

## Distribution and Seasonal Activity of Mosquitoes (Diptera: Culicidae) in Al-Qassim Region, Saudi Arabia

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**Abstract.** A mosquito (Diptera: Culicidae) survey was conducted during the period March 2004 to February 2006 in Al-Qassim Region, Saudi Arabia; and 14 species which belong to four genera were encountered: *Aedes* (1 sp.), *Anopheles* (5 spp.), *Culex* (7 spp.) and *Culiseta* (1 sp.). The following mosquito species were collected: *Aedes caspius* Palls, *Anopheles cinereus* Theobald, *An. d'thali* Patton, *An. multicolor* Cambouliou, *An. stephensi* Liston, *An. superpictus* Grassi, *Culex laticinctus* Edwards, *Cx. pipiens* Linnaeus, *Cx. pusillus* Macquart, *Cx. quinquefasciatus* Say, *Cx. torrentium* Martini, *Cx. tritaeniorhynchus* Giles, *Cx. univittatus* Theobald and *Culiseta longiareolata* Macquart.

Among the 2,425 mosquito larvae collected, 2,018 (83.21%) were *Culex* spp., 215 (8.87%) were *Culiseta* spp., and 192 (7.92%) were *Aedes* sp. The study of the physical properties of water in the larval breeding sites revealed that the total dissolved salts (TDS) varied between 115 ppm to 12,800 ppm and pH ranged between 5.7 to 9.9. The results showed that there was no significant correlation between pH and TDS of the water in the breeding sites and the distribution of different mosquito larvae species.

Light traps collected 2,846 adult mosquitoes, among which *Aedes* spp. were the most prevalent and 1,372 (48.21%) were collected, followed by 1,138 (39.98%) *Culex* spp., 301 (10.58%) *Culiseta* sp. and 35 (1.23%) *Anopheles* spp. Adult mosquitoes were collected throughout the year, but at different densities depending on the prevailing climatic conditions. The effects of temperature and rainfall on the seasonal activity of adult mosquitoes are discussed. The presence of *Cx. tritaeniorhynchus*, the main vector of Rift Valley fever in Al-Qassim Region constitutes a major health problem, and every effort should be made to prevent the spread of this mosquito species.

### Introduction

During the past few decades, Saudi Arabia has witnessed tremendous efforts in social development and urbanization in all regions, which have affected insect fauna, particularly mosquitoes (Diptera: Culicidae). The expansion of agricultural projects and the development of water resources, in addition to the favorable climatic conditions for mosquito survival and development in Al-Qassim Region, have led to a creation of more permanent and temporary breeding sites for mosquitoes. Malaria is considered as one of the most dangerous mosquito-transmitted diseases. The occurrence, transmission, persistence and establishment of such disease is regulated by many complex interacting factors such as the malaria pathogen species, human population structure and environmental conditions.

Several reports on mosquito fauna of Saudi Arabia are available (Mattingly and Knight, 1956; Zaher, 1973; Buttiker, 1981; Wills *et al.*, 1985; Abdullah and Merdan, 1995; Jupp *et al.*, 2000; Miller *et al.*, 2000; Abdoon and Al-Shahrani, 2003; Alahmed *et al.*, 2007; Al-Ghamdi *et al.*, 2008), but scanty information is available on mosquito fauna of Al-Qassim Region. The breeding sites and seasonal activity of mosquitoes in Al-Qassim Region are unknown, and the effects of pH and total dissolved salts (TDS) on the survival and development of immature stages of mosquitoes need to be investigated. The present work was undertaken to study the distribution of mosquito larvae, and the effects of TDS and pH on their distribution in Al-Qassim Region. An attempt was made to study the seasonal activity of adult mosquitoes in the study area.

## Materials and Methods

### The study area

Al-Qassim Region is located at the heart of the Kingdom, between long. 23°E-28°E and lat. 24°N-29°N (Fig. 1), and has a typical desert climate, which is cold rainy in winter and hot dry or with low humidity in summer. Al-Qassim Region is divided by Wadi Al-Rumma (Rumma Valley), which is the longest valley in Arabian Peninsula, from the west to northeast. The Region lies at an altitude of 600-750 meters above sea level, and it is gliding from west to east in general. Agriculture is the cornerstone of the region's economy, and it produces corn, dates, citrus and some vegetables.

### Larval collection

During the period March 2005 to February 2006, a mosquito survey was conducted in Al-Qassim Region of Saudi Arabia (Fig. 1). Biweekly field trips

were made to collect mosquito larvae from all potential breeding sites by a standard mosquito larval dipper with extendable handle, and three to five scoops were taken from each breeding site (350 ml each). Larvae were extracted, preserved into 80% ethyl alcohol in glass vials with screw caps, labeled and sent to the Entomology Laboratory, College of Food and Agricultural Sciences, King Saud University, Riyadh. Larvae were mounted as described by R. E. Harbach from Natural History Museum in London (personal communication), and identified using standard identification keys (Mattingly and Knight, 1956; Hopkins, 1952; Harbach, 1988; Al-Tubiakh, 1995). Representative samples of identified larvae were sent to Prof. Harbach, British Natural History Museum in London, for confirmation. During the larval collection, the following information about each breeding site was recorded:

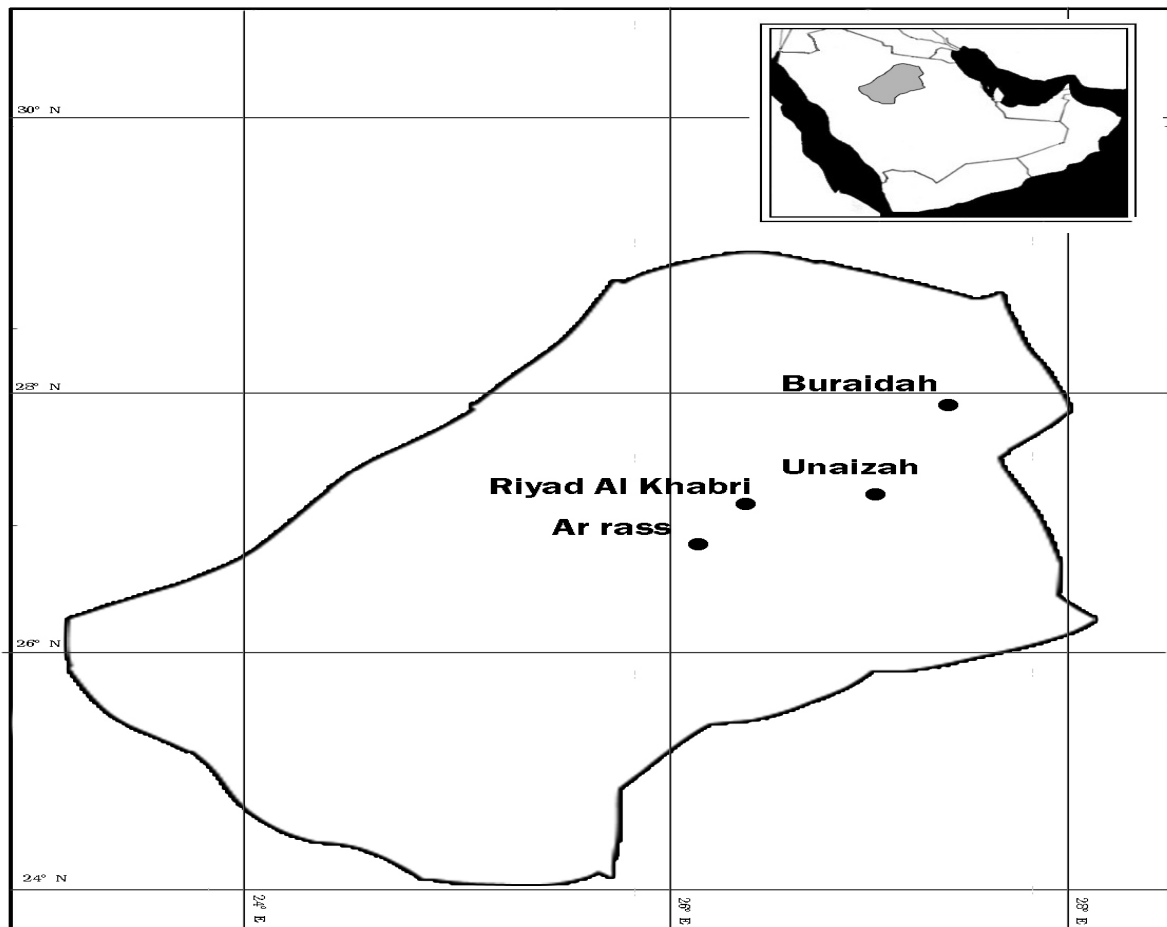


Fig. 1. Collection sites of mosquitoes in Al-Qassim Region, Saudi Arabia.

1. Date and time of larval collection.
2. Determination of coordinates of the collection site using GPS (Garmin International, Inc., 1200 Olathe, KS, 66062, USA).
3. pH using pH-meter (Bioquip Products, Inc., Gardena, CA 90248-3602, USA).
4. TDS in ppm using TDS-meter (Bioquip Products, Inc., Gardena, CA 90248-3602, USA).
5. Water temperature using an aquatic thermometer.
6. Type of breeding sites (e.g., ponds, irrigation canal, exposed water containers, rain water collections, abandoned wells or fountains).
7. Turbidity of water (clear, turbid or semi-turbid).
8. Aquatic plants (present or absent; floating or submerged).
9. Presence or absence of shadow or algae.

#### Adult collection

Adult mosquitoes were collected from different sites in Al-Qassim Region (Fig. 1) using one CDC and one standard New Jersey (NJ) light traps (Bioquip Company, Gardena, CA, 90248-3602, USA) in each collection site. The CDC and the NJ light traps were attached to a battery that supplies power, and installed permanently near suitable mosquito breeding sites. The light traps were operated once every two weeks from sunset to sunrise the following day throughout the study period. The collected mosquitoes were packed, labeled and transported to the Entomology Laboratory in Riyadh. Adult mosquitoes were counted and identified using standard identification keys (Mattingly and Knight, 1956; Harbach, 1988; Al-Tubiakh, 1995; Glick, 1992). Some representative samples of identified mosquitoes were sent to Prof. R. Harbach, British Natural History Museum in London for confirmation. The mean monthly temperature and relative humidity during the study period was obtained from the National Center for Meteorology, Riyadh. Pearson correlation coefficient ( $r$ ) was used to study the effects of pH and TDS on the distribution of different mosquito larvae at 0.05 level (SAS, 2001).

#### Results

During this study 5,271 adults and mosquito larvae, which belong to 14 species and 4 genera, were encountered: *Aedes* (1 sp.), *Anopheles* (5 spp.), *Culex* (7 spp.) and *Culiseta* (1 sp.). The following species were collected and identified: *Aedes caspius* Palls, *Anopheles cinereus* Theobald, *An. d'thali* Patton, *An. multicolor* Cambouliou, *An. stephensi* Liston, *An. superpictus* Grassi, *Culex laticinctus* Edwards, *Cx. pipiens* Linnaeus, *Cx. pusillus* Macquart, *Cx.*

*quinquefasciatus* Say, *Cx. torrentium* Martini, *Cx. tritaeniorhynchus* Giles, *Cx. univittatus* Theobald and *Culiseta longiareolata* Macquart.

Among the 2,425 mosquito larvae collected, *Culex* larvae were the most abundant and 2,018 (83.21%) were collected, followed by 215 (8.87%) *Culiseta* sp. and 192 (7.92%) *Aedes* sp. (Table 1). Most of the larvae were collected from the stagnant or slowly running irrigation canals with submerged or floating plants, grassy or slightly shaded water pools and water storage tanks. Larvae were also encountered in temporary or permanent brackish polluted water, drainage water collections with some algae.

Light traps collected 2,846 adult mosquitoes, 1,676 (58.89%) of them were collected by CDC light traps and 1,170 (41.11%) by NJ light traps (Tables 2 and 3). Among the adult mosquitoes collected, *Aedes* sp. were the most prevalent and 1,372 (48.21%) were attracted to the light traps, followed by 1,138 (39.98%) *Culex* spp., 301 (10.58%) *Culiseta* sp. and 35 (1.23%) *Anopheles* spp.

The study of the physical properties of water in the larval breeding sites revealed that the TDS varied between 115 ppm to 12,800 ppm, pH ranged between 5.7-9.9, and water temperature varied between 16.2°C during winter and 33.7°C during summer. The results showed that no significant correlation between pH and distribution of mosquito larvae ( $r = 0.03$ ,  $P > 0.05$ ). Similarly, the results showed no significant correlation between TDS and distribution of mosquito larvae ( $r = 0.07$ ,  $P > 0.05$ ).

#### The effects of temperature and rainfall on seasonal activity of mosquitoes

The population density of adult mosquitoes started to increase in March when the temperature was 20°C, and a peak of activity was attained in July when the temperature was 35°C. In August, the population density started to decline, and a minimum activity was attained in October. During the rest of the year, the activity of mosquitoes was fluctuating depending on the prevailing climatic conditions (Fig. 2). The seasonal activity of mosquito was closely linked with the rainfall. The rainy season (November-April) provided more breeding sites for mosquitoes, and a peak of activity was attained in July (Fig. 3).

#### Discussion

This study showed that *Culex* larvae were the most abundant (83.21%), and were collected from various habitats. The widespread of *Culex* larvae might be due to the fact that they can exploit a wide variety of aquatic habitats for their development and

survival, and can tolerate highly polluted aquatic environment and relatively saline water. In fact, beside water quality, there are some other factors which determine the suitability of various types of aquatic habitats for mosquitoes, like presence or

absence of shade, aquatic vegetations, depth and degree of water motion and turbidity. Irrigation systems can also affect the distribution of different mosquito larvae (Al-Zahrani, 2007).

**Table 1.** *Culex*, *Aedes* and *Culiseta* larvae collected from Al-Qassim Region

Date	<i>Culex</i>						<i>Aedes</i>	<i>Culiseta</i>
	<i>laticinctus</i>	<i>pipiens</i>	<i>pusillus</i>	<i>quinquefasciatus</i>	<i>tritaeniorhynchus</i>	<i>univittatus</i>	<i>caspius</i>	<i>longiareolata</i>
Mar. 04	0	3	0	0	0	0	135	0
Apr. 04	0	98	0	0	0	0	0	136
May 04	0	180	0	0	0	150	0	71
Jun. 04	0	1,085	0	1	2	0	0	0
Jul. 04	0	0	0	0	2	6	0	0
Aug. 04	0	45	0	0	0	0	0	0
Sep. 04	0	0	0	0	0	0	0	0
Oct. 04	0	0	0	0	0	0	0	0
Nov. 04	0	42	0	0	0	0	0	0
Dec. 04	0	5	0	0	0	19	18	0
Jan. 05	0	0	0	0	0	0	35	0
Feb. 05	0	0	0	0	0	0	0	0
Mar. 05	0	0	0	0	0	0	4	7
Apr. 05	0	0	0	0	0	0	0	0
May 05	0	0	0	0	0	0	0	0
Jun. 05	0	25	0	0	0	25	0	0
Jul. 05	0	22	0	0	16	49	0	0
Aug. 05	0	25	4	0	0	0	0	1
Sep. 05	0	0	0	0	0	0	0	0
Oct. 05	0	7	0	0	0	27	0	0
Nov. 05	0	78	0	0	0	65	0	0
Dec. 05	8	9	0	0	0	20	0	0
Jan. 06	0	0	0	0	0	0	0	0
Feb. 06	0	0	0	0	0	0	0	0
Total	8	1,624	4	1	20	361	192	215

**Table 2. Adult *Culex* collected from Al-Qassim Region**

Date	<i>Culex</i>								
	<i>quinquefasciatus</i>		<i>pipiens</i>		<i>torrentium</i>		Total		Total
	CDC	NJ	CDC	NJ	CDC	NJ	CDC	NJ	
Mar. 04	0	0	57	47	0	0	57	47	104
Apr. 04	0	0	57	50	0	0	57	50	107
May 04	0	0	71	70	5	23	76	119	195
Jun. 04	0	0	60	116	3	21	62	116	178
Jul. 04	0	17	67	0	0	0	67	17	84
Aug. 04	9	0	5	0	0	0	14	0	14
Sep. 04	0	0	0	0	9	0	9	0	9
Oct. 04	0	0	14	0	0	0	14	0	14
Nov. 04	9	0	24	11	0	0	33	11	44
Dec. 04	0	0	24	58	0	0	24	58	82
Jan. 05	0	0	64	61	0	0	64	61	125
Feb. 05	0	0	12	2	3	4	15	2	17
Mar. 05	0	0	11	17	1	2	11	17	28
Apr. 05	0	5	23	2	0	0	23	7	30
May 05	0	0	17	3	0	0	17	3	20
Jun. 05	0	0	19	7	0	0	19	7	26
Jul. 05	9	0	13	10	0	0	22	10	32
Aug. 05	0	0	0	3	0	0	0	3	3
Sep. 05	0	0	0	0	0	0	0	0	0
Oct. 05	0	0	0	1	0	0	0	1	1
Nov. 05	0	0	2	4	0	0	2	4	6
Dec. 05	0	0	0	3	0	0	0	3	3
Jan. 06	0	0	4	4	0	0	4	4	8
Feb. 06	0	0	1	6	0	0	1	6	7
Total	27	22	545	475	21	50	592	546	1,138

**Table 3. Adult *Aedes*, *Anopheles* and *Culiseta* collected from Al-Qassim Region**

Date	<i>Anopheles</i>										<i>Aedes</i>			<i>Culiseta</i>			
	<i>superpictus</i>		<i>multicolor</i>		<i>stephensi</i>		<i>cinereus</i>		<i>d'hali</i>		Total <i>An.</i>	<i>caspius</i>		Total <i>Ae</i>	<i>longiareolata</i>		Total <i>Cs.</i>
	CDC	NJ	CDC	NJ	CDC	NJ	CDC	NJ	CDC	NJ		CDC	NJ		CDC	NJ	
Mar. 04	0	0	0	0	0	0	0	0	0	0	0	19	6	25	4	18	22
Apr. 04	0	0	0	0	0	0	0	0	0	0	0	17	50	67	45	65	110
May 04	0	0	0	0	0	0	0	0	0	0	0	31	50	81	0	5	5
Jun. 04	0	0	0	0	0	0	0	0	0	0	0	167	73	240	0	0	0
Jul. 04	0	0	0	0	0	0	0	0	0	0	0	379	52	431	0	0	0
Aug. 04	0	0	0	0	0	0	0	0	0	0	0	220	32	252	0	0	0
Sep. 04	0	0	0	0	0	0	0	7	0	0	7	17	12	29	1	0	1
Oct. 04	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Nov. 04	0	0	0	0	0	0	0	0	0	0	0	6	2	8	0	0	0
Dec. 04	0	0	0	0	7	0	0	0	0	0	7	6	2	8	2	0	2
Jan. 05	2	0	0	0	9	1	0	0	0	0	11	9	14	23	2	0	2
Feb. 05	0	0	0	0	0	0	0	0	0	4	4	0	2	2	3	0	3
Mar. 05	0	0	0	0	0	0	0	0	0	0	0	2	4	6	1	7	8
Apr. 05	0	0	0	0	0	0	0	0	0	0	0	14	33	47	2	7	9
May 05	0	0	0	0	0	0	0	0	0	0	0	19	8	27	1	6	7
Jun. 05	0	0	4	0	0	0	0	0	0	0	4	4	35	39	4	23	27
Jul. 05	2	0	0	0	0	0	0	0	0	0	2	5	48	53	0	9	9
Aug. 05	0	0	0	0	0	0	0	0	0	0	0	2	1	3	1	1	2
Sep. 05	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0
Oct. 05	0	0	0	0	0	0	0	0	0	0	0	0	14	14	0	0	0
Nov. 05	0	0	0	0	0	0	0	0	0	0	0	3	1	4	1	0	1
Dec. 05	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	1	1
Jan. 06	0	0	0	0	0	0	0	0	0	0	0	1	2	3	1	8	9
Feb. 06	0	0	0	0	0	0	0	0	0	0	0	0	4	4	19	64	83
Total	4	0	4	0	16	1	0	7	0	4	35	922	450	1,372	87	214	301

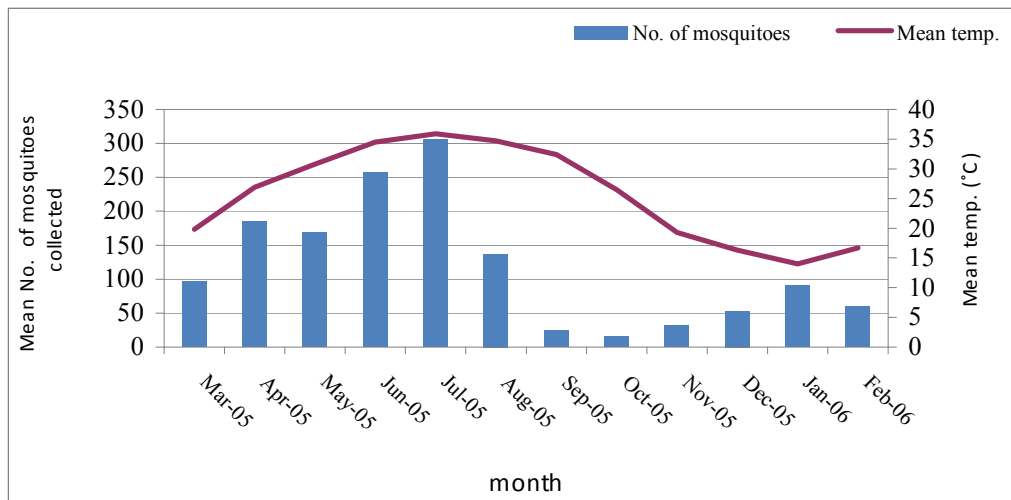


Fig. 2. The effect of temperature on seasonal activity of mosquitoes in Al-Qassim Region.

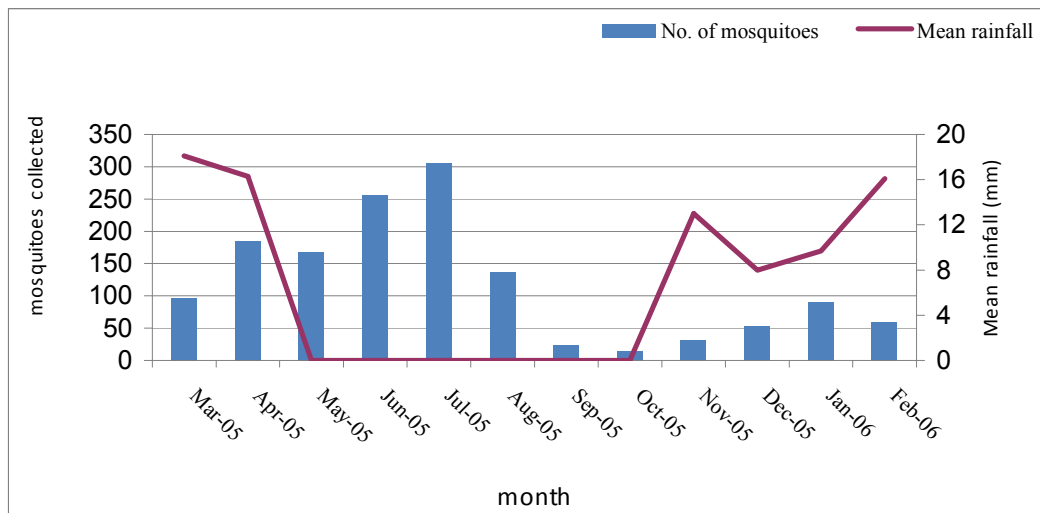


Fig. 3. The effect of rainfall on seasonal activity of mosquito in Al-Qassim Region.

In this study, *Culex tritaeniorhynchus*, the main vector of Rift Valley fever virus in the southern part of Saudi Arabia (Jupp *et al.*, 2002; Miller *et al.*, 2002) and *Cx. univittatus*, the main vector of sindbis virus in the Eastern Region of Saudi Arabia (Wills *et al.*, 1985) were encountered in Al-Qassim Region. Although at the present time the occurrence of human disease infection with sindbis virus in Saudi Arabia is unknown, it may be encountered in the future. The presence of these serious mosquito vectors in Al-Qassim Region constitutes a great health problem, and every effort should be made to control them.

*Culiseta longiareolata* was reported during this study, but in few numbers. The adults of this species never enter houses and rarely bite man (Salit *et al.*, 1994), so this species appears to be of no medical

importance, but its larvae may be cannibalistic and prey on aquatic insects and tadpoles (Blaustein and Margalit, 1994). Further studies on the medical importance of *Culiseta longiareolata* in Saudi Arabia are required.

The results of this study showed that adult mosquitoes were collected throughout the year in Al-Qassim Region, but in different densities. In fact, the climate in Al-Qassim is conducive for the development and survival of mosquitoes which makes the control programs very difficult. Agricultural expansions and new irrigation canals, pools and extensive farming may also help in wide spread and occurrence of mosquitoes in Al-Qassim Region.

In this study, some species of mosquitoes were collected as larvae but not as adults, and vice versa.

This might be due to some differences in the adult behavior, some of these mosquitoes are indoors feeders and they do not come near light traps which were placed outside houses. For the collection of indoor feeder mosquitoes (e.g. *Anopheles*), we suggest the use of more efficient methods for sampling indoors mosquitoes feeders (e.g. *Anopheles*) like the use of spray sheet method.

In this study, 14 species of mosquitoes were encountered. The presence of these mosquitoes in the region constitutes a serious health problem, and further studies on their ecology, biology and vectorial capacity in disease transmission are required before embarking on large scale control projects.

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## توزيع البعوض (Diptera: Culicidae) ونشاطه الموسمي في

### منطقة القصيم بالمملكة العربية السعودية

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(قدم للنشر في ١٠/٢٢/١٤٣٠هـ؛ وقيل للنشر في ٢٧/٥/١٤٣١هـ)

كلمات مفتاحية: البعوض، انتشار، النشاط الموسمي، منطقة القصيم، المملكة العربية السعودية.

ملخص البحث. تم عمل حصر للبعوض (Diptera: Culicidae) في منطقة القصيم خلال الفترة من مارس عام ٢٠٠٤م حتى فبراير عام ٢٠٠٦م، وقد تم جمع ١٤ نوعاً من البعوض تنتمي لأربعة أجناس هي: نوع واحد من جنس *Aedes*، وخمسة أنواع من جنس *Anopheles*، وسبعة أنواع من جنس *Culex*، ونوع واحد من جنس *Culiseta* وهذه الأنواع هي: *Aedes caspius* Palls, *Anopheles cinereus* Theobald, *An. d'thali* Patton, *An. multicolor* Cambouliou, *An. stephensi* Liston, *An. superpictus* Grassi, *Culex laticinctus* Edwards, *Cx. pipiens* Linnaeus, *Cx. pusillus* Macquart, *Cx. quinquefasciatus* Say, *Cx. torrentium* Martini, *Cx. tritaeniorhynchus* Giles, *Cx. univittatus* Theobald and *Culiseta longiareolata* Macquart.

تم جمع ٢٤٢٥ يرقة بعوض من جميع الأعمار اليرقية وكان معظمها تنتمي للجنس *Culex* حيث تم جمع ٢٠١٨ يرقة (٨٣,٢١٪)، يليها جنس *Culiseta* ٢١٥ يرقة (٨,٨٧٪)، ثم جنس *Aedes* حيث تم جمع ١٩٢ يرقة (٧,٩٢٪).

بالنسبة لدراسة الخصائص الفيزيائية للمياه التي تعيش فيها اليرقات وجد أن نسبة الأملاح المذابة (TDS) تتراوح بين ١١٥-١٢٨٠٠ جزء بالمليون. أما درجة الحموضة (pH) فكانت تتراوح بين ٥,٧-٩,٩، بينما كان متوسط درجات حرارة الماء فتتراوح بين ١٦,٢م شتاءً و٣٣,٧م صيفاً. وأوضحت الدراسة أنه لا توجد علاقة معنوية بين الأملاح المذابة (TDS) أو درجة الحموضة (pH) من جهة وبين توزيع يرقات البعوض وانتشارها من جهة أخرى.

أما بالنسبة للطور البالغ فقد تم جمع ٢٨٤٦ حشرة باستخدام المصائد الضوئية، وكانت أغلب أنواع البعوض تنتمي للجنس *Aedes* حيث تم جمع ١٣٧٢ (٤٨,٢١٪) حشرة، يليها جنس *Culex* حيث تم جمع ١١٣٨ (٣٩,٩٨٪) حشرة، بينما تم جمع ٣٠١ حشرة من جنس *Culiseta*، وأخيراً جنس *Anopheles* حيث تم جمع ٣٥ (١,٢٣٪) حشرة.