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FAUNA OF MOSQUITO LARVAE (DIPTERA: CULICIDA) IN ASIR PROVENCE, KINGDOM OF SAUDI ARABIA

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Abstract

An entomological survey was undertaken for one year to update the mosquito fauna of Asir Region, Kingdom of Saudi Arabia. A total of 31 species of 8 genera were reported of which genus *Culex* (55%) was the most common. Most of collected larvae (59%) belonged to genus *Culex* (+ *Lutzia*) followed by *Culiseta* (26%), *Anopheles* (13%) and Aedine *spp*. (2%). *Cx*. *pipiens* (39%) and *Cs*. *longiareolata* (26. %) were generally the most abundant of all collected larvae. Of the *Anopheles spp*., *An*. *dthali* was common (40%), of *Culex spp.*, *Cx. pipiens* was predominating (66%) and of Aedine *spp.*, *St*. *aegypti* was predominating (71%). Four species: *An. fluviatilis*, *Cx*. *mattinglyi, Cx*. *arbieeni* and *Cx*. *mimeticus* were new reports in Asir Region and *Cx*. *wigglesworthi* recorded for the first time from the kingdom. Larvae were more common in low- and highlands than in the moderately altitude areas. In general all species prefer stagnant water but with the exception of Aedine larvae (altogether), the other species prefer presence of algae, vegetation and shade and absence of turbidity (except *Culex spp*.). A total of 98 different forms of association were reported of which 9 forms were common. All genera breed year round with peaks of abundance during spring for *Anopheles spp*. and *Culex spp*. and during winter for Aedine *spp.* and *Cs. longiareolata*. A complete list of mosquito fauna of Asir Region comprising 45 *spp.* was presented based on the present and previous surveys. The study concluded that the occurrence and prevalence of mosquito species mainly the disease vectors in Asir carry the thread of maintaining and transmission of several mosquito-borne diseases.

Key words: Mosquito fauna, Mosquito larvae, Relative abundance, Breeding water characteristics, Seasonal abundance, Asir Province, Saudi Arabia.

Introduction

Asir Province (19°0′N, 43°0′E to 19.000°N, 43.000°E) is located in the southwest of Saudi Arabia sharing a short border with Yemen. It has an area of 81,000 km² and a population of 1,913,392 (2010 Census). Administratively, the Province comprises 12 Governorates and its capital is Abha. Geographically, Asir is situated on a high plateau consists of the highlands that rise to almost 3,000 meters at Jebel Sawdah near Abha which is the extension of the Sarawat mountains parallel to the Red Sea and a narrow sandy coastal strip of lowlands known as Tehamah Plain. The Tehamah Plain is considered to be a geographic extension of the Jizan Region. The area receives more rainfall than the rest of the country. The average annual rainfall in the highlands ranges from 300 to 500 millimeters (12 to 20 inches) and is falling in two rainy seasons, the chief one being in March and April with some rain in the summer. Temperatures are very extreme and in the highlands are generally lower than the other part of the Region. The coastal plain zone is generally characterized by lower rainfall and high temperature and RH.

During the last decade (2000-2010), 16 mosquito surveys were conducted in the Kingdom of Saudi Arabia, of which 6 were focused to the southwestern Region, in particular the Asir Region due to the

epidemic of the Rift Valley fever (RVF) in 2000.

The distribution of mosquitoes in several regions of Saudi Arabia was reported by Mattingly and Knight, 1956; Zahar, 1974; Büttiker, 1981; Wills *et al*, 1985; Al-Seghayer *et al,* 1999; Jupp*et al,* 2002; Abdoon and Alshahrani, 2003; Alahmed *et al.,* 2007; 2009; Al Ghamdi *et al,* 2008; AI-Ali *et al,* 2008; Al Ahmed *et al*, 2010; Ahmed *et al*, 2011 and Alahmed, 2012. Moreover, mosquitoes were surveyed in Asir Region or generally in the south western area by some workers. Abdullah and Merdan (1995) reported 9 mosquito species: 4 Anophelines, 3 Culicines, 1 Aedine and *Culiseta subochrea* in Asir. Miller *et al.* (2002) carried out a survey following the outbreak of RVF in Asir to assess the potential mosquito vectors in the Region and get virus isolate from *Ae. vexans arabiensis* females collected near the city of Muhayil. In addition, the authors collected 5 *Aedes*, 2 *Anopheles*, 4 *Culex* species. Abdoon and Alshahrani (2003) studied the prevalence and distribution of Anopheline mosquitoes in malaria endemic areas of Asir Region and reported 7 species. Marvin *et al.* (2003) conducted entomological surveillance in Asir, Jizan, and Makkah Regions following the appearance of RVF in Asir and collected *Aedes* (*Stegomyia*) *unilineatus* from Muhayil and near Rejal Almaa which represented the first record of this species from the Arabian Peninsula. Abdoon (2004) recorded for the first time three afrotopical *Culex* species in Asir Region.

In Saudi Arabia, several mosquito species are important as vectors of diseases. The most common mosquito-borne diseases include dengue (Fakeeh and Zaki, 2001; 2003; Ayyub *et al,* 2006; Khan *et al,* 2008), filariasis (Sebai *et al*, 1974; Omar, 1996), malaria (Warrel, 1993; Al-Seghayer *et al*, 1999; Abdoon and Alshahrani, 2003) and RVF (Jupp *et al,* 2002; Miller *et al,* 2002; Al-Hazmi *et al,* 2003; Balkhy and Memish, 2003; Madani *et al,* 2003).

For the past few decades, Saudi Arabia has witnessed tremendous advances in social development and urbanization in almost all Regions (Alahmed, 2012; Abdullah and Merdan, 1995) which presumably have affected the insect fauna, particularly mosquitoes (Al Ahmed *et al,* 2010).

The present work was undertaken to update and study the distribution and some ecological aspects of mosquitoes in Asir Region.

Materials and Methods

The study included a total of 24 sites in 12 localities representing 8 out of the 12 Governorates of Asir Province (Fig. 1). The coordinates and elevation above sea level were recorded for each study site using a global positioning system (GPS) unit. The survey was carried out monthly (June 2009 to May 2010) in Abha "18°13′1″N, 42°30′19″E" (Abha dam and valley), Bishah "20°0′0″N, 42°36′0″E" (Sheep market and Northern belt), Muhayil "18° 31′ 590″ N, 041°57′ 899″ E" (Hela valley) and Al Namas "19°07′12″N, 42°07′48″E" (Tanomah dam and valley, Al mehfar resort and Red mountain valley). The other Governorates: Sarat Abidah "18° 00′ 852″ N, 043° 09′ E" (Sarat Abidah city, Al Goba dam and El Raboaa), Rejal Almaa "18° 14′ 590″ N, 042° 16′ 538″ E" (Rejal Almaa city), Balqarn "19° 33′ 763″ N, 041° 56′ 954″ E" (Al Kobri village and Balqarn valley) and Tathleth "19° 13′ 825″ N, 043° 31′ 456″E" (Tathleth city) were infrequently surveyed (twice or three times during the year period).

In each site, inspections of the water bodies for mosquito larvae were carried out by using a plastic dipper, 125 mm in diameter with a 90 cm wooden handle. Three samples of 10 dips per breeding site were taken. Collected larvae were placed in labeled plastic bags and transported to the laboratory in an ice box containing cold water to prevent overheating. At the laboratory, 3rd and 4th larval instars were

identified according to published keys of Hopkins (1952), Mattingly and Knight (1956) and Hardback (1985; 1988).

Along with larval collection, the natural characteristics of the breeding water were recorded as present or absent and included: algae, aquatic vegetation, shade, turbidity due suspended particles and movement. The frequency of occurrence (%) of each reported species related to the presence or absence of such characters were examined and analyzed by Chi-squared test. The ranges of associated species with the most frequent species were calculated. The seasonal abundance of the different genera of the reported species was also examined. Based on the reported species in this survey and those in previous reports, a complete list of mosquito fauna of Asir Region was presented.

Results

A total of 31 species were reported (Tab. 1): 8 *Anopheles spp*. (25.81%), 17 *Culex spp.* (54.84%) and one species each of *Lutzia* (= *Culex*), *Aedimorphus* (=*Aedes*), *Fredwardsius* (=*Aedes*), *Ochlerotatus*, *Stegomyia* (=*Aedes*) and *Culiseta.* A total of 7247 larvae were collected, most of them (4304: 59.39%) belonged to genus *Culex* (+*Lutzia*) followed by *Culiseta* (1896: 26.16%), *Anopheles* (942: 13%) and *Aedes* as represented by *Aedes*, *Aedimorphus*, *Fredwardsius*, *Ochlerotatus* and *Stegomyia* (105: 1.45%). *Culex pipiens* (2827 larva: 39.01%) and *Cs*. *longiareolata* (1896 larva: 26.16%) were generally the most abundant of all species. Of the *Anopheles spp*., *An*. *dthali* was common (40.13%: 378/942 larva) while *An*. *culicifacies* and *An. fluviatilis* were rare (0.21%: 2/942 larva each). Among the *Culex spp.*, *Cx. pipiens* was predominating (65.68%: 2827/4304 larva) while *Cx. nebulosus, Cx*. *perexiguus* and *Cx*. *wigglesworthi* were rare (altogether 0.16%: 7/4304 larva). Of Aedine *spp.*, *St*. *aegypti* (=*Ae*. *aegypt*i) was predominating (71.43%: 75/105 larva) while *Am*. *v. arabiensis* (=*Ae. v. arabiensis*) was uncommon (3.81%: 4/105 larva).

The number of the reported species varied among the surveyed Governorates. The heavily infested Governorates were Muhayil and Al Namas (23 *sp* each out of 31 total *sp.*: 74.19%) followed by Abha (12 *sp.*: 38.71%), Bishah (10 *sp*.: 32.26%), Rejal Almaa (6 *sp.*: 19.35%), Balqarn and Sarat Abidah (4 *sp*. each: 12.90%), and Tathleth (2*sp*.: 6.45%). The distribution of the species in relation to the altitude ranges of the surveyed localities is presented in Table 2. The results indicated that mosquito larvae were more common in lowlands "<500 m" and highlands ">2000 m" (23 and 25 *sp.*, respectively out of 31) than in the moderately altitude areas (1100 -1200 m). All species except *An*. *culicifacies*, *Cx*. *arbieeni*, *Cx. bitaeniorhynchus*, *Cx. duttoni*, *Cx. mattinglyi*, *Cx. nebulosus*, *Cx*. *quinquefasciatus* and *Cs. longiareolata* were collected in Muhayil (378-465 m). Only *An*. *arabiensis*, *An. cinereus, An*. *dthali*, *Cx. bitaeniorhynchus, Cx. laticinctus, Cx*. *mimeticus*, *Cx*. *pipiens, Cx*. *quinquefasciatus*, *Cx. simpsoni, Cx. sinaiticus, Cx*. *theileri*, *Lt*. *tigripes*, *Oc. caspius* and *Cs*. *longiareolata* were reported in moderately altitude areas. All species except *An*. *arabiensis, An. fluviatilis*, *An*. *multicolor*, *An*. *sergentii*, *Cx*. *wigglesworthi*, and *Am*. *v. arabiensis* were reported in the highlands.

Results of the occurrence frequency (%) of larvae related to presence/absence of the breeding water characteristics (Tab. 3) revealed that in general, except for *Aedine spp.* (altogether) the others prefer presence of algae (65-83%), vegetation (55-64%) and shade (67-75%). Both *Culex spp.* (64%) and *Aedine spp.* (75%) prefer turbid water while *Anopheles spp.* (72%) and *Culiseta* sp. (65%) prefer clear water. All species prefer stagnant water (75-100%). Each single species prefers +/- of certain character: (1) Algae: most of the species prefer the presence of algae except *Cx. decens*, *Fr. vittatus* and *St. aegypti* that breed only in

water devoid of algae (100%, P<0.05), *Cx. laticinctus* prefers (P>0.05) absence of algae (57%) and *Cx. duttoni, Cx. mattinglyi, Cx. mimeticus* and *Oc. caspius* indiferentially breed (50%, P>0.05) in presence or absence of algae. (2) Aquatic vegetation: most of the species prefer presence of vegetation except *Cx. simpisoni*, *Fr. vittatus* and *St. aegypti* that breed only in water free of vegetation (100%, P<0.05), *Cx. laticinctus* and *An. cinerius* prefer (P>0.05) absence of vegetation (57% and 80%, respectively) than its presence and *Cx. duttoni*, *Cx. mimeticus, Cx. pipiens* and *Oc. caspius* indiferentially breed (50%, P>0.05) in presence or absence of vegetation. (3) Shade: most of the species prefer shaded sites than those exposed to sun except *Cx. decens, Cx. simpisoni*, *Cx. tritaeniorhynchus, Fr. vittatus* and *St. aegypti* that breed in water completely exposed to sun (100%, P<0.05), *Cx. theileri* prefers (P>0.05) sunny sites (57%) than shaded ones and *Cx. duttoni, Cx. mattinglyi, Cx. mimeticus,* and *Oc. caspius* breed (P>0.05) in the presence or absence of shade (50%). (4) Turbidity: most of the species prefer clear water than turbid water except *Cx. simpisoni*, *Cx. tritaeniorhynchus, Cx. wigglesworth, Fr. vittatus* and *Oc. caspius* that breed only in turbid water (100%, P<0.05) and *Cx. arbieeni, Cx. duttoni, Cx. mimeticus, Cx. pipiens* and *Cx. salisburiensis* indiferentially breed (50%, P>0.05) in presence or absence of turbidity. (5) Water movement: most of the species prefer sites having stagnant water than those having running water except *Cx. duttoni, Cx. mimeticus* and *Oc. caspius* that indiferentially breed (50%, P>0.05) in stagnant or moving water.

The joint occurrence or association among the reported species was recorded. A total of 98 different forms of association were reported for the more frequent species. The different species had different ranges of associated species (Tab. 4): *Cs. longiareolata* had association with 15 species, both *Cx. pipiens* and *Cx. tigripes* had 13 species, *Cx. theileri* had 12 species, *An. cinereus* had 10 species, *An. turkhudi*, *Cx. laticinctus* and *Cx. sinaiticus* had 9 species each and *Cx. salisburensis* had 8 species. Of the different forms, the common ones were *An. turkhudi-Cx. theileri, An. turkhudi-Cx. tigripes, An. turkhudi-Cs. longiareolata*, *Cx. pipiens-Cx. tigripes, Cx. pipiens-Cs. longiareolata*, *Cx. theileri-Cx. sinaiticus, Cx. theileri-Cx. tigripes, Cx. theileri-Cs. longiareolata* and *Cx. tigripes-Cs. longiareolata.*

All reported genera were found breeding a year round (Fig. 2) with peaks of abundance during spring months for *Anopheles* (14.00 larva/10 dip) and *Culex* (35.35 larva/10 dip) and during winter for Aedine *spp.* (2.94 larva/10 dip) and *Cs. longiareolata* (9.29 larva/ 10 dip).

Based on the results of the present survey and reports of the previous surveys, a complete list of mosquito fauna in Asir Region that comprises 45 species was prepared and presented in Table 5.

Discussion

Totally, 31 species of 8 genera were reported of which *Culex* was the most abundant genus (*ca*. 55% of the reported species), followed by *Anopheles* (*ca*. 26%), Aedine *spp*. (*ca*. 13%), and *Lutzia* and *Culiseta* (3% each). Similar result was obtained by Al Ahmed *et al.* (2010) in the adjacent Region, Najran where *Culex spp.* represented 54.48% followed by *Anopheles* (34.99 %) and *Aedes* (0.34%). The wide spreading of *Culex* larvae may 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 (Alahmed, 2012).

Culex pipiens (*ca*.39%) and *Cs. longiareolata* (*ca*.26%) were the most abundant of all collected larvae. Similarly of 26 larval *spp.* collected in Abha (Al Ahmad *et al.*, 2011), Cx. *tritaeniorhynchus* (1344 larva), *Cx. pipiens* (1036 larva), and *Cs. longiareolata* (847 larva) were the common species. Of the *Anopheles* larvae, *An. dthali*

was common (*ca*.40%) in agreement with the findings of Abdoon and Alshahrani (2003) in Asir and of Al Ahmad *et al.* (2011) in Abha. Among the *Culex spp.*, *Cx. pipiens* was predominating (*ca*. 66%). Abdullah and Merdan (1995) reported that *Cx. pipiens* is the most common Culicine *spp.* in the Southwestern Region. AI-Ali *et al.* (2008) in Al Madinah encountered 7 *Culex spp*. of which *Cx. pipiens* was the most common (59.3% adults and 60% larvae). Of the Aedine *spp.*, *St*. *aegypti* was predominating (*ca*.71%). Similarly, out of 5 Aedine *spp.* collected in Abha, *St*. *aegypti* (102 larva) was the most common species (Al Ahmad *et al*, 2011).

According to the previous surveys, 14 species were missed during the present study. These are *An*. (*Ano.*) *tenebrosus* Dönitz, *An*. (*Cel*.) *gambiae* Giles s.l, *An*. (*Cel*.) *pretoriensis* Theobald, *An.* (*Cel.*) *rupicolus* Lewis, *An*. (*Cel*.) *stephensi* Liston, *An*. (*Cel*.) *subpictus* Grassi s.l, *Cx*. (*Cux*.) *sitiens* Wiedmann, *Cx*. (*Cux*.) *torrentium* Martini, *Cx*. (*Cux*.) *univittatus* Theobald, *Aedes (St.*) *unilineatus* (Theobald), *Oc*. (*Och*.) *caballus* (Theobald), *Oc*. (*Och*.) *detritus* (Haliday), *Cs*. (*Cs*) *subochrea* Edwards and *Orthopodomyia sp.* (Abdullah and Merdan, 1995; Miller *et al*, 2002; Abdoon and Alshahrani, 2003; Godsey *et al*, 2003; Ahmed *et al*, 2011; Al Ahmad *et al*, 2011). Consequently, mosquito fauna of Asir Region comprises 45 species: 14 *Anopheles*, 20 *Culex*, 1 *species* each of *Lutzia, Aedes, Aedimorphus*, *Fredwardsius, Stegomyia* and *Orthopodomyia,* 3 *Ochlerotatus* (and 2 *Culiseta.*

In the present study, five of the reported species were not encountered before in Asir Region, these are: (1) Species that were reported in other Regions: *An. fluviatilis* in Dammam (Büttiker, 1981), Eastern Region (Wills *et al*, 1985; Alahmed, 2012) and Jeddah (Al Ghamdi *et al*, 2008) and *Cx. mattinglyi* in Riyadh (Al Ahmad *et al*, 2011), (2) Species that were reported in the neighboring and other Regions: *Cx. arbieeni* in Najran (AL Ahmed *et al*, 2010), Al Madinah (Kheir *et al*,2010) and Makkah (Alahmad *et al*, 2009), and *Cx*. *mimeticus* in Jizan, Al Bahah and Makkah (Khater *et al,* 2013). So that, these four species may be considered a new report in Asir Region, (3) *Cx*. *wigglesworthi* collected in Muhayil was not reported in any Region of the Kingdom so that may be considered a new record in the kingdom of Saudi Arabia

The finding that Rejal Almaa, Balqarn, Sarat Abidah and Tathleth yielded low numbers of species (2-*6 sp*.: *ca.* 7-19%) comparable to the other Governorates (Muhayil, Al Namas and Abha, 10-23 *sp.*: *ca.*32-74%) is due to that these governorates were surveyed for short periods.

Examining the distribution of the different species in relation to altitudes of the surveyed localities revealed that mosquito larvae were more common in low- and highlands than in the moderately altitude areas. Although few species (*An*. *cinereus, An*. *dthali, Cx*. *laticinctus, Cx. mimeticus, Cx*. *pipiens, Cx*. *simpsoni, Cx*. *sinaiticus, Cx*. *theileri, Lt. tigripes* and *Oc*. *caspius*) have no distinct altitude range and occur in all altitudes, still some species have specific ranges for example: (1) *An. fluviatilis*, *An*. *multicolor, An*. *sergentii, Cx*. *wigglesworthi* and *Am*. *v. arabiensis* were reported only from lowlands, (2) *An*. *culicifacies*, *Cx*. *arbieeni, Cx*. *duttoni*, *Cx. mattinglyi* and *Cx. nebulosu*s were restricted to highlands, (3) *An*. *turkhudi, Cx. decens, Cx*. *perexiguus*, *Cx. salisburensis*, *Cx*. *tritaeniorhynchus*, *Fr. vittatus* and *St. aegypti* were reported from low- and highlands, (4) *Cx. bitaeniorhynchus*, *Cx*. *quinquefasciatus* and *Cs*. *longiareolata* were reported from moderately altitude areas and highlands while (5) *An*. *arabiensis* was reported from lowlands and moderately altitude areas. In only single study on this respect in Asir, Abdullah and Merdan (1995) collected *An. arabiensis* and *Cx. pipiens* in different altitudes from sea level up to highlands, *An. sergentii* from Red sea costal area (RSCA)

and Muhayil (500 m) which is moderately elevated area while collection failed at highlands, *An. multicolor* at the RSCAs and also at a relatively elevated place of Tehamah Asir, *Cx. quinquefaciatus* from the RSCA, *Cx. theileri* at highlands (Najran, khamis Mushait and Al Namas, 1700-2400 m), and *Ae. caspius* at sea level, moderately elevated and highlands (Abha, Bihshah and Al Namas).

Mosquito larvae showed different preference for the natural characters of their breeding water, but in general with the exception of Aedine larvae (altogether), the other species prefer presence of algae, vegetation and shade and absence of turbidity (except *Culex spp.*). All species prefer stagnant water. Fritsch (1997) reported that the effect of sunlight or shade varies depending on the mosquito species. The favorable effect of sunlight on mosquito larval population is to the requirement of algae (favorable larval food) to sunlight. Sattler *et al.* (2005) indicated that in turbid breeding sites, Culicine larvae are much more likely to be present, whereas the *Anopheles* larvae are much more likely to be absent. The presence of floating plants and algae provide optimal breeding conditions for mosquito larvae by acting as food sources, shelter from predators and creates stagnant conditions by decreasing water movement (Greenway *et al*, 2003) and offering newly emerged adults and gravid mosquitoes a shaded resting site (Mutuku *et al,* 2009). In Egypt, most of mosquito larvae significantly prefer stagnant water (Ammar *et al*, 2013).

Different forms of association among mosquito larvae were observed of which 9 forms: *An. turkhudi* with *Cx. theileri, Cx. tigripes* and *Cs. longiareolata*; *Cx. pipiens* with *Cx. tigripes* and *Cs. longiareolata*; *Cx. theileri* with *Cx. sinaiticus, Cs. longiareolata*, and *Cx. tigripes* and *Cx. tigripes* with *Cs. longiareolata* were the common ones. No available reports on mosquito association in any part of the kingdom except that of Abdullah and Merdan (1995) who reported several forms of association in Asir. These are *An. arabiensis* with *An. tenebrosus*, *Cx. pipiens* and *Cx. theileri; An. sergentii* with *Cx. pipiens*, *Cx. quinquefasciatus* and *Cs. subochrea*; *An. multicolor* with *Cx. quinquefasciatus, Oc. caspius,* and *Cs. subochrea; Cx. pipiens with Cx. quinquefasciatus, Cx. theileri, Oc. caspius,* and *Cs. subochrea; Cx. theileri* with *Oc. caspius* and *Cs. subochrea* and *Oc. caspius* with *Cx. quinquefasciatus* and *Cs. subochrea.*

Mosquitoes were found breeding all year round with peaks of abundance during spring for *Anopheles* and *Culex spp.* and during winter for *Aedine spp*. and *Cs. longiareolata*, *i.e.* during mild and cold months almost similar to observation of Abdullah and Merdan (1995) in Asir. Ahmed *et al.* (2011) reported that mosquitoes in AL Ahsaa are prevalent in both winter and spring seasons, rarely encountered in summer and are found in moderation during the autumn months.

Several mosquito species of Asir Region are implicated as vectors of diseases either in Asir or in several other parts of the Kingdom. *An. arabiensis* is a primary vector and *An. sergentii* is a secondary vector responsible for malaria transmission in Asir (Al Seghayer *et al,* 1999; Abdoon and Alshahrani, 2003). Malaria is highly endemic in the Southwest (Jizan and Asir) where 83% of the Kingdom total cases are reported (Al Seghayer *et al*, 1999). Moreover, other reported *Anopheles spp*. in Asir has roles in malaria transmission in the other parts of the Kingdom for example: *An. stephensi* (Eastern Province) and *An. superpictus* (Northern Province). In addition, *An. fluviatilis* and *An. sergentii* in the Eastern Province are considered as secondary vectors (Daggy, 1959; MOH, 1983). Another species is of importance in malaria transmission in other countries, *An. multicolor,* a suspected oases vector in Egypt (Kenawy *et al*, 1986) and North Africa

(Zahar, 1974) and is regarded as a secondary malaria vector in some localities of Saudi Arabia (Abdoon and Alshahrani, 2003).

Culex mosquitoes, especially *Cx. pipiens* and *Cx. quinquefasciatus,* are the chief vectors of bancroftian filariasis, *Wuchereria bancrofti* in many parts of the world including the Middle East and Eastern Mediterranean countries (AI-Ali *et al.,* 2008). The disease has been reported from the southwestern districts of the Kingdom. Omar (1996) identified *W. bancrofti* among expatriate workers from five South-East Asian countries in Abha and reported that the local *Cx. pipiens* is highly susceptible to the parasite and concluded that this mosquito species may act as a potential vector of introduced bancroftian filariasis to Saudi Arabia. Al-Ali *et al.* (2008) found *Cx. pipiens* to harbor West Nile Virus (WNV) in the examined mosquitoes from Al Madinah and concluded that there is a potential danger of the transmission of WNV in Al Madinah especially by *Cx. pipiens.* Miller *et al.* (2002) and Jupp *et al.* (2002) indicated that *Cx. tritaeniorhynchus* and *Ae. v. arabiensis* are the main proven vectors of RVF virus in the southern part of Saudi Arabia. In mid September 2000, RVF out-break began in Jizan and Yemen, and then extended northwards into Asir and Al Quenfadah. It was the first time to report RVF outside Africa. El-Badry and Al-Ali (2010) reported that *Ae. aegypti* is the primary established indigenous domestic vector of Dengue fever, which was isolated for the first time from an adult in Jeddah in 1994 (Ahmed *et al*, 2011) and from February 1994 via December 2002 the total proved cases were 319 (Fakeeh and Zaki, 2003). Wills *et al.* (1985) isolated Sindbis virus, a human pathogen causing a dengue-like illness from *Cx. univittatus* in Eastern Region.

Conclusion

The outcome data showed that four species: *An. fluviatilis*, *Cx. arbieeni*, *Cx. mattinglyi* and *Cx. mimeticus* are considered as new report in Asir Region and *Cx. wiglesworthi* recorded for the first time from the kingdom. The occurrence and prevalence of different mosquito species mainly the disease vectors in Asir carry the thread of transmission of several mosquito-borne diseases, mainly maintaing malaria and RVF transmission and introduction of other diseases as filariasis and dengue and other viruses.

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Table 1: Reported mosquito species and their relative abundance in Asir Province

Species*	No of collected larvae	
	Total (7247)	%
01. *Anopheles* (*Cellia*) *arabiensis* Patton	164	2.26
02. *An*. (*Cel*.) *cinereus* Theobald	170	2.35
03. *An*. (*Cel*.) *culicifacies* Giles s.l.	2	0.03
04. *An*. (*Cel*.) *dthali* Patton	378	5.22
05. *An. (Cel.) fluviatilis* James	2	0.03
06. *An*. (*Cel*.) *multicolor* Cambouliu	13	0.18
07. *An*. (*Cel*.) *sergentii* Theobald	128	1.77
08. *An*. (*Cel*.) *turkhudi* Liston	85	1.17
09. *Cx*. (*Culex*) *decens* Theobald	13	0.18
10. *Cx*.(*Cux*.) *duttoni* Theobald	43	0.59
11. *Cx*. (*Cux*.) *laticinctus* Edwards	116	1.60
12. *Cx*. (*Cux*.) *mattinglyi* Knight	8	0.11
13. *Cx*. (*Cux*.) *mimeticus* Noè	8	0.11
14. *Cx*. (*Cux*.) *perexiguus* Theobald	3	0.04
15. *Cx*. (*Cux*.) *pipiens* L.	2827	39.00
16. *Cx*. (*Cux*.) *quinquefasciatus* Say	10	0.14
17. *Cx*. (*Cux*.) *simpsoni* Theobald	25	0.34
18. *Cx*. (*Cux*.) *sinaiticus* Kirkpatrik	158	2.18
19. *Cx*. (*Cux*.) *theileri* Theobald	672	9.27
20. *Cx*. (*Cux*.) *tritaeniorhynchus* Giles	206	2.84
21. *Cx*. (*Culiciomyia*) *nebulosus* Theobald,	2	0.03
22. *Cx*. *(Eumelanomyia) wigglesworthi* Edwards	2	0.03
23. *Cx*. (*Maillotia*) *arbieeni* Salem	12	0.17
24. *Cx*. (*Maillotia*) *salisburiensis* Theobald	11	0.15
25. *Cx*. (*Oculeomyia*)*bitaeniorhynchus* Giles	19	0.26
26. *Lutzia* (*Metalutzia*) *tigripes* (de Grandpre & de Charmoy)	169	2.33
27. *Aedimorphus vexans arabiensis* (Patton)	4	0.06
28. *Fredwardsius vittatus* (Bigot)	10	0.14
29. *Ochlerotatus* (*Oc*.) *caspius* (Pallas)	16	0.22
30. *Stegomyia* (*St*.) *aegypti* (L.)	75	1.03
31. *Culiseta* (*Allotheobaldia*) *longiareolata* Macquart	1896	26.16

*In addition to 98 *Culex sp.* and 3 *Anopheles sp*.

Table 2: Mosquito larval species in relation to elevation above sea level of surveyed areas in Asir Province

Species	Low lands: foothills (Muhayil) 378-465 m	Moderately altitude: (Bishah, Rejal Almaa and Tathleth) 1103-1194 m	High lands (Abha, Sarat Abidah, Balqarn and Al Namas) 1770-2388 m
An. arabiensis			
An. cinereus			
An. culicifacies			
An. dthali			
An. fluviatilis			
An. multicolor			
An. sergentii			
An. turkhudi			
Cx. arbieeni			
Cx. bitaeniorhynchus			
Cx. decens			
Cx. duttoni			
Cx. laticinctus			
Cx. mattinglyi			
Cx. mimeticus			
Cx. nebulosus			
Cx. perexiguus			
Cx. pipiens			
Cx. quinquefasciatus			
Cx salisburensis			
Cx. simpsoni			
Cx. sinaiticus			
Cx. theileri			
Cx. tritaeniorhynchus			
Cx. wigglesworthi			
Lt. tigripes			
Am. v. arabiensis			
Fr. vittatus			
Oc. caspius			
St. aegypti			
Cs. longiareolata			
No of species	23	14	25

Table 3: Occurrence frequencies (%) of mosquito larvae in different characteristics of breeding habitats

Genus	Algae +/-	Vegetation +/-	Shade +/-	Turbidity +/-	Water movement +/-
Anopheles	83/17*	61/39	67/33*	28/72*	0/100*
Culex	70/30*	64/36	69/31	64/36	18/82*
*Aedes***	25/75*	25/75*	25/75*	75/25*	25/75*
Culiseta	65/35*	55/45	75/25*	35/65*	20/80*

*Significant P<0.05, **Represented by *Aedes*, *Aedimorphus*, *Fredwardsius*, *Ochlerotatus* and *Stegomyia*.

Table 4: Different forms of association among reported mosquito larvae in Asir Province (♣common forms)

Associated species	*An. cinereus*	*An. turkhudi*	*Cx. laticinctus*	*Cx. pipiens*	*Cx. salisburensis*	*Cx. sinaiticus*	*Cx. theileri*	*Lt. tigripes*	*Cs. longiareolata*
An. cinereus		■	■	■	■	■	■	■	■
An. fluviatilis							■		
An. sergentii				■	■			■	
An. turkhudi	■		■	■		■	■	■	♣
Cx. arbieeni		■						■	■
Cx. decens						■	■		■
Cx. duttoni	■			■	■			■	■
Cx. laticinctus	■	■		■		■	■	■	■
Cx. mattinglyi			■			■	■		■
Cx. nebulosus	■			■	■			■	■
Cx. pipiens	■	■	■		■	■	■	♣	♣
Cx. salisburensis	■			■				■	■
Cx. simpsoni				■					■
Cx. sinaiticus	■	■	■	■			♣	■	■
Cx. theileri	■	♣	■	■		♣		♣	♣
Cx. tritaeniorhynchus							●		
Cx. wigglesworthi		■		■	■		■	■	
Lt. tigripes	■	♣	■	♣	■	■	♣		♣
Oc. caspius									■
St. aegypti			■						
Cs. longiareolata	■	♣	■	♣	■	■	♣	♣	
No of species	10	9	9	13	8	9	12	13	15

Table 5: Mosquito fauna of Asir Province (*Not collected in this survey)

Species	Asir Province	Neigbouring Regions: Jizan (J), Najran (N), Al Bahah (B), Al Madinah (M)	Other Saudi Regions
An. arabiensis	Abdullah & Merdan 1995, Al-Seghayer *et al* 1999, Abdoon & Alshahrani 2003	Al-Seghayer *et al* 1999 (Western & southern areas), Khater *et al* 2013 (J,B)	Glick 1992, Khater *et al* 2013, Gaffigan *et al* 2014
An. cinereus	Al Ahmad *et al* 2011		Mattingly & Knight 1956, Glick 1992, Alahmed 2012
An. culicifacies	Al Ahmad *et al* 2011	Al Ahmad *et al* 2011 (N)	Al Ghamdi *et al* 2008
An. dthali	Al-Seghayer *et al* 1999, Miller *et al* 2002 , Abdoon & Alshahrani 2003, Al Ahmad *et al* 2011	Al-Seghayer *et al* 1999 (Western & southern areas), Miller *et al* 2002 (J), Kheir *et al* 2010 (M), Al-Sheik 2011 (J), Khater *et al.* 2013 (J,B)	Glick 1992 , Miller *et al* 2002, El Khereji *et al* 2007, Al Ghamdi *et al* 2008, Alahmad *et al* 2009, Al Ahmad *et al* 2011, Alahmad 2012, Khater *et al.* 2013, Gaffigan *et al* 2014
An. fluviatilis			Mattingly & Knight 1956, Büttiker 1981, Wills *et al* 1985, Glick 1992, Al-Seghayer *et al* 1999, Al Ghamdi *et al* 2008, Alahmed 2012, Gaffigan *et al* 2014
An. gambiae s.l*	Al Ahmad *et al* 2011	Al-Sheik 2011 (J)	Mattingly & Knight 1956, Al Ghamdi *et al* 2008, Alahmad *et al* 2009, Alahmed 2012

An. multicolor	Abdullah & Merdan 1995, Al-Seghayer *et al* 1999, Abdoon & Alshahrani 2003, Al Ahmad *et al* 2011	Al-Seghayer *et al* 1999 (Wes-tern & southern areas), Al-Sheik 2011 (J,M)	Mattingly & Knight 1956, Glick 1992, Al-Seghayer *et al* 1999, Al Ghamdi *et al* 2008, Alahmad *et al* 2009, A Ahmad *et al* 2011, Alahmed 2012, Gaffigan *et al* 2014
An. pretoriensis *	Abdoon & Alshahrani 2003, Al Ahmad *et al* 2011	Al-Sheik 2011 (J)	Glick 1992, El Khereji *et al* 2007, Alahmed 2012
*An. rupicolus**	Al-Seghayer *et al* 1999, Abdoon & Alshahrani 2003	Al-Seghayer *et al* 1999 (Wes-tern & southern areas), Al-Sheik 2011 (J)	Glick 1992, Al Ghamdi *et al* 2008
An. sergentii	Abdullah & Merdan 1995, Al-Seghayer *et al* 1999, Abdoon & Alshahrani 2003, Al Ahmad *et al* 2011	Al-Seghayer *et al* 1999 (Wes-tern & southern areas), Al-Sheik 2011 (J), Khater *et al* 2013 (J,B)	Mattingly & Knight 1956, Büttiker 1981, Wills *et al* 1985, Glick 1992, Al Ghamdi *et al* 2008, Alahmed *et al* 2009, Alahmed 2012, Khater *et al* 2013, Gaffigan *et al* 2014
*An. stephensi**	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Mattingly & Knight 1956, Büttiker 1981, Glick 1992, Al-Seghayer *et al* 1999, El Khereji *et al* 2007, Al Ghamdi *et al* 2008, Alahmed *et al* 2009, Alahmed 2012
*An. subpictus**	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Al Ghamdi *et al* 2008, Alahmad *et al* 2009, Alahmed 2012
*An. tenebrosus**	Abdullah & Merdan 1995		Mattingly & Knight 1956, Wills *et al* 1985, Al-Seghayer *et al* 1999, Al Ahmad *et al* 2011, Alahmed 2012, Gaffigan *et al* 2014
An. turkhudi	Al-Seghayer *et al* 1999, Abdoon & Alshahrani 2003, Al Ahmad *et al* 2011	Al-Seghayer *et al* 1999 (Wes-tern & southern areas), Al-Sheik 2011 (J,M)	Mattingly & Knight 1956, Glick 1992, Al Ghamdi *et al* 2008, Alahmed *et al* 2009, Gaffigan *et al* 2014
Cx. arbieeni		AL Ahmed *et al* 2010 (N), Kheir *et al* 2010 (M)	Alahmed *et al* 2009
Cx.. bitaeniorhynchus	Abdoon 2004		Gaffigan *et al* 2014
Cx. decens	Abdoon 2004, Ahmed *et al* 2011	AI-Ali *et al* 2008 (M)	Gaffigan *et al* 2014
Cx. duttoni	Abdoon 2004	AI-Ali *et al* 2008 (M), Khater *et al* 2013 (J,B)	Khater *et al* 2013, Gaffigan *et al* 2014
Cx. laticinctus	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Mattingly & Knight 1956, Harbach 1985, El Khereji *et al* 2007, Alahmed *et al* 2009, Alahmed 2012, Gaffigan *et al* 2014
Cx. mattinglyi			Mattingly & Knight 1956, Harbach 1985, Al Ahmad *et al* 2011, Gaffigan *et al* 2014
Cx. mimeticus		Khater *et al* 2013 (J,B)	Harbach 1985, Khater *et al* 2013, Gaffigan *et al* 2014
Cx. nebulosus	Miller *et al* 2002	Miller *et al* 2002 (J)	Büttiker 1981, Miller *et al* 2002
Cx. perexiguus	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Harbach 1985, El Khereji *et al* 2007, Alahmed *et al* 2009, Ahmed *et al* 2011, Alahmed 2012, Gaffigan *et al* 2014
Cx. pipiens	Abdullah & Merdan 1995, Miller *et al* 2002, Al Ahmad *et al* 2011	Miller *et al* 2002 (J), AI-Ali *et al* 2008 (M), Kheir *et al* 2010 (M)	Mattingly & Knight 1956, Harbach 1985, Wills *et al* 1985, Jupp *et al* 2002 , Miller *et al* 2002, Al Ahmed *et al* 2009, Al Ahmad *et al* 2011, Alahmed 2012, El Khereji *et al* 2007, Gaffigan *et al* 2014
Cx. quinquefasciatus	Abdullah & Merdan 1995, Al Ahmad *et al* 2011	AI-Ali *et al* 2008 (M), Kheir *et al* 2010 (M), Khater *et al* 2013 (J,B)	Harbach 1985, Wills *et al* 1985, El Khereji *et al* 2007, Alahmed *et al* 2009, Alahmed 2012, Khater *et al.* 2013, Gaffigan *et al* 2014
Cx.	Miller *et al* 2002	Miller *et al* 2002 (J)	Miller *et al* 2002

salisburiensis			
Cx. simpsoni	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	El Khereji *et al* 2007, Alahmed *et al* 2009, Alahmed 2012
Cx. sinaiticus	Al Ahmad *et al* 2011		Mattingly & Knight 1956, Harbach 1985, El Khereji *et al* 2007, Alahmed *et al* 2009, Gaffigan *et al* 2014
*Cx. sitiens**	Al Ahmad *et al* 2011		Mattingly & Knight 1956, Harbach 1985, Gaffigan *et al* 2014
Cx. theileri	Abdullah & Merdan 1995	Kheir *et al* 2010 (M), Al Ahmad *et al* 2011 (N), Khater *et al* 2013 (J,B)	Harbach 1985, Büttiker 1981, El Khereji *et al* 2007, Alahmed *et al* 2009, Gaffigan *et al* 2014
*Cx. torrentium**	Ahmed *et al* 2011		Alahmed 2012
Cx. tritaeniorhynchus	Miller *et al* 2002, Al Ahmad *et al* 2011	Miller *et al* 2002 (J), Kheir *et al* 2010 (M), Khater *et al* 2013 (J,B)	Mattingly & Knight 1956, Harbach1985, Wills *et al* 1985, Jupp *et al* 2002, Miller *et al* 2002, El Khereji *et al* 2007, Alahmed *et al* 2009, Alahmed 2012, Khater *et al* 2013, Gaffigan *et al* 2014
*Cx. univittatus**	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Wills *et al* 1985, El Khereji *et al* 2007 ,Alahmed *et al* 2009, Alahmed 2012
Cx. wigglesworthi			
Lt. tigripes	Al Ahmad *et al* 2011		Mattingly & Knight 1956, Alahmed *et al* 2009 as *Cx. tig*…
Ae. unilineatus*	Miller *et al* 2002, Godsey *et al* 2003	Miller *et al* 2002 (J)	Miller *et al* 2002, Gaffigan *et al* 2014
Am. vexans arabiensis	Miller *et al* 2002, Al Ahmad *et al* 2011	Miller *et al* 2002 (J)	Mattingly & Knight 1956, Miller *et al* 2002, AI-Ali *et al* 2008, Kheir *et al* 2010, Gaffigan *et al* 2014
Fr. vittatus	Miller *et al* 2002, Al Ahmad *et al* 2011	Miller *et al* 2002 (J)	Jupp *et al* 2002, Miller *et al* 2002, Gaffigan *et al* 2014
*Oc. caballus**	Ahmed *et al* 2011		Jupp*et al* 2002
Oc. caspius	Abdullah & Merdan 1995, Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Mattingly & Knight 1956, Büttiker 1981, Wills *et al* 1985, Jupp *et al* 2002, El Khereji *et al* 2007, Alahmed *et al* 2009, Ahmed *et al* 2011, Alahmed 2012, Gaffigan *et al* 2014
Oc. detritus*	Al Ahmad *et al* 2011		
St. aegypti	Miller *et al* 2002, Al Ahmad *et al* 2011	Miller *et al* 2002 (J), El-Badry & Al-Ali 2010 (M), Kheir *et al* 2010 (M), Khater *et al* 2013 (J,B)	Mattingly & Knight 1956, Miller *et al* 2002, Alahmed *et al* 2009, Khater *et al.* 2013
Cs. longiareolata	Al Ahmad *et al* 2011	Kheir *et al* 2010 (M)	Mattingly & Knight 1956 , Wills *et al* 1985, El Khereji *et al* 2007, Alahmed *et al* 2009, Alahmed 2012
*Cs. subochrea**	Abdullah & Merdan 1995		Al Ahmad *et al* 2011, Gaffigan *et al* 2014
*Orthopodomyia sp.**	Ahmed *et al* 2011		

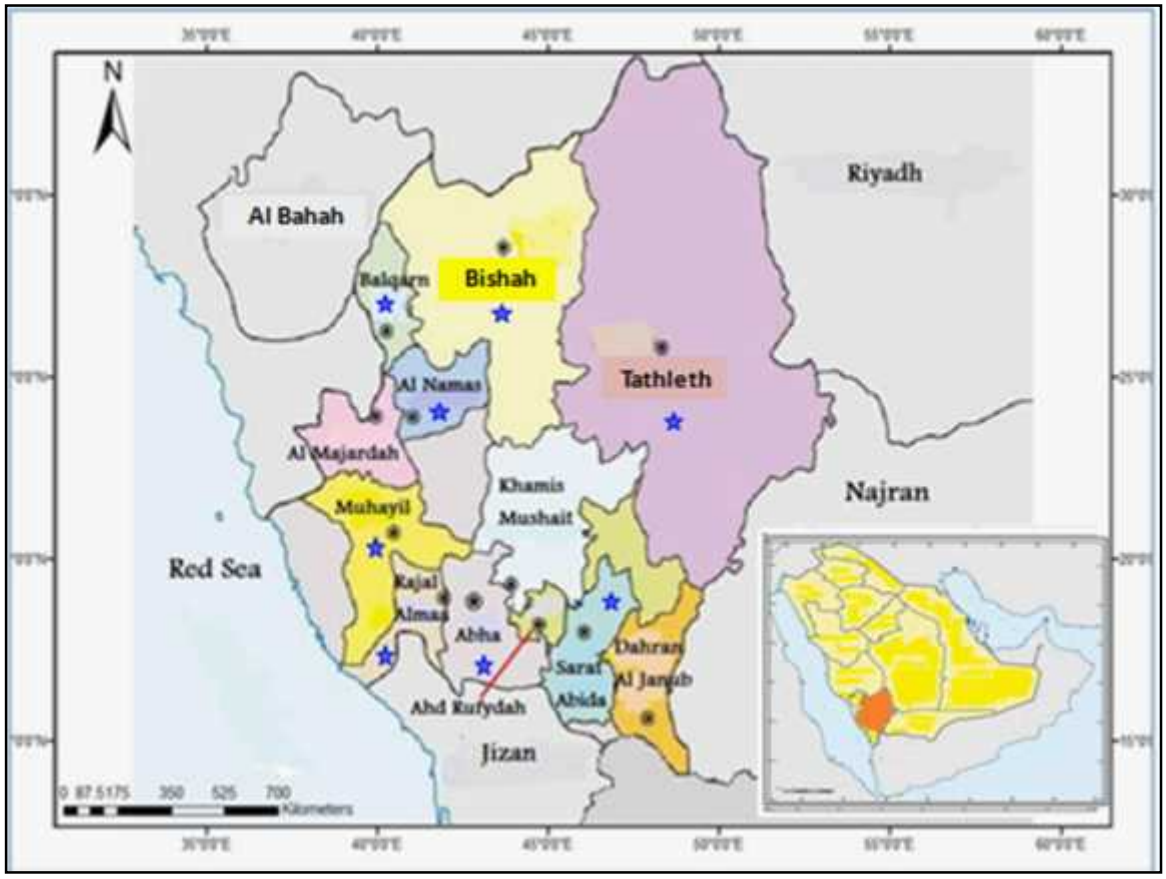

Fig. 1: Map of Asir Province showing surveyed Governorates

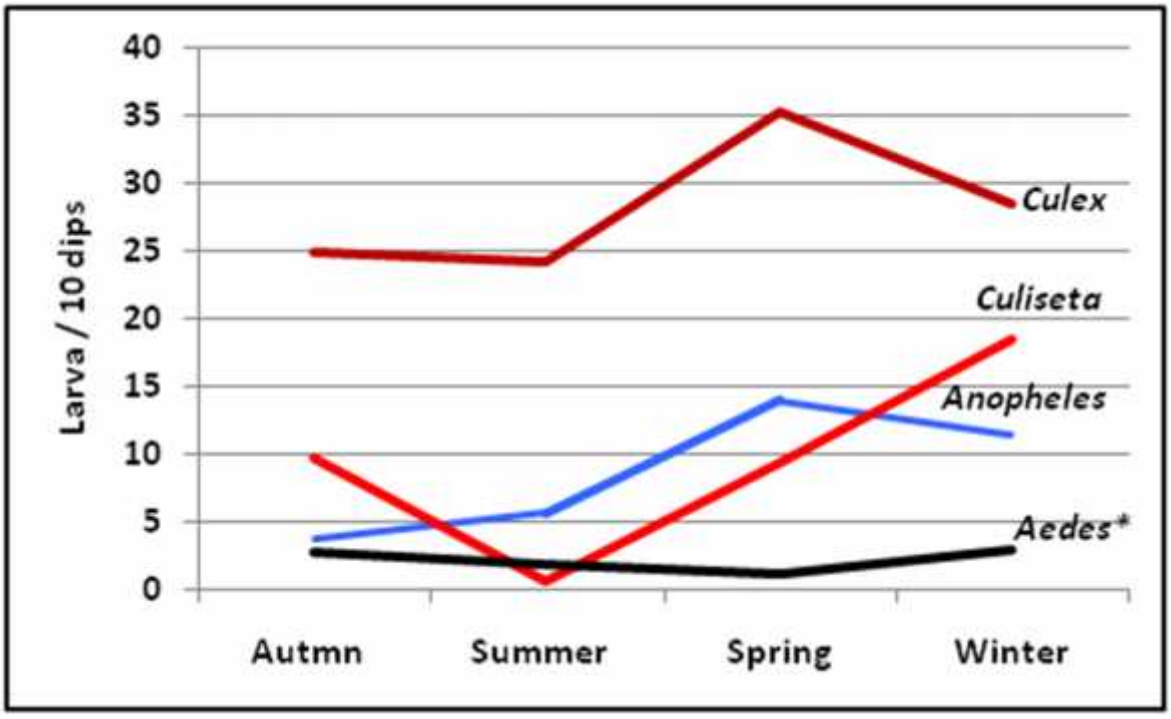

Fig. 2: Seasonal abundance of mosquito larvae in Asir Province (*Represented by *Aedes*, *Aedimorphus*, *Fredwardsius*, *Ochlerotatus* and *Stegomyia*)