



ORIGINAL ARTICLE

Seasonal activity of *Culicoides bahrainensis* Boorman, 1989 (Diptera: Ceratopogonidae) in Saud Arabia

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Abstract Very little information is available on *Culicoides* (Diptera: Ceratopogonidae) fauna of Saudi Arabia. During the period March 2004–February 2006, a country-wide survey was conducted to study the distribution of *Culicoides* or biting midges in Saudi Arabia using light traps. During the study, 2308 specimens of *Culicoides bahrainensis* Boorman, 1989 were collected for the first time in Saudi Arabia from Al Hassa and Al Dammam on the Arabian Gulf, and from Jeddaha on the Red Sea. This distribution suggests that *C. bahrainensis* requires high humidity for its survival and development. This observation was further supported by the positive significant correlation between the number of *Culicoides* collected and the relative humidity. The seasonal activity of *C. bahrainensis* showed two seasonal peaks, a higher peak in April and a lower peak in November where the temperature varied between 22.4 and 29.3 °C and the relative humidity varied between 34% and 66%. No *Culicoides* was collected during the period July–August where the temperature varied between 33 and 38 °C and the relative humidity varied between 24% and 54%.

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1. Introduction

The biting midges or *Culicoides* Latreille (Diptera: Ceratopogonidae) are very tiny haematophagous insects measuring from 1 to 3 mm in size. More than 1400 species have been

identified, and they occur on all large landmasses, with the exception of Antarctica and New Zealand, ranging from the tropics to tundra and from sea level to 4000 m above sea level (Mellor et al., 2000).

The role of *Culicoides* in disease transmission has been reviewed by many workers (Du Toit, 1944; Kettle, 1965; Linley et al., 1983; Lane, 1983; Boorman, 1989; Lane and Crosskey, 1993; Mellor et al., 2000). More than 50 viruses have been isolated from *Culicoides* species, and the most important of these are African Horse Sickness Virus (AHSV), Blue Tongue Virus (BTV), Akabane Virus (AKAV) and Bovine Ephemeral Fever Virus (BEFV). Some species of *Culicoides* cause considerable nuisance through their bites (Linley et al., 1983).

Despite reports of severe outbreaks of arboviral diseases in domestic animals in Saudi Arabia (Anderson et al., 1989; Abu

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El Zein et al., 1998a,b), very little effort has been made to study the potential vectors of these diseases such as *Culicoides*.

Few reports are available on the distribution and seasonal activity of *Culicoides* in Saudi Arabia (Lane, 1983; Boorman, 1989; Abu El Zein et al., 2002; Hilali et al., 2003; Boorman and Harten, 2003; Alahmed and Kheir, 2005). More recent information on distribution, seasonal activity and vectorial capacity of *Culicoides* species in Saudi Arabia is required to assess the economic losses due to these serious haematophagous pests. During a recent study of distribution of *Culicoides* in Saudi Arabia, Alahmed et al. (2010) encountered *Culicoides bahrainensis* for the first time in Saudi Arabia in the Eastern and the Western Regions, but no studies on its seasonal abundance are available. In this study, an attempt was made to study the seasonal activity of *C. bahrainensis* in Saudi Arabia.

2. Materials and methods

2.1. Study area

Saudi Arabia is a vast country with an area of about 2.25 million km². It lies in the southwestern part of Asia, between lat. 15° 44' N–32° 9' N and long. 34° 24' E–55° 39' E (Fig. 1). The kingdom is an extremely arid area, except the southwestern region and some coastal zones. The mountains in the south and

the west, plateaus in the north and the center, sand dunes and desert in the east and some scattered valleys characterize the topography of the Kingdom (Brown, 1968; Mohammedin, 2001).

Most of the Eastern Region of Saudi Arabia is a desert region, which includes the part of the Kingdom located along the Arabian Gulf between Sultanate of Oman in the south and Kuwait in the north. The region is separated from the interior by the sand dunes known as Al Dahna, and is bordered to the south by Al Rub Al Khali or the Empty Quarter desert (Fig. 1).

The western coastal escarpment can be considered as two mountain ranges separated by a gap at the vicinity of Makka Al Mukarrama. The northern range seldom exceeds 2100 m above sea level, and the elevation gradually decreases towards the south to about 600 m around Makka Al Mukarrama, with some coastal plains. The climate is hot dry in summer and warm, slightly humid in winter. The vegetative cover is very poor in the study areas, except for some coastal zones.

2.2. Collection and identification of *Culicoides bahrainensis*

During the period March 2004–February 2006, a country-wide survey for collection of *Culicoides* by light traps was conducted in Saudi Arabia (Fig. 1), and *C. bahrainensis* was reported for

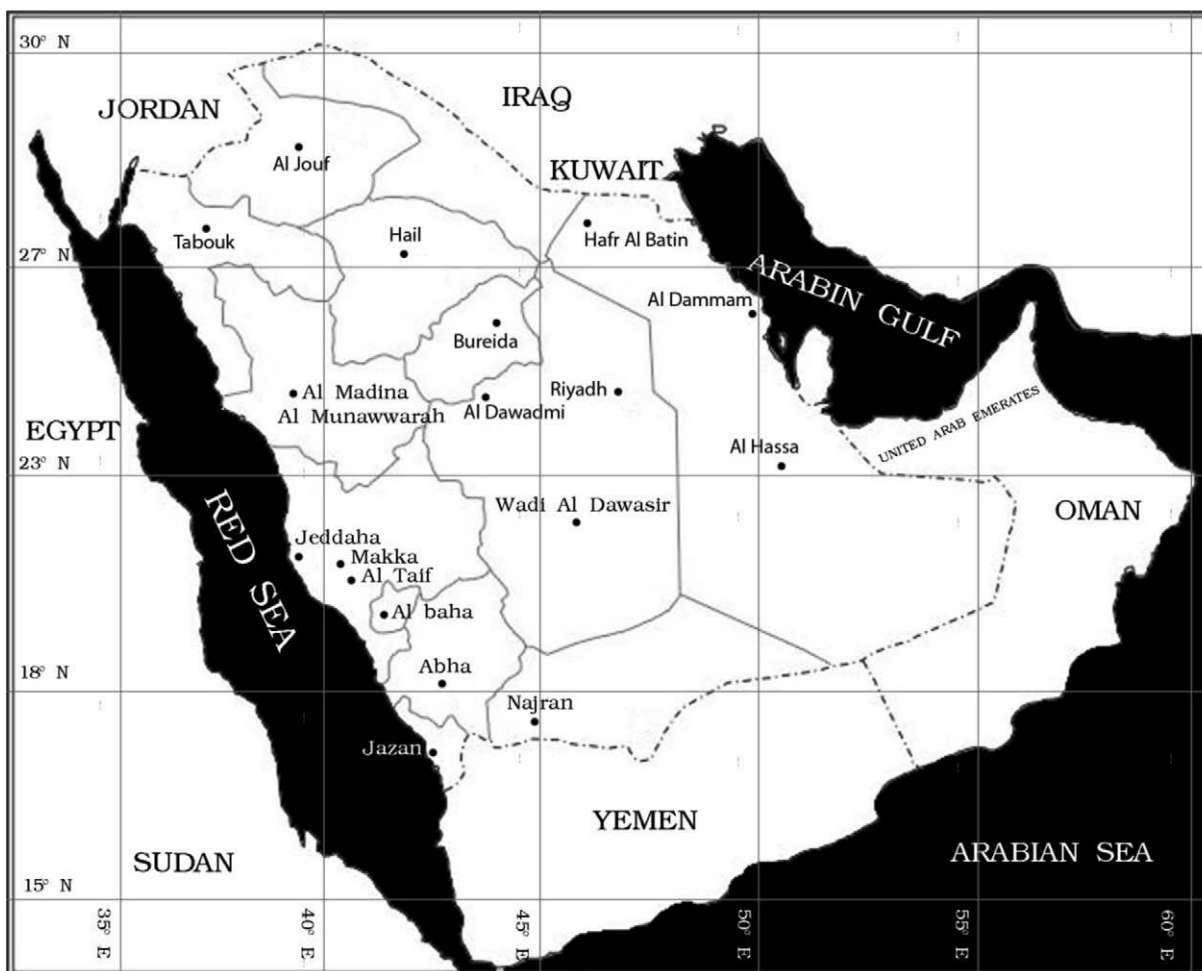


Figure 1 Collection sites of *Culicoides* in Saudi Arabia.

the first time in Saudi Arabia from Al Dammam, Al Hassa and Jeddaha (Alahmed et al., 2010). *C. bahrainensis* were collected by one Center for Disease Control (CDC) miniature light trap and one standard New Jersey (NJ) light trap (Bioquip Company, Gardena, CA, 90248-3602, USA) from Al Dammam, Al Hassa and Jeddaha (Fig. 1). The CDC and the NJ light traps were attached to a battery that supplies power, and installed permanently near suitable breeding sites of *Culicoides* such as near animal farms with aquatic habitats, human habitations and animal housings. The farms were surrounded by plantation. The light traps were operated once every 2 weeks from sunset to sunrise the following day throughout the study period. The collected adult *Culicoides* were preserved into 70% 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. The collected *Culicoides* spp. were identified by Dr. Art Borkent, Department of Entomology, Royal British Columbia Museum for Natural History, British Columbia, Canada, according to the method described by Borkent and Bissett (1990). The meteorological data of the study areas was obtained from National Centre for Meteorology and Ecology, Riyadh, Saudi Arabia.

For statistical analysis, comparison of two means (*t*-test) to compare the efficiency of CDC and NJ light traps, and the correlation coefficient (*r*) between relative humidity and the number of *Culicoides* were calculated (SAS, 2001).

3. Results

The seasonal activity of *C. bahrainensis* in the three collection sites showed two distinct peaks, a higher peak in April (after the end of the rainy season), and a lower peak in November (after the end of the dry season), while no *Culicoides* was collected during the dry season (July–August). In Al Dammam (Fig. 2), 872 specimens of *C. bahrainensis* were collected, and the highest number was collected during May, when the mean monthly temperature was 31.5 °C and mean monthly relative humidity was 29%. In June, the population density started to decline, and no *Culicoides* was collected during July, when the mean monthly temperature was 36.4 °C and the mean monthly relative humidity was 27%. In September, after the end of the dry season, the population density started to increase and a peak was attained in November when the mean monthly temperature was 22.4 °C and mean monthly relative

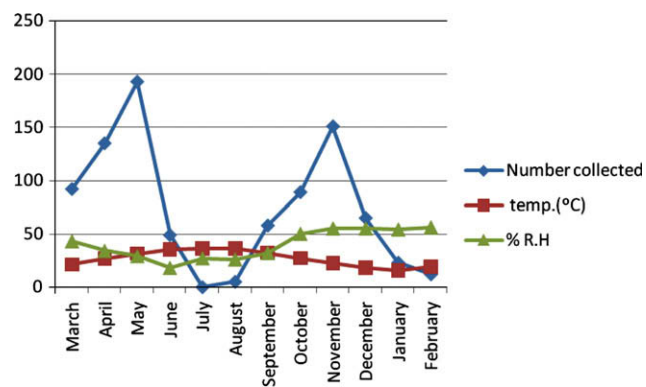


Figure 2 Seasonal activity of *Culicoides bahrainensis* in Al Dammam Region.

humidity was 55%. In December the population density started to decline because of the onset of winter season and reached the minimum in February, when the mean monthly temperature was 18.9 °C and the mean monthly relative humidity was 56%. In March, the population density started to rebuild and a peak was attained in May. Similarly, in Al Hassa (Fig. 3), the activity of *Culicoides* was lowest during the period July–August when the temperature was 37–38 °C and relative humidity was 24–25%. In September, the population size started to increase because of the improvement of temperature and humidity and a peak was attained in November when the mean monthly temperature was 22.5 °C and relative humidity was 54%. In December and January, the number of *Culicoides* collected decreased because of low temperatures during winter (15–18 °C). In March, *Culicoides* population started to rebuild, and a peak was attained in April when the temperature was 28 °C and relative humidity was 40%. In June, the activity of *Culicoides* started to decrease because of the onset of the dry season. In Jeddaha (Fig. 4), a higher peak of activity was attained in April, when the temperature was 29 °C and relative humidity was 64%; and a lower peak in November when the temperature was 25.8 °C and relative humidity was 66%. During the period July–August, the activity of *Culicoides* was lowest, where the temperature was 33 °C and relative humidity was 54–66%.

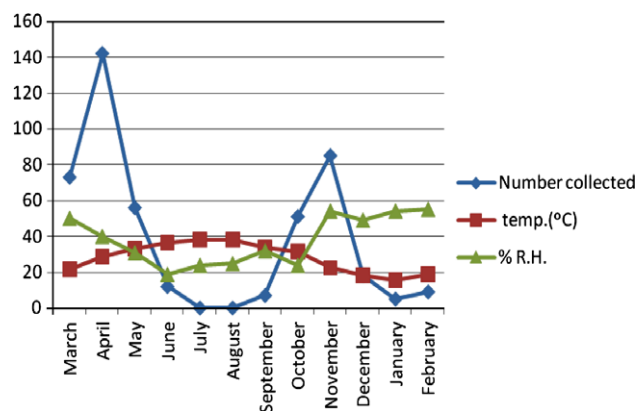


Figure 3 Seasonal activity of *Culicoides bahrainensis* in Al Hassa Region.

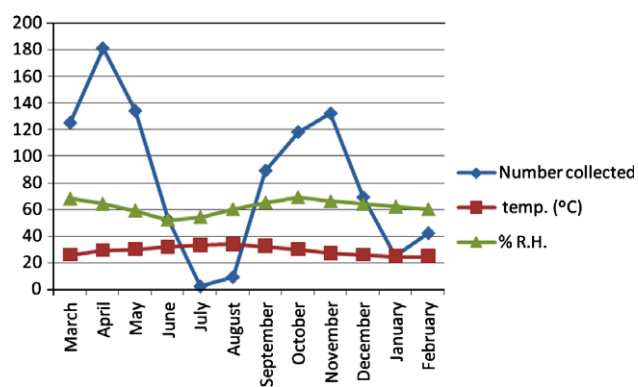


Figure 4 Seasonal activity of *Culicoides bahrainensis* in Jeddaha Region.

Table 1 *Culicoides bahrainensis* collected from Al Dammam during the period March 2005–February 2006.

Date	Mean monthly			Number of <i>Culicoides</i> collected		
	Rainfall (mm)	% R.H.	Temperature (°C)	CDC trap	NJ trap	Total
March 2005	11.1	43	21.4	38	54	92
April 2005	3.4	34	26.9	66	69	135
May 2005	0	29	31.5	102	91	193
June 2005	0	18	35.2	21	28	49
July 2005	0	27	36.4	0	0	0
August 2005	0	26	36.2	1	4	5
September 2005	0	32	32.4	26	32	58
October 2005	0	50	27.2	43	46	89
November 2005	7.9	55	22.4	81	70	151
December 2005	0	55	18.1	31	34	65
January 2006	2.3	54	15.5	11	12	23
February 2006	6	56	18.9	7	5	12
Total				427 (48.96%)	445 (51.04%)	872 (100%)

Table 2 *Culicoides* collected from Al Hassa during the period March 2005–Feb. 2006.

Date	Mean monthly			Number of <i>Culicoides</i> collected		
	Rainfall (mm)	% R.H.	Temperature (°C)	CDC trap	NJ trap	Total
March 2005	9.3	50	21.7	35	38	73
April 2005	0	40	28.5	81	61	142
May 2005	0	31	32.9	31	25	56
June 2005	0	19	36.5	8	4	12
July 2005	0	24	38	0	0	0
August 2005	0	25	37.8	0	0	0
September 2005	0	32	33.9	2	5	7
October 2005	0	24	31.6	23	28	51
November 2005	10.8	54	22.5	41	44	85
December 2005	0	49	18.4	7	11	18
January 2006	0	54	15.6	3	2	5
February 2006	4.7	55	18.8	6	3	9
Total				237 (51.75%)	221 (48.25%)	458 (100%)

In this study, 872 specimens of *C. bahrainensis* were collected from Al Dammam by the light traps (Table 1). Out of these, 427 (48.96%) were collected by CDC light trap, and 445 (51.04%) by NJ light trap. Similarly, 458 specimens were collected by the light traps from Al Hassa (Table 2). Out of these, 237 (51.75%) were collected by CDC light trap and 221 (48.25%) by NJ light trap. In Jeddaha (Table 3), the light traps collected 978 specimens of *C. bahrainensis*, 505 (51.64%) were collected by CDC light trap and 473 (48.36%) by NJ light traps. In the three collection sites, there was no significant differences in the mean catches of CDC and NJ light traps ($P > 0.05$ for the three collection sites). The results have shown a significant positive correlation between the mean monthly catches of *C. bahrainensis* collected and the mean monthly relative humidity in Al Dammam, Al Hassa and Jeddaha ($r = 0.88$; $r = 0.76$ and $r = 0.71$ respectively; $P < 0.05$; $P < 0.05$ and $P < 0.05$ respectively).

4. Discussion

The distribution of *C. bahrainensis* in Saudi Arabia is restricted to Al Hassa and Al Dammam on the Arabian Gulf, and Jeddaha on the Red Sea (Alahmed et al., 2010). This distribution

suggests that *C. bahrainensis* requires high humidity for its survival and development, since it was collected from near Arabian Gulf and Red Sea only. This observation is further supported by the positive significant correlation between the number of *C. bahrainensis* collected and the relative humidity in the three collection sites.

In this study, two peaks of seasonal activity were observed for *C. bahrainensis*, a higher peak in May (after the rainy season) and a lower peak in November (after the dry season). In fact, the prevailing climatic conditions influence the seasonal activity of *Culicoides* (Summer, 2009). Cooler conditions inhibit development of immature stages of *Culicoides* species, while high temperature may adversely affect adult survival (Hunt et al., 1989). Within favourable limits, the development of immature stages of *Culicoides* species is directly related to temperature (Akey et al., 1978; Mullen and Rutz, 1983; Bishop et al., 1996; Mellor et al., 2000). In fact, when the temperature is suitable, relative humidity can influence the abundance and seasonal activity of biting *Culicoides* species, through its effects on the availability of breeding sites. Further studies on the effect of temperature and humidity on the distribution of *C. bahrainensis* in Saudi Arabia are required.

Table 3 *Culicoides* collected from Jeddaha during the period March 2005–February 2006.

Date	Mean monthly			Number of <i>Culicoides</i> collected		
	Rainfall (mm)	% R.H.	Temperature (°C)	CDC trap	NJ trap	Total
March 2005	0	68	25.6	59	66	125
April 2005	45	64	29.3	103	78	181
May 2005	0	59	30	71	63	134
June 2005	0	52	31.7	24	28	52
July 2005	0	54	33	0	2	2
August 2005	0	60	33.8	3	6	9
September 2005	0	65	32.1	48	41	89
October 2005	0	69	29.9	64	54	118
November 2005	0	66	26.9	72	60	132
December 2005	1	64	25.8	31	38	69
January 2006	0	62	24.5	11	14	25
February 2006	0	60	24.8	19	23	42
Total				505 (51.64%)	473 (48.36%)	978 (100%)

Changes in the distribution and abundance of *Culicoides* are likely to be amongst the most important and immediate effects of climate change (Mellor, 1996; Summer, 2009). This is particularly worrying in case of insects that transmit pathogens or parasites to humans and livestock, since it is likely to affect the prevalence of insect-borne diseases. The role of *C. bahrainensis* in disease transmission requires further investigation. Climatic factors play a major role in the distribution and vectorial capacity of *Culicoides* population (Wittman and Baylis, 2000). Low temperatures tend to be more significant than high temperatures as determinants of distribution (Gates, 1993). Wind speed and direction can also affect *Culicoides* distribution, through their influence on the passive dispersal of the adults. Due to their small size, *Culicoides* can be easily dispersed by wind.

In this study, few numbers of *C. bahrainensis* were collected by the light traps, particularly in Al Hassa oasis. Despite the arid conditions of Saudi Arabia, the ecological conditions in the oases, which could be manifested by the presence of stagnant water, boggy lands, irrigated canal with cultivated margins along with summer climatic conditions were expected to support the breeding sites of *Culicoides* in large numbers (Nevill and Neville, 1995). However this did not seem to match the low number of *Culicoides* caught during this study. This could have been due to unforeseen adverse conditions, such as the existence of predators preying on *Culicoides* larvae, or presence of residual insecticides or other toxic chemicals in the collection sites.

Similar pattern of seasonal activity was shown by *C. bahrainensis* in the three study areas, and this may be due to the similar climatic conditions in these collection sites. On the other hand, different seasonal activity patterns exist with regard to *Culicoides imicola* (Diptera: Ceratopogonidae). In Morocco, and winter rainfall regions of South Africa, *C. imicola* showed a pronounced peak of activity at the end of summer and it was absent during winter (Baylis and Rawlings, 1998; Mellor et al., 2000). In contrast, the annual peak of activity in Nigeria occurred shortly after the rainy season and during winter (Mellor et al., 2000). In Sudan and summer rainfall regions of South Africa, the peak activity of *C. imicola* occurred towards the end of the hot rainy seasons (Mellor et al., 2000). These differences in activity pattern of *C. imicola*

might be due to the effect of the weather, larval development, adult survival and dispersal (Nevill et al., 1988; Mellor et al., 2000).

During the identification of *C. bahrainensis*, significant morphological variations were observed within this species (Borkent, personal communication), and this may be due to the fact that this species is conspecific with *C. badooshensis* and *C. kurensis* which are more broadly distributed throughout much of western Palaearctic Region (Boorman, 1989). Another possibility for these morphological variations is that there may be more species in this species group that are not described in this study. More research is needed to better understand the taxonomy of this species.

The results of this study have shown that there were no significant differences between the number of biting midges caught either by CDC or NJ light traps in the three collection sites, suggesting that the two light traps can be used for collection of biting midges. It has been found that the height of the light trap may have an effect on the catch of *Culicoides*, since Braverman and Linely (1993) showed that *C. circumscriptus*, *C. cataneli* and *C. imicola* were caught in greater numbers in the higher than in lower light traps, while more females of *C. schultzi* group were caught in lower than higher traps. In fact, the species collected more frequently in higher traps may be more prone to carriage for long distances by air currents and therefore are more likely to be important as dispersal vectors. In this study few numbers of *C. bahrainensis* were collected, this might be due to some limitations in the light traps. Further studies on the effect of the height of the trap and the attractiveness of light on the catch of *Culicoides* are required.

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