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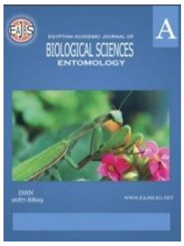

Comparative Morphogenesis of Antennal Sensilla Between the *Leptocybe invasa* and *Ophelimus maskelli* (Hymenoptera: Eulophidae) and its relationship to their vital Capacity

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ABSTRACT

Insects have several sensory (sensilla) structures on their antennae, which are crucial for the concept of environmental cues as well as host recognition and positioning strategies. Sensilla thus have a significant impact on how parasite hosts locate, classify, and maybe accept a host. Based on the types, numbers, and locations of sensory organs, it is possible to deduce how they perform certain tasks. The examined biological variables are listed. The purpose of this work was to describe the external sensilla found on the antennae of *Ophelimus Maskelli* (Ashmead) and *Leptocype Invasa* (Fisher and La Salle) (Hymenoptera: Chalcidoidea: Eulophidae). In Egypt, *Eucalyptus camaldulensis* was primarily plagued by these two inducer insects. The sensilla have been labelled according to their distribution, size, and shape. May also use scanning electron microscopy to reveal sensory organs. On the antennae of *L. invasa*, sensilla were dispersed in six different types, while on the antennae of *O. maskelli*, they were placed in nine different types. According to this study, *O. maskelli* had more sensilla overall than *L. invasa*; along the antenna, *O. maskelli* had 100 sensilla compared to *L. invasa* more than 37 sensilla. The results from the measured biological characteristics were explained by the qualitative and quantitative differences in the sensilla types of the two species on the antenna, favouring *O. Maskelli*. The results tended to show that *O. Maskelli* was the strongest rival that could displace *L. invasa*.

INTRODUCTION

The Middle East and North Africa's low-altitude desert and semiarid terrain are covered with afforested areas supported by eucalyptus trees. Eucalyptus plantations serve as a significant supply of lumber, fuel, and honeybee foraging. They are also used as relaxation spaces, windbreaks around agricultural land, and as shelter from sandstorms. In the Middle East and the Mediterranean region, eucalyptus trees were thought to be virtually pest-free until a few years ago. Two insect species that cause galls were introduced to the Mediterranean basin in the past ten years. On the North West coast of Egypt, Ramadan (2004) first observed a gall inducer on Eucalyptus species, but mistook it for Aprostocetus species. *Ophelimus maskelli* (Ashmead) was identified by Ramadan & Karam (2005) as another gall-inducing agent. In Alexandria on eucalyptus trees. Recently, these two wasps

Leptocybe invasa Fisher and La Salle and *Ophelimus maskelli* were identified (Ashmead). While the second species, *O. maskelli*, was discovered to solely infest the leaf blade, the first species, *L. invasa*, was found to infest leaf midrib, petoil, and juvenile shoots. The current research aims to examine the distribution of these two species' sensory organs on each antenna and estimate the various measurements of these organs. As they are wasps that cause galls and are aware of the mechanisms and sense organs inherent in ovipositors for excreting poison and irritant, a comparison between the two species based on their vital capacity and competitive ability to feed to cultivate cells that develop galls while laying eggs.

The relevance of a sensory organ for an animal is typically correlated with its relative size in comparison to the size of the body. Whereas larger organs require more active investment but can aid in improving sensitivity and/or selectivity of pertinent signals. The ability of different organs to expand in relation to body size must be balanced against one other because sensory systems are exceedingly expensive to construct and maintain (Koontz and Schneider) (1987). The outcomes of such trade-offs ultimately dictate how an individual responds to its environment and evolves over its lifespan, according to Stevens (2015). They also produce variety in the relative amplitude of sensory qualities within and between species.

Leptocybe invasa and *Ophelimus maskelli* female sensory systems was the subject of an extensive allometric investigation, which examines how an organ's size fluctuates in relation to body size, to start filling in this information gap. Since these wasps actively specialise in one type of habitat, they probably need to deal with a variety of sensory inputs to locate a host. The investigation concentrated on the symmetry relationship between antennae, which are sensory features primarily connected to foraging and reproductive activity. The sensory density of the antennae was also examined to shed more light on how the size of these sensory organs affects the number of sensory structures they express. We propose that, similar to several insects that have been the focus of So far, symmetry analyses Taylor *et al*. 2015; Jander and Jander 2002; Kramer et al. 2015; Kunte 2007 The rates at which each feature rises in size with body size vary between both species to reflect variances in their behavioural environments, but there will be a positive association between body size and the sensory organs evaluated in 2019.

Important appendages known as antennae have sensory organs known as senilla, which are concentrated in this organ more than other insect body parts (Norton & Vinson, 1974; Bleeker et al., 2004). (Bleeker *et al*., 2004; Bruyne & Baker, 2008; Chen & Fadamiro, 2008). Structures called sensilla are made up of complimentary thyrogens, trichogenes, and neurons (Keil, 1997). Sensilla is defined by its shape and is mechanically, chemically, thermally, and hygroscopic (Van Baaren et al., 2007; Zhou *et al.*, 2011; Ahmed *et al*., 2013). (Onagbola *et al*., 2009). Sensilla play crucial roles in the choice, localization, discrimination, and acceptance of hosts by parasitoids (Keil, 1997; Zhang *et al*., 2014). Additionally, Norton & Vinson (1974) and others have documented sexual dimorphism of antennae by type, distribution, and sensory abundance for a variety of insects. Delvare & Lasalle, 1993; Chen & Fadamiro, 2008; Onagbola *et al*., 2009; Barlin & Vinson, 1981; Chen & Fadamiro, 2008) Because sensilla are crucial for identifying mating partners and locating hosts (Weseloh, 1972; Battaglia *et al*., 2002), (Van Baaren *et al*., 2007). For various parasitoid species, the shape of the sensory antennae has been reported (Bleeker *et al*., 2004; Dweck & Gadallah, 2008; Zhou *et al*., 2013a, 2013b). Important information about the antennal sensilla of both species has been gathered by these studies, but further in-depth information about these structures for other species is still required. Two species' common habits may point to its use in controlling them. The behavioural elements of their inducer galls can be understood with the aid of knowledge of the antennal properties. The first description of the antennal structure of both *L.invasa* and *O.maskelli*

Here, the external morphology, type, and distribution sensilla of the antennal of *L. invasa* and *O. maskelli* were described using scanning electron microscopy (SEM). On the basis of both their morphological characteristics and comparisons to other Hymenopteran wasps, their possible roles were also addressed. This information helps to clarify how these sensilla work in the host selection process and forms the basis for further research on the behaviour of *L. invasa* and *O. maskelli* that cause galls (host location, recognition, and acceptance). Finding methods for managing and controlling them.

MATERIALS AND METHODS

Biological Studies:

To estimate fecundity for the two species, 40 newly emerged adults of each species were used for this purpose. Each individual was kept inside (a 6 x 3 cm) plastic tube provided with a plastic cover. Each tube was hung on a eucalyptus sapling with a rubber band. Clean and free of infestation leaf was inserted inside each tube. Adults were left inside the tubes with eucalyptus leaves until adults died. After a few days, the leaves were inspected and the number of deposited eggs was counted. The mean number of deposited eggs from 40 females was calculated for each species.

Sampling Procedures:

Regular field excursions were carried out at ten days intervals to farm agriculture at Ain Shams University for collecting *Leptocype invasa* and *Ophelimus maskelli* for one year only starting from 1st January to the end of December 2020.

Samples of 30 infested leaves were picked at random from the labeled trees for both species, kept in polyethylene bags and transferred to the laboratory for inspection. Counts were carried out by using a stereoscopic binocular microscope. Galls of both species were dissected by using a sharp razor and sorted into immature stages (larva + pupa) and adult (inside the galls or emerged through holls) and counted. Means for each stage/ leaf were calculated from 30 leaves for each species.

Insects:

The insect specimens of the present study were obtained from ***Eucalyptus camcludulensis*** trees planted at the Farm of Faculty of Agriculture, Shoubra El–Kheima, Qalyubiya Governorate. These trees were heavily infested with the two-galls inducer species. Leaf samples infested with each species were kept in a breeding cage and observed until adult emergence. The wasps were collected with aid of an aspirator and kept in specimen tubes.

Scanning Electron Microscopy:

To prepare specimens for Scanning Electron Microscope (SEM), wasps were washed several times with distilled water, then fixed using 2.5 gluteralhyde in 1M phosphate buffer, pH 7.2 at 4°C for 2 hs (two changes). Dehydration was carried out by using ascending series of ethanol, ending with absolute ethanol (10 minutes for each concentration). Dehydrated specimens were mounted on aluminum stabs covered by double stickum solytape. Dehydrated specimens were coated with a thin layer of carbon, then coated with gold-palladium alloy by using Ladd sputter-coater. Coated specimens were examined with a JEOL JSM- T300A Scanning EM in Electron Microscopic Unit, Central laboratory. Faculty of Agriculture, Cairo University.

Sensilla's Terminology:

Using the nomenclature proposed by Zhou *et al.* (2013a), which was based on the terminology of Amornsak *et al*., Sensilla was discovered and given a name based on its external morphology (1998).

Data Evaluation:

For both species of *L. invasa* and *O. maskelli*, the antennal size and sensilla morphology were examined at the dorsal and ventral antennal surfaces. Image-Pro Plus was used to measure antennas from pictures taken with a scanning electron microscope, and SPSS was used to submit the results to nonparametric Mann-Whitney U statistical tests at a 5% level of significance (version 22.0).

RESULTS AND DISCUSSION

Results obtained from the tested biological parameters are given in Table 1. These results revealed that for *O. maskelli*, the mean number of galls per leaf was 146.69±14.55; the mean duration of total developmental stages was 130.14±1.58 and the mean fecundity was 259±47 eggs/female. While for *L. invasa* the mean number of galls/leaf was 17.61±1.34; mean fecundity was 50±20 eggs/female and the duration of the total developmental stage was 112.64 ± 1.86. These results tend *O.maskelli* is a better competitor which could displace *L. invasa*.

Table 1: Comparison between L. invasa and O. maskelli in the mean number of induced galls /leaf of eucalyptus during 2019**.**

Parameter species	*L. invasa*	*O. maskelli*
Mean number of galls /leaf	17.61 ± 1.43	146.69 ± 14.55
Fecundity/(eggs/f)	50 ± 20	259 ± 47
Developmental stages/(in days)	112.64 ± 1.86	130.14 ± 1.58

The sizes and other characteristics of sensory qualities, including as antennae, were measured in a thorough allometric investigation on *female Leptocybe invasa* and *Ophelimus maskelli*. These results demonstrated that among all sensory features investigated, the antenna had an allometric connection with body size and that *L. invasa* and *O. maskelli* differ in the amount of energy invested in various sensory systems. Additionally, *L. invasa* had significantly larger antennae than *O. maskelli*, indicating that they expend more energy on these organs in comparison to *O. maskelli* in exchange for a rise in the number of sense organs, which accounts for *O. maskelli* relative numerical density to *L. invasa*. However, the findings of this study reveal the numerical density of the sense organs that controls the vital efficiency of the wasps that cause galls. The size of the sensory traits in *L. invasa* and *O. maskelli* are not necessarily related to body size and raise questions about other factors that drive sensory trait investment in these wasps. The following research will demonstrate this.

Antennal Sensilla:

Gross Morphology of the Antenna:

Females of *Leptocype invasa* and female *Ophelimus maskelli* have geniculate antennae with eight antennal segments that were positioned frontally on the head between the compound eyes. They had a flagellum with a funicle with two antennomers and a terminal clava with three antennomers, as well as a radicula, a lengthy scape, a pedicel, and these features. Female *L. invasa* antennae were longer (4736.39 m) than female O. maskelli antennae (2276.26 m) (Table 2). In both species, the scape was the largest antennal segment. Compared to *O. maskelli*, *L. invasa* had a greater scape length (197 2.64 m vs. 62 88 m). However, the scape width of *L. invasa* was identical to *O. maskelli* (34.831.51 m)

(34.490.74 m) (Table 2; Figs. 1a, 2a). Further, *L. invasa* possessed a pedicel that was 51.66 mm longer than *O. maskelli* (32.67 mm), despite the fact that *L. invasa* pedicel was thicker (51.93 mm) than *O. maskelli* (24.83 mm) (Table 2; Figs. 1a, 2a). While *O. maskelli* antennal flagellum only had one funicle (F1) and terminal clava, *L. invasa* was divided into funicle (F1 to F3) and terminal clava (three antennomers, C1, C2, and C3) (three antennomers, C1, C2, and C3). *O. maskelli* flagella were shorter (100.17 3.04 m) than *L. invasa* (137.6 4.77 m) (Table 2; Figs. 1a, 2a). Comparing the clava of *L. invasa* (125.34 0.88 mm) to *O. maskelli* (83 1.79 mm), the results showed a similar pattern. The three antennomers' dimensions (length and width) in both species, the antennal clava shrank from C1 to C3 (Table 2; Figs. 1a, 2a). However, *L. invasa* had longer antennomers overall (Table 2; Figs. 1a, 2a).

Table 2. Length and Width (Mean ±SE, n = 10) antennal segments in *L.invasa* and *O.maskelli* (Hymenoptera: Eulophidae).

Antennal segments	Length		Width	
	L.invasa	***O.maskelli***	***L.invasa***	***O.maskelli***
Whole antennae	473±6.39	227±6.26	---	---
Scape	197±2.64	62±88	34.49±0.74	34.83±1.51
Pedicel	51.66±1.83	32.67±1.98	51.93±0.40	24.83±0.52
Flagellum	137.6± 4.77	100.17 ±3.04	---	---
Clava	125.34± 0.88	83± 1.79	---	---
Funicle1	27.78±0.88	13.66±0.81	31.32±1.01	17.33±1.02
Funicle2	27.84±1.27	---	32.21±0.82	---
Funicle3	27.66±1.81	---	29.74±1.26	---
Clava1	28.56±0.62	18.66±0.61	28.94±1.32	35.32±0.57
Clava2	28.47±0.77	18.23±0.42	28.31±0.67	36.79±1.34
Clava3	24.44±0.54	21.88±0.72	23.92±1.41	28.51±0.86

Means followed by different letters in the same line are significantly different by the nonparametric Mann–Whitney U test ($p<0.05$)

Morphological Characters of the Sensilla on the Antenna:

On the antennae of *L. invasa*, there were six different forms of sensilla: one basiconic sensilla (BS), four Trichoderma sensilla types (TS1-AP, TS2-AP, TS3-AP, and TS4-AP), and a multi-porous plate sensillum (MPS). On the antennae of *O. maskelli*, nine different forms of sensilla were found, including the finger-like sensilla (FL), the multi-porous plate sensillum (MPS), the Unipore chaetic sensillum (ChS-UP), sensilla chaetica (CH), basiconic sensilla (BS) and four varieties of trichodea sensilla (TS1-AP, TS2-AP, TS3-, and TS4-AP). In both species of *L. invasa* and *O. maskelli* antennal segments, Trichodea sensilla was most prevalent and was present in every segment (Figs. 1 and 2). The scape, pedicel, and flagellum all included many of these long, pointed sensilla. Considering the level of diversity's morphological sensilla of antennae O. maskelli were more sophisticated than those of antennae L. invasa in this area. Four different varieties of Trichodea sensilla were identified.

The ST1-AP was found on the flagellum on funculi 2 and clava (1, 2) in *L. invasa*, on other hand, was found on the scape, funculi 1, and pedicel in *O. maskelli* and was characterized by a smooth and slightly bent tip. The size of this type of sensilla varied from 13.44±0.27µm in length to 0.23±0.033µm in width at the base and their numbers were 2 sensillum in *L. invasa* (Table 3, Fig.1C), while *O. maskelli* sensilla ST1-AP in scape varied from 10.48±0.64 µm in length, and 1.33±0.01µm in width at the base and their numbers were 6 sensillum. In addition, its presence on pedicel varied from 25.83±0.40µm in length, and 1.23±0.05 µm in width at the base and their numbers were 10 sensillum. *O. maskelli* antennae have a greater number of this type of sensilla compared to *L. invasa* (Table 3, Fig. 2E).

The ST2-AP type was found on the pedicel of *L. invasa*, on other hand, it was found in funicle1 and in some segments of the antennal flagellum of *O. maskelli* and they were short and curved with a tapered tip without curvature. However, their numbers were fewer on *L. invasa*, compared to *O. maskelli* antennae ($t = 20.6$, $P < 0.05$). The average length of ST2-AP in *L. invasa* was 10.5±0.83 µm and width at the base is 0.24±0.098µm and their numbers were 5 sensillum (Table 3, Fig.1B) while ST2-AP type of *O. maskelli* was with the average length it's on funiculi (1) 7.31±1.01 µm and width at the base was 0.63±0.02 µm and its average length on Clava1 was 7.21±1.01 µm and width at the base was 0.62±0.01µm, and it's the average length on Clava2 11.12±0.37µm and width at the base was 0.43±0.087µm, to be the sum of their numbers 24 sensillum (Table 3, Fig. 2B). The ST3-AP was long with a tapered end and a straight curvature at the apex and was found in the funicle2 (average length was 25.23±0.46µm and width at the base was 1.88±0.065 µm) and clava3 (average length was 26.34±0.54 µm and width at the base was 1.28±0.023 µm) to be the sum of their numbers 15 sensillum of *L. invasa* (Table 3, Fig. 1C, 1E), while ST3-AP in *O. maskelli* was found in the Clava2 (average length was 15.6±0.28µm and width at the base was 0.32±0.045µm) and their numbers were 8 sensillum, However, their numbers were fewer on *O. maskelli* compared to *L. invasa* antennae (Table 3, Fig. 2B).

The ST4-AP was long with a tapered end and a strong curvature at the apex and was found in the Clava2 (average length was 18.43±0.73µm and width at the base was 0.43±0.073µm) and clava3 (average length was 31.44±0.54 µm and width at the base was 0.88±0.043µm) to be the sum of their numbers 6 sensillum of *L. invasa* (Table 3, Fig. 1D, 1E), on other hand, ST4-AP short with a tapered end and a strong curvature at the apex in *O. maskelli*. It was found in the Clava1 (average length was 5.52±0.53µm and width at the base was 0.72±0.045µm) and their numbers were 8 sensillum. This means that there are more numbers of this sensillum on *O. maskelli* compared to *L. invasa* antennae (Table 3, Fig. 2B).

One BS was found on the flagellum of both *L. invasa* and *O. maskelli*, in *L. invasa*, it was characterized by long pouches, inserted around the base of depression in the cuticle and was found in Funicle3 (average length was 26.5±1.81µm and width at the base was 12.5±0.33µm) (Table 3, Fig. 1C), while in *O. maskelli* BS was characterized by small pouches, inserted around the base of depression in the cuticle and was found in the Clava1 (average length was 4.31±0.63µm and width at the base was 3.25±0.063µm) (Table 3, Fig. 2B).

O. maskelli antennae only had two different segments, a large and robust base connected to a tapering tip (average length was 11.210.42m and breadth at the base was 0.730.46m), where the finger-like sensilla were discovered (Table 3, Fig. 2B). Only clava3 of *O. maskelli* included sensilla chaetica, which were more numerous than the other sensilla. Similar to ST sensilla but shorter, with a tapered tip, and placed in cuticular depressions, these sensilla were characterised by thick and short hair-like structures with smooth surfaces (average length was 6.530.25m and breadth at the base was 0.220.023m), and their number was 4 sensillum (Table 3, Fig. 2B).

The MPS was long and thick without a tapered end and a strong curvature at the middle. Flattened and pressed from top to bottom and were found in the most abundant all antennal segments of both species of *L. invasa* and *O. maskelli* (Figs. 1 and 2). It was found in funicle1 (average length was 14.54±0.78µm and width at the base was 1.63±0.082µm) and clava1 (average length was 27.56±0.42µm and width at the base was 18.66±0.43µm) to be the sum of their numbers 8 sensillum of *L. invasa* (Table 3, Fig. 1C, 1D), while MPS in *O. maskelli* was found in the Clava1 (average length was 13.31±0.57µm and width at the base was 2.32±0.033µm), clava2 (average length was 13.33±0.47µm and width at the base was 2.22±0.023µm) and clava3 (average length was 13.13±0.67µm and width at the base was 2.41±0.031µm) to be the sum of their numbers were 16 sensillum. This means, there is a greater number of them on *O. maskelli* compared to *L. invasa* antennae (Table 3, Fig. 2B).

Unipore chaetic sensillum (ChS-UP) short hairs were found with more number at the apex of the antennae of *O. maskelli* only in the Clava3 (average length was 6.53±0.25µm and width at the base was 0.22±0.023µm) to be the sum of their numbers 22 sensillum (Table 3, Fig. 2B).

Both species of *O. maskelli* and *L. invasa* do have not the same types of sensilla. However, *L. invasa* has longer antennal segments than *O. maskelli*. Our findings indicated that *O. maskelli* obtained more than nine types of sensilla. They were distributed on antennae of *O. maskelli* (Fig. 2): four types of trichodea sensilla (TS1-AP, TS2-AP, TS3-, TS4-AP), one type of basiconic sensilla (BS), finger-like sensilla (FL), sensilla chaetica (CH), multi- porous plate sensillum (MPS) and unipore chaetic sensillum (ChS-UP). Distribution of sensilla types on each segment of the *O. maskelli* antennae was found in higher numbers where it witnessed a diversity of sensilla in terms of diversity and quantity as opposed to *L. invasa*, where they did not have all finger-like sensilla (FL), sensilla chaetica and unipore chaetic sensillum (ChS-UP) as in terms of diversity. At the level of the total number of sensilla, the number of *O. maskelli* was higher than *L. invasa*, where the sensilla numbers along the antenna were 100 sensillum in *O. maskelli* versus 37 sensillum in *L. invasa* as in Table 3.

Table 3. Length and Width (Mean ±SE, n = 10) of sensilla on antennal segments in *L.invasa* and *O.maskelli* (Hymenoptera: Eulophidae).

Antennal segments	*L.invasa*				*O.maskelli*			
	Type of sensilla	No.	Length	Width	type of sensilla	No.	Length	Width
Scape	---	---	---	---	ST1-AP	6	10.48±0.64	1.33±0.01
Pedicel	ST2 -AP	5	10.5±0.83	0.24±0.098	ST1-AP	10	25.83±0.40	1.23±0.05
Funicle1	MPS	2	14.54±0.78	1.63±0.082	ST2-AP	8	7.31±1.01	0.63±0.02
Funicle2	ST1 -AP	2	13.44±0.27	0.23±0.033	---		---	---
	ST3-AP	6	25.23±0.46	1.88±0.065	---		---	---
Funicle3	BS	1	26.5±1.81	12.5±0.33	---		---	---
Clava1	MPS	6	27.56±0.42	18.66±0.43	MPS	2	13.31±0.57	2.32±0.033
	---	---	---	---	ST4-AP	8	5.52±0.53	0.72±0.045
	---	---	---	---	ST2-AP	10	7.21±1.01	0.62±0.01
	---	---	---	---	CH	4	2.12±0.23	2.12±0.23
	---	---	---	---	BS	1	4.31±0.63	3.25±0.063
Clava2	ST4-AP	4	18.43±0.73	0.43±0.073	MPS	8	13.33±0.47	2.22±0.023
	---		---	---	ST2-AP	6	11.12±0.37	0.43±0.087
	---		---	---	ST3-AP	8	15.6±0.28	0.32±0.045
Clava3	ST4-AP	2	31.44±0.54	0.88±0.043	MPS	6	13.13±0.67	2.41±0.031
	ST3-AP	9	26.34±0.54	1.28±0.023	Chs-UP	22	6.53±0.25	0.22±0.023
	---	---	---	---	FL	1	11.21±0.42	0.73±0.46
Total number of sensilla		37				100		

Means followed by different letters in the same line are significantly different by the nonparametric Mann–Whitney U test (p<0.05).

Leptocybe invasa

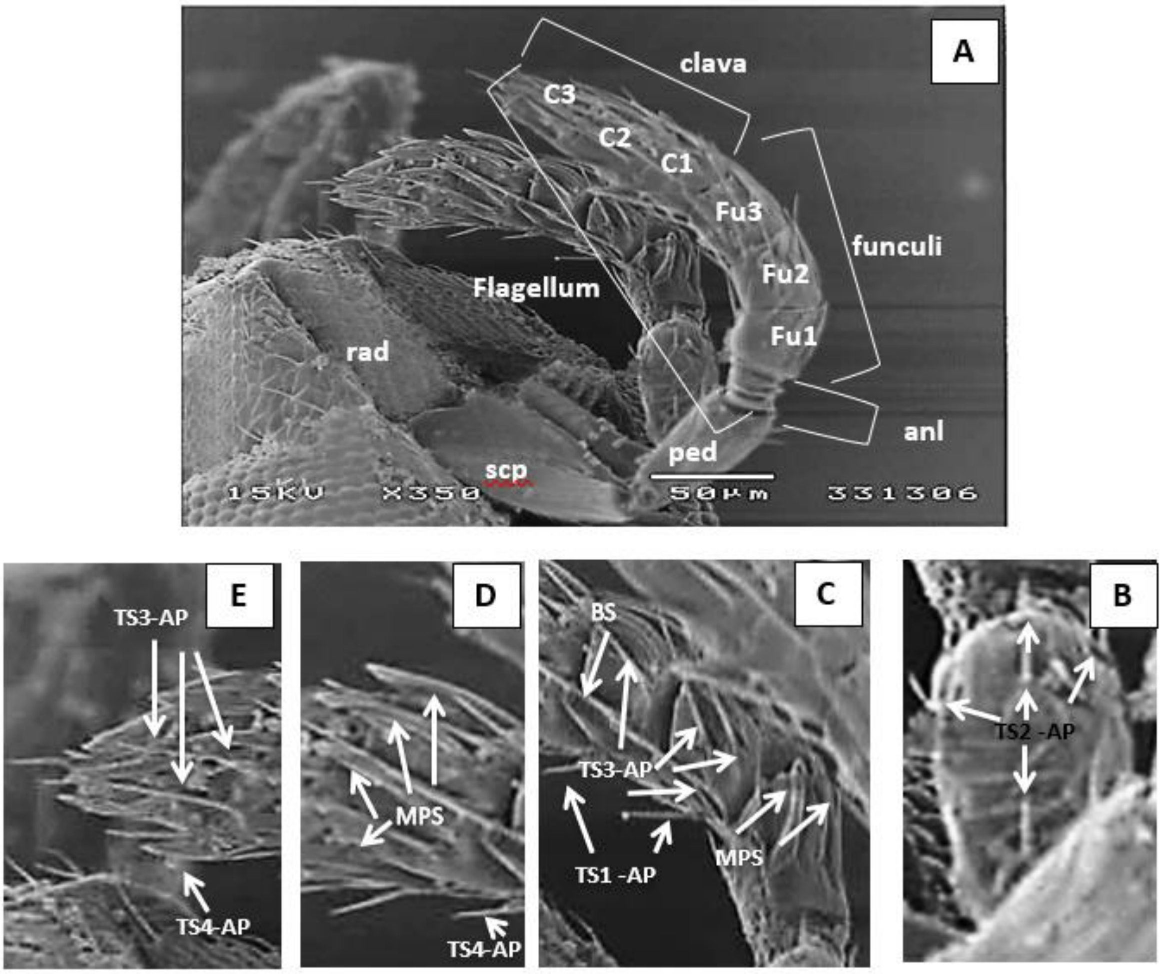

Fig.1: Scanning electron micrographs of *Leptocybe invasa* antennal segments and sensilla distributions on the antennomeres. (A) Antenna, anl. , anelli; clv. , clava. C1-C3. , clava segment ; ful-fu3., funicle segment ; ped., pedicel; rad., radical; scp., scape.(B) Elongate pedicel with type II sensilla trichodea (TS2 -AP) (C) funculi with type I sensilla trichodea (TS1 -AP), type III sensilla trichodea (TS3 -AP), type sensilla basiconica (BS) and multi-porous plate sensillum (MPS).(D) Clava 1,2 with type IIII sensilla trichodea (TS4 -AP) and multi- porous plate sensillum (MPS). (E) Clava 3 with type III sensilla trichodea (TS3 -AP) and type IIII sensilla trichodea (TS4 -AP).

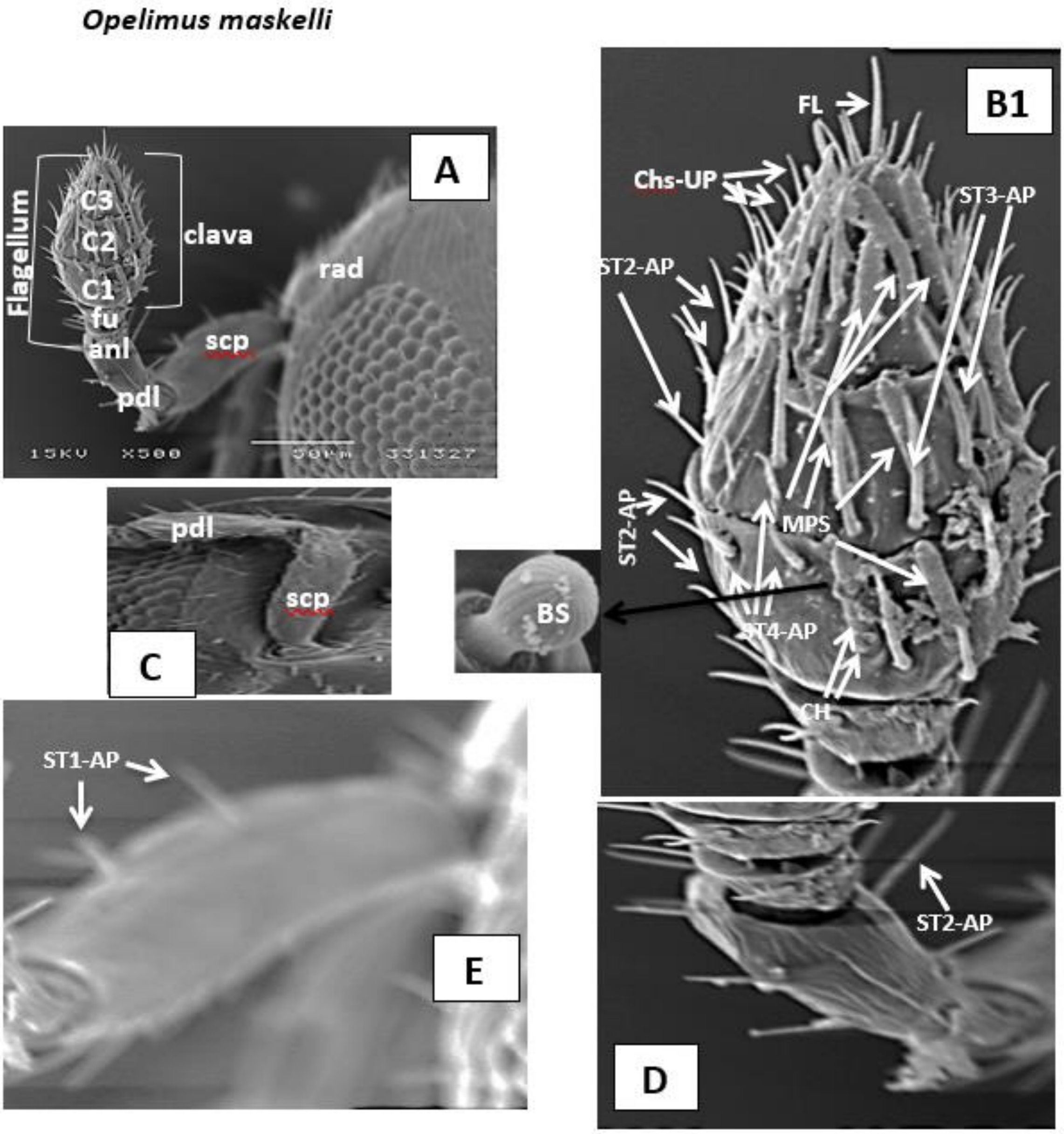

Fig. 2: Scanning electron micrographs of ***Opelimus maskelli*** antennal segments and sensilla distributions on the antennomeres. (A) Antenna, anl. , anelli; clv. , clava. C1-C3. , clava segment ; fu1., funicle segment ; ped., pedicel; rad., radical; scp., scape.(B) Clava with type II sensilla trichodea (TS2 -AP), type III sensilla trichodea (TS3 -AP) , type IIII sensilla trichodea (TS4 -AP) , type sensilla basiconica (BS), type unipore (Chs- UP), type sensilla chaetica (CH) , finger-like sensilla (FL) and multi- porous plate sensillum (MPS), (C) Dorsal view of scape type I sensilla trichodea (TS1 -AP) and pedicel with type II sensilla trichodea (TS2 -AP), (D) ventral view of pedicel type II sensilla trichodea (TS2 -AP), (E) ventral view of scape with type I sensilla trichodea

The distribution and numbers of sensilla on the different parts of the antenna in *Leptocybe invasa* we find them varying in number and terms of presence as in Figure (3) and the most sensillum in terms of numerical density in the order as follows, where (ST3-AP) is the densest distribution on funicle2, clava3 followed by (MPS) on funicle2, clava1, then the type (ST2-AP) on pedicel, followed by the type (ST4-AP) on clava2 and clava3 followed by the type (ST1-AP) on funicle2 then the least (BS) on funicle3 of them in terms of numerical density and the values were respectively 15, 8, 6, 4, 2 and 1 as in Figure (4).

On the other hand, it was the distribution and numbers of sensilla on the different parts of the antenna in *Opelimus maskelli* we find them varying in number and in terms of presence as in Figure (3) and the most sensillum in terms of numerical density in the order as follows, where (ST2-AP) is the densest, followed by (Chs-UP) distribution on funicl1e, clava1 and clava2 then type (ST1-AP) distribution on scape and pedicel, then the type (ST4-AP) on clava1, followed by the type (MPS) on clava1 and clava2 followed type (ST3-AP) on clava2 then (CH) then on clava1, and the least equally by the two types (BS) on clava1 and (FL) on clava3 of them in terms of numerical density and the values were respectively 23, 22, 16, 10, 8, 4, 1 and 1 as in Figure (4).

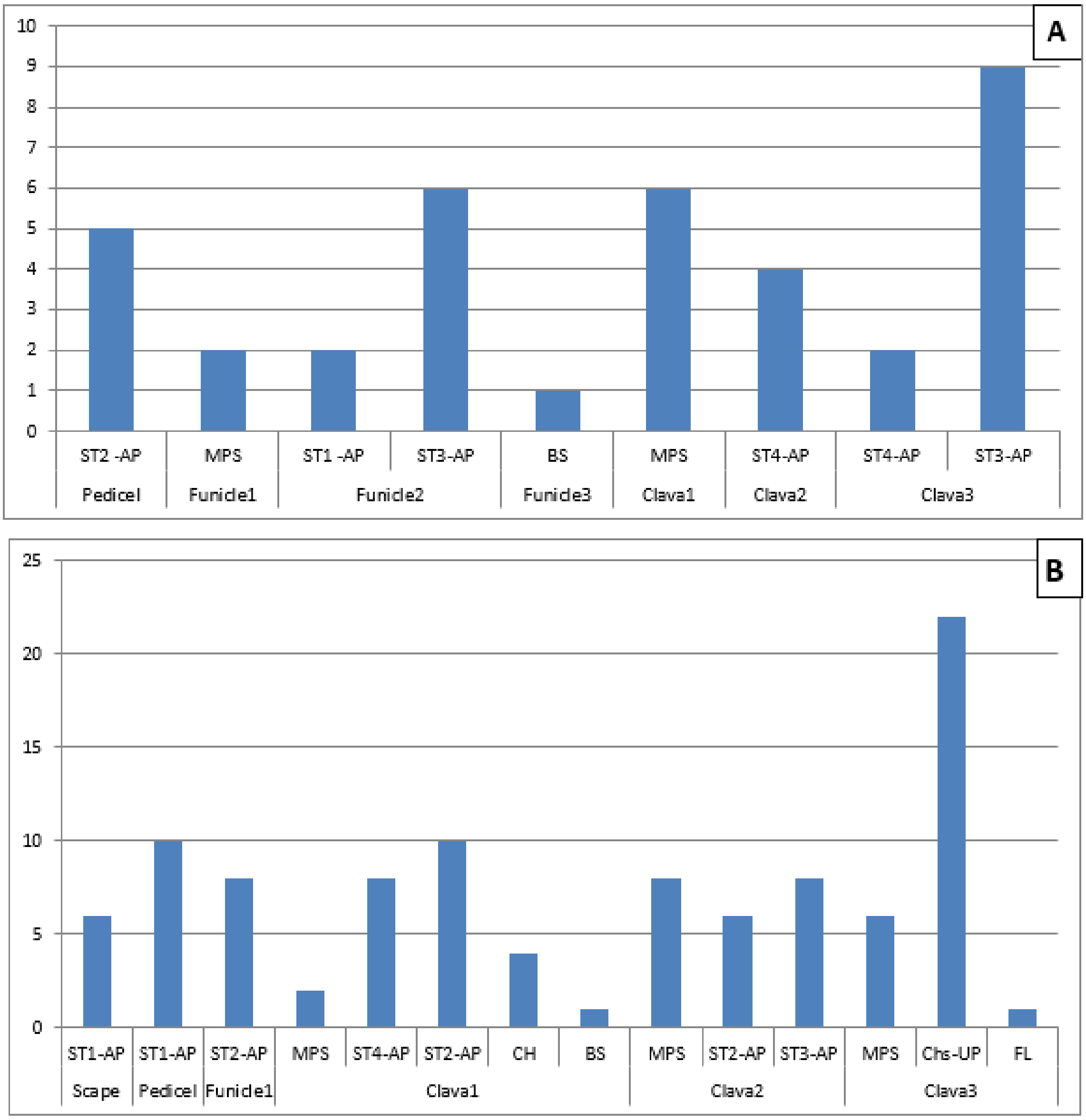

Fig.3: showing a comparison between the numbers of type sensilla and their distribution on the different parts of the antenna for both species A: ***Leptocybe invasa***, b: ***Ophelimus maskelli***

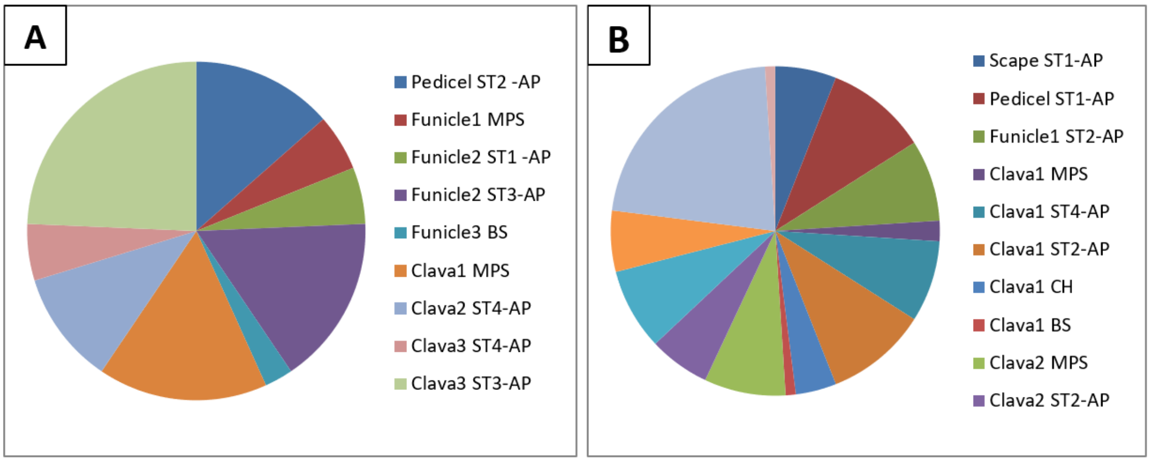

Fig.4: showing a comparison between the proportions of the presence of different types of sensilla and their distribution on the antenna for both species A: ***Leptocybe invasa***, B: ***Ophelimus maskelli***

Hymenoptera are known for their geniculate antennae, which have a long scape, a basal radicula, a pedicel in the form of a barrel, and a long flagellum that is separated into a funicle and a clava (Olson & Andow, 1993; Onagbola & Fadamiro, 2008). Varying South American countries' holotypes of *P. elaeisis* from the Eulophidae family had different funicular segment sizes (Delvare & Lasalle, 1993). To increase the surface area of sensory receptors, the antennal size may be linked to the number and size of sensilla. The parasitoids antennal size and the size of the placoidea sensilla have been connected (Borden *et al*., 1978; Amornsak *et al*., 1998; Zhou *et al*., 2013a).

Both species of *L. invasa* and *O. maskelli* have a higher density of trichodea sensilla dispersed on the flagellum and an increasing concentration on the clava. As with other parasitoids, TS-1 was the most prevalent sensilla type, covering the entire surface of both species' antennae (Norton & Vinson, 1974; Ochieng *et al*., 2000; Zhou *et al*., 2013a). Mechanoreceptor function is served by TS-1 (Roux *et al*., 2005; Marques-Silva *et al*., 2006; Dweck, 2009). Similar to TS-1, TS-3 also has a mechanosensory function and is found in various Eulophidae as well as both species of *L. invasa* and *O. maskelli* (Onagbola & Fadamiro, 2008; Onagbola *et al*., 2009). (Zhou *et al*., 2013a).

Mechanoreceptors like TS-1 and TS-3 may have a larger concentration in females because of the vital functions they perform in detecting air currents and vibration signals.Mechanoreceptors are also crucial before and during oviposition because females probe the host surface with them (Van Baaren et al., 2007; Onagbola & Fadamiro, 2008; Onagbola et al., 2009; Wenninger et al., 2009). They are crucial because parasitoids choose various host sizes and regulate the quantity of eggs laid depending on host size (Klomp & Teerink, 1962).

In parasitoids, TS-2 was previously described as "trichoidea sensilla 4" in *Trichogramma australicum* (Hymenoptera: Trichogrammatidae) and "multiporous sensilla trichoidea" in *Trichogramma galloi* Zucchi and *Trichogramma pretiosum* Riley (Hymenoptera: Trichogrammatidae). It has a chemoreceptor functional role and may be related to cue Because this parasite, like several other Eulophidae, does not distinguish between host features like age or parasitic host, as previously found in *L. invasa* and *O. Maskelli*, differences in the amount of TS-2 in both species may be connected to host identification.

In Eulophidae, BS have been identified as "basiconic capitate peg sensilla" in T. radiata (Waterston) and *Quadrastichus erythrinae* Kim (Li *et al*., 2013), "peg-like sensilla" or "sensilla coeloconica" in *Sympiesis sericeicornis* Nees (Meyhöfer *et al*., 1997) and capability as thermo-hygro receptors (Wibel *et al*., 1984; Pettersson *et al.*, 2001; Onagbola and Fadamiro, 2008).

The form of finger-like sensilla makes it simple to identify them as "Nonporous fingerlike sensilla" (Zhou *et al*., 2013b). Despite being seldom described in Hymenoptera, other parasitoids with similar antennal positions also contain them (Viggiani, 1982; Zhou *et al*., 2013a, 2013b). *O. maskelli* only has single finger-like sensilla at the tip of the clavus, in contrast to other species.

O. maskelli has sensilla chaetica in its antennal clava, which are comparable to those in the Braconidae species *Macrocentrus cingulum*, *Microplitis croceipes*, and *Apanteles cypris* (Ochieng *et al*., 2000; Zhou *et al*., 2011; Ahmed *et al*., 2013). The sensilla chaetica possibly have a mechanosensory role with the sense of the antennal movement because of their placement (Ochieng *et al*., 2000; Dweck, 2009; Zhou *et al*., 2011). With the potential to serve as proprioceptors, these sensilla are implanted into cuticular depressions (Zhou *et al*., 2011; Ahmed *et al*., 2013).

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