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DIVERSITY AND ABUNDANCE OF MOSQUITOES (DIPTERA: CULICIDAE) IN UNIVERSITI MALAYSIA SABAH CAMPUS, KOTA KINABALU, SABAH, MALAYSIA

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ABSTRACT

A study on the abundance and diversity of mosquitoes (Diptera: Culicidae) was carried out in University Malaysia Sabah (UMS). The study was conducted (i) to observe the diversity of mosquitoes in UMS, (ii) to compare the abundance of mosquitoes in study sites, (iii) to observe the interactions of abiotic factors such as time and temperature and (iv) to observe the mosquitoes' breeding sites. The samplings were done for 16 days for indoor and outdoor by using bare leg capture method and were done for 12 hours on every sampling day. Temperature was recorded every hour within 1800 until 0600. A total of four genera and 11 species of mosquitoes were recorded from the samplings. The highest abundance recorded were *Culex annulirostris*, *Culex sitiens*, *Culex pipiens*, *Culex tritaeniorhynchus* and *Aedes albopictus*. Hostel A-B recorded

seven species, Hostel C-D recorded six species, Hostel E recorded six species, library's cafe recorded six species and library's lake recorded seven species. The dominant species at each study site were *Culex annulirostris*, *Culex sitiens*, *Culex pipiens* and *Culex tritaeniorhynchus*.

Keywords: mosquitoes, Culicidae, diversity, abundance.

ABSTRAK

Satu kajian mengenai kelimpahan dan kepelbagaian nyamuk (Diptera: Culicidae) telah dijalankan di Universiti Malaysia Sabah (UMS). Kajian ini telah dijalankan (i) untuk memerhatikan kepelbagaian nyamuk di UMS, (ii) untuk membandingkan kelimpahan nyamuk di tapak kajian, (iii) untuk memerhatikan interaksi faktor abiotik seperti masa dan suhu dan (iv) untuk memerhati tempat pembiakan nyamuk. The sampel telah dilakukan selama 16 hari untuk dalaman dan luaran dengan menggunakan kaedah menangkap kaki yang terdedah dan dilakukan selama 12 jam pada setiap hari persampelan. Suhu dicatatkan setiap jam dalam 1800 sehingga 0600. Sebanyak empat genus dan 11 spesies nyamuk direkodkan daripada sampel. Kelimpahan tertinggi direkodkan adalah *Culex annulirostris*, *Culex sitiens*, *Culex pipiens*, *Culex tritaeniorhynchus* dan *Aedes albopictus*. Hostel A-B mencatatkan tujuh spesies, Hostel C-D mencatatkan enam spesies, Hostel E mencatatkan enam spesies, kafe perpustakaan mencatatkan enam spesies dan tasik perpustakaan mencatatkan tujuh spesies. Spesies dominan di setiap tapak kajian adalah annulirostris Culex, sitiens Culex, pipiens Culex dan tritaeniorhynchus Culex.

Kata kunci: nyamuk, Culicidae, kepelbagaian, kelimpahan.

INTRODUCTION

Mosquitoes are medically important insects because the females are bloodsucking and serve as vectors in the transmission of several important and dangerous human diseases such dengue fever, malaria, yellow fever, chikungunya, Japanese encephalitis and filariasis (Tolle, 2009). In order to develop their eggs, female mosquitoes have to take bloodmeal and also feed on plant sugars for flight and production of energy reserves (Scott and Takken, 2012).

Dengue fever (DF) and dengue haemorrhagic fever (DHF), for example, have had a major negative impact on the lives of billions of people in all tropical and subtropical regions (Guzman and Istúriz, 2010), while malaria has had a greater impact on world history than any other infectious disease (Garcia, 2010). In 2010 alone, it was estimated that there were about 655,000 (range 537,000 – 907,000) malaria deaths, of which 91% (596,000, range 468,000 – 837,000) were in the African Region, and more than 80% of malaria deaths globally were of children under 5 years of age (World Health Organization, 2011).

Systematically mosquitoes are placed in the family Culicidae, order Diptera. Mosquitos can be divided into 3 sub-families, namely Anophelinae, Culicinae and Toxorhynchitinae. Only members in sub-family Toxorhynchitinae are non-bloodsuckers (Lehane, 1996). Sub-family Anophelinae contains 430 species in 3 genera, which are *Bironella*, *Chagasia* and *Anopheles*. On the other hand, sub-family Culicinae has 2,908 species and their taxonomy is more complex. The mosquitoes that we commonly encounter such as *Culex*, *Aedes*, *Sabesthes*, *Mansonia*, *Culiseta*, *Psorophora*, *Wyeomyia*, *Haemagogus* and *Armigeres* are genera from sub-family Culicinae.

Mosquitoes lay their eggs on the surface of water as their larvae and pupae live in aquatic habitats. Female mosquitoes can produce up to 100 eggs at a time. *Anopheles* mosquitoes produce eggs singly with floats while *Culex* mosquitoes lay a group of eggs in the form of a raft. The larvae of most species feed on algae and organic debris, but a few are predaceous and feed on other mosquito larvae (Triplehorn and Johnson, 2005). Most adult mosquitoes can be found near to water bodies in which they spent their larval stage.

The eggs will hatch after a few days and the larvae feed on algae and organic debris. However, some larvae are predacious and feed on other mosquito larvae. The larvae will turn into pupae after the 4^{th} instar. In this stage, pupae do not feed, but instead the process of morphological and physiological development will take place. Unlike most insect pupae, mosquito pupae are quite active and can move away when disturbed.

The life cycle of a mosquito usually will take about 1 to 2 weeks. After the adult emerges from the pupa, it will rest for a while on the pupal case to dry its body and wings. When it is ready to fly, female mosquito will find her first blood meal while the male will feed on plant juices (Triplehorn and Johnson, 2005).

As mosquitoes are important in human health because they act as vectors of deadly human diseases, studies on mosquitoes are important in order to prevent the spread of these diseases to human beings. From 20 genera of mosquitoes that can be found in Malaysia, four are medically important as they are vectors of certain diseases such as dengue and malaria. These four genera are *Aedes*, *Culex*, *Anopheles* and *Mansonia*. *Aedes* includes species which transmit yellow fever, dengue, and other arboviruses. *Culex* is able to transmit Japanese

encephalitis virus in the Oriental Region and *Cx. tarsalis*, *Cx. nigripalpus*, *Cx. restuans* and *Cx. pipiens* are recognized vectors of encephalitis viruses in North America. Mosquitoes of genus *Anopheles* are the sole vectors of human malarial parasites while *Mansonia* mosquitoes are mainly important as vectors of the helminths that cause Brugian filariasis in India and Southeast Asia (Harbach, 2011).

METHODOLOGY

Study locations

Mosquitoes were collected in the Campus of Universiti Malaysia Sabah. The campus has an area of 999 acres which is located in Sepanggar Bay. The campus has many different kinds of environments such as hostel areas, forested areas and lake areas. For the purpose of this study, 5 sampling areas were selected, i) college AB, ii) college CD iii) college E, iv) lake in front of University Library and v) the library's café area.

Mosquito samplings

Mosquitoes locate their host by using compounds known as kairomones, substances from the emitters (hosts) that are favourable to mosquitoes. Hosts produce heat, water vapour, carbon dioxide and various odours that can attract mosquitoes (Service, 1993). In this study, hands and legs of collector (host) were exposed to attract mosquitoes. Mosquitoes that landed on hands or legs of the collector were caught by using a small tube. Once a mosquito was caught, the mouth of the tube was quickly covered with a cotton ball. Collections were made for 12 hours starting from 18:00 h until 05:00 h. Altogether, collections were done for 16 nights. In college areas, 2 nights were spent for indoor collections and another 2 nights were spent for outdoor collections. However in the lake and café areas, only outdoor samplings could be carried out. Mosquitoes were later morphologically identified using available dichotomous keys (Stojanovich and Scott, 1966; Chau, 1982)**.**

RESULTS

In total 4 genera and 11 species in 2 sub-families of mosquitoes were caught with the total number of 590 individuals from the 5 sampling areas. Sub-family Culicinae dominated the number of catch where a total of 589 individuals were caught. On the other hand, only 1 individual from sub-family Anophelinae was caught.

Table 1 Number of mosquitoes caught in the respective locations.

Spesies	**AB**	**CD**	**E**	**Cafe**	**Lake**	**Total**
Aedes albopictus	5	4	0	3	3	15
Aedes sp.	0	1	1	0	0	2
Anopheles sp.	0	0	0	0	1	1
Culex annulirostris	69	51	27	44	215	406
Culex erythothorax	0	0	3	0	0	3
Culex gelidus	1	0	0	0	0	1
Culex pipiens	5	1	1	11	3	21
Culex sitiens	14	11	10	12	74	121
Culex triteaniorhynchus	1	1	1	3	9	15
Mansonia annulifera	0	0	0	2	2	4
Mansonia bonnea	1	0	0	0	0	1
Total	96	69	43	75	307	590

Majority of the mosquitoes collected were from genus *Culex*, which comprised of 96% of the total individual number. *Culex annulirotis* recorded the highest individual number collected (406 individuals) followed by *Culex sitiens* (121 individuals). Genus *Culex* was also the most speciose genus with 6 species, followed by *Aedes* and *Mansonia* (both 2 species) while *Anopheles* with only 1 species.

In terms of the study locations, the lake area showed highest individual numbers collected (307 individuals) while college E showed the lowest (43 individuals). The two most commonly encountered species throughout the sampling locations were *Culex annulirostris* and *Culex sitiens*. Other species were rarely collected more than 10 individuals in each sampling location.

Figure 1 below shows the abundance of mosquitoes that was collected indoors and outdoors at 3 different locations at college AB, CD and E. The figure shows that college AB has higher mosquito abundance compared to the other colleges. In total, college AB recorded 96 individuals, college CD 69 individuals and college E recorded 43 individuals.

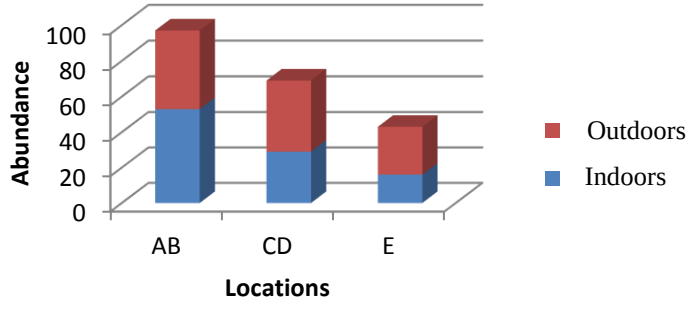

Figure 1 Abundance of mosquitoes collected indoors and outdoors from college AB, CD and E

Figure 2 shows the abundance of mosquitos collected indoors in college AB, was higher than college CD and E. In total, 98 mosquito individuals were caught from indoor collections where college AB recorded the highest individual number which was 53, followed by college CD with 29 individuals while college E recorded the lowest catch, with only 16 individuals. From the figure below, it is clear that the peak biting period indoors was at 20:00 h and at 5:00 h, no mosquito was collected.

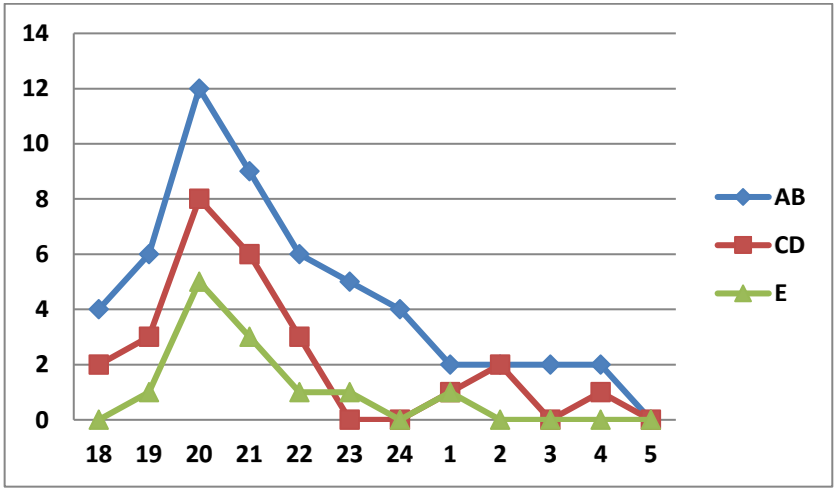

Figure 2 Abundance of mosquitoes collected at three different locations, college AB, CD and E

Figure 3 shows the abundance of mosquitoes collected outdoors. The lake area showed the highest catch (306 individuals), followed by the café area (75 individuals), college AB (43 individuals) college CD (40 individuals) and college E showed the lowest catch (27 individuals). Similarly, to the indoors, the peak biting time for outdoors was also recorded at 20:00 h and at 5:00 h, no mosquitoes were caught except in the lake area.

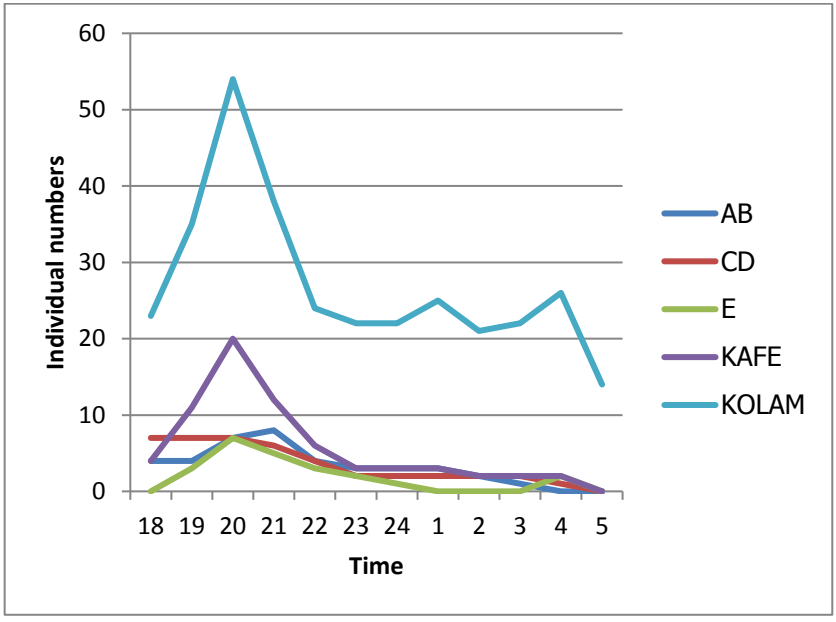

Figure 3 Abundance of mosquitoes collected outdoors at five different locations: College AB, college CD, college E, cafe area and lake area

Figure 4 shows the diversity of mosquitoes collected during the specified collection time period. The figure clearly shows that Culex mosquitoes were mainly collected between 1900 h to 2200 h. Their numbers dropped and fluctuated gradually from 2300 h to 0500 h.

Aedes albopictus had the highest number collected at 18:00 h while *Culex sitiens* at 21:00 h. Although the individual number of *Culex annulirostris* was the highest collected at each hour, it showed its highest number at 20:00 h. The number of mosquitoes collected had significant correlation with time ($r=0.431$, $p<0.05$ for indoor collections and $r=0.343$, $p<0.05$ for

outdoor collections). Species collected were also influenced by time. *Culex annulirostris* had the highest number of individuals collected at 1900 h to 2200 h while *Aedes albopictus* were mostly collected from 1800 h to 1900 h. On the other hand, *Culex sitiens* reached the peak between 2100 h to 2200 h.

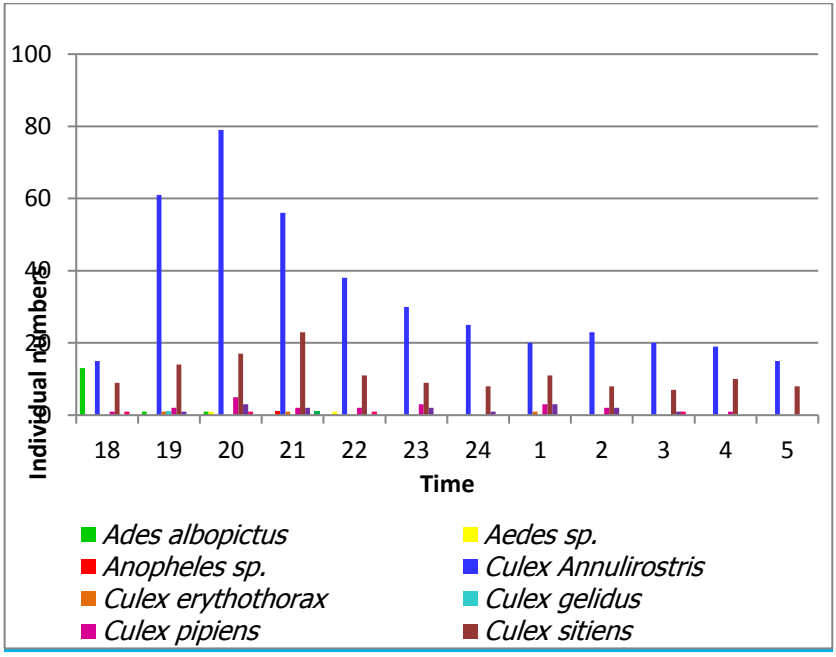

Figure 4 Diversity of mosquitoes collected against time

DISCUSSION

According to Knight *et al*. (2003), factors affecting adult mosquito abundance include weather/climate, diurnal patterns and host abundance. Weather/climate would mostly affect the activities of mosquitoes in temperate regions since low air temperatures greatly reduce mosquito activity in the wintertime. This factor would have less effect on mosquito abundance in tropical regions due to uniform weather/climate throughout the

year. Female *Anopheles* and *Culex* mosquitoes are mainly active at night, thus not many of them are found during daytime. On the other hand, host-feeding patterns are influenced by the (1) the mosquito's host preference, (2) the availability of specific hosts and (3) environmental conditions that impact the process of finding a suitable host (Knight *et al*. 2003). General feeder like *Culex quinquefasciatus* and *Cx. erythrothorax*, would have higher populations. Likewise, if the host of the mosquitoes is specific, generally, the population of the mosquitoes would be lower.

In this study, we found that *Culex* mosquitoes were the predominant genus at all the study locations and recorded the highest individual numbers caught compared to other genera. The conditions surrounding UMS Campus, which has a lot of stagnant water bodies such as clogged waterways, small ponds and water logged areas support the breeding of *Culex* mosquitoes (Whelan, 2010). As Lutambi *et al*. (2013) poited out, living in proximity to mosquito breeding sites increases exposure to mosquito bites and potentially also to disease because the vector-host ratio is higher around breeding sites.

Culex mosquitoes also have short range of dispersal, between 4-10 km, as the adults tend to be living around the water bodies where they spent as larvae (Hill *et al*., 2006). Mansonia mosquitoes, on the other hand, were recorded higher around the lake and café areas as they prefer to take their bloodmeals outdoor. This is due to the fact that *Mansonia* mosquitoes prefer to rest in areas with vegetation and close to water bodies (Department of Health and Families, 2010).

From the study, it shows that *Culex* mosquitoes were mainly collected after 1800 h. *Aedes albopictus*, on the other hand reached its peak at 1800 h, and after 1800 h, very few of them were collected. This is due to the fact that *Culex*

mosquitoes are night time attackers, while *Aedes* mosquitoes prefer to feed at dusk (Isra *et al*., 2006).

Other factors that influence mosquito activities are the flow of air currents and relative humidity (Sivanathan, 2006). Mosquitoes are more active when relative humidity exceeds 90% with relatively stagnant air flow (Queensland Health, 2002). Malaysia, with constant high humidity and high temperature all year round provide a suitable environment for *Anopheles* mosquitoes to breed and spread malaria (Ho, 2008). Furthermore, heavy rainfall that Malaysia receives throughout the year supports the life cycle of many mosquito species (WHO, 2012).

The occurrence of *Anopheles* sp. and two species of *Aedes* mosquitoes should be considered seriously by the university management since these mosquitoes have the potentials to spread malaria and dengue fever in the campus. The *Anopheles* collected in this study was captured at the lake area. Although it has been known that *Anopheles* prefer to bite outdoors than indoors (Vythilingam *et al*., 2005), it has been shown that Anopheles mosquitoes will still rest indoors even in a short period of time (Tanrang *et al*., 1999). Unfortunately, we could not identify the *Anopheles* specimen up to species level as the important characters for the identification were broken during the preservation process. In Sabah, *Anopheles balabacensis* and *Anopheles donaldi* have been known as the main vectors for malaria, with *Anopheles sundaicus* and *Anopheles flavirostris* as secondary vectors in coastal areas. *Anopheles maculatus* is also present in Sabah, but has never been recorded as vectors. In Sarawak, *Anopheles leucosphyrus* used to be the main vector but it has been displaced by *Anopheles donaldi* (Vythilingam *et al*., 2005).

The fact that the lake area harbors the highest mosquito populations should be taken into consideration. Stern action has to be taken to control the mosquito population in the area. Larvivorous fish such as of mosquito fish, *Gambusia holbrooki* and *Gambusia affinis* can be used as an effective biological agent (Russell, 1999; Knight *et al*., 2003).

Rahman *et al*. (1993) reported that the density patterns of *Anopheles aconitus* near the Malaysia-Thailand border were affected by rainfall. In the present study, there were a few sampling occasions with heavy rainfall. This could affect the collection of *Anopheles* mosquitoes as only one specimen was collected. The washing away of larvae could be the reason of the decline of adult number in the rainy season (Rahman *et al*., 1993). However, another study performed in Sarawak has shown the opposite result, where *Anopheles* population increased following rainy season, and thus increasing malaria incidence (Chang *et al*. 1997).

In Malaysia, *Aedes aegypti* and *Aedes albopictus* are the important vectors for dengue fever (DF) and dengue haemorrhagic fever (DHF) (Pang *et al*., 1988). *Aedes aegypty* particularly, has a close association with humans and is adaptable to the domestic environments that allow this mosquito to persist in regions that may otherwise be unsuitable for it to survive (Jansen and Beebe, 2010). In Sarawak, the principle dengue mosquito vector in towns is *Aedes aegypti*, while in villages, *Aedes albopictus* is the more important vector (Holmes *et al*. 2009). In this study, we found *Aedes* mosquitoes in all of the study sites. This indicated that the human populations in the campus are exposed to the spread of dengue fever and dengue haemorrhagic fever when suitable conditions exist. Even for mosquitoes that do not transmit diseases, their presence can be a substantial nuisance for humans in many residential situations and during various occupational and recreational activities

(Russell, 1999). Thus, certain measures to control the population of mosquitoes have to be addressed by the university's management in order to make sure that the campus is free from mosquitoes that have the potentials to spread mosquito-borne diseases.

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