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Population Dynamics of Mosquitoes in Various Breeding Habitats at University of Peshawar Campus, Khyber Pukhtunkhwa Pakistan

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ABSTRACT
A study of mosquitoes was conducted to identify the population dynamics, relative abundance, distribution and habitat preferences of mosquitos of University of Peshawar Campus. Six habitats including discarded containers, waste water open drains, bamboo glasses, rain water pools, flower vases and tyres were used for the collection of immature stages of mosquitoes. A total of 2419 adult mosquitoes (1433 females and 985 males) comprising six species viz. *Aedes albopictus* (57.1%), *Aedes unilineatus* (2.52%), *Aedes w-albus* (2.8%), *Armigeres subalbatus* (3.84%), *Culex quinquefasciatus* (33.7%) and *Anopheles stephensi* (0.04%) were recovered from all studied habitats. *Ae. Albopictus* was found to be the dominant and frequently distributed specie. *Cx. Quinquefasciatus* was the second dominant specie with moderate distribution. *Ar. Subalbatus*, *Ae. unilineatus* and *Ae. W-albus* were all identified as sub-dominant species with the former two as infrequent and the later one as sporadic species. *An. stephensi* was identified as satellite cum sporadic species during the study. Bamboo glasses were the richest habitat from where 4 species were recovered while no larvae were found in the tyres. The highest number of mosquitoes were detected during October (481) while the lowest in December (224).

Keywords: *Aedes*, immature stages, bamboo glasses, population dynamics.

1. Introduction
Majority of the world's population live in such areas which are at risk of insect borne diseases, most of which are spread through mosquitoes. The vector of wide range of parasitic and viral harmful disease is mosquito which affects both animals and humans [1]. The life of millions of people has been intimidated by the introduction of mosquito borne diseases around the globe [2]. Approximately one million people died because of mosquito borne diseases and about 247 million people become ill in subtropical and tropical areas of the world as reported by the World Health Organization [1].

Mosquitoes are small biting insects belonging to family Culicidae, suborder Nemertocera and order Diptera [3]. Approximately 3,500 mosquito species are present which have been classified into 41 genera [4]. Different mosquito species belonging to genera *Culex*, *Aedes* and *Anopheles* serves as vectors for many diseases [5, 6]. They are considered as most significant vectors for various diseases because of their abundance, vector capability, recurrent infection and diversity [7].

Distribution of disease causing vectors and consequently the spread and occurrence of the human pathogen has been affected by various environmental factors like urbanization, increased exchanges and climatic change [8]. Ecology and behavior of mosquito at a limited scale i.e. is from 100 m to 1 km, plays a significant role in regulating the propagation of transmission. Mosquitoes can move in several directions and like other animals, their movement is provoked by availability of resources and other sources of their dispersion, but they can move over local distances [9]. Almost all types of aquatic habitats are utilized by the mosquitoes for their breeding purpose [10]. Discarded tires, Water tanks, flower pots, jars, coconut shells and ant traps are the most dominant breeding sites of mosquitoes [11]. Container breeding and flood water breeding mosquitoes lay their eggs on damp soil or any other moist places whereas standing water and permanent water mosquito species lay their eggs on the surface of water and hatching of their eggs occur in 1 to 4 days depending mainly on the temperature [12].

Various factors like temperature of water, vegetation, water movement, various types of water

sources, condition of water i.e. fresh or polluted water and many other factors greatly affect larval distribution of mosquitoes [13]. The reproductive ability of the female mosquitoes and their larval development is affected by nutrition. This means that reproduction potential of a female mosquito can be influenced by nutrition deficiency in both adult and larval stages [14]. Thus laying egg, larval development, emanation of the adult and other developmental processes in the larval habitats of mosquitoes, play a key role in the determination of abundance and distribution of mosquitoes [15].

2. Study Area Description

The research was carried out at University of Peshawar Campus from May to December 2012. University of Peshawar was founded in 1950. Its total area is 1050 acres and is 1190 feet above sea level [16]. It is at the distance of about six kilometers from Peshawar cantonment and eight kilometers from Babe-e-Khyber (the gateway of Khyber). It includes institutions like academic blocks, hostels, residential houses, lawns, other buildings and commercial markets etc [16]. The mean annual minimum temperature of the campus is recorded to be 15.87 ^{0}C from 1190 to 2010 while the mean maximum annual temperature was recorded to be 29.44 ^{0}C. Moreover, mean annual precipitation was recorded to be 403.82 mm and relative humidity as 54.72 percent for the same era [17]. University of Peshawar is a residential university and most of the teaching staff, students and employees live in the campus. The approximate population of the campus is more than 15,000 including both teaching and non-teaching staff [16].

3. Methodology

Mosquitoes oviposit in different types of habitats containing water and food sufficient for the immature stages [18] which may be tree hole, bamboo glasses, discarded cans, containers, tyres etc. Different habitats such as sewage water open drains and pools made after rain water along various constructed habitats including discarded containers, bamboo glasses, flower vases and tyres [19] were studied for the analysis.

3.1 Sampling sites

Details of all the habitats are given below.

3.1.1 Bamboo glasses: A thick bamboo stick having 3" inner diameter was cut in to nine pieces, each of 13 inches in length. These pieces were then half filled with water and dry crushed mulberry leaves were added to them [20] to provide nutrients for the immature stages of mosquitoes and were hung on different trees in different localities at a height of more than six feet [21].

3.1.2 Discarded Containers: Five wide mouth discarded containers [18] were placed at different sites. These were also half filed with water and provided with some dried crushed mulberry leaves as nutrition for the growth of immature stages of mosquitoes.

3.1.3 Flower vases: Five flower vases [22] placed in shady area at Botany Department, containing water and other plant debris e.g. algae were also used for the collection of immature stages of mosquitoes [20].

3.1.4 Tyres: Two tyres, one in hanging position and other in horizontal position, kept in Fatima Jinnah Girls Hostel UOP were used for the collection of immature stages of mosquitoes [23].

3.1.5 Open drains: Immature stages of mosquitoes were collected from waste water [15] at two localities of University Campus i.e. one each at Computer Science and Chemistry Departments.

3.1.6 Water Pools: Two water pools one located at Teacher Student Centre and other at Botany Department were used for the collection [23].

3.2 Sampling

Fortnight collection was made from the mentioned habitats using various methods e.g. the bamboo glasses, tyres and discarded containers were emptied in wide mouth plastic jars containing water for collection of immature stages [21]. These habitats were placed at their respective sites with fresh water and dried leaves again after collection of previous contents. While dipper and strainers were used for sampling from flower vases, water pools and open drains [18]. One to two dips were taken from each of these habitats at morning. All plastic jars containing collected larvae and pupae were covered with a net to avoid escape of adult mosquitoes after their emergence. A small hole was made in the net for collection of adult mosquitoes and was kept close with cotton swab.

3.3 Collection, killing and preservation of adult mosquitoes from jars

The adult mosquitoes were collected from different plastic jars after their emergence, by carefully sucking through aspirator. The collected specimens were transferred to the dry airtight conical jars. Adult mosquitoes were killed by using chloroform dipped cotton swab immersed in the jar's opening [15]. It took two to four minutes to kill adult mosquitoes. Mosquitoes were preserved in test tubes. A small amount of silica gel was used in the test tube as preservative and was covered with cork to keep dry. Silica gel was replaced on change of color. The killed adults were later identified using Taxonomic keys provided in "The fauna of British India, including Ceylon and Burma" by Christophers [24] and Barraud [25].

3.4 Analysis

Only the adult mosquitoes obtained by rearing stages in the laboratory were used for analysis. Variations of secrecies in different seasons were analyzed in terms of distribution and relative abundance by using the given formulae (modified as the figure "1" is changed to 'n') [15].

$$\text{Relative abundance} = n/L * 100$$

Where,
n = number of each species specimens
L = total number of specimens.
The mosquito species were classified in different relative abundance classes [26] given in table 1.

Table 1: Classification of species based on their relative abundance

Relative abundance (%)	Classification
Less than 1	Satellite species
Less than 5	sub-dominant species
More than 5	dominant species

Ali *et al.* [15] was followed for identification of percent distribution of all these species in various habitats, using the formula,

Distribution (C) = n/N * 100

Where
n = number of those habitats where species was found,
N = total number of habitats

Different classes were also analyzed after %age distribution of mosquito's species [26] which are illustrated in table 2.

Table 2: Different classes of species based on their distribution

classes	Distribution (%)	Classification
C1	0-20	Sporadic
C2	20.1-40%	Infrequent
C3	40.1-60%;	Moderate
C4	60.1-80%;	Frequent
C5	80.1-100%	Constant

4. Results

4.1 Species composition

Only immature stages were collected during the study and were reared up to adult stage in laboratory. Altogether 2419 adults were collected from the jars comprising 986 male and1433 female individuals. Taxonomic study revealed six species belonging to four genera *Aedes, Armigeres*, *Culex*, and *Anopheles*. Genus *Aedes* was represented by three species *Ae. albopictus, Ae. unilineatus* and *Ae. w-albus* while the rest three genera were represented by single specie only i.e. genus *Culex* by *Cx. quinquefasciatus*; genus *Armigeres* by *Ar. Subalbatus* and genus *Anopheles* by *An. stephensi*. The details are shown in figure 1 and 2.

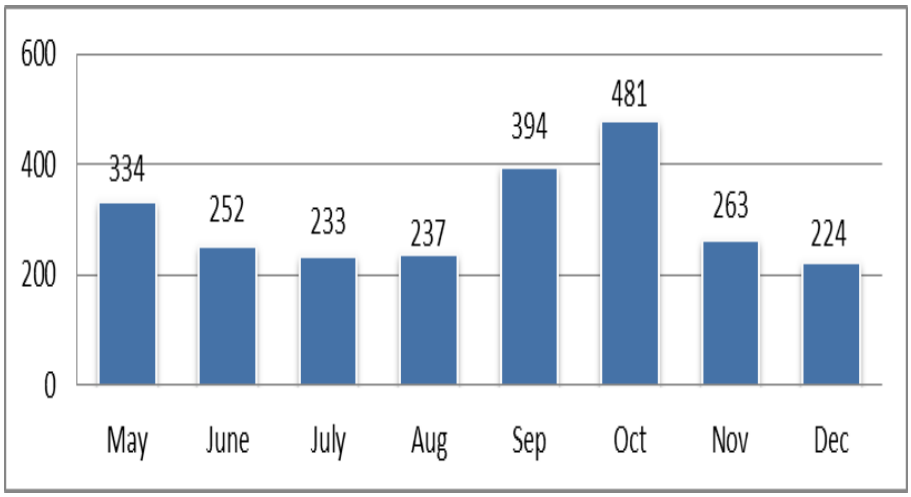

Fig 1: Variation in mosquitos' number during different months at University of Peshawar Campus.

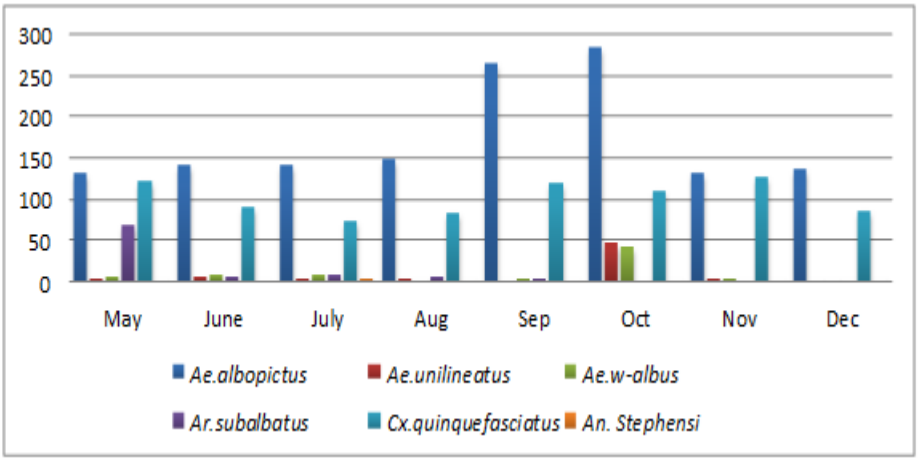

Fig 2: Different mosquitoes' species and their number recovered during different months at University of Peshawar Campus.

4.2 Distribution status and relative abundance of recuperated mosquito species

In terms of distribution of the mosquito's species, one species was found to be frequent, one moderate, two infrequent and two Sporadic. On the other hand, on the basis of relative abundance, two species were identified as dominant species; three were sub-dominant while one was identified as satellite specie among all the species recovered during the study. The details are given in table 3.

Table 3: Distribution and relative abundance of mosquito species recovered from different breeding habitats in University of Peshawar Campus.

Species	Total	Relative Abundance	Distribution	Relative Abundance Status	Distribution Class
Ae. albopictus	1382	57.1	66.6%	Dominant	Frequent
Ae. unilineatus	61	2.52	33.3%	Sub-Dominant	Infrequent
Ae. w-albus	68	2.8	16.7%	Sub-Dominant	Sporadic
Ar. Subalbatus	93	3.84	33.3%	Sub-Dominant	Infrequent
Cx. quinquefasciatus	814	33.7	50%	Dominant	Moderate
An. Stephensi	01	0.04	16.7%	Satellite	Sporadic

4.3 Most preferred habitat by different species

It was observed during the study that bamboo glasses were the most preferred habitat for breeding by mosquitoes from where 4 species and 826 mosquitoes were recovered which was 34.1% of the total mosquitoes recovered by rearing of immature stages. Open drains and discarded containers were found to be the second preferred habitats and both were inhabited by 3 species and 679 (28.1%) and 638 (26.3%) mosquitoes respectively. Tyres were found to be the least preferred habitats where no mosquitoes were recovered followed by rain water pools where only one species was found having 137 (5.7%) individuals. The details are given in table 4.

Table 4: Different mosquito species recovered from various temporary breeding habitats by rearing immature stages at Peshawar University Campus

	Bamboo glasses	Open drains	Discarded containers	Flower vases	Rain water pools	Tyres	Total
Ae .albopictus	612 (74.1%)	138 (20.3%)	630 (98.8%)	2 (1.4%)	0	Nil	1382
Ae. unilineatus	59 (7.2%)	0	2 (0.3%)	0	0	Nil	61
Ae. w-albus	68 (8.2%)	0	0	0	0	Nil	68
Ar. subalbatus	87 (10.5%)	0	6 (0.9%)	0	0	Nil	93
Cx. quinquefasciatus	0	540 (79.5%)	0	137 (98.6%)	137 (100%)	Nil	814
An. Stephensi	0	1 (0.2%)	0	0	0	Nil	1
No. of total individuals	826 (34.1%)	679 (28.1%)	638 (26.3%)	139 (5.8%)	137 (5.7%)	0 %	2419
No. of species	4	3	3	2	1	0	

5. Discussion

The knowledge of habitat type where mosquitoes breed is very important so that such breeding sites are considered on priority basis for the effective control of their larvae [27]. The immature stages of mosquitoes are restricted to aquatic habitats as compared to the adult flying mosquitoes and can't escape readily from mosquito control techniques [28].

No published data is available regarding the species composition and population dynamics of mosquitoes of University of Peshawar Campus. So this study aimed to contribute knowledge regarding the occurrence and frequency of mosquitos' species in the area and different habitats inhabited by them. This forge assessment was focused on collection of premature stages of mosquitoes from various breeding habitats as this is the best productive technique and provides maximum number of mosquitoes and their species [29]. Six mosquito species belonging to four genera *Aedes*, *Culex*, *Armigeres* and *Anopheles* were recovered during the study. The quantity of species identified is lower than the 31 species identified

by Suleman and Khan [29] in Peshawar city and the 15 species collected by Ali *et al.* [15] in Swat Ranizai. The more probable reason of this difference in number of species is because of the extent of present study area which is comparatively smaller than the aforementioned areas studied. Another possible cause of this difference might be the climatic conditions as well as the procedure adopted for sampling [26]. Yet, the species composition of the present study is communal with the aforementioned surveys.

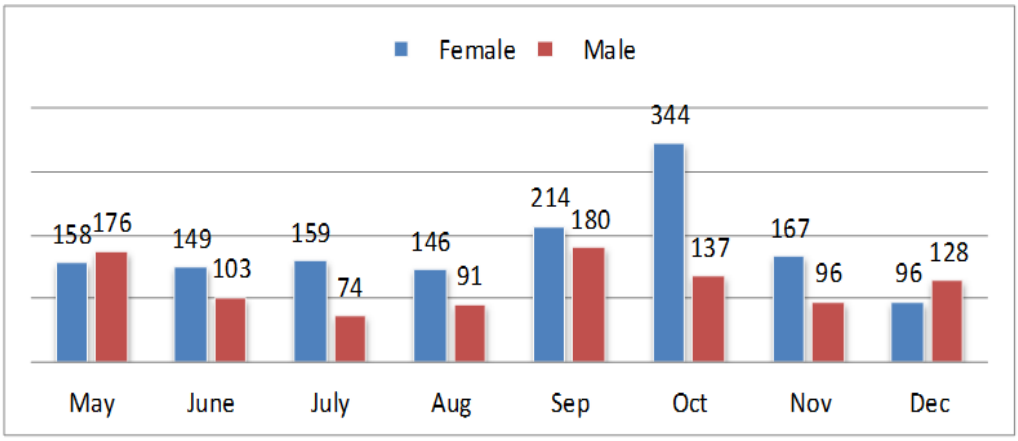

Fig 3: Total number of males and females collected during the survey

Table 5: Monthly variations of different mosquito species at University of Peshawar Campus

	May	June	July	August	September	October	November	December	Total
Bamboo glasses									
Ae. albopictus	52	57	55	58	141	161	55	33	612
Ae. unilineatus	3	5	2	1	0	46	2	0	59
Ae. w-albus	6	9	7	0	4	41	1	0	68
Ar. subalbatus	65	6	7	5	4	0	0	0	87
Total	**126**	**77**	**71**	**64**	**149**	**248**	**58**	**33**	**826**
Discarded containers									
Ae. albopictus	30	83	86	83	120	122	65	41	630
Ae. unilineatus	1	0	1	0		0	0	0	2
Ar. subalbatus	5	0	1	0	0	0	0	0	6
Total	**36**	**83**	**88**	**83**	**120**	**122**	**65**	**41**	**638**
Flower vases									
Cx. quinquefasciatus	10	12	22	16	9	36	13	19	137
Ae. albopictus	0	0	0	1	1	0	0	0	2
Total	**10**	**12**	**22**	**17**	**10**	**36**	**13**	**19**	**139**
Rain water pools									
Cx. quinquefasciatus	18	25	9	12	22	22	17	12	137
Total	**18**	**25**	**9**	**12**	**22**	**22**	**17**	**12**	**137**
Open drains									
Cx. quinquefasciatus	95	54	43	55	90	51	97	55	540
Ae.albopictus	49	1	0	6	3	2	13	64	138
An. Stephensi	0	0	1	0	0	0	0	0	1
Total	**144**	**55**	**44**	**61**	**93**	**53**	**110**	**119**	**679**
Tyres									
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Grand total	**334**	**252**	**234**	**237**	**394**	**481**	**263**	**224**	**2419**

Mukhtar *et al.* [30] studied the role of wastewater irrigation in mosquitoes breeding in Southern Punjab. The current study shows some similarity with their study. They collected 133 samples belonging to three genera *Aedes*, *Culex* and *Anopheles*. The present study shares only two species with his identifications i.e. *Cx. quinquefasciatus* and *An. Stephensi* which were collected from wastewater. These species were also collected from waste water drains in the present study supporting the view about wastewater as

the preferential habitat of these species.
Kumar and Vam [31] studied breeding habitats of mosquitoes in nine categories including fountains, tanks, tires, barrels and tins in Panaji, India. Among the six species they reported three species are shared i.e. *Cx. quinquefasciatus*, *An. stephensi* and *Ae. albopictus* with the present study.
Ali and Rashid [26] surveyed immature stages of mosquitoes in polluted water of Palosai stream near Peshawar University campus from April to June 2006 and then October to January 2007. They collected a total of 7382 mosquitoes belonging to two genera *Culex* and *Anopheles*. Two species *Cx. quinquefasciatus* and *An. stephensi* are recorded in both studies but species belonging to the genus *Aedes* identified in current study is missing in their survey, which is probably because of the reason that *Aedes* sp. are mostly the inhabitants of temporary habitats.

Mwangangi *et al.* [32] carried out a study on different species of mosquitoes in Kibwezi, Kenya. Their study was based on habitats like water reservoir tanks, puddles, temporary pools and tyre tracks. They collected a total of 2660 mosquito larvae belonging to three genera *Anopheles, Culex* and *Aedes*. Although the genera of the studied species are the same but only one species *Cx. quinquefasciatus* is shared with their study because of large geographical differences of the two studies.
Adityaa *et al.* [33] studied different temporary larval habitats and species composition of mosquitoes in Darjeeling Himalayas, India. They recorded mosquitoes belonging to four genera *Aedes*, *Armigeres*, *Culex* and *Toxorhynchites* in which the first three genera are communal with the current study. They did not report the type of species.
Suleman and Khan [29] recovered 90% of *Ae. albopictus* from tree holes containing water while in the present study it was collected from bamboo glasses the habitat comparable with the tree holes. In the present studies this species was the most abundant mosquito species recovered from habitats like bamboo glasses, discarded containers, flower vases and waste water open drains.
Ilahi and Suleman [3] collected different species of genus *Aedes* (*Ae. aegypt linnaeus* and *Ae. pseudotaeniatus giles*) in District Swat from tyres and fresh water ponds. Species of the same genus, *Ae. unilineatus* was recovered from two habitats bamboo glasses mostly and some from discarded containers in the present study. Its peak abundance was recorded during the month of May from both habitats. Another species belonging to the same genus i.e. *Ae. w-albus* was collected only from bamboo glasses from May to September and not available in the other study months. The species could not be found in the other studied habitats showing its confineness to bamboo glasses.
Ar. subalbatus was identified as waste water restricted species in a study done in Swat Ranizai by Ali *et al.* [15]. This species was identified as the third most abundant mosquito collected during the survey and found in bamboo glasses and discarded containers. However, it was absent from other habitats. Its peak abundance was recorded during May.
An. Stephensi, a vector mosquito was collected in Southern Punjab from waste water irrigation system mainly during July by Mukhtar *et al.* [30]. In the present collection, it is also recovered from waste water during April although just a single larva could be collected.
Cx. Quinquefasciatusis, the second most abundant mosquito collected during this survey from different temporary habitats like ponds, mud pots and waste water while it was not collected from bamboo glasses and discarded containers. Ali and Rasheed [26] collected it in polluted water of Palosai stream passing near University of Peshawar Campus. In the present study it is also collected from waste water confirming its main inclination for polluted water.

6. Conclusion
Some trends of habitat preference were observed in this study. *Ae. w-albus* was collected only from bamboo traps while *Ar. subalbatus* and *Ae. unilineatus* were collected from bamboo traps and discarded cans showing strong inclination towards temporary habitats. One species each belonging to the genera *Culex* and *Anophelese* were collected from wastewater and pond water but none of the other studied habitats with relatively less water content, indicating their more likeness for large water bodies rather than small bodies of water.

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