

## Distribution and Habitats of Mosquito Larvae (Diptera: Culicidae) in Riyadh Region, Saudi Arabia

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**Abstract.** A mosquito larval survey was conducted in Riyadh Region, Saudi Arabia, between March 2003-March 2005, in which 10,324 mosquito larvae were collected from 32 different sites in the study area. The results revealed the presence of 20 different mosquito larvae species. Eleven of them belong to the genus *Culex*, seven belong to the genus *Anopheles* and one species to each of *Culiseta* and *Aedes* genera. Among the 10,324 mosquito larvae collected, 8112 (78.57%) were *Culex*, 1691 (16.38%) were *Culiseta*, 391 (3.79%) were *Aedes* and 130 (1.26%) were *Anopheles*.

The *Culex* larvae collected during this survey were: *Culex (Barraudius) pusillus* Macquart, *Cx. (Cx.) aticinctus* Edwards, *Cx. (Cx.) mattinglyi* Knight, *Cx. (Cx.) perexguus* Theobald, *Cx. (Cx.) pipiens* L., *Cx. (Cx.) quinquefasciatus* Say, *Cx. (Cx.) simpsoni* Theobald, *Cx. (Cx.) sinaiticus* Kirkpatrick, *Cx. (Cx.) ritaeniorhynchus* Giles, *Cx. (Cx.) theileri* Theobald and *Cx. (Cx.) univittatus* Theobald. The *Anopheles* larvae collected were: *Anopheles (Anopheles) coustani* Laveran, *An. (Cellia) d'thali* Patton, *An. (Cel.) multicolor* Cambouliou, *An. (Cel.) pretoriensis* Theobald, *An. (Cel.) stephensi* Liston, *An. (Cel.) subpictus* Grassi and *An. (Cel.) turkhudi* Liston. Similarly, *Aedes (Ochlerotatus) caspius* Pallas and *Culiseta (Allotheobaldia) ongiareolata* Macquart were also reported in the study area.

Some of the physical and chemical properties of the water in the breeding sites of larvae were investigated. The water temperature in the larval habitats ranged between 14.8-38°C, pH varied between 6.5-11.1, and the total dissolved salts (TDS) ranged between 90-9920 ppm.

The mosquito larvae were collected from various habitats, most of them were collected from stagnant or slowly running shady water collections with algae, regardless of water turbidity in the breeding site. The habitat characteristics for mosquito larvae were discussed.

**Keywords:** Distribution, Habitats, Mosquito larvae, Riyadh Region.

### Introduction

In the previous few years, mosquitoes (Diptera: Culicidae) have become widespread in Riyadh Region, and some mosquito-transmitted pathogens, such as Rift Valley fever virus in the southern part of the Kingdom, Malaria and Dengue virus fever in the eastern part of the Kingdom, have become serious problems [1].

Very little investigation has been done on the distribution, ecology and biology of mosquitoes in Riyadh Region [2-5]. In the past three decades, agricultural expansion and urbanization have tremendously affected insect fauna, particularly mosquitoes, in Riyadh Region. The breeding sites of mosquito are unknown, and the effects of pH and total dissolved salts (TDS) in the breeding sites on the survival and development of immature stages of mosquito need to be investigated. More recent and comprehensive detailed studies on mosquito ecology and biology in Riyadh Region are required before embarking on large scale control projects.

The aim of this study was to collect and identify different mosquito larvae species and to investigate their distribution in Riyadh Region. An attempt was also made to study the effects of pH, TDS and water temperature in the breeding sites on larva survival and development.

## Material and Methods

### Larval collection and identification

A two-year survey for mosquito larvae collection and identification was carried out in Riyadh Region between March 2003 – March 2005. Mosquito eggs, larvae and pupae were collected by a white plastic mosquito larvae dipper with extendable handle (Bioquip Products, Inc., California, USA) from 32 sites representing different mosquito breeding sites in Riyadh Region (Fig. 1). All the the breeding sites were visited once or twice a year, and a reasonable number of mosquito larvae were collected each time depending on the availability of larvae. The mosquito immature stages were collected from the potential breeding sites such as shady stagnant or slowly running water collections with aquatic plants, temporary or permanent water accumulations, irrigator canals, sewage drain, wells, fountains, exposed water tanks and drinking water in animal pens.

The collected mosquito immature stages were put in vials, and each vial was given a code number represented date of sampling and site of collection, then taken to the Entomology Laboratory at the College of Food Sciences and Agriculture of King Saud University. The 4<sup>th</sup> larval instars were separated, killed in hot water and placed in absolute ethyl alcohol for 6-12 hrs (repeated twice), and put on a microscopic slide (26 x 76 mm), then covered with a drop of Canada Balsam and incubated at 50°C for 24 hr. The following day, the incubated larvae were taken out and another drop of Canada Balsam was placed on the larval preparation and covered with cover glass (18 x 18 mm) and incubated again at 50°C for six weeks to dry. The larvae were identified according to the available identification keys [2, 6, 7]. Some larvae were sent to the British History Museum, London for confirmation.

Egg masses, 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> mosquito larval instars and pupae were reared to the adult stage in mosquito breeders (Bioquip Products, Inc., California, USA). When the adults emerged, they were killed and identified [2, 6-8].

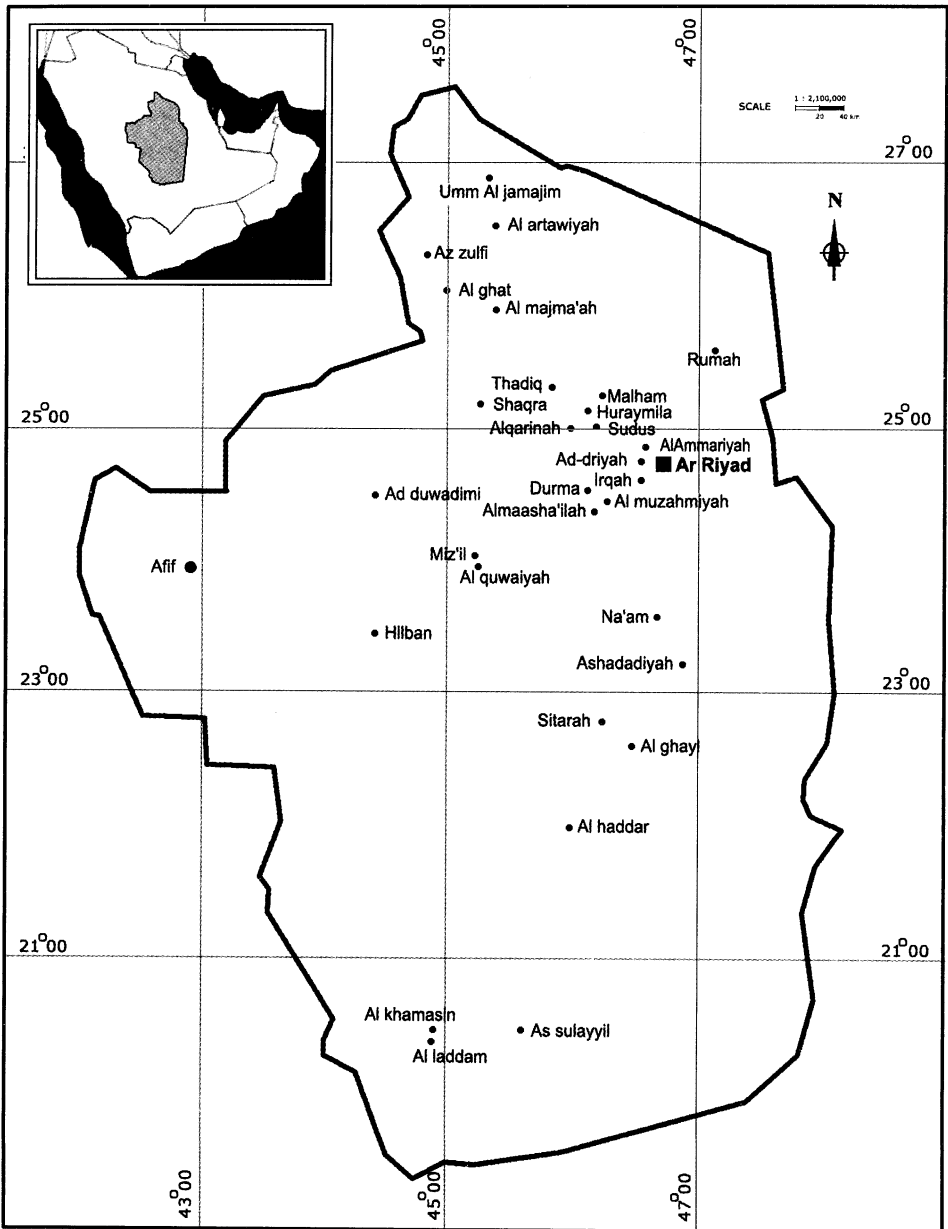


Fig. 1. Collection sites of mosquito immature stages in Riyadh Region.

Source: *Maps Atlas of Kingdom of Saudi Arabia* by: Zaki M. Farsi, 1422 H., 256.

### Determination of water temperature, pH and TDS in the breeding sites

During the collection of mosquito immature stages, the following information about water in each breeding site was recorded:

1. pH using pH-meter (Bioquip Products, Inc., California, USA).
2. TDS in ppm using TDS-meter (Bioquip Products, Inc., California, USA).
3. Water temperature using aquatic thermometer.
4. Type of breeding site (ponds, irrigation canal, fountains, water tanks, exposed water containers, wells and sewage drains).
5. Turbidity of water (clear, turbid, semi-turbid).
6. Aquatic plants and algae (whether present or absent, floating or submerged).
7. Determination of the coordinates of the collection sites using GPS (Garmin Int Co., USA).

### Results

Mosquito larvae collected during this survey are shown in Table 1. During the study, 10,324 mosquito larvae representing 20 species and four genera were collected from 32 sites in Riyadh Region (Table 2). Out of the total larvae collected, 8112 were *Culex* (78.57%), 1691 were *Culiseta* (16.38%), 391 were *Aedes* (3.79%) and 130 were *Anopheles* (1.26%). The results showed that mosquito larvae could survive in an environment in which the water temperature ranged between 14.8-38°C, pH varied between 6.5-11.1 and TDS ranged between 90-9920 ppm (Table 3).

The results showed that most of mosquito larvae preferred small shady stagnant clear or semi-turbid water with algae; however, some species preferred large shady slowly running clear water collections (Table 4).

### Mosquito larvae collected

#### a. *Culex* larvae

In this study, *Culex* larvae collected belong to 11 species. They were: *Culex (Barraudius) pusillus* Macquart, *Cx. (Cx.) laticinctus* Edwards, *Cx. (Cx.) mattinglyi* Knight, *Cx. (Cx.) perexiguus* Theobald, *Cx. (Cx.) pipiens* L., *Cx. (Cx.) quinquefasciatus* Say, *Cx. (Cx.) simpsoni* Theobald, *Cx. (Cx.) sinaiticus* Kirkpatrick, *Cx. (Cx.) tritaeniorhynchus* Giles, *Cx. (Cx.) theileri* Theobald and *Cx. (Cx.) univittatus* (Table 5).

The study showed that *Culex* larvae were the most abundant, and 8112 larvae (78.57%) were collected from 27 sites in Riyadh Region. Most of the larvae were collected from Riyadh (1617 larvae, 19.93%), followed by As sulayyl (1176 larvae 14.5%) and only 7 larvae (0.09%) from Huriyilla. Among *Culex* larvae, *Cx. pipiens* was the most prevalent, with 4478 larvae (55.2%), followed by *Cx. quinquefasciatus* with 1464 larvae (18.05%). The least number of *Culex* larvae collected was *Cx. mattinglyi* with 16 larvae (0.2%) (Table 5).

**Table 1. Mosquito larvae collected from Riyadh Region**

Mosquito sp.	Place of Collection	Date of Collection
<i>Cx. pipiens</i>	Riyadh	08/03/2003, 22/04/2003, 17/09/2003, 29/12/2003, 28/03/2004, 17/04/2004, 20/04/2004, 25/04/2004, 12/05/2004
	Alqarinah	19/03/2003
	Ammariyah	23/03/2003, 03/05/2003, 10/07/2003, 01/05/2004
	Huraiymila	02/04/2003
	Al majmma	09/04/2003, 13/02/2004
	Shagra	02/06/2003, 18/03/2004
	Afif	03/06/2003, 19/03/2004
	Assulayl	25/08/2003, 01/04/2004
	Zulfi	12/02/2004
	Al ghat	13/02/2004
	Al Khamasin	03/13/2004, 27/04/2004
	Hilban	19/03/2004
	Um Aljamajim	26/03/2004
	Al artawiyaha	26/03/2004
	Addriyah	07/04/2004
	Muzahmitah	10/04/2004
	Durma	10/04/2004
	Ramah	17/04/2004
	Irqa	17/04/2004
	Malham	28/04/2004
Al laddam	11/05/2004	
Alghayl	22/05/2004	
Ad duwadmi	19/07/2004	
<i>Cx. quinquefasciatus</i>	Thadiq	24/03/2003
	Muzahmitah	07/04/2003, 10/04/2004
	Riyadh	22/04/2003, 28/03/2004, 20/04/2004, 06/05/2004
	Ammariyah	10/07/2003
	Assulayl	25/08/2003, 01/04/2004
	Addriyah	07/04/2004
<i>Cx. sinaiticus</i>	Malham	28/04/2004
	Riyadh	19/04/2003
<i>Cx. simpsoni</i>	Ad duwadmi	04/06/2003
	Riyadh	12/05/2004
	Alghayl	22/05/2004
	Sitara	22/05/2004
<i>Cx. pusillus</i>	Ad duwadmi	04/06/2003, 18/03/2004, 29/06/2004, 06/07/2004, 11/07/2004, 19/07/2004, 01/08/2004
	Sitara	22/05/2004
	Riyadh	19/12/2003
<i>Cx. perexguus</i>	Ad duwadmi	11/07/2004, 19/07/2004, 01/08/2004
	Al Khamasin	20/09/2004, 13/10/2004

**Table 1. (Contd.)**

<b>Mosquito sp.</b>	<b>Place of Collection</b>	<b>Date of Collection</b>
<i>Cx. mattinglyi</i>	Zulfi	12/02/2004
	Ad duwadmi	18/03/2004
<i>Cx. tritaeniorhynchus</i>	Ad duwadmi	04/06/2003, 18/03/2003
	Riyadh	17/04/2004
	Malham	28/04/2004
	Sudus	01/05/2004
	Alghayl	22/05/2004
<i>Cx. univittatus</i>	Irqa	17/04/2004
	Ammariyah	01/05/2004
	Riyadh	12/05/2004
	Sitara	22/05/2004
	Al Khamasin	06/10/2004, 13/10/2004, 18/10/2004, 22/10/2004
<i>Cx. laticinctus</i>	Alquwaiyah	09/04/2004, 16/05/2004, 03/12/2004, 09/12/2004
	Ad duwadmi	05/12/2004, 24/12/2004, 31/12/2004, 07/01/2005
<i>Cx. theileri</i>	Malham	28/04/2004
	Ammariyah	01/05/2004
	Sudus	01/05/2004
<i>An. pretoriensis</i>	Ammariyah	10/07/2003
<i>An. d'thali</i>	Al Khamasin	25/08/2003, 27/04/2004, 08/09/2004, 06/10/2004
	Sitara	22/05/2004
<i>An. stephensi</i>	Riyadh	17/09/2003
	Irqa	17/04/2004
<i>An. subpictus</i>	Al Khamasin	27/04/2004
	Sitara	22/05/2004
	Ashadadiyah	22/05/2004
<i>An. multicolor</i>	Ad duwadmi	05/05/2004
<i>An. coustani</i>	Riyadh	12/05/2004
<i>An. turkhudi</i>	Sitara	22/05/2004
<i>Cs. longiareolata</i>	Malham	19/03/2003, 28/04/2004
	Alqarinah	19/03/2003
	Ammariyah	23/03/2003, 03/05/2003, 01/05/2004
	Thadiq	24/03/2003
	Huraiymila	02/04/2003
	Al majmma	09/04/2003, 13/02/2004
	Zulfi	12/02/2004
	Al ghat	13/02/2004
	Na'am	04/03/2004
	Hilban	19/03/2004
	Um Aljamajim	26/03/2004
	Al artawiyaha	26/03/2004
	Assulayl	01/04/2004
	Al haddar	01/04/2004
	Muzil	07/04/2004
	Addriyah	07/04/2004
	Alquwaiyah	09/04/2004
	Muzahmiyah	10/04/2004

**Table 1. (Contd.)**

Mosquito sp.	Place of Collection	Date of Collection
<i>Cs. longiareolata</i>	Durma	10/04/2004
	Ramah	17/04/2004
	Irqa	17/04/2004
	Almashalla	25/04/2004
	Riyadh	25/04/2004
	Ad duwadmi	28/04/2004, 05/05/2004, 12/05/2004, 12/02/2005, 20/02/2005, 01/03/2005
<i>Ae. caspius</i>	Sodus	01/05/2004
	Riyadh	19/04/2003
	Ad duwadmi	04/06/2003
	Al Khamasin	28/05/2003, 31/03/2004

**Table 2. Sites and number of different mosquito larvae collected in Riyadh Region (According to GPS readings)**

No.	Site	Coordinates		Altitude (m)	<i>Aedes</i>	<i>Anopheles</i>	<i>Culex</i>	<i>Culiseta</i>	Total
		N:	E:						
1	Al artawiyaha	26°30.081	045°20.036	612	0	0	31	95	126
2	Al Khamasin	20°28.620	044°44.527	696	330	22	855	0	1207
3	Addriyah	24°46.575	046°31.845	670	0	0	32	10	42
4	Ad duwadmi	24°31.506	044°25.036	963	59	1	768	142	970
5	Riyadh	24°35.037	046°42.677	584	2	30	1617	13	1662
6	Zulfi	26°32.711	044°40.257	630	0	0	65	2	67
7	Assulayl	20°27.540	045°34.493	616	0	0	1176	9	1185
8	Ashadadiyah	23°12.728	046°53.736	595	0	4	0	0	4
9	Ammariyah	24°49.847	046°29.627	697	0	6	707	218	931
10	Al ghat	26°00.429	045°01.325	715	0	0	21	18	39
11	Alghayl	22°36.046	046°27.169	726	0	0	32	0	32
12	Alqarinah	25°08.566	046°09.747	721	0	0	19	40	59
13	Alquwaiyah	24°15.253	045°36.311	700	0	0	168	14	182
14	Al laddam	20°28.500	044°47.143	695	0	0	80	0	80
15	Al majmma	25°52.809	045°19.710	750	0	0	72	41	113
16	Muzahmitah	24°28.147	046°13.897	636	0	0	97	13	110
17	Almashalla	24°26.620	046°06.740	727	0	0	0	55	55
18	Al haddar	21°52.975	045°55.505	748	0	0	0	27	27
19	Um Aljamajim	26°46.001	045°19.828	575	0	0	17	9	26
20	Thadiq	25°16.823	045°52.561	726	0	0	50	104	154
21	Huraiymila	25°07.544	046°07.404	769	0	0	7	108	115
22	Hilban	23°31.064	044°25.674	932	0	0	119	47	166
23	Ramah	25°10.163	046°48.822	645	0	0	10	8	18
24	Sitara	22°36.831	046°18.930	799	0	61	190	0	251
25	Sodus	25°03.955	046°10.509	848	0	3	59	121	183
26	Shagra	25°18.061	045°11.629	720	0	0	529	0	529
27	Durma	24°36.274	046°07.192	647	0	0	550	300	850
28	Irqa	24°40.460	046°36.651	631	0	3	690	2	695
29	Afif	23°54.779	042°55.440	1051	0	0	40	0	40
30	Muzil	23°59.302	045°10.587	872	0	0	0	35	35
31	Malham	25°09.540	046°18.060	713	0	0	111	220	331
32	Naam	23°37.587	046°37.947	587	0	0	0	40	40
<b>Total</b>					<b>391</b> <b>(3.79%)</b>	<b>130</b> <b>(1.26%)</b>	<b>8112</b> <b>(78.57%)</b>	<b>1691</b> <b>(16.38%)</b>	<b>10324</b> <b>(100%)</b>

**Table 3. Physical and chemical properties of water in breeding sites of larvae**

Property		Temp. (C)		pH		TDS (ppm)	
		Min.	Max.	Min.	Max.	Min.	Max.
Larva sp.	<i>Aedes caspius</i>	27.8	36.9	7.1	9.1	1574	9600
	<i>Anopheles</i>						
	<i>coustani</i>	27.3	31.4	7.9	8.1	2720	3098
	<i>d'thali</i>	27.9	38	7.5	8.5	480	9600
	<i>multicolor</i>	25.4	25.4	7	7	9472	9472
	<i>pretoriensis</i>	25.6	25.6	9.1	9.1	2912	2912
	<i>stephensi</i>	25.9	29.1	9.2	10.7	442	966
	<i>subpictus</i>	27.9	38	7.9	8.4	250	2483
	<i>turkhudi</i>	38	38	8.2	8.2	1030	1030
<i>Culex</i>	<i>laticinctus</i>	17.4	22.5	6.7	9.7	314	1280
	<i>mattinglyi</i>	18	25.6	7.8	8	2285	3546
	<i>perexiguus</i>	18.6	34.5	7.8	8.1	467	3968
	<i>pipiens</i>	14.8	34.6	7.5	11.1	134	4934
	<i>pusillus</i>	25.6	38	7.2	9.1	1024	5504
	<i>quinquefasciatus</i>	24	33	7.6	11.1	403	2912
	<i>simpsoni</i>	27.3	38	8.1	9.4	218	5504
	<i>sinaiticus</i>	29.1	29.1	8.1	8.1	1574	1574
	<i>theileri</i>	26.1	33	8.1	9.2	403	3034
	<i>tritaeniorhynchus</i>	24.7	36.9	7.8	10.3	403	5504
	<i>univittatus</i>	25.6	38	7.9	9.2	461	3034
<i>Culiseta longiareolata</i>	19	33	6.5	11.1	90	9920	

**Table 4. Breeding site characteristics of mosquito larvae in Riyadh Region**

Larva sp.	Size		Turbidity		Water movement		Shadow		Algae		Aquatic plant	
	Small	Big	Clear	Turbid	Running	Stagnant	P	A	P	A	P	A
<i>Aedes caspius</i>	0	4	0	4	2	2	4	0	4	0	4	0
<i>coustani</i>	1	1	2	0	1	1	2	0	1	1	1	1
<i>d'thali</i>	1	5	2	4	0	6	5	1	5	1	4	2
<i>multicolor</i>	0	1	0	1	0	1	1	0	1	0	0	1
<i>pretoriensis</i>	1	0	1	0	1	0	1	0	1	0	0	1
<i>stephensi</i>	1	1	2	0	1	1	1	1	2	0	0	2
<i>subpictus</i>	0	3	2	1	0	3	2	1	3	0	1	2
<i>turkhudi</i>	0	1	1	0	0	1	1	0	1	0	0	1
<b>Total</b>	<b>4</b>	<b>12</b>	<b>10</b>	<b>6</b>	<b>3</b>	<b>13</b>	<b>13</b>	<b>3</b>	<b>14</b>	<b>2</b>	<b>6</b>	<b>10</b>
<i>laticinctus</i>	9	1	3	7	0	10	1	9	9	1	2	8
<i>mattinglyi</i>	1	1	0	2	0	2	1	1	2	0	1	1
<i>perexiguus</i>	4	2	3	3	1	5	3	3	3	3	3	3
<i>pipiens</i>	35	13	21	27	8	40	39	9	28	20	11	37
<i>pusillus</i>	2	6	3	5	2	6	6	2	7	1	6	2
<i>quinquefasciatus</i>	11	2	7	6	3	10	8	5	8	5	1	12
<i>simpsoni</i>	1	3	3	1	1	3	3	1	3	1	2	2
<i>sinaiticus</i>	0	1	0	1	1	0	1	0	1	0	1	0
<i>theileri</i>	1	2	3	0	0	3	2	1	3	0	2	1
<i>tritaeniorhynchus</i>	0	6	4	2	1	5	3	3	5	1	4	2
<i>univittatus</i>	2	6	6	2	2	6	3	5	7	1	5	3
<b>Total</b>	<b>66</b>	<b>43</b>	<b>53</b>	<b>56</b>	<b>19</b>	<b>90</b>	<b>70</b>	<b>39</b>	<b>76</b>	<b>33</b>	<b>38</b>	<b>71</b>
<i>Culiseta longiareolata</i>	33	12	26	19	3	42	28	17	27	18	7	38
<b>Total</b>	<b>103</b>	<b>71</b>	<b>89</b>	<b>85</b>	<b>27</b>	<b>147</b>	<b>115</b>	<b>59</b>	<b>121</b>	<b>53</b>	<b>55</b>	<b>119</b>

P: Present; A: Absent.

Table 5. Sites and numbers of *Culex* larvae collected in Riyadh Region (according to GPS readings)

No.	Site	Coordinates		Altitude (m)	<i>Culex</i>										Total	
		N:	E:		<i>laticinctus</i>	<i>meatingyi</i>	<i>perexiguus</i>	<i>pipiens</i>	<i>pustillus</i>	<i>quinquefasciatus</i>	<i>simpsoni</i>	<i>shelleri</i>	<i>tritatorhynchus</i>	<i>univittatus</i>		
1	Al arawiya	26°30.081	045°20.036	612	0	0	0	31	0	0	0	0	0	0	0	31
2	Khamasin	20°28.620	044°34.527	696	0	0	354	69	0	0	0	0	0	0	432	855
3	Adriyah	24°46.575	046°31.845	670	0	0	18	0	14	0	0	0	0	0	0	32
4	Duwadmi	24°31.506	044°25.036	963	269	9	14	3	340	0	19	0	0	114	0	768
5	At Riyad	24°35.037	046°42.677	584	0	0	29	639	0	874	3	27	0	20	25	1617
6	Zulfi	26°32.711	044°40.257	630	0	7	0	58	0	0	0	0	0	0	0	65
7	Asiyyal	20°27.540	045°34.493	616	0	0	0	858	0	318	0	0	0	0	0	1176
8	Amariyah	24°49.847	046°29.627	697	0	0	0	544	0	119	0	11	0	0	33	707
9	Al ghat	26°00.429	045°01.325	715	0	0	0	21	0	0	0	0	0	0	0	21
10	Alghayl	22°36.046	046°27.169	726	0	0	0	14	0	0	13	0	0	5	0	32
11	Alqarnah	25°08.566	046°09.747	721	0	0	0	19	0	0	0	0	0	0	0	19
12	Alquwayyah	24°15.253	045°36.311	700	168	0	0	0	0	0	0	0	0	0	0	168
13	Al laddam	20°28.500	044°47.143	695	0	0	0	80	0	0	0	0	0	0	0	80
14	Almajma'ah	25°52.809	045°19.710	750	0	0	0	72	0	0	0	0	0	0	0	72
15	Muzalmiya	24°28.147	046°13.897	636	0	0	0	15	0	82	0	0	0	0	0	97
16	jamajim	26°46.001	045°19.828	575	0	0	0	17	0	0	0	0	0	0	0	17
17	Thadiq	25°16.823	045°52.561	726	0	0	0	0	0	50	0	0	0	0	0	50
18	Hursaymli	25°07.544	046°07.404	769	0	0	0	7	0	0	0	0	0	0	0	7
19	Hilban	23°31.064	044°25.674	932	0	0	0	119	0	0	0	0	0	0	0	119
20	Rumrah	25°10.163	046°48.822	645	0	0	0	10	0	0	0	0	0	0	0	10
21	Sitarah	22°36.831	046°18.930	799	0	0	0	0	86	0	35	0	0	0	69	190
22	Sudus	25°03.955	046°10.509	848	0	0	0	0	0	0	0	20	0	39	0	59
23	shaqra*	25°18.061	045°11.629	720	0	0	0	529	0	0	0	0	0	0	0	529
24	Durma	24°36.274	046°07.192	647	0	0	0	550	0	0	0	0	0	0	0	550
25	Iraqh	24°40.460	046°36.651	631	0	0	0	687	0	0	0	0	0	0	3	690
26	Aifif	23°54.879	042°55.430	1051	0	0	0	40	0	0	0	0	0	0	0	40
27	Malhann	25°09.540	046°18.060	713	0	0	0	78	0	7	0	0	6	20	0	111
<b>Total</b>					<b>437</b>	<b>16</b>	<b>397</b>	<b>4478</b>	<b>426</b>	<b>1464</b>	<b>70</b>	<b>27</b>	<b>37</b>	<b>198</b>	<b>562</b>	<b>8112</b>

*Culex* larvae were collected from many different and diverse habitats in which the pH ranged between 6.7-11.1, water temperature varied between 14.8-38°C and TDS ranged between 134-5504 ppm (Table 3). The larvae were collected from small stagnant shady water collections with algae, clear or turbid water accumulations, slowly running irrigation canals, fountains and sewage drains (Table 4). In general, *Culex* larvae preferred shallow water, especially when green algae are present.

#### **b. *Culiseta* larvae**

In this study, 1691 *Culiseta* larvae were collected and they all belong to *Cs. longiareolata* (Table 6). These larvae are widespread in Riyadh Region, and collected from Durma (300 larvae), Malham (220 larvae), As sulayyl (218 larvae), Dirrhyia (142 larvae) and Sudus (121 larvae). *Culiseta* larvae were collected from breeding sites in which the pH varied between 6.5-11.1, water temperature ranged between 19-33°C and TDS ranged between 90-9920 ppm (Table 3).

The breeding sites of *Culiseta longiareolata* are widespread (Table 4). The larvae were collected from small or big shady stagnant or slowly running water collections with algae.

#### **c. *Aedes* larvae**

During this survey, 391 *Aedes* larvae were collected, and all of them were *Ae. caspius*. Out of these, 330 *Aedes* larvae were collected from Al Khamasin, 59 from Ad duwadmi and 2 larvae from Riyadh (Table 7). Water temperature in the breeding sites of *Ae. caspius* ranged between 27.8°C (in winter) and 36.9°C (in summer), pH varied between 7.1-9.1 and TDS between 1574-9600 ppm (Table 3). Most of *Ae. caspius* larvae were found in stagnant or slowly running shady turbid water collections with submerged aquatic plants and algae (Table 4).

#### **d. *Anopheles* larvae**

Distribution of *Anopheles* larvae collected in Riyadh Region is shown in Table 8. During this study, 130 *Anopheles* larvae were collected, and they belong to seven different species. These were: *Anopheles (Anopheles) coustani* Laveran, *An. (Cellia) d'thali* Patton, *An. (Cel.) multicolor* Cambouliou, *An. (Cel.) pretoriensis* Theobald, *An. (Cel.) stephensi* Liston, *An. (Cel.) subpictus* Grassi and *An. (Cel.) turkhudi* Liston. Different *Anopheles* larvae were collected from Sitara (61 larvae), Riyadh (30 larvae), Al Khamasin (22 larvae) and Ad duwadmi (1 larva). Among these larvae, *An. d'thali* was the most prevalent (39 larvae, 30%), followed by *An. subpictus* (36 larvae, 27.69%) and *An. stephensi* (27 larvae, 20.77%). During this study, only one larva of *An. multicolor* was collected.

Most of *Anopheles* larvae were collected from small clear stagnant shady water collections with algae. Water temperature ranged between 25.4-38°C, pH varied between 7-10.7 and TDS varied between 250-9600 ppm (Table 3). The *Anopheles* larvae were also collected from shady, clear or turbid stagnant water accumulations with algae (Table 4).

**Table 6. Sites and numbers of *Culiseta* larvae collected in Riyadh Region (according to GPS readings)**

No.	Site	Coordinates		Altitude (m)	<i>Culiseta longiareolata</i>
		N:	E:		
1	Artawiya	26°30.081	045°20.036	612	95
2	Addiriyah	24°46.575	046°31.845	670	10
3	Ad duwadmi	24°31.506	044°25.036	963	142
4	Riyadh	24°35.037	046°42.677	584	13
5	Zulfi	26°32.711	044°40.257	630	2
6	Assulayl	20°27.540	045°34.493	616	9
7	Ammariyaha	24°49.847	046°29.627	697	218
8	Al ghat	26°00.429	045°01.325	715	18
9	Alqarinah	25°08.566	046°09.747	721	40
10	Al quwaiyah	24°15.253	045°36.311	700	14
11	Al majmaah	25°52.809	045°19.710	750	41
12	Muzzahmiya	24°28.147	046°13.897	636	13
13	Almashalla	24°26.620	046°06.740	727	55
14	Haddar	21°52.975	045°55.505	748	27
15	Umm jamajim	26°46.001	045°19.828	575	9
16	Thadiq	25°16.823	045°52.561	726	104
17	Hurriymila	25°07.544	046°07.404	769	108
18	Hilban	23°31.064	044°25.674	932	47
19	Ramah	25°10.163	046°48.822	645	8
20	Sodus	25°03.955	046°10.509	848	121
21	Durma	24°36.274	046°07.192	647	300
22	Irqa	24°40.460	046°36.651	631	2
23	Mizil	23°59.302	045°10.587	872	35
24	Malham	25°09.540	046°18.060	713	220
25	Na'am	23°37.587	046°37.947	587	40
<b>Total</b>					<b>1691</b>

**Table 7. Sites and number of *Aedes* larvae collected in Riyadh Region (according to GPS readings)**

No.	Site	Coordinates		Altitude (m)	<i>Aedes caspius</i>
		N:	E:		
1	Al Khamasin	20°28.620	044°44.527	696	330
2	Ad duwadmi	24°31.506	044°25.036	963	59
3	Ar Riyadh	24°35.037	046°42.677	584	2
<b>Total</b>					<b>391</b>

Table 8. Sites and numbers of *Anopheles* larvae collected in Riyadh Region (according to GPS readings)

Site	Coordinates		Altitude (m)	<i>Anopheles</i>							Total		
	N:	E:		<i>coustanti</i>	<i>d'thali</i>	<i>multicolor</i>	<i>pretoriensis</i>	<i>stephensi</i>	<i>subpicus</i>	<i>turkkudi</i>			
Al Khmasin	20°28.620	044°44.527	696	0	21	0	0	0	0	0	1	0	22
Ad duwadimi	24°31.506	044°25.036	963	0	0	1	0	0	0	0	0	0	1
Riyadh	24°35.037	046°42.677	584	6	0	0	0	0	24	0	0	0	30
Shaddadiya	23°12.728	046°53.736	595	0	0	0	0	0	0	4	0	0	4
Ammariyah	24°49.847	046°29.627	697	0	0	0	0	6	0	0	0	0	6
Sitarah	22°36.831	046°18.930	799	0	15	0	0	0	0	31	15	15	61
Sodus	25°03.955	046°10.509	848	0	3	0	0	0	0	0	0	0	3
Irqa	24°40.460	046°36.651	631	0	0	0	0	0	3	0	0	0	3
<b>Total</b>				<b>6</b>	<b>39</b>	<b>1</b>	<b>6</b>	<b>27</b>	<b>36</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>130</b>

## Discussion

In this study, 20 mosquito larvae species, which belong to four genera, were encountered in Riyadh Region. Among the mosquito larvae collected, four species were reported for the first time in Saudi Arabia. These were *Cx. mattingli*, *Cx. perexigus*, *An. pretoriensis* and *An. subpictus*. With the exception of *Cx. pipiens*, the remaining 19 mosquito larvae species were reported for the first time in Riyadh Region [4]. These results show clearly that mosquitoes have become widespread in Riyadh Region, and further ecological and biological studies are required before embarking on large-scale control projects.

The study has shown that *Culex* larvae were the most abundant and widespread in Riyadh Region. They were collected from different habitats. This clearly shows that *Culex* larvae have great degree of adaptability to different habitats than other mosquito larvae. Further ecological studies on larval habitats and larval distribution in Riyadh Region are needed.

During the survey, seven species of *Anopheles*, the vector of human malaria, and *Cx. tritaeniorhynchus*, the main vector of Rift Valley fever in the Southern Region of Saudi Arabia [1], were reported in Riyadh Region. The presence of these two disease vectors constitutes a major potential health problem. Further studies on the vectorial capacity of these disease pathogens vectors are required and every effort should be made to prevent their spread in Riyadh Region.

The results of this study have shown that most of mosquito larvae can survive well in neutral or slightly alkaline water habitats. Similar results were reported by Abdullah and Merdan [9] in Saudi Arabia and Al-Tubiakh [7] in Kuwait. However, MacGregor [10] reported that there were definitely acidophile and alkalinophile species. Woodhill [11] reported that *Cx. fatigans* can survive in acidic habitats, but the rate of development was slow. More studies on physical and chemical properties of water in larval breeding sites in Riyadh Region are required.

In this study, most of mosquito larvae were collected from water accumulations with different degree of turbidity. Hopkins [12] attributed the favorable effect of sunlight on mosquito larval population to the requirement of algae to sunlight. These algae are frequently favorable as larval food or an aid in maintaining the balance of dissolved gases and in utilizing organic materials unfavorable for larvae. Kenawy and El-Sayed [13] reported that turbidity has no significant effect on Culicine larvae; however, habitats that were shaded, vegetated and having stagnant water were generally preferable for larval breeding.

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## انتشار يرقات البعوض (Diptera: Culicidae) وبيئاتها المختلفة في منطقة الرياض بالمملكة العربية السعودية

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(قدم للنشر في ١٤٢٧/٩/٢هـ؛ وقبل للنشر في ١٤٢٨/٥/٤هـ)

**ملخص البحث.** تم حصر أنواع يرقات البعوض ودراسة أماكن تكاثرها وانتشارها في منطقة الرياض خلال الفترة من مارس ٢٠٠٣م حتى مارس ٢٠٠٥م. تم في هذه الدراسة جمع ١٠٣٢٤ يرقة بعوض من ٣٢ موقعاً في منطقة الدراسة وكانت تمثل ٢٠ نوعاً، منها ١١ نوعاً تنتمي إلى جنس *Culex*، و٧ أنواع تنتمي إلى جنس *Anopheles*، ونوع واحد ينتمي لكل من الجنسين *Aedes* و *Culiseta*. من بين اليرقات التي جمعت كانت هناك ٨١١٢ يرقة (*Anopheles* ٧٨.٥٧٪، *Culex* ١٦٩١ (*Culiseta* ١.٦٦،٣٨٪) يرقة، و٣٩١ (*Aedes* ٣.٧٩٪) يرقة، و١٣٠ (*Aedes* ١.٢٦٪) يرقة *Anopheles*. يرقات *Culex* التي تم جمعها في هذه الدراسة هي:

*Culex (Barraudius) pusillus* Macquart *Cx. (Cx.) laticinctus* Edwards, *Cx. (Cx.) mattinglyi* Knight *Cx. (Cx.) perexguus* Theobald, *Cx. (Cx.) pipiens* L., *Cx. (Cx.) quinquefasciatus* Say, *Cx. (Cx.) simpsoni* Theobald, *Cx. (Cx.) sinaiticus* Kirkpatrick, *Cx. (Cx.) tritaeniorhynchus* Giles, *Cx. (Cx.) theileri* Theobald and *Cx. (Cx.) univittatus* Theobald.

أما يرقات *Anopheles* التي تم جمعها هي:

*Anopheles (Anopheles) coustani* Laveran, *An. (Cellia) d'thali* Patton, *An. (Cel.) multicolor* Cambouliou, *An. (Cel.) pretoriensis* Theobald, *An. (Cel.) stephensi* Liston, *An. (Cel.) subpictus* Grassi and *An. (Cel.) turkhudi* Liston.

تم أيضاً جمع يرقات البعوض من النوعين:

*Aedes (Ochlerotatus) caspius* Pallas and *Culiseta (Allotheobaldia) longiareolata* Macquart.

تمت دراسة بعض الخصائص الفيزيائية والكيميائية للماء في مواقع تكاثر يرقات البعوض، فقد كانت درجات حرارة الماء تتراوح بين ١٤.٨-٣٨<sup>o</sup>م، ودرجات الحموضة والقلوية تتراوح بين ٦.٥-١١.١، أما كمية

الأملاح المذابة في الماء كانت تتراوح بين ٩٠-٩٩٢٠ جزء في المليون. تم في هذه الدراسة جمع يرقات البعوض من بيئات مختلفة ، ولكن وجد أن معظم اليرقات تفضل البيئات المائية الصغيرة الظليلة والتي تكون بطيئة التحرك أو التدفق أو راكدة وبها بعض الطحالب أو النباتات المائية بغض النظر عن درجة تعكرها ، هذا وقد تمت مناقشة الصفات البيئية المختلفة لكل نوع من أنواع اليرقات التي تم جمعها.



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