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Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

JEZS Journal of Entomology and Zoology Studies

ISSN 2320-7078
JEZS 2013;1 (5): 16-21

Received 17-08-2013
Accepted: 3-09-2013

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Variations in the Ommatidia and Compound Eyes of Three Species of Mosquito Vectors

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ABSTRACT

The compound eye is one of the most important organs of the insects, which is made up of compact individual eye elements known as ommatidia. Each ommatidium is externally visible as a facet. The number of ommatidia was found to be different in numbers in compound eyes of different mosquitoes vector species (*Anopheles stephensi, Culex quinquefasciatus* and *Aeedes aegypti*), which was manually counted by corneal spreads. Laboratory- reared mosquitoes were used in this study. The mean number of ommatidia was different in numbers among adults (610-900) and pupae (455-896) in three different mosquito species examined *Anopheles stephensi, Culex quinquefasciatus* and *Aeedes aegypti* respectively. Variability was observed in number of ommatidia in aquatic and adult stages within the species and among three different mosquito species. The ommatidia in compound eye of the mosquito vectors were found to be hexagonal shape and regular in size. It was observed that the *An. stephansi* male and female have dichoptic eye whereas *Cx. quinquefasciatus* and *Ae. aegypti* male and female have holoptic eye.

Keywords: Mosquito Vectors, Compound Eye, Ommatidia, Malaria

1. Introduction

Mosquitoes play an important role in transmission of diseases in human and animals. The three genera of mosquito found in India viz., *Anopheles* species known for transmission of malaria, *Culex* known for JE and filaria and *Aedes* for dengue and yellow fever. Different characters are used for identification of mosquito viz., palpi, antennae, wings, genitalia, speckling on legs and egg float ridge number. One of these could be the number of ommatidia, shape and size of compound eye of mosquito vectors. The number of mean range of ommatidia of adults, blow flies , house flies and flesh flies species has been reported as *Lucilia cuprina* 3665(M), 3608(F); *Mussca domestica* 3484 (M), 3433 (F), and *Liosarcophaga dux* 6032 (M), 6086(F) [1]. The numbers of ommatidia vary in Arthropod insect order Hymenoptera: Formicidae; [2].The comparative surface morphology in eggs of *Cx. tritaeniorhynchus* and *Cx. quinquefasciatus* show high structural similarity [3]. The surface morphology and morphometrics of mosquito eggs were helpful in taxonomic identification [4]. High numbers of ommatidia such as 10,000-28,000 in Odonata and 12,000-17,000 in some Lepidoptera has been estimated in some group of insects [2]. When insects were exposed to UV radiation, the screening pigment of its retina cells of compound eye was bleached, but the UV radiation did not kill the insects (*P. rambuHri*) [5] and the body parts also did not recover easily [6]. *Aedes scutellaris* complex have shown variation in ommatidia shape and size [7]. The present study was carried out to determine the number of ommatidia and structure of compound eye of the above mentioned vector. The aim of the current study was to determine the number of ommatidia of arboreal and aquatic stages of *An. stephensi, Cx. quinquefasciatus* and *Ae.aegypti* which are medically important in India. The observations showed that the ommatidia number, shape and size are different in both sexes of these three mosquitos' vector species in aquatic and arboreal stages.

2. Material and Methods

2.1 Determination of Ommatidial Number

Adult mosquitoes used in the present study were obtained from the laboratory colonies maintained of National Institute of Malaria Research New Delhi. Three species of mosquitoes belonging to different genera, viz., *An. stephensi, Cx. quinquefasciatus* and *Ae. aegypti* were used. A total 100 mosquitoes (adults and pupae) of each sex of each genus were examined from the reared colonies. For the dissection of the compound eye and to soften the tissue of eyes, the heads of the mosquitoes (adults and pupae) were soaked in 10 % KOH (potassium hydroxide) solution at room temperature for two –four days. The head of each mosquito was dissected from

the body using a sharp blade under a dissection microscope. The clear compound eye was then dissected into three to five small parts on a microscope slide using fine needles under the dissection microscope [1]. A glass cover slip was placed on each slide, thereby flattening each part of the compound eye on a microscopic slide. Each part of compound eye was observed under the microscope with camera attached. The photograph of each magnified part was taken and the total number of ommatidia per eye was counted manually with the help of counter. Images of each part were obtained using a compound microscope connected to a camera and data compared using paired *t* -test.

2.2. Examination of Compound eye shape and position

Laboratory reared mosquitoes (10 adults of each genus) were pinned through thorax between fore legs and middle legs. Legs were pushed down away from thorax, and wings turned upward or sideways from body so that no characters on body were obscured. A wing of the mosquito was flipped upward and specimen was laid on its back before pinning and pressure was applied simultaneously to the base of each wing with a pair of blunt forceps. The head was straightened and parallel to the base to make the compound eyes clearly visible. Mouth parts were straightened by gentle brushing with an aid of camel's hair brush. The pinned mosquito was put under the microscope which was attached to a camera for taking the photographs of the head with the compound eyes.

3. Results

3.1. Microscopic observations

3.1.1. Ommatidia number

The compound eyes of *An. stephensi*, *Cx. quinquefasciatus* and *Ae. aegypti* are located on the dorso-lateral side of the head. Each compound eye of *An. stephensi, Cx. quinquefasciatus* and *Ae aegypti* is made up of numerous compact ommatidia with number ranging from 610-900 in adult and 455-890 in pupa (Table 1).

Table 1: Number of ommatidium in three genera of mosquito vectors

Species	Adult (P<0.05)		Pupa (P<0.05)	
	Male	female	Male	Female
An. stephensi	679±61.8 (640-780)	720±76.6 (610-720)	555.4±75.5 (455-650)	631±37 (509-700)
Cx. quinquefasciatus	792.6±21.4 (780-830)	833±50.1 (760-900)	534.6±47.5 (440-590)	754.9±73.2 (611-844)
Ae.aegypti	776.6±53.8 (650-824)	780±32.4 (700-800)	735.2±67.8 (630-817)	896.4±70.1 (746-890)

(P value <0.05 paired t test)

For adults, the average number of ommatidia was statistically different among mosquito species examined. *An. stephensi* (female 720, male 679), *Cx. quinquefasciatus* (female 833, male 792) and *Ae. aegypti* (female 780, male 776). For pupa, the average number of ommatidia was also statistically different in three species examined: *An. stephensi* (female 631; male 555), *Cx. quinquefasciatus* (female 755; male 534) and *Ae. aegypti* (female 896; male 735). The statistical difference between the number of ommatidia in male and female; adult and pupa was also significant. The mean numbers of ommatidia in male were statistically different among all the three species, viz *An. stephensi, Cx. quinquefasciatus* and *Ae. aegypti*. In female, the mean number of ommatidia was statistically different in adult and pupa (fig. 1-4).

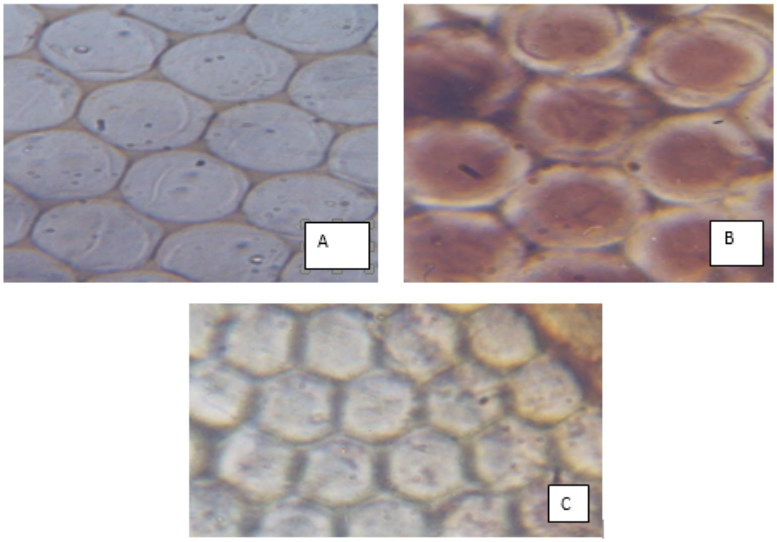

Fig: 1 A. Ommatidia of *An. stephensi* adult female. B. *Cx. quinquefasciatus adult* female. *C. Ae.aegypti* adult female.

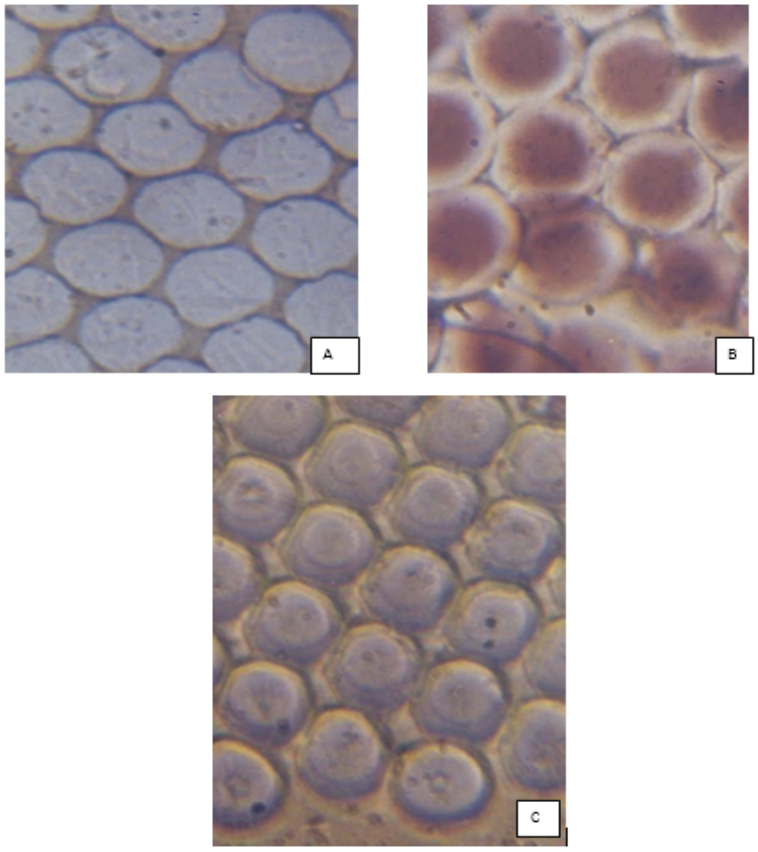

Fig 2: A. Ommatidia *An. stephensi* adult male. B. *Cx. quinquefasciatus* adult male. C. *Ae.aegypti* adult male.

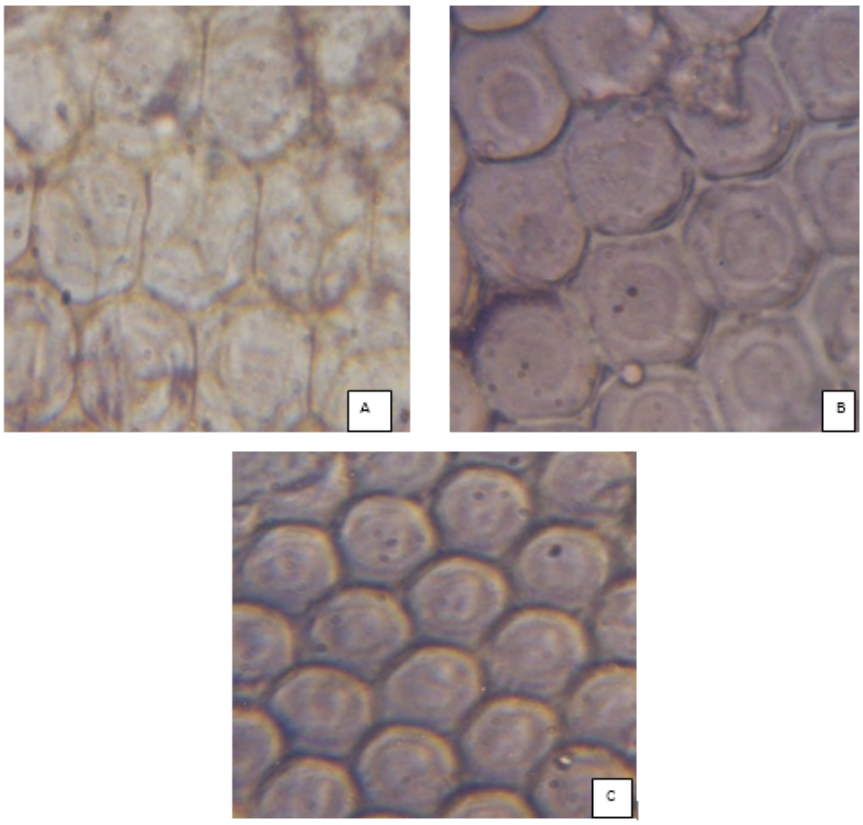

Fig 3: A. Ommatidia *An. stephensi* pupa female. B. *Cx. quinquefasciatus* pupa female. C. *Ae.aegypti* pupa female.

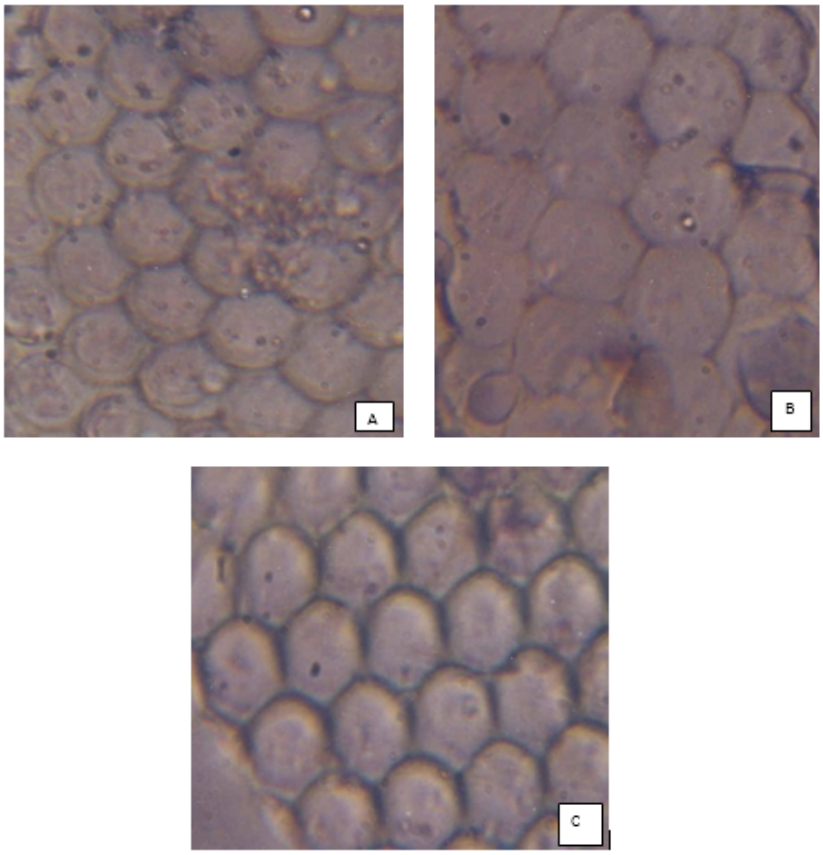

Fig 4: A. Ommatidia *An. stephensi* pupa male B. *Cx. quinquefasciatus* pupa male C. *Ae.aegypti* pupa male

3.1.2. Ommatidia shape and size

In mosquitoes, clear differences in eye structure are also related to light intensity. Nocturnal species have significantly fewer facets of generally larger diameter compared to diurnal species, indicating that nocturnal mosquitoes trade sensitivity against spatial resolution [8]. The shape of ommatidia of *An. stephensi* male and female (adult) was hexagonal and spherical respectively. In case of pupa, shape of ommatidia in male and female was hexagonal. Size of ommatidia in *An. stephensi* male and female (adult) as well as in pupa, was regular. In *Cx. quinquefasciatus* shape of ommatidia in male and female (adult) was hexagonal. In case of pupa, shape of ommatidia was hexagonal. Size of *Cx. quinquefasciatus* adult male and female was hexagonal, whereas in pupa, it in both sexes was regular. In *Ae. aegypti* shape of ommatidia male and female (adult) was hexagonal. On other hand, in pupa the shape of ommatidia in both sexes was hexagonal. Size of ommatidia of pupa in male and female was regular (Table-2).

Table 2: Shapes and sizes of ommatidium in three genera of mosquito vectors

Species	Adult				Pupa			
	Male		female		Male		female	
	Shape	Size	Shape	Size	Shape	Size	Shape	Size
An. stephensi	Hexagonal	Regular	Hexagonal	Regular	Hexagonal	Regular	Hexagonal	Regular
Cx. quinquefasciatus	Hexagonal	Regular	Hexagonal	Regular	Hexagonal	Regular	Hexagonal	Regular
Ae. aegypti	Hexagonal	Regular	Hexagonal	Regular	Hexagonal	Regular	Hexagonal	Regular

3.1.3. Compound eye

The present study revealed that the mean ommatidial number in male and female adults and pupae of *Cx. quinquefasciatus, Ae. aegypti* and *An. stephensi* were significantly different in both the sexes. In case of adults *An. stephensi* male and female, the Compound eyes was wide by separation in dorso-central region of the head whereas in *Cx. quinquefasciatus* and *Ae. aegypti* male and female both eyes were almost meeting in dorso-central region of the head (fig 5. A-F).

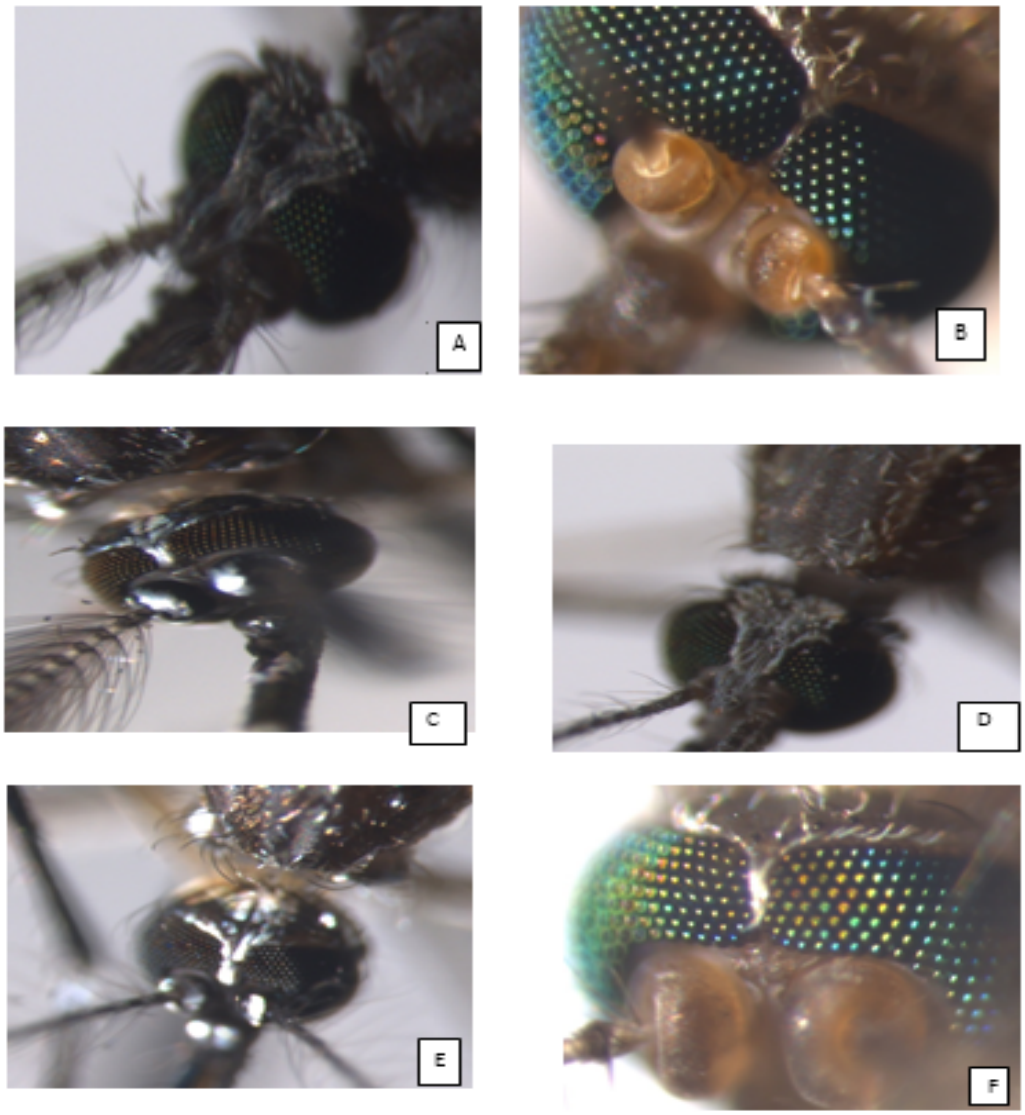

Fig: 5 A. *An. stephensi* male (dichoptic) B. *Cx. quinquefasciatus* male and C. *Ae.aegypti* male (holoptic eyes) *D. An. stephensi female (dichoptic eye), E. Cx. quinquefasciatus female and F. Ae.aegypti female (holoptic eyes)*

4. Discussion

The structure of compound eye of insects provides more important behavioral character control of the image formation. The ommatidial number varies depending on the biology of the insect [9]. Superposition eyes can achieve greater sensitivity than apposition eyes, hence are better suited to dark-dwelling/nocturnal creatures [10]. Apposition eyes are generally regarded as being of greater use to diurnally rather than nocturnally achieve insects [11]. The apposition eyes occur in nocturnal or crepuscular insects such as helictid bee *Megalopta genalis* [12]. Certain structural modifications to the eye design are apparent. Noguchi [13] stated that the total number of ommatidia is segregated for each sex of *Cx. pipiens molestus* and *pollens*. The female of *Cx. pipiens molestus* has eight ommatidia while male has seven. Whereas, in Cx. *pipiens pollens*, these values for female and male are nine and eight respectively. Chapman (1998) has discussed variations in an inter-ommatidial angle, and including ommatidial structure. One possible interpretation for such a sexual difference may be that the large ommatidia in males were a characteristic feature to provide substantial potential in following the rapid movements of females during mating flight [14].

The observations showed that the number of ommatidia of three genera of mosquito vectors vary in both the sexes of adult and pupa. The data analysis showed that the number of ommatidia seems to be correlated with size of the compound eyes. A greater number of ommatidia allow arthropods and insects to perceive better visual resolution and efficacy [15]. Fast flying insect (mosquito) that have a large number of ommatidia give them increased visually acuity.

Correlation has been reported in mosquito vector in which

corresponding facets numbers of *Ae. aegypti* has the average head widths of males and females with 0.75 and 0.85 mm respectively, and corresponding facet numbers with 419 and 516 ommatidia per compound eye [8]. A comparative study of the number of ommatidia of three species of Carabid beetles variations was observed in *Carabus preslii* Dejean(average no. 2056)*Carabus lefevrei* Dejean (average no. 2828), and *Carabus coriaceus* L (average no. 3323). *Carabus coriaceus* has more ommatidia and are adapted adequately to open habitats than other two Carabus species [16]. Similarly *Chrysomya rufifacies* (with more ommatidia) and Chrysomya *nigripes* (having less ommatidium) are closely related species but differ in their habitats. *Chrysomya rufifacies* was found near human habitations while *Chrysomya nigripes* in forested area[17].

The present study also revealed that in adults, the average number of ommatidia was statistically different ($p<0.05$) among the three mosquito species examined. *An. stephensi* (female 720, male 679), *Cx. quinquefasciatus* (female 833, male 792) and *Ae. aegypti* (female 780, male 776). In pupa, the average number of ommatidia was also statistically different ($p<0.05$) in *An. stephensi* (female 631; male 555), *Cx. quinquefasciatus* (female 755; male 534) and *Ae. aegypti* (female 896; male 735). The number of ommatidia in male and female; adult and pupa was also found statistically different in the above mentioned species.

Ommatidial comparative study revealed that there are less number of ommatidia in male than in female *An. stephensi, Cx. quinquefasciatus, Ae. aegypti* mosquitoes and also less number of ommatidia in male than in female pupae of these species. The male mosquitoes of these genera are mostly found outside the human habitat while female mosquitos are mostly found in human habitation and are nocturnal/crepuscular. Sukontason (2008) categorized compound eyes as holoptic (compound eyes meeting in the dorso-central region of the head) and dichoptic eyes (displaying wide separation in dorso-central region of the head). In present study *An. stephensi* male and female the compound eyes were found to be dichoptic, whereas in Cx. *quinquefasciatus* and *Ae. aegypti* male and female both the eyes meet in dorso-central region and was found to be holoptic [1].

5. Acknowledgement

Authors acknowledge the technical help rendered by Mr. Narender Kumar, Mr. Kamal Dev, Mr. G.N. Sharma and Mr. Satyapal Singh for this work. The authors also thank Mr. Rajender Kumar for his help in preparation of the manuscript and photographs.

6. Reference:

1. Sukontason Kabkaew L, Chaiwong Trainee, Piangjai Somsaka, Upakut Sorawit, Moophayak KittiKhun, Sukontason Kom .Ommatidia of blow fly, house fly and flesh fly: implication of their vision efficiency. Parasitol. Res. 2008; 103 (1): 123-131.
2. Richards OW, Davies RG .Imms' general textbook of entomology: structure, physiology and development. 10th edn. Chapman and Hall. London, 1977.
3. Suman D S, Shrivastava A R, Parashar B D, Pant S C, Agrawal O P, Prakash Shri Scanning electron microscopic studies on egg surface morphology and morphometrics of C*ulex tritaeniorhynchus* and *Culex quinquefasciatus* (Diptera: Culicidae) Parasitology Research 2008; 1162-1166.
4. Service MW, Duzak D, Linley JR. SEM examination of the eggs of five British *Aedes* species. J. Am. Mosq. Control. Assoc. 1997; 13: 47-65.
5. Meyer-Rochow, VB Kashiwagi, Mishra M .Structure and putative function of dark- and light-adapted as well as UV-exposed eyes of the food store pest *Psyllipsocus ramburi* Sélys-Longchamps (Insecta: Psocoptera: Psylippsocidae). J. Insect. Physiol 2007; 53: 157-169.
6. Meyer-Rochow, Kashiwagi VB, Eguchi T E .Selective photoreceptor damage in four species of insects induced by experimental exposure to UV- radiation. Micron 2002; 33**:** 23-31.
7. Milan Trpis .Scrimpy eye, a sex-linked mutant in the /Aedes scutellaris/ Complex of mosquitoes; journal of heredity 1979; 70 (1): 51-56.
8. Land MF Gibson, Horwood G J, Zeil J. Fundamental differences in the optical structure of the eyes of nocturnal and diurnal mosquitoes. Journal of comparative Physiology 1999; 185: 91-103.
9. Elzinga RJ Fundamentals of entomology, 6th edn. Pearson. Education, Inc., New Jersey. 2004, p 512.
10. Land MF, Fernald RD .The evolution of eyes. Anuall. Review of Neuroscience 1992; 15: 1-29.
11. Warrant E J, Mclntyre P D .Arthropod eye design and the physical limits to spatial resolving power. Progress in Neurobiology 1993; 40: 413-461.
12. Greiner B, W A Ribi, EJ Warrant. Retina and optical adaptations for nocturnal vision in the halictid bee Megalopta gelanis. Cell and Tissue Research 2004; 316: 377-390.
13. Noguchi Yoshiko, Syoziro Asahina. Ommatidial number as a diagnostic character for Japanese Autogenus Culex molestus . J.Med. Ent. 1966; 3(2): 146-148.
14. Chapman R F, The insects' structure and function, 4th edn. Cambridge University Press, Cambridge .1998
15. Jander U, Jander R. Allometry and resolution of bee eyes (Apoida). Arthropod struct Dev 2002; 30: 179-193.
16. Talarico F, Romeo M, Massolo A, Brandmayr P, Zetto T .Morphometry and eye morphology in three species of *Carabus* (Coleoptera: Carabidae) in relation to habitat demands. J. Zool. Syst. Evol. Res. 2007; 45: 33-38.
17. Lertthamnongtham S, Sukontason K, Sukontaso K S, Piangjai Choochote, W RC Vogtsberger, Olson JK .Seasonal fluctuations in populations of the two most forensically important fly species in northern Thailand. Ann. Trop. Med. Parasitol 2003; 97: 87-91.