane su karakteristike prednjih krila koje koristeći krilne koordinate za 20 orijentira. Računarske tehnike su primenjene prilikom uzimanja navedenih mera.

Podaci dobijeni u ovom istraživanju mogu se koristiti za upoređivanje sa drugim podvrstama.

Ključne reči: stršljenovi, *Vespa*, *vespidae*, morfologija, matice.

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