Annual Review & Research in Biology
3(1): 52-69, 2013

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Morphology and Morphometry of *Aedes aegypti* Adult Mosquito

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Research Article

Received 15th November 2012
Accepted 3rd January 2013
Published 6th February 2013

ABSTRACT

Aim: To study the morphology and morphometry of *Aedes aegypti* mosquito.
Place and Duration of Study: Laboratory of St. John's College, Agra. From June, 2011 to May, 2012.
Methodology: 20 male and 20 female adult *Aedes aegypti* were taken for the study. Head, clypeus, vertex, antenna, maxillary palp, thorax, wings, legs and abdomen were studied. The type of scales, their morphology, bands and patches were observed. Morphometric study was done using Image J software. Kruskal-Wallis one way analysis of variance (ANOVA) was employed.
Results: The clypeus of female has two silvery white dots whereas, male had no dots. The vertex of male and female has silvery white flat scales. The size of head, proboscis, maxillary palp, antenna, thorax, its lyre marking and median longitudinal lines were measured. The scales and bristles of thoracic regions were observed. The wing membrane has no white scales. It bears specific venation which had flat scales. The size of the wing, legs, abdomen were measured and their scales were observed. The claws of fore, mid and hind legs varied in male and female *Ae. aegypti.*
Conclusion: This study revealed the morphologic features of *Ae. aegypti* adult in Agra for better understanding of the key characters.

Keywords: Ae. aegypti; dengue vector; Agra; morphology; morphometry.

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1. INTRODUCTION

Aedes (Stegomyia) *aegypti* the main vector of Dengue is prevalent in Agra city. Due to the pressure of urbanization, improper management of the domestic and other neglected water collections occur. Construction sites in the city and excessive usage of water coolers in summer also are the sources of *Ae. aegypti* breeding [1].The female *Ae. aegypti* preferably lay eggs in artificial collections of water. The hatched larvae undergo growth and metamorphosis and attain adult stage. Identification of *Ae. aegypti* larvae, pupae and adults by their morphologic features immediately after collection is of considerable value in recognising vector prevalence. Most of the identification keys of the *Ae. aegypti* are based exclusively on the characteristics of female *Ae. aegypti* [2-6] whereas, the morphology of male *Ae. aegypti* is described by a few authors [4-6]. The adults vary in size and ornamentation [4].

In *Ae. aegypti* the head is a round or globular structure [2]. The clypeus region of the head in female *Ae. aegypti* has two white silvery scale markings [2-6] whereas, in male, the clypeus is bare [6]. The anterior margin of the clypeus was bulging and sometimes it was straight. A bundle of scales which looked like a dot was present on the clypeus [7]. Christopher [5] mentioned that sometimes the male clypeus has a few white scales. In this study, the morphology and morphometry of head, the scale patches and the scale types in the clypeus of male and female had been studied.

Middle of vertex in *Ae. aegypti* has silvery white flat scales [2,4,5,6]. Rueda [3] described the vertex has erect forked scales which are restricted to occiput. In this present study, the scales of vertex in male and female had been studied.

The proboscis of *Ae. aegypti* is slender , black, long, straight and cylindrical [2,5,6]. The maxillary palpi in male are long as proboscis. Huang [6] described that palpi in male is 5 segmented with white basal band on 2-5 segments. In female, the maxillary palps are small and 4 or 5 segmented. They have silvery white scale patches at the tip [2,4,5,6]. The size of antennae is different in male and female *Ae. aegypti*. The number of antenal segments in *Ae. aegypti* vary in the observation of various authors. In *Ae. aegypti* 14 [8], 13 [5] and 15 [2] segments were described. In this present study, the morphology and morphometry of maxillary palpi, proboscis and number of segments of flagellum in male and female were observed.

The scutum in *Ae. aegypti* is narrow with dark [6], black or brown scales [3]. It has a characteristic lyre shaped marking of white scales [2,3,5,9,10]. The scutum also has a pair of submedian-longitudinal white lines [3,9]. In *Ae. aegypti,* scutellum is 3 lobed and has 3 white silvery scale patches [4-6]. Huang [6] described that at the apex of mid lobe, dark scales are present. In *Ae. aegypti* the post spiracular area of the mesothoracic spiracle bears post spiracular bristles [2,5,9]. The paratergite has a broad white scale patch [3,5,6,10]. In front of the wing root is a prominent knob, the pre alar knob. It bears pre alar bristles [5]. Mesepimeron has 2 well separated white scale patches [2,3,5]. Christopher [5] described that posterior to the mesepimeron, a triangular area is present. On its upper part is the metathoracic spiracle. In this present study, the morphology and morphometry of male and female thoracic parts and markings had been studied.

Wings are bi-dimensional rigid structures. They are well suited for morphometric work [11]. Wing is oval in shape at tip, broader at middle and narrower at base in both male and female and the posterior hind margin of the wing has erect fringe scales [2,5]. The wing scales are

dark brown and unornamented [12]. For species identification and characterization, wing shape was utilized [13]. In this present study, the morphology and morphometry of male and female wing had been studied.

The legs of *Ae. aegypti* are long and jointed structures. The coxae have white scale patches in both male and female [5,6]. The trochanter are short cylindrical which join with coxa [5]. Christopher [5] – in male and female, Huang [6] in male and female, Ribeiro et al., [10]- adult and Rueda [3]- female, described that the femur of mid leg has a median longitudinal line of white scales. Christopher [5] described that the tibia in all the legs are dark. In fore and mid legs there are pale spots [5] or white bands [6] at the base of first and second tarsal segments. Huang [6] described that hind tarsus has a basal white band on tarsomeres I-4. Sathe and Girhe [2] and Rueda [3] described that the hind tarsomere 5 is entirely white. Christopher [5] and Huang [6] described that in male the foreleg has the tarsal claws unequal, the larger one toothed, the smaller one simple. The midleg has tarsal claws unequal and both are simple. The hindleg has simple equal tarsal claws. In female fore- and midlegs have the tarsal claws equal and all are toothed. In this present study, the morphology and morphometry of different parts of male and female legs and scales had been studied.

Barraud [4], Christopher [5] and Sathe and Girhe [2] described that the II –VI segments of abdomen have basal bands of white scales on the tergite. Barraud [4] - on I-VII segments, Christopher [5] and Sathe and Girhe [2] described that laterally silvery spots are present on tergite. In this present study, the morphology and morphometry of male and female abdomen and their scales had been studied.

Various adult forms like sensu strictu, the type form, *formosus* (walker) and *queenslandensis* (Theobald) were reported within *Ae. aegypti* [6,14]. Hence, the morphology of *Ae. aegypti* adult in our collection was studied in detail and morphometry of above mentioned regions were also done.

2. MATERIALS AND METHODS

The adult mosquitoes were collected from specific sampling sites of Agra in the vicinity of St. John's College area from 2011 to 2012. Larvae of *Aedes aegypti* were brought to the laboratory and reared in the cages. The adult mosquitoes were killed by mosquito coil and dry materials were pinned by minutants and kept on thermacool sheet. 20 male and 20 female adult *Aedes aegypti* were taken for the study. The preserved and pinned adult *Ae. aegypti* mosquitoes were used for morphological study. The morphology of male and female *Ae. aegypti* were observed under a stereo binocular microscope.

a) The morphology of the various structures of head, clypeus, vertex, antenna, maxillary palp, thorax, wings, legs and abdomen were studied. The type of scales, their morphology, bands and patches were observed.
b) Their images were transferred on a computer, photographed under an image documentation system and their sizes (length/width) were measured by using image J software for morphometric study.

2.1 Statistical Analysis

The documented morphometric data were analysed statistically. Kruskal-Wallis one way analysis of variance (ANOVA) was employed to determine the significant difference among the readings using Sigma plot software along with Mean ± Standard deviation (SD).

3. RESULTS

Aedes aegypti male and female, are almost similar in appearance except for the differences in size of antennae, maxillary palp, abdomen, claws and in scale markings.

Table 1. Length and width of head, thorax, wing and abdomen of adult *Ae. aegypti*

Present study				Authors	Male	Female
Region	**Parameters (mm)**	**Male**	**Female**			
Head	Length	0.53^{a}±0.06	0.55^{a}±0.09	Sathe and Girhe [2]		0.06
	Width	0.81^{a}±0.13	0.73^{a}±0.11	Christopher [5]		0.78
				Sathe and Girhe [2]		0.5
Thorax	Length	0.41^{a}±0.06	0.5^{a}±0.08	Sathe and		1.0
	Width	0.29^{a}±0.02	0.35^{a}±0.07	Girhe [2]		0.8
Lyre marking	Length	0.22^{a}±0.02	0.27^{b}±0.03			
Submedian line	Length	0.41^{a}±0.02	0.46^{b}±0.04			
Wing	Length	2.93^{a}±0.52	3.09^{a}±0.36	Christopher [5]		3.41
				Sathe and Girhe [2]		3.8
	Width	0.66^{a}±0.08	0.71^{a}±0.16	Christopher [5]		0.86
				Sathe and Girhe [2]		0.95
Abdomen	Length	3.03^{a}±0.18	2.94^{a}±0.20			
	Width	0.51^{a}±0.07	0.41^{a}±0.06			
Palpi	Length	0.77^{a}±0.06	0.08^{b}±0.01			
Proboscis	Length	0.76^{a}±0.04	0.66^{a}±0.03	Christopher [5]		2.13
				Sathe and Girhe [2]		2.20
Antenna	Length	0.57^{a}±0.03	0.52^{a}±0.07	Sathe and Girhe [2]		1.95
Fore femur	Length	1.81^{a}±0.09	1.85^{a}±0.06	Christopher [5]	2.07	
Mid femur	Length	1.86^{a}±0.07	2.21^{b}±0.21	Christopher [5]	2.15	
Hind femur	Length	1.74^{a}±0.04	1.72^{a}±0.05	Christopher [5]	2.18	

				Sathe and Girhe [2]	1.40
Fore tibia	Length	1.86[a]±0.06	1.79[a]±0.13	Christopher [5]	2.05
Mid tibia	Length	2.09[a]±0.21	1.88[b]±0.10	Christopher [5]	2.25
Hind tibia	Length	1.77[a]±0.27	2.50[b]±0.27	Christopher [5]	2.33
				Sathe and Girhe [2]	2.20
Fore tarsus	Length	2.28[a]±0.29	2.42[b]±0.07	Christopher [5]	6.54
Mid tarsus	Length	2.77[a]±0.03	2.75[b]±0.15	Christopher [5]	7.03
Hind tarsus	Length	3.51[a]±0.06	3.86[b]±0.05	Christopher [5]	8.56
				Sathe and Girhe [2]	3.40

a, b - significant difference (p< 0.001) at adult stage in same row for specific parameters

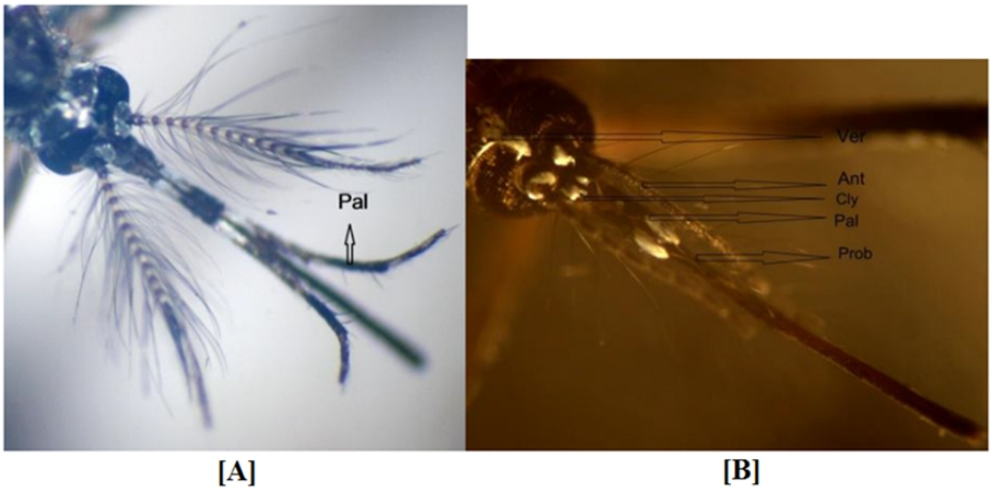

Fig. 1. Head of male (A) and female (B) adult *Ae. aegypti* in 108x magnification (Ant - Antenna, Pal - Maxillary palp, cly - Clypeus, Prob - Proboscis, Ver - Vertex scales)

3.1 Head

In both male and female *Ae. aegypti,* dorsally the head is globular in shape. It is convex laterally and round towards the occiput. The female clypeus has two silvery white dots (Fig. 1). Whereas, male has no dots. The vertex of male and female has silvery white flat scales which are extended forward to the interocular area in between the compound eyes.

In male the vertex scales are round in shape and in female the scales are oval in shape (Fig. 1). Dark scales have covered rest of the dorsal surface of the head. The size of the head capsule in male and female varied. The antero-posterior length of the head capsule in

female (0.55±0.09 mm) is larger than male (0.53±0.06 mm) (Table 1) whereas, the width in male (0.81±0.13 mm) is larger than female (0.73±0.11 mm) (Table 1).

3.1.1 Proboscis

In *Ae. aegypti* proboscis is long, straight and dark in colour. There are no white scale patches on proboscis in both male and female (Fig. 1). The length of the proboscis in male is longer (0.76±0.04 mm) than female (0.66 ±0.03 mm) (Table 1).

3.1.2 Maxillary palp

Mouth parts of *Ae. aegypti* has a pair of maxillary palps. In male the maxillary pallpi are longer (0.77±0.06 mm) and it has 5 white scale bands. In female maxillary palpi are very short (0.08 ±0.01mm) (Table 1) and white scales are present at the tip of the palpi (Fig. 1).

3.1.3 Antenna

In the antenna of *Ae. Aegypti*, scape is very much reduced and the antennae arise from its globular pedicel. The antennae have 13 flagellar segments and from the inter segmental region antennal hairs are arranged in a whorl fashion. In male, the length of the antennae are longer (0.57±0.03 mm) than female (0.52±0.07 mm) (Table 1). The antennal hairs are bushy and plumose in male whereas in female, they are smaller and less dense. On the basal lobes of antennae, white scales are present in both male and female (Fig. 1).

3.2 Thorax

The size of the thorax in female *Ae. aegypti* is found larger than male and its length measured 0.5±0.08 mm (Table 1) and the width 0.35±0.07 mm (Table 1) whereas, the length of thorax in male is 0.41±0.06 mm (Table 1) and the width 0.29±0.02 mm (Table 1). Thorax of *Ae. aegypti* was of black or dark brown colored. The thoracic region consists of the pro, meso and meta thoracic segments which comprises wings, legs and halteres. Its scutum has white scale patches in both male and female. The dorsum has a lyre shaped marking of white scales and in between the marking two median longitudinal lines of white scales are present (Fig. 2). In male the size of the lyre marking (0.22±0.02 mm- length) and the length of the median longitudinal lines (0.41±0.02 mm) are smaller than female lyre marking (0.27±0.03 mm) and the median longitudinal lines (0.46±0.04 mm) (Table 1). The scutellum in *Ae. aegypti* is three lobed and each lobe has silvery white scale patches in both male and female. A few dark scales are present at the apex of midlobe (Fig. 3).

Mesothoracic spiracle of *Ae. aegypti* in male and female are on the upper part of mesothorax. Mesothoracic spiracle in male and female appeared oval in shape (Fig. 4). The post spiracular area of the mesothoracic spiracle bears post spiracular bristles. This area has no scales (Fig. 4). Posterior to the mesothoracic spiracle, the paratergite area has a broad, prominent bright white scale patch in male and female (Fig. 4). Posterior to the paratergite is a pre alar knob which carries pre-alar bristles in both male and female (Fig. 4). The mesepimeron region in female has 2 white flat scale patches whereas, in male, another small white flat scale patch was also noticed below the two mesepimeral patches (Fig. 4). The meta thoracic region has the meta thoracic spiracle and it also appears oval in shape. Its dorsal part carries the halteres (Fig. 4).

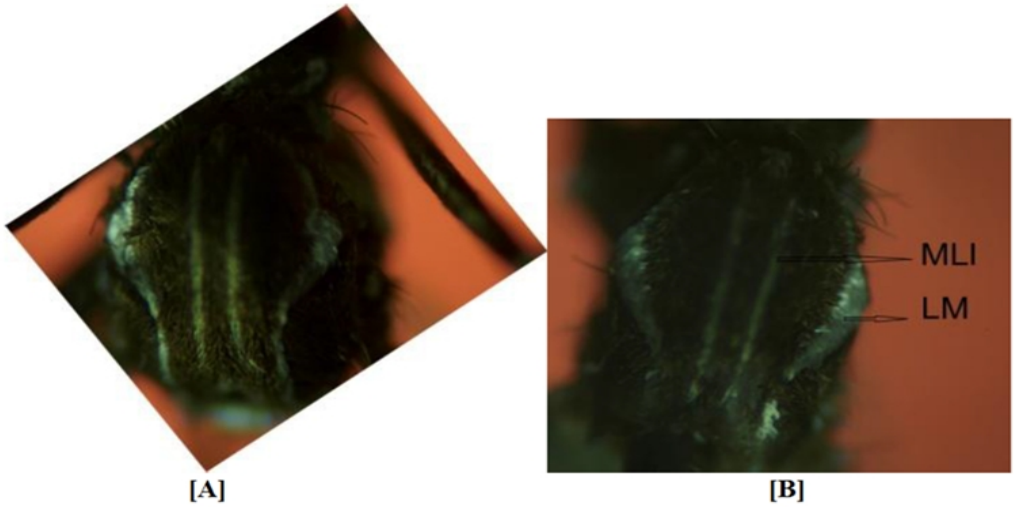

Fig. 2. Thorax of male (A) and female (B) adult *Ae. aegypti* in 108x magnification (LM- lyre marking, MLI- submedian longitudinal line)

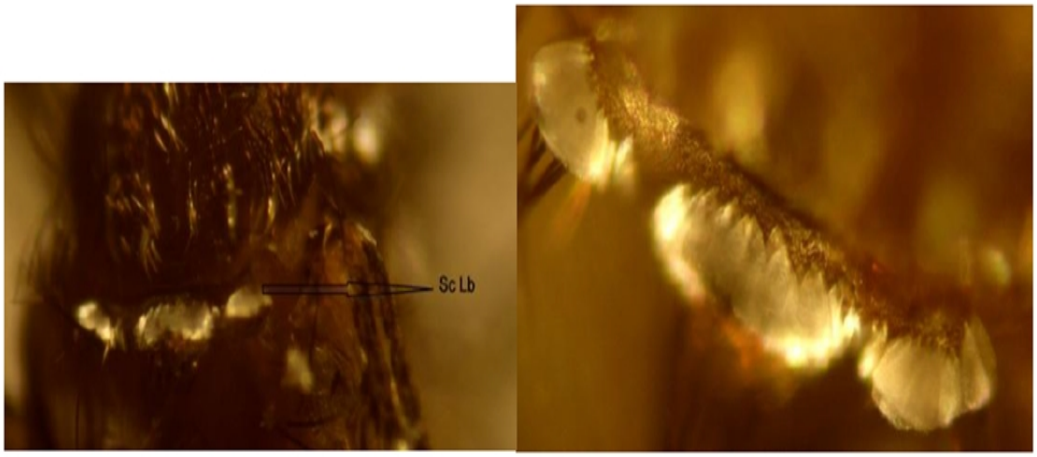

Fig. 3. Scutellar lobes [Sc Lb] and scales of male and female *Ae. aegypti* in 108x and 196x magnification

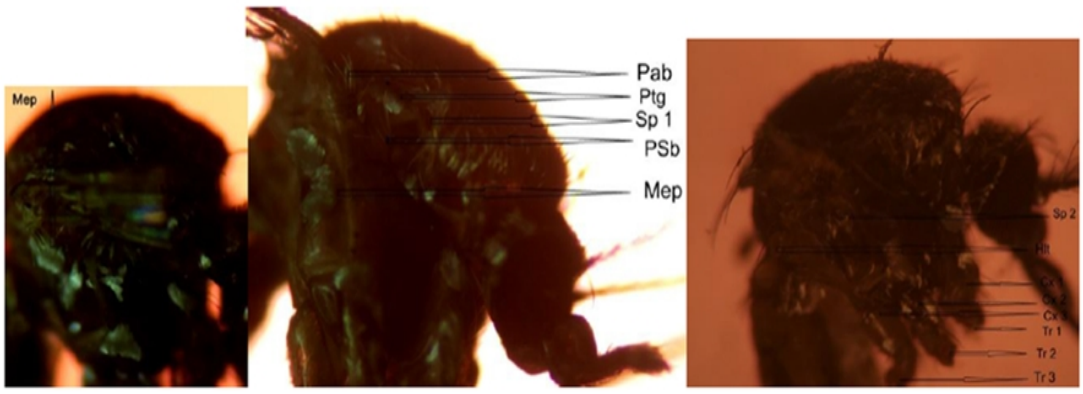

Fig. 4. Thoracic ornamentation of adult *Ae. aegypti* in 108x magnification (Sp 1 - Mesothoracic Spiracle, PSb - Post spiracular bristle, Pab - Pre alar bristle, Mep - Mesepimeron, Ptg - paratergite, Sp 2 - meta thoracic spiracle, Hlt - Haltere, Cx1, 2 and 3 - Coxa 1, 2 and 3, Tr 1, 2 and 3- Trochanter 1, 2 and 3)

3.3 Wing

The wings in male and female *Ae. aegypti* are flat, narrow and membranous. The wing membranes have no white scales. The wings bear specific venation. They have flat scales. The anterior part of wing is oval, broad at middle and at base narrow. The anterior margin of the wing is linear and almost flat whereas its posterior margin has erect fringe scales. At the base of the wing is a slightly convex region, the alula, which carries small fringe scales (Fig. 5).

Fig. 5. Wings of male [A] and female [B] adult *Ae. aegypti* in 22x magnification

In *Ae. aegypti* the size of the wing is larger in female (length 3.09±0.36 mm and width 0.71±0.16 mm) than male (length 2.93±0.52 mm and the width 0.66±0.08 mm) - (Table 1).

3.4 Leg

In *Ae. aegypti* the three pairs of legs (Fig. 4) has coxa , trochanter, femur, tibia and the tarsal segments. The last tarsal segment carries claws.

In the legs of *Ae. aegypti,* the first segment coxa (an elongate cylindrical part) joins the thorax with trochanter. White flat scale patches are present in the segment. Fore coxa has a scale patch. Mid coxa has two scale patches and hind coxa has a scale patch. Trochanter is a small cylindrical structure which joints with femur.

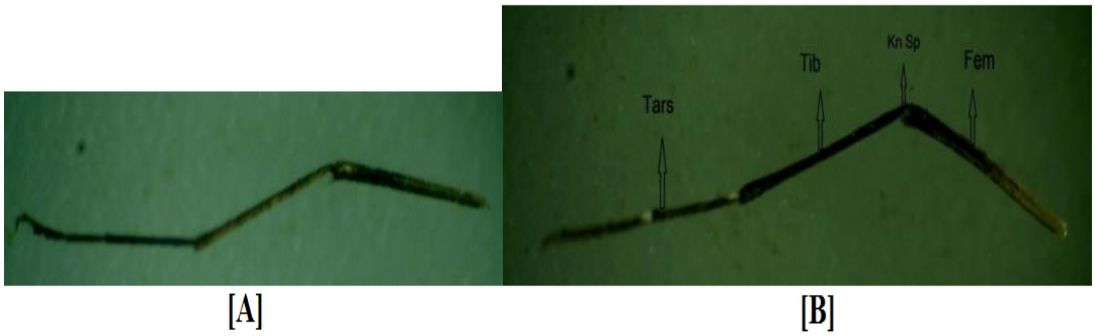

Fig. 6. Fore leg of male [A] and female [B] of adult *Ae. aegypti* in 22x magnification [Fem- femur, Kn Sp- knee spot, Tib- tibia, Tars- tarsus]

In female the length of femur in the fore (1.85±0.06 mm) and mid legs (2.21b±0.21 mm) are larger than male (1.81±0.09 mm and 1.86±0.07 mm) whereas, the length of femur in the hind leg of male (1.74±0.04 mm) is larger than male (1.72±0.05 mm) (Table 1). The mid leg of male and female femur has a white longitudinal median stripe. It runs the whole length of femur and it is not continuous upto the knee. The posterior part of the femur has a knee shaped portion in fore, mid and hind legs and this part of all the femurs have pale coloured knee spots in both male and female. The anterior half of fore and hind legs are white in both male and female (Figs. 6, 7 and 8).

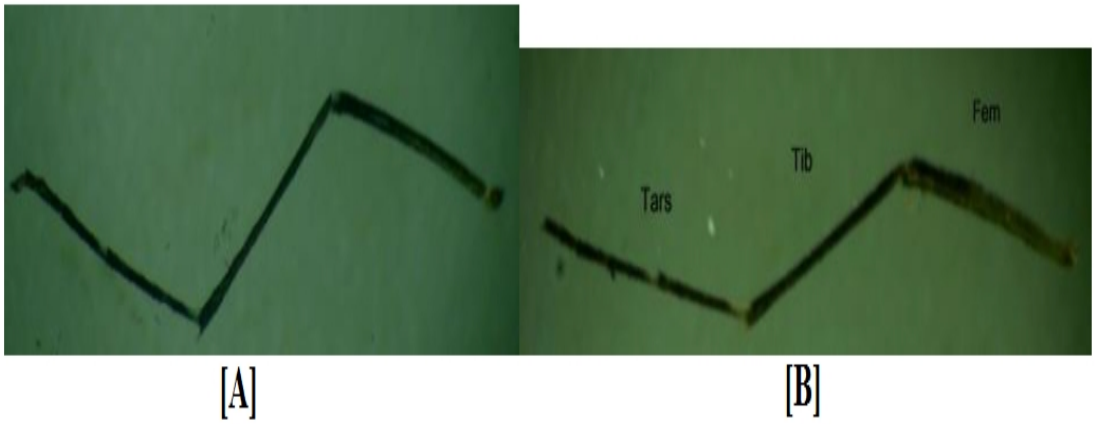

Fig. 7. Mid leg of male [A] and female [B] adult *Ae. aegypti* [Fem- femur, Tib- tibia, Tars- tarsus]

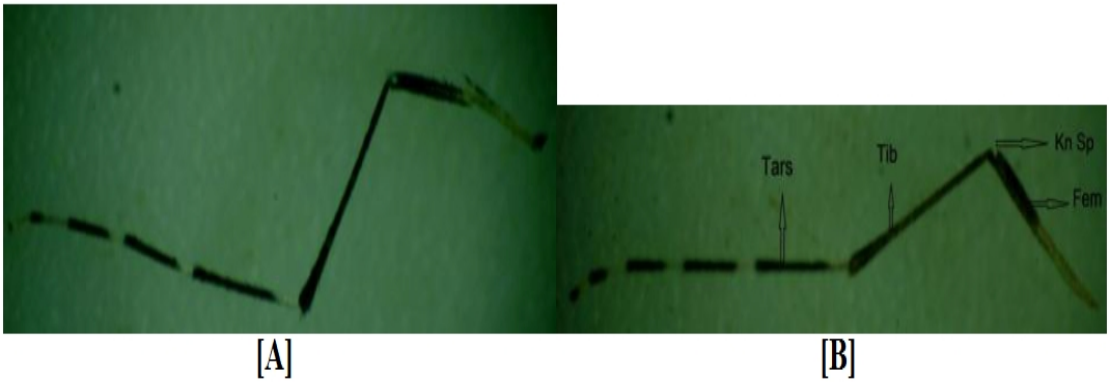

Fig. 8. Hind leg of male [A] and female [B] adult *Ae. aegypti* [Fem- femur, Kn Sp- knee spot, Tib- tibia, Tars- tarsus]

In *Ae. aegypti* tibia is cylindrical, long and black in colour articulated with femur (Figs. 6, 7 and 8) . In male the length of the fore tibia (1.86a±0.06mm) and mid tibia (2.09a±0.21mm) are larger than female (1.79a±0.13 mm and 1.88b±0.10mm). In female the length of the tibia of hind leg (2.50b±0.27mm) is larger than male (1.77a±0.27 mm) - (Table 1).

In *Ae. aegypti* tarsus has 5 segments in both male and female legs. In fore and mid legs of both male and female, the first two segments of tarsus has white bands in each. In hind leg, each segment of the tarsi has dark and white bands in both male and female. 5th tarsal segment in both male and female are entirely white (Figs. 6, 7 and 8). In female the length of the fore (2.42b±0.07 mm) and hind (3.86b±0.05 mm) tarsus are longer than male fore (2.28 a±0.29 mm) and hind (3.51a±0.06 mm) tarsus. The length of the mid tarsus is longer in male (2.77a±0.03 mm) than female (2.75b±0.15 mm) - (Table 1).

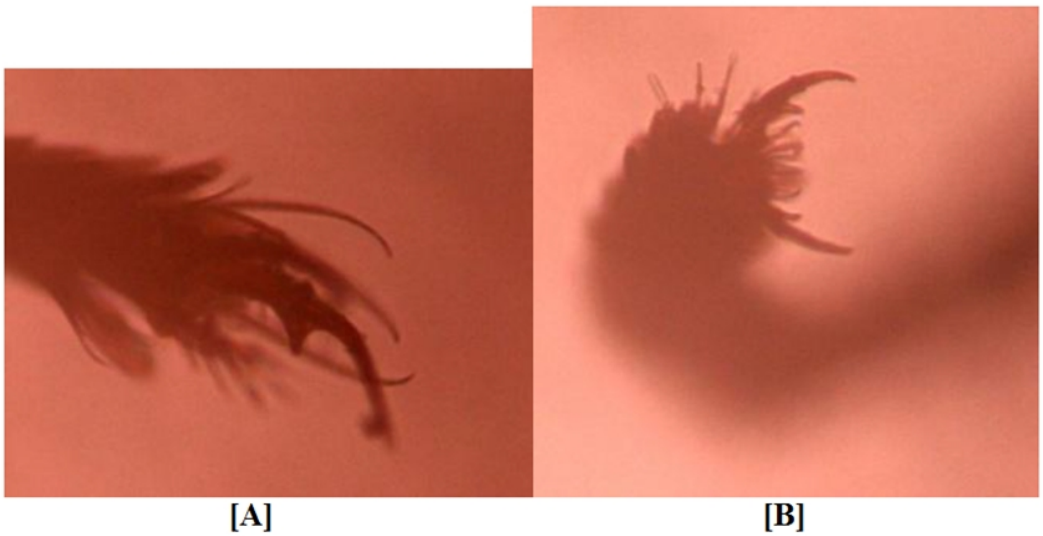

Fig. 9. Claw of fore leg of male [A] and female [B] adult *Ae. aegypti* in 196x magnification

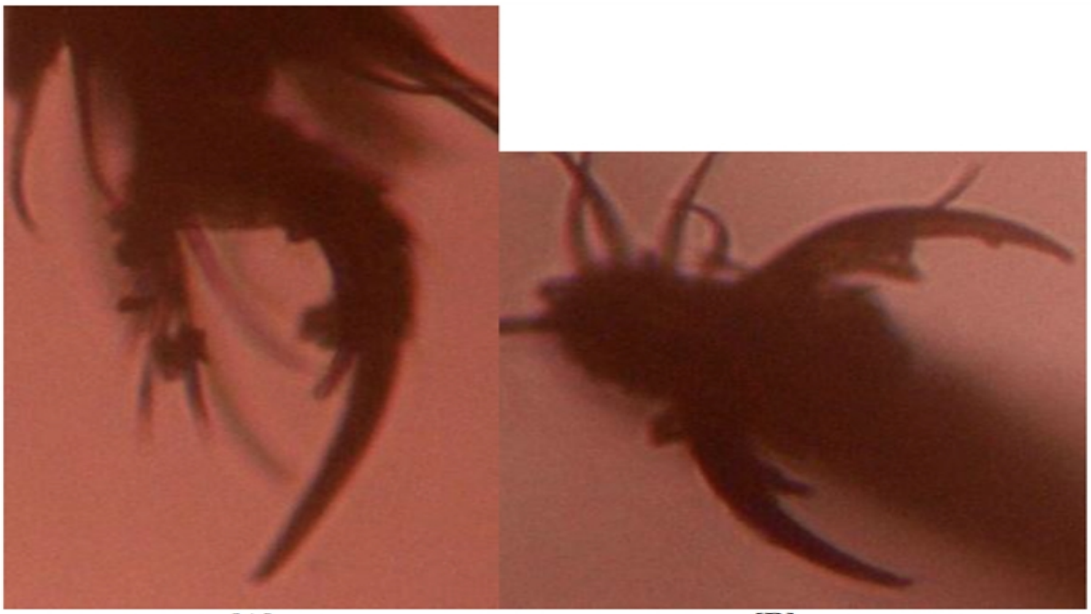

Fig. 10. Claw of mid leg of male [A] and female [B] adult *Ae. aegypti*

Claw in the male and female *Ae. aegypti* are different in the three pairs of legs. In fore leg of male, one claw is uniserrate and larger than another claw which is simple (Fig. 9). In mid leg outer claw is very large than other claw and both are simple (Fig. 10). In hind leg of male two small simple and equal claws are present (Fig. 11).

In female *Ae. aegypti*, in fore leg two large uniserrate and equal claws are present (Fig. 9). In mid leg two median sized uniserrate equal claws are present (Fig. 10) and in hind leg two small simple equal claws are present (Fig. 11).

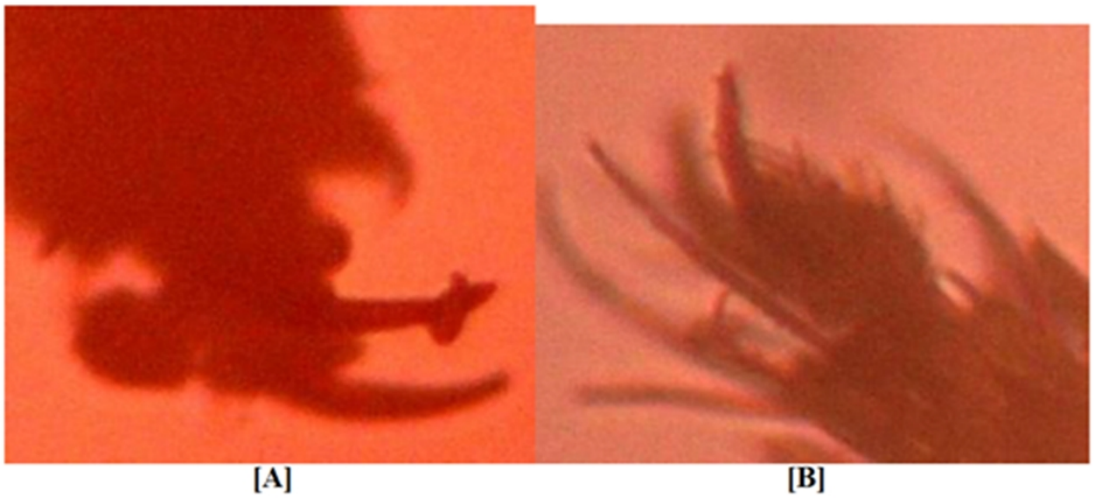

Fig. 11. Claw of hind leg of male [A] and female [B] adult *Ae. aegypti*

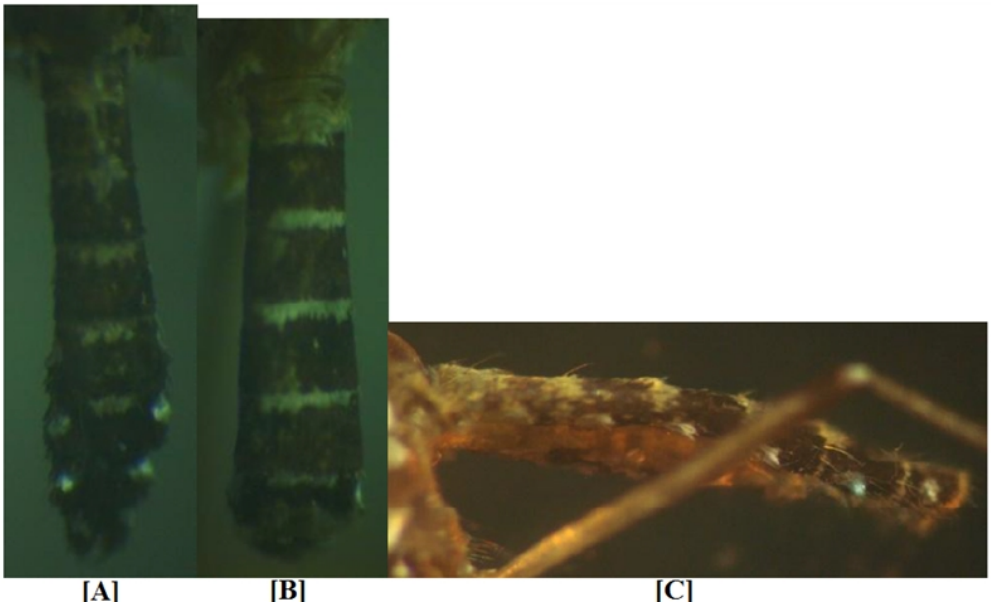

Fig. 12. Abdomen of male [A] and female [B] adult *Ae. aegypti* and patches of laterotergite [C] in 28x magnification

3.5 Abdomen

Ae. aegypti abdomen is 8 segmented, and the segments are covered with dark and white scales in both male and female. In female the 8th segment is greatly reduced. The tergites are dark brown in colour and the Ist abdominal segment has a median pale scale patch. The dorsal side of the abdominal segments II to VII has transverse white bands.

The lateral sides of the abdomen of I-VII segments have silvery white scale patches in both male and female. The posterior tip of abdomen in male is narrow and in female it has a broad and round shape. In male, terminal VI and VII segments has white scale patches dorsolaterally (Fig. 12). The size of abdomen in male is larger (length 3.03a±0.18 mm and width 0.51a±0.07 mm) than female (length 2.94a±0.20 mm and width 0.41a±0.06 mm) – (Table 1).

4. DISCUSSION

Aedes aegypti differs in characteristic white scale ornamentation from many other Culicine species.

The anterior half of the head has large convex kidney shaped compound eyes laterally. Its facial region carries the antennae directed forward and a long proboscis extended from its lower end.

The size of head of *Ae. aegypti* was described by various authors. In *Aedes aegypt*i, the head is globular dorsally, convex laterally and rounded towards the occiput. Christopher [5] described that the width of the head in female *Ae. aegypti* measured 0.78 mm. Sathe and Girhe [2] described the size of head of female *Ae. aegypti,* measured 0.6 mm length and 0.5

mm width. In this study, the antero-posterior length of the head capsule in *Ae. aegypti* was measured in both male and female. The antero-posterior length of the head capsule in female (0.55±0.09) is found larger than male (0.53±0.06) and the width of the head in male (0.81±0.13) is found larger than female (0.73±0.11).

Clypeus of the female *Ae. aegypti* has two white silvery scale markings. Barraud [4] and Sathe and Girhe [2] described them as dots whereas, Christopher [5], Huang [6] and Rueda [3] described them as patches. In this study also, the clypeus of female has two white dot like silvery scale patches. In male *Ae. aegypti*, clypeus is bare [6] whereas, sometimes a few white scales are seen [5]. In this study, in male, no white or pale scales were found on the clypeus. In the images of female mosquitoes of *Aedes* species [4], clypeus of *A. vittatus* Big (image- 4), *A. edwardsi* Barr (image- 5), *A. w-albus* Theo (image- 6) and *A. mediopunctatus* Theo (image- 10) also had dots of scale patches.

Christopher [5] described that the dark scales covered the most of the part of the head region. The middle of the vertex has silvery white flat scales which extended to the interocular area between the eyes [2,4,5,6]. In this study also, in both male and female *Ae. aegypti* the middle of the vertex had silvery white flat scales and the flat white scales extend between the eyes. The scales in male were round in shape and flat whereas, in female the scales were flat and somewhat oval in shape.

Proboscis of *Ae. aegypti* is slender , black, long, straight and cylindrical [2,5,6]. Other species of *Aedes* like *A. desmotes* had black proboscis [4]. In this study also, proboscis of *Ae. aegypti* was found as a long, straight, dark coloured and without any white scale patches. The length of the female proboscis measured 2.13 mm [5] and 2.2 mm [2]. In this study, the length of the proboscis of *Ae. aegypti* in male measured 0.76±0.04 mm and in female 0.66 ±0.03 mm. Proboscis in male *Ae. aegypti* was larger than female.

The clypeus region of *Ae. aegypti* has a pair of maxillary palpi. Maxillary palpi are short in female and are longer in male. Female maxillary palpi had silvery white scale patches at the tip of the palpi [2,4,5,6]. Huang [6] described that in female, the palpi were 4 or 5 segmented. Huang [6] described that in male it was 5 segmented and it was as long as proboscis. It was dark with a white basal band on 2-5 segments. In this study, male maxillary palpi had 5 white scale bands from 2-5 segments. In female, white scales were present at the tips of the palpi and it is 4 segmented. Sathe and Girhe [2] described the length of maxillary palpi in *Ae. aegypti* female as 0.6 mm. In this study, the length of the proboscis in male was found longer (0.77±0.06 mm) than female (0.08 ±0.01 mm).

Ae. Aegypti, antennae are long and its antennal hairs are arranged in a whorl fashion. Scape is greatly reduced. Flagellum arise from the globular pedicel. In male, antennae is of plumose type [5,6]. The number of antennal segments in *Ae. aegypti* varied in the observation of various authors i. e. in adult -14 [8], in male and female- 13 [5] and in female - 15 [2]. In this study, antennae in male and female were 13 segmented after pedicel. The antenna was shorter than proboscis [6]. Christopher [5] described that the basal lobes of the antennae had white scales in both male and female. In this study, basal lobes of the antennae had white scales in both male and female. In this study the antennae were black in colour. Hairs were long and in whorl fashion. Male antenna was bushy and plumose. Female antenna had less hairs. Sathe and Girhe [2] described that the length of antenna in female was 1.95 mm. In this study, in male, the length of the antennae were found longer (0.57±0.03 mm) than female (0.52±0.07 mm) having difference with previous worker.

Thorax of *Ae. aegypti* is broad having black or dark brown color and it consisted of the pro, meso and meta thoracic segments which comprise wings, legs and halteres. Its scutum is narrow with dark [6] or brown scales [3] and it has a characteristic lyre shaped marking of white scales [2,3,5,9,10]. Barraud [4] described that other *Aedes* species like *A. elsiae* Barr (image- 1), *A. pallirostris* Edw (image- 7), *A. chrysolineatus* Theo (image- 8), *A. oreophilus* Edw (image- 9) and *A. macdougalli* Edw (image- 14) also had lyre shaped markings. The scutum has a pair of submedian-longitudinal white lines also [3.9]. Huang [6] described that the submedian-longitudinal lines had narrow pale yellowish scales. Other *Aedes* species like *A. desmotes* and *A. pallidostriatus* also had a pair of narrow submedian lines [4]. In this study, the dorsum of *Ae. aegypti* having a lyre shaped marking of white scales and in between the marking, two submedian longitudinal lines with white scales were noticed. In female *Ae. aegypti*, the length of the thorax was described as 1.0 mm and width 0.8 mm[2]. In this study, the size of the thorax was measured in *Ae. aegypti* and was found larger in female (length- 0.5±0.08 mm, width- 0.35±0.07 mm) than male (length- 0.41±0.06 mm, width- 0.29±0.02 mm). In female the size of the lyre marking (length- 0.27±0.03 mm) and the median longitudinal lines (0.46±0.04 mm) were also larger than male lyre marking (length - 0.22±0.02 mm) and the median longitudinal lines (length - 0.41±0.02 mm).

The scutellum of *Ae. aegypti* is three lobed and each lobe has silvery white patches [4,5,6]. In this study also, the three lobed scutellum and silvery white flat scale patches in each lobe were noticed. The scutellar lobes of *A. albopictus* and *A. jamesi* also had silvery white flat scales [4]. Huang [6] described that scutellum of *Ae. aegypti* had a few broad dark scales at apex of its midlobe. In this study also, the apex of midlobe had a few dark scales.

Ae. aegypti male and female has a pair of mesothoracic spiracles on the upper part of the mesothorax. Christopher [5], Darsie *et al*. [9] and Sathe and Girhe [2] described that the post spiracular area of the mesothoracic spiracle of *Ae. aegypti* bore post spiracular bristles. Huang [6] described that post spiracular area had no scale. In this study, the spiracle was oval shaped and the post spiracular area bore post spiracular bristles where no white scales were present in this area.

On the lateral aspect of the thorax of *Ae. aegypti*, posterior to the mesothoracic spiracle is the paratergite with a broad white scale patch [3,5,6,10]. In this study also, posterior to the mesothoracic spiracle, the paratergite area having a prominent bright white scale patch was noticed in both male and female *Ae. aegypti*. In front of the wing root is a prominent pre alar knob and it has pre alar bristles [5]. In this study also, posterior to the paratergite pre alar knob carrying pre-alar bristles was noticed in both male and female.

Thoracic region of *Ae. aegypti* has a broad structure mesepimeron and it has two well separated white scale patches [2,3,5]. The scales of the patches are white and flat. Among the two patches, the upper mesepimeral patch is not connected with the lower mesepimeral patch [5,6]. In this study also the mesepimeron region in both male and female *Ae. aegypti* had the two white flat scale patches. In male of *Ae. aegypti* another small white flat scale patch was also noticed below the two mesepimeral patches.

Posterior to the mesepimeron is a triangular area. On its upper part is the metathoracic spiracle. Halteres are found on its more dorsal portion [5]. In this study also, the meta thoracic spiracle appears oval in shape and its dorsal part carries halteres.

The wing of *Ae. aegypti* is membranous, narrow and possess veins. The membrane is free from white scales whereas, the veins have scales. Wing is oval in shape at tip, broader at

middle and narrower at base in both male and female and the posterior hind margin of the wing has erect fringe scales [2,5]. The alula region at the wing base is convex and transparent [2] and carries small and inconspicuous fringe scales [5]. In this study also, the above morphologic features were observed. In this study, the size of the wing in *Ae. aegypti* male and female were measured. The size of the wing was larger in female (length- 3.09±0.36 mm, width- 0.71±0.16 mm) than male (length- 2.93±0.52 mm, width- 0.66±0.08 mm).

The size of wing in *Ae. aegypti* was measured as an index by various authors . On average, females were always significantly larger than males [11]. In female *Ae. aegypti*, the length and width of the wing measured 3.41mm and 0.86 mm [5] and 3.8 mm and 0.95 mm [2] respectively.

The three pairs of legs of *Ae. aegypti* have coxa, trochanter, femur, tibia and the tarsal segments. The last tarsal segment carried claw. In the legs of *Ae. aegypti,* the first segment coxa (an elongate cylindrical part) joins the thorax with trochanter. White flat scale patches were present in coxa. Christopher [5] described about the white scale patches of coxae in both male and female. The coxae carrid patches of flat white scales. In this study also, on fore coxa a 'V' shaped patch, on mid coxa two small patches and on hind coxa a large patch were present. On fore coxa, one scale patch, on mid coxa, two scale patches and on hind coxa one scale patch were present.

Christopher [5] described that the trochanter were short cylindrical structure which joins coxa. In this study also, trochanter was observed as a small dark- brown cylindrical structure which joints with femur.

The femur of mid leg of *Ae. aegypti* has a median longitudinal line of white scales (Christopher [5], Huang [6] – in male and female, Ribeiro and Ramos [10] - in adult and Rueda [3] - in female). Barraud [4] described that fore femur was black with white line beneath. Huang [6] described that fore femur also had a narrow white longitudinal stripe on ventral half of anterior surface. In this study, on the femur of mid leg, a white longitudinal line of scales were present which run whole length of femur but did not connect the knee spot. Christopher [5], Huang [6] – in male and female and Rueda [3] - female, described that all the femur had pale knee spot. Huang [6] and Sathe and Girhe [2] described that the femur of hind leg in female has white knee spot. Barraud [4] described that mid femur had white knee spots. In *A. annandalei,* mid femur and hind femur were black with white knee spot [4]. In this study, all the femur possessed pale coloured knee spot. The length of fore, mid and hind legs in female were 2.07, 2.15, 2.18 mm [5] and the length of the hind femur was 1.4 mm [2]. In this study, in female the length of femur in the fore (1.85a±0.06 mm) and mid legs (2.21b±0.21mm) were larger than male fore (1.81a±0.09 mm) and mid legs (1.86a±0.07 mm). The length of male hind femur (1.74±0.04 mm) was larger than female (1.72±0.05 mm).

In *Ae. aegypti,* tibia was a cylindrical long, dark and black in colour articulated with femur. Christopher [5] described that the tibia in all the legs were dark. Huang [6] described that tibia was dark anteriorly. In this study, tibia had no white scales and throughout dark in colour. The length of the tibia in female fore, mid and hind legs were 2.05, 2.25 and 2.33 mm [5] and the length of hind leg in female was 2.20 mm [2]. In this study, in male the length of the fore tibia (1.86a±0.06mm) and mid tibia (2.09a±0.21mm) were larger than female (1.79a±0.13 mm and 1.88b±0.10mm). In female the length of the tibia of hind leg (2.50b±0.27mm) was larger than male (1.77a±0.27 mm).

In *Ae. aegypti,* tarsus was a cylindrical structure and has 5 segments. In fore and mid legs there were pale spots [5] or white band [6] at the base of first and second tarsal segments. Christopher [5] described that the hind tarsi had broad basal pale bands on all the segments. The fifth segment was entirely white [2,3,5]. Huang [6] described that the hind tarsus had a basal white band on tarsomeres I-4. Sathe and Girhe [2] described that hind tarsus had 5 dark and white bands. In this study, in fore and mid legs, two white bands were present at the base in the first two segments of tarsus of male and female. In hind leg, each segment had dark and white band in male and female. 5th segment is entirely white. The length of the fore, mid and hind tarsus were 6.54, 7.03 and 8.56 mm in female [5]. Sathe and Girhe [2] described that the tarsus of the hind leg in female was 3.4 mm long. In this study, in female the length of the fore (2.42b±0.07 mm) and hind (3.86b±0.05 mm) tarsus were longer than male fore (2.28 a±0.29 mm) and hind (3.51a±0.06 mm) tarsus. The length of the mid tarsus was longer in male (2.77a±0.03 mm) than female (2.75b±0.15 mm).

In *Ae. aegypti*, both male and female, at the terminal part of tarsus, claws were present. It differed in male and female on different legs. Christopher [5] and Huang [6] described that in male the foreleg had the tarsal claws unequal, the larger one toothed, the smaller one simple. The mid leg had tarsal claws unequal and both were simple. The hind leg had simple equal tarsal claws. In female fore and mid legs had the tarsal claws equal and all were toothed. Sathe and Girhe [2] described that the claws in female were toothed. In this study also, the claws in the male and female *Ae. aegypti* were different in the three pairs of legs. In fore leg of male, one claw was uniserrate and larger than another claw which was simple. In mid leg outer claw was very large than other claw and both were simple and in hind leg of male two small simple claws were present. In female *Ae. aegypti*, in fore leg two large uniserrate claws, in mid leg two median sized uniserrate equal claws and in hind leg two small simple equal claws were present.

Ae. aegypti abdomen is 8 segmented, and the segments were covered with dark and white scales in both male and female. In female the 8th segment was greatly reduced. Barraud [4] and Sathe and Girhe [2] described that in female, tergite was brownish black. The segment I had a median large pale patch [6]. In this study, the tergite was dark brown in colour and I abdominal segment had a median pale scale patch. Barraud [4] described that the dorsum of *A. annandalei* and *A. pipersalatus* were also black with white basal bands on segments II-VII. The II –VI segments had basal bands of white scales on the tergite [2,4,5]. Huang [6] described that the III –VI segments had basal bands of white scales. In this study, the dorsal side of the abdominal segments II to VII had transverse white bands. Christopher [5] and Sathe and Girhe [2] described that on the laterotergite silvery spots were present. Barraud [4] described that the spots were on I-VII segments. Huang [6] described that in female, terga II-VIII had basolateral white spots which did not connect with basal bands . In this study, On the lateral sides of the abdomen, I-VII segments carried silvery white scale patches in both male and female.

In male terminal part of abdomen was different and its sternite (in dorsal position due to rotation) had some conspicuous white scales [5]. In this study, the posterior tip of abdomen in male was narrow and in female it was broad and round shaped. In male, terminal VI and VII segments carried white scale patches dorsolaterally.

The length and width of female abdomen in *Ae. aegypti* were 3.26 mm and 0.78 mm [5] and 3.7 mm and 0.7 mm [2]. In this study, the size of male and female *Ae. aegypti* were measured. The size of abdomen in male was larger (length- 3.03a±0.18 mm, width- 0.51a±0.07 mm) than female (length 2.94a±0.20 mm and width 0.41a±0.06 mm).

Thus, the morphology of *Ae. aegypti* male and female mosquitoes, locally available, were studied in detail and differences were noticed.

5. CONCLUSION

In this study the morphology of *Aedes aegypti* in Agra was observed in detail and the important adult characters of the head, thorax, wings, legs and abdomen were studied by morphometry. The morphometric evaluations of the various regions of adult reveal that the size of the different regions varied in male and female *Ae. aegypti.* In some regions, difference in scale type was also noticed i.e. vertex scale and silvery white scales were present on the female clypeus which was absent in male mosquito. The morphologic features of adult *Ae. aegypti* in Agra will help for the better understanding of the key characters of this vector mosquito.

ACKNOWLEDGEMENTS

Authors are grateful to the University Grants Commission, New Delhi for providing the grants through the Major Project F. No. 34-481/2008 (SR).

COMPETING INTERESTS

Authors have declared that no competing interest exist

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