



Journal of  
**Entomology**

ISSN 1812-5670



Academic  
Journals Inc.

[www.academicjournals.com](http://www.academicjournals.com)

## Distribution of *Culicoides* Latreille (Diptera: Ceratopogonidae) in Saudi Arabia

<sup>1</sup>A.M. Alahmed, <sup>1</sup>S.M. Kheir and <sup>2</sup>M.A. Al Khereiiji

<sup>1</sup>Department of Plant Protection, College of Food and Agricultural Sciences,  
King Saudi University, P.O. Box 2460, Riyadh 11451, Saudi Arabia

<sup>2</sup>King Abdul Aziz City for Science and Technology, Riyadh, Saudi Arabia

---

**Abstract:** Scanty information is available about the *Culicoides* Latreille (Diptera: Ceratopogonidae) fauna of Saudi Arabia. This study was undertaken to investigate the distribution of *Culicoides* species in the kingdom. In this study, which was conducted during the period March 2004 to February 2006, light traps collected 43505 specimens of *Culicoides* biting midges. Eight species of *Culicoides* were identified: *Culicoides bahrainensis* Boorman, *C. imicola* Kieffer, *C. kingi* Austen, *C. navaiae* Lane, *C. newsteadi* Austen, *C. oxystoma* Kieffer, *C. punctatus* Meigen and *C. sahariensis* Kieffer. Among these species, *C. bahrainensis* was reported for the first time in Saudi Arabia. A recent and up to date distribution map of *Culicoides* in Saudi Arabia is provided and the medicinal importance of some of these species was discussed.

**Key words:** Distribution, *Culicoides*, Saudi Arabia

---

### INTRODUCTION

*Culicoides* Latreille (Diptera: Ceratopogonidae) or the biting midges are very small haematophagous insects measuring from 1-3 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.a.s.l. (Mellor *et al.*, 2000).

The role of *Culicoides* in disease transmission has been reviewed by many workers (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).

The climate can influence the distribution of *Culicoides*. Low temperatures tend to be more significant than high temperatures as determinants of distribution (Gates, 1993). When the temperature is suitable, precipitation can influence the distribution of *Culicoides* through its effects on availability of breeding sites. Wind speed and direction can also affect *Culicoides* distribution (Wittman and Baylis, 2000). The climatic factors can also influence the vectorial capacity of a *Culicoides* population both through changes in the overall size of the adult population and in the proportion of adults within the population

---

**Corresponding Author:** S.M. Kheir, Department of Plant Protection,  
College of Food and Agricultural Sciences, King Saudi University,  
P.O. Box 2460, Riyadh 11451, Saudi Arabia

capable of transmitting viruses (Wittman and Baylis, 2000). The recent spread of bluetongue and African horse sickness viruses in Europe has been attributed to climate change (Summer, 2009).

Although, several reports on the distribution of *Culicoides* in Saudi Arabia are available (Lane, 1983; Boorman, 1989; Abu-El-Zein *et al.*, 2002; Hilali *et al.*, 2003; Boorman and Harten, 2003; Alahmed and Kheir, 2005) but, very little is known about *Culicoides* fauna in Saudi Arabia. Despite reports of severe outbreaks of arboviral diseases in domestic animals in Saudi Arabia (Anderson *et al.*, 1989; Abu-El-Zein *et al.*, 1998a, b), but very little effort has been made to study the potential vectors of these diseases such as *Culicoides*. More, recent information on distribution and seasonal activity of *Culicoides* species in Saudi Arabia is required to assess the economic losses due to this serious haematophagous pest. In this study, an attempt was made to investigate the distribution of *Culicoides* species in Saudi Arabia.

## MATERIAL AND METHODS

### Study Area

Saudi Arabia is a vast country with an area of about 2.25 million km<sup>2</sup>. 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; Mohammedein, 2001).

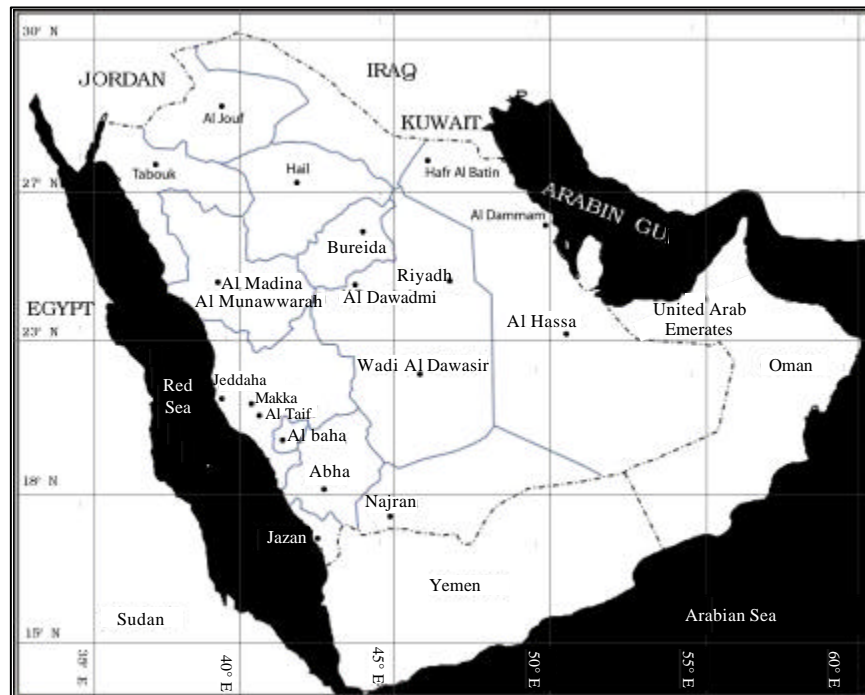


Fig. 1: Collection sites of *Culicoides* sp. in Saudi Arabia

The Southwestern part of Saudi Arabia, which is a mountainous area, is divided into 3 distinct topographical zones depending on the geographical characteristics: Sarawat Asir (which is mountain series extending North-South along the coastal plains of the Red Sea), Asir Plateau and Tihama lowlands (Fig. 1).

Most of the Eastern region of Saudi Arabia is a desert, 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.

Al Qassim region is located at the heart of the kingdom 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 the Northeast. The region lies at an altitude of 600-750 m.a.s.l., 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.

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.a.s.l. 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 area, except for some coastal zones. Al Madinah Al Munawwarah region is an upland plateau scored by numerous valleys (wadis) covered with grasses and scrub vegetations which are used for pasture. It has a typical desert climate, which is cold rainy in winter and hot dry in summer. Al Madinah Al Munawwarah is one of the biggest oases in the region and famous for growing dates. The topography of the of the Northern region is characterized by the presence of high plateaus which are extension of Badiat Al Sham. The climate and vegetation of Saudi Arabia has been studied by several authors (Khatab and El-Hadidy, 1971; Mandaville, 1973; Abuelfatih and El-Khalili, 1978).

#### **Collection and Identification of *Culicoides***

*Culicoides* biting midges were collected during the period March 2004 to February 2006, during a country-wide survey for mosquitoes (Diptera: Culicidae). For collection, 18 collection sites representing different ecological zones in the kingdom were selected (Fig. 1). *Culicoides* were collected using one Center for Disease Control miniature light trap (CDC light traps) and one standard New Jersey (NJ) light trap (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 breeding sites of *Culicoides* such as near animal farms with aquatic habitats, human habitations and animal housings. The light traps were operated once every 2 weeks from sunset at 18:00 to sunrise at 06:00 h the following day throughout the study period. The collected adult *Culicoides* in the light traps were taken and recorded, then 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* sp., were identified by Dr. Art Borkent, from Royal British Columbia Museum in Victoria, British Columbia, Canada and American Museum of Natural History, New York, USA according to the method described by Borkent and Bissett (1990).

## RESULTS AND DISCUSSION

In this study, 43505 specimens of *Culicoides*, which represented eight species, were collected and identified as: *Culicoides bahrainensis* Boorman.; *C. imicola* Kieffer; *C. kingi* Austen; *C. navaiae* Lane; *C. newsteadi* Austen; *C. oxystoma* Kieffer; *C. punctatus* Meigen and *C. sahariensis* Kieffer (Table 1). Among these species, *C. bahrainensis* was reported for the first time in Saudi Arabia from Al Hassa and Al Dammam on Arab Gulf and Jeddaha on the Red Sea (Fig. 1). Two specimens were identified as *C. montanus* and *C. langeroni*, but not with high certainty until more specimens are available (especially males of these species). The two-suspected species were reported earlier in the Arabian Peninsula (Boorman, 1989).

Among the total *Culicoides* collected in the kingdom, *C. imicola* and *C. punctatus* were the most abundant species and they represented 19.51 and 19.31% of the total collection, respectively, followed by *C. kingi* (17.49%), *C. oxystoma* (15.31%), *C. navaiae* (11.18%), *C. newsteadi* (9.02%), *C. bahrainensis* (5.31%) and *C. sahariensis* (3.05%). The highest number of *Culicoides* was collected from Al Hassa (10.95%) and Al Dammam (10.62%), followed by Jeddaha (9.93%), Riyadh (8.53%), Abha (7.56%), Al Qassim (7.31%), Makka Al Mukarrama (7.04%), Jazan (6.87%), Hail (5.77%), Al Madinah Al Munawwara (4.51%), Hafr Al Batin (3.85%), Najran (3.72%), Al Jouf (3.14%), Al Taif (3.05%), Addawadmi (2.22%), Wadi Addawasir (2.16%), Al Baha (2.09%) and Tabouk (0.68%) (Table 1).

Out of 4765 *Culicoides* specimens collected at Al Hassa, 9.61% were *Culicoides bahrainensis*, 20.61% were *C. imicola*, 7.53% were *C. kingi*, 15.01% were *C. navaiae*, 13.81% were *C. oxystoma* and 33.43% were *C. punctatus* (Table 2). Similarly, 2308 specimens of *C. bahrainensis* were collected during this study, 458 (9.61%) of them were collected from Al Hassa, 872 (18.87%) from Al Dammam and 978 (22.63%) from Jeddaha. The relative percent abundance of each *Culicoides* species in each collection site is shown in Table 2.

In this study, 8 species of *Culicoides* were encountered and some of them were important vectors of some arboviruses (Lane, 1983; Anderson *et al.*, 1989; Mellor and Boorman, 1995; Mellor *et al.*, 2000). *Culicoides kingi*, which is the main vector of bovine ephemeral fever in Kenya (Davies and Walker, 1974) and onchocerciasis in Sudan (El-Sinary and Hussein, 1980), was reported earlier in Saudi Arabia from Central and Eastern Regions

Table 1: Distribution of *Culicoides* sp. in Saudi Arabia

Collection site	<i>Culicoides bahrainensis</i>	<i>Culicoides imicola</i>	<i>Culicoides kingi</i>	<i>Culicoides navaiae</i>	<i>Culicoides newsteadi</i>	<i>Culicoides oxystoma</i>	<i>Culicoides punctatus</i>	<i>Culicoides sahariensis</i>	Total	
									Collected	%
Al Hassa	458	982	359	715	0	658	1593	0	4765	10.95
Al Dammam	872	658	954	695	0	548	895	0	4622	10.62
Hafr Al Batin	0	0	0	852	0	365	0	458	1675	3.85
Hail	0	421	759	259	0	289	782	0	2510	5.77
Al Jouf	0	0	251	0	0	356	759	0	1366	3.14
Tabouk	0	0	189	0	0	0	108	0	297	0.68
Al Madinah	0	0	0	524	528	238	672	0	1962	4.51
Al Munawwara										
Makka Al Mukarrama	0	514	952	0	856	583	156	0	3061	7.04
Jeddaha	978	875	524	0	958	857	129	0	4321	9.93
Al Taif	0	459	0	0	0	345	524	0	1328	3.05
Al Baha	0	0	265	0	56	589	0	0	910	2.09
Abha	0	1835	287	578	261	326	0	0	3287	7.56
Jazan	0	526	658	782	562	459	0	0	2987	6.87
Najran	0	694	251	458	124	91	0	0	1618	3.72
Wadi addwasir	0	0	232	0	0	352	120	234	938	2.16
Riyadh	0	936	358	0	0	248	2169	0	3711	8.53
Addawadmi	0	0	584	0	0	0	0	381	965	2.22
Al Qassim	0	586	986	0	581	359	416	254	3182	7.31
Total collected	2308	8486	7609	4863	3926	6663	8323	1327	43505	100.00
Total (%)	5.31	19.51	17.49	11.18	9.02	15.31	19.13	3.05	100	

Table 2: Percent distribution of *Culicoides* sp. in each collection site in Saudi Arabia

Collection site	<i>Culicoides bahrainensis</i>	<i>Culicoides imicola</i>	<i>Culicoides kingi</i>	<i>Culicoides navaiae</i>	<i>Culicoides newsteadi</i>	<i>Culicoides oxystoma</i>	<i>Culicoides punctatus</i>	<i>Culicoides sahariensis</i>	Total (%)
Al Hassa	9.61	20.61	7.53	15.01	0.00	13.81	33.43	0.00	100
Al Dammam	18.87	14.24	20.64	15.04	0.00	11.85	19.36	0.00	100
Hafr Al Batin	0.00	0.00	0.00	50.87	0.00	21.79	0.00	27.34	100
Hail	0.00	16.77	30.24	10.32	0.00	11.51	31.16	0.00	100
Al Jouf	0.00	0.00	18.38	0.00	0.00	26.06	55.56	0.00	100
Tabouk	0.00	0.00	63.64	0.00	0.00	0.00	36.36	0.00	100
Al Madinah	0.00	0.00	0.00	26.71	26.91	12.13	34.25	0.00	100
Al Munawwara									
Makka Al Mukarrama	0.00	16.79	31.10	0.00	27.96	19.05	5.10	0.00	100
Jeddaha	22.63	20.25	12.13	0.00	22.17	19.83	2.99	0.00	100
Al Taif	0.00	34.56	0.00	0.00	0.00	25.98	39.46	0.00	100
Al Baha	0.00	0.00	29.12	0.00	6.15	64.73	0.00	0.00	100
Abha	0.00	55.83	8.73	17.58	7.94	9.92	0.00	0.00	100
Jazan	0.00	17.61	22.03	26.18	18.81	15.37	0.00	0.00	100
Najran	0.00	42.89	15.51	28.31	7.66	5.63	0.00	0.00	100
Wadi addawasir	0.00	0.00	24.73	0.00	0.00	37.53	12.79	24.95	100
Riyadh	0.00	25.22	9.65	0.00	0.00	6.68	58.45	0.00	100
Addawadmi	0.00	0.00	60.52	0.00	0.00	0.00	0.00	39.48	100
Al Qassim	0.00	18.42	30.99	0.00	18.26	11.28	13.07	7.98	100
Total (%)	5.31	19.51	17.49	11.18	9.02	15.31	19.13	3.05	100

(Boorman, 1989). In this study, it was encountered for the first time in the Northern region (Al Jouf, Tabouk and Hail), Western region (Makka Al Mukarrama and Jeddaha) the Southwestern region (Al Baha, Abha, Najran and Jazan), Wadi Addawasir, Addawadmi and Al Qassim. Nothing is known about its biology and medical importance in the kingdom.

*Culicoides oxystoma* is broadly distributed species throughout the Palaearctic region, the Oriental region and possibly even Northern Australia. In Saudi Arabia, it was reported from Central and Eastern regions (Lane, 1983; Boorman, 1989). In this study, it was reported for the first time from the Northern region (Al Jouf and Hail), Western region (Makka Al Mukarrama, Al Madinah Al Munawwara, Al Taif and Jeddaha), the Southwestern region (Abha, Najran and Jazan), Wadi Addawasir and Al Qassim. *Culicoides oxystoma* is a serious pest of large ungulates, including cattle. It is a potential vector of bovine ephemeral fever in Arabian Peninsula (Boorman, 1989) and also associated with the transmission of some filariae to livestock in the Sudan (El-Sinary and Hussein, 1980). Kurogi *et al.* (1987) isolated Akabane virus from *C. oxystoma* in Japan. The widespread of *Culicoides kingi* and *Culicoides oxystoma* in Saudi Arabia may lead to appearance of bovine ephemeral fever in many parts of the kingdom in the near future and every effort should be made to prevent the spread of this disease.

In this study, *C. bahrainensis* was reported for the first time in Saudi Arabia from Al Hassa and Al Dammam on the Arab Gulf and from Jeddaha on the Red Sea suggesting that this species requires high humidity for its survival and development. Significant variations were observed within this species (Borkent, pers. comm.) and it may be 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 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 these species. Nothing is known about the habits and biology of this *Culicoides* species.

In Saudi Arabia *Culicoides sahariensis* was reported in the Eastern region from Al Hassa and Al Hofuf (Boorman, 1989). In this study, it was reported for the first time in Saudi Arabia from Hafr Al Batin, Wadi Addawasir, Addawadmi and Al Qassim. Nothing is known about its biology and relation to disease in the kingdom.

*Culicoides navaiae* is known only from Bahrain and from the Eastern region in Saudi Arabia (Lane, 1983; Boorman, 1989). In this study, it was reported for the first time from Hafr Al Batin, Hail, Al Madinah Al Munawwara, Abha, Jazan and Najran regions. Further studies on biology and habits of *Culicoides navaiae* in Saudi Arabia are required.

*Culicoides newsteadi* is distributed around the Mediterranean and Middle East and often is associated with livestock. It was reported earlier in Saudi Arabia only from Al Hassa (Abu-El-Zein *et al.*, 2002) but in this study was reported from Al Madinah Al Munawwara, Makka Al Mukarrama, Jeddaha, Al Baha, Abha, Jazan, Najran and Al Qassim. More studies on biology and habits of this *Culicoides* species in Saudi Arabia are needed.

Although, *C. punctatus* was reported in Saudi Arabia only from Al Kharj (Hilali *et al.*, 2003) but in this study, it was widely distributed in the kingdom and reported for the first time from Al Hassa, Al Dammam, Hail, Al Jouf, Tabouk, Al Madinah Al Munawwara, Makka Al Mukarrama, Jeddaha, Al Taif, Wadi Addawasir, Riyadh and Al Qassim. Boorman (1989) reported that *C. punctatus* may cause an allergic reaction in horses. The habits, biology and medical importance of *C. punctatus* in Saudi Arabia requires further investigations.

This study has confirmed the presence of *C. imicola*, the main field vector of AHSV and BTV (Lane, 1983; Anderson *et al.*, 1989; Mellor and Boorman, 1995; Mellor *et al.*, 2000) in Saudi Arabia. The biting midge was reported earlier in Saudi Arabia from Riyadh (Alahmed and Kheir, 2005; Boorman, 1989) and from Abha, Jazan and Al Kharj (Hilali *et al.*, 2003). In this study *C. imicola* was reported for the first time in Al Hassa, Al Dammam, Hail, Al Madinah Al Munawwara, Makka Al Mukarrama, Jeddaha, Al Taif, Abha, Jazan, Najran and Al Qassim. This widespread of *C. imicola* suggests that horses, particularly racehorses, dairy and beef cattle are potentially at risk and every effort should be made to protect beef and dairy industry in Saudi Arabia from devastating effects of this serious biting *Culicoides*. Further studies on the distribution and vectorial capacity of these *Culicoides* are required to evaluate the medical importance of these biting midges in Saudi Arabia before embarking on large scale control projects.

During a recent confirmed outbreak of bluetongue in sheep in Italy, Savini *et al.* (2005) collected 15 species of *Culicoides* and species belonging to the *Obsoletus* complex dominated the light trap collection. He did not collect a single specimen of the classical Afro-Asiatic blue tongue vector, *C. imicola*. These results indicate that a species other than *C. imicola* is involved in the current emergence of bluetongue in the Mediterranean basin.

Although, the number of biting midges caught in this study was relatively high, but there was no great diversity in species composition. This might be due to some limitations in the light traps used in this study, since they were permanently stationed in one place at a fixed height throughout the study period. 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, 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.

Changes in the distribution and abundance of *Culicoides* are likely to be amongst the most important and immediate effects of climate change (Mellor, 1996). 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 effect of climate change on distribution and abundance of *Culicoides* has been discussed by Bethan *et al.* (2005). Further studies on the effects of temperature and rainfall on distribution and seasonal abundance of *Culicoides* in Saudi Arabia are required.

#### ACKNOWLEDGMENT

We would like to thank Dr. Art Borkent, Royal Museum and American Museum for Natural History, British Columbia, Canada, for his identification of *Culicoides* specimens and valuable comments on *Culicoides* of Saudi Arabia. Thanks are also extended to King Abdul Aziz City for Science and Technology, Riyadh, for financial support.

#### REFERENCES

- Abu-El-Zein, E.M.E., H. Aitchison, A.I. Al-afaleq, A.M. Al-Bashir, A.D. Ibrahim and F.M.T. Housawi, 1998a. A study on Bluetongue virus infection in Saudi Arabia using sentinel ruminants. *Onderstepoort J. Vet. Res.*, 65: 243-251.
- Abu-El-Zein, E.M.E., A.I. Al-Afaleq, P.S. Mellor, A.M. Al-Bashir and M.M. Hassanien, 1998b. Study of Akabane infection in Saudi Arabia by use of sentinel ruminants. *J. Comp. Pathol.*, 119: 473-474.
- Abu-El-Zein, E., M.A. Hilali, A.I. Al-Afaleq, P.S. Mellor, J. Boorman and S. Al-Atiya, 2002. Seasonal abundance of four *Culicoides* sp. Diptera: Ceratopogonidae at Al Ahsa Oasis, Eastern Province, Saudi Arabia. *Onderstepoort J. Vet. Res.*, 69: 2115-2122.
- Abuelfatih, H.A. and A.D. Al-Khalili, 1978. Biological survey of Abha Lake. *J. Saudi Arab Nat. Hist. Soc.*, 25: 17-22.
- Alahmed, A.M. and S.M. Kheir, 2005. Seasonal activity of some Haematophagous insects in the Riyadh region, Saudi Arabia. *J. Saudi Soc. Agric. Sci.*, 4: 95-104.
- Anderson, E.C., P.S. Mellor and C. Hamblin, 1989. African horse sickness in Saudi Arabia. *Vet Rec.*, 125: 489-489.
- Bethan, V.P., P.S. Mellor, D.J. Rogers, A.R. Sammeul, P.P.C. Mertins and M. Baylis, 2005. Climate change and recent emergence of blue tongue in Europe. *Nature Rev. Microbiol.*, 3: 171-181.
- Boorman, J., 1989. *Culicoides* Diptera: Ceratopogonidae of Arabian Peninsula with notes on their medical and veterinary importance. *Fauna Saudi Arabia*, 10: 160-224.
- Boorman, J. and A.V. Harten, 2003. Some Ceratopogonidae Insecta: Diptera from Arabian Peninsula, with particular reference to the Republic of Yemen. *Fauna Arabia*, 19: 427-462.
- Borkent, A. and B. Bissett, 1990. A revision of the Holarctic species of *Serromyia* Meign Diptera: Ceratopogonidae. *Syst. Entomol.*, 15: 153-217.
- Braverman, Y. and J. Linely, 1993. Effect of light trap height on catch of *Culicoides* Diptera: Ceratopogonidae in Israel. *J. Med. Entomol.*, 30: 1060-1063.
- Brown, Jr. G.W., 1968. *Desert Biology*. Vol. 1, Academic Press, New York, USA.
- Davies, F.G. and A.R. Walker, 1974. The isolation of ephemeral fever virus from cattle and *Culicoides* midges in Kenya. *Vet. Rec.*, 20: 63-64.
- El-Sinnary, K. and S.H. Hussein, 1980. *Culicoides kingi* Austen: A vector of *Onchocerca gutturosa* Neumann, 1910 in the Sudan. *Ann. Tropical Med. Parasitol.*, 74: 655-656.
- Gates, D.M., 1993. *Climate Change and its Biological Consequences*. Sinauer Associates, Sunderland.
- Hilali, M.E., Abu-El-Zein, A.I. A-Afaleq, P. Mellor, J. Boorman, S. Al-Atiya and A. Alnaeem, 2003. *Culicoides* midges Diptera: Ceratopogonidae in some localities of Saudi Arabia and their veterinary significance. *Vet. Arhiv.*, 73: 285-294.



- Kettle, D.S., 1965. Biting ceratopogonidae as vector of human and animal diseases. *Acta Tropica*, 22: 356-362.
- Khattab, A. and M. El-Haddidy, 1971. Results of Botanical Expedition to Arabia. University of Cairo Herbarium Publications, Egypt.
- Kurogi, H., H. Akiba, Y. Inaba and M. Matumoto, 1987. Isolation of Akabane virus from the biting midge *Culicoides oxystoma* Diptera: Ceratopogonidae in Japan. *Vet. Microbiol.*, 15: 243-248.
- Lane, R.P., 1983. Insects of Saudi Arabia: *Culicoides* Diptera: Ceratopogonidae of Saudi Arabia and their potential veterinary importance. *Fauna Saudi Arabia*, 5: 529-544.
- Lane, R.P. and R.W. Crosskey, 1993. *Culicoides* Diptera: Ceratopogonidae. In: *Medical Insects and Archnids*, Lane, R.P. and R.W. Crosskey (Eds.). Chapman and Hall, Londo.
- Linley, J.R., A.L. Hoch and F.P. Pinheiro, 1983. Biting midges Diptera: Ceratopogonidae and human health. *J. Med. Entomol.*, 20: 347-364.
- Mandaville, Jr. J.P., 1973. A Contribution to the Flora of Asir, Southwestern Arabia. Florida Research Publications, Miami, Florida.
- Mellor, P.S. and J. Boorman, 1995. The transmission and geographical spread of African horse sickness and blue tongue viruses. *Ann. Trop. Med. Parasitol.*, 89: 1-15.
- Mellor, S.P., 1996. *Culicoides*: Climate change and disease risk. *Vet. Bull.*, 66: 1-30.
- Mellor, P.S., J. Boorman and M. Baylis, 2000. *Culicoides* Biting midges: Their role as arbovirus vectors. *Annu. Rev. Entomol.*, 45: 307-340.
- Mohammedin, M.M., 2001. Kingdom of Saudi Arabia: A Geographical Study. Al Khereji Printing Press, Riyadh, Saudi Arabia.
- Savini, G., M. Goffredo, F. Monaco, A. Di Gennarco and M.A. Cafiero *et al.*, 2005. Bluetongue virus isolation from midges belonging to the Obsoletus Complex *Culicoides*, Diptera: Ceratopogonidae in Italy. *Vet. Rec.*, 157: 133-139.
- Summer, B.A., 2009. Climate change and animal diseases. *Vet. Pathol.*, 46: 1185-1186.
- Toit, R.M.D., 1944. The transmission of blue tongue and African horse sickness by *Culicoides*. *Onderstepoort J. Vet. Res. Anim. Husbandry*, 19: 7-16.
- Wittman, E.J. and M. Baylis, 2000. Climate change: Effects on *Culicoides*-transmitted viruses and implications for the UK. *Vet. J.*, 160: 107-117.