Prevalence of different species of *Culicoides* in Bangalore rural and urban districts of South India

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Abstract A study was conducted to observe the prevalence of *Culicoides* a biting midge, important pest and prime vector for various viruses, protozoa and filarid worms. In the vicinity of 11 different farms of cattle, buffalo, sheep and goats in Bangalore rural and urban districts the flies were collected by using UV traps (Onderstepoort Veterinary Institute. ARC. LNR) connected with suction fan for the period of 1 year (2012–2013). Around 83,629 *Culicoides* were collected of which 77,906 (93.16 %) were female and 5,723 (6.84 %) were males and 40,120 (47.97 %) of *C. imicola*, 39,366 (47.07 %) *C. oxystoma*, 2,504 (2.99 %) *C. actoni*, 1,145 (1.37 %) *C. peregrinus*, 145 (0.17 %) *C. huffi*, 120 (0.16 %) *C. innoxius*, 90 (0.11 %) *C. palpifer*, 67 (0.08 %) *C. anopheles*, 37 (0.04 %) *C. circumscriptus* and 25 (0.03 %) were *C. arakawae*. It was observed that *C. imicola* and *C. oxystoma* were the most predominant species prevalent in Bangalore rural and urban districts of Karnataka.

Keywords *Culicoides* · Biting midge · Prevalence · Karnataka

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Culicoides is an important human and animal pest with great economic significance and a prime vector for the blue tongue disease, African horse sickness, epizootic hemorrhagic disease, akabane, aino, chuzan, and bovine ephemeral fever, vesicular stomatitis, equine encephalosis, protozoa such as *Haemoproteus* sp., *Leucocytozoon* sp. and *Hepatozoon*, filarid nematodes such as *Onchocerca cervicalis*, *Dipetalonema reconditum* and *Mansonella perstans* and *ozzardi* (Prasad and Bhatnagar 2000).

Culicoides or biting midges are nematoceros flies and one of the world's smallest haematophagous flies measuring from 1 to 3 mm in size. More than 1,400 species in the genus *Culicoides* have been identified worldwide of which about 96 % are obligate blood feeders attacking mammals and birds and occur on virtually all large land masses with the exception of Antarctica and New Zealand, ranging from the tropics to the tundra and from sea level to 4,000 m (Mellor et al. 2000).

In India 63 species of *Culicoides* were identified morphologically and their prevalence reported by many authors viz Sen and Dasgupta (1958, 1959, 1962) from Kolkata and the neighbouring areas, Sen and Fletcher (1962) from Assam, Bengal and other parts of India, Jayalakshmi (1966) from Chennai, Narladkar et al. (1993) in the Marathwada region of Maharashtra, Ganesh Udupa (2001) and Ilango (2006) from Tamil Nadu, Reddy and Hafeez (2008) from Chittoor and Prakasam districts of Andhra Pradesh and Bhoyar et al. (2009) from Karnataka. In Karnataka state, little information is available hence the study was undertaken to know the prevalence of *Culicoides* in Bangalore districts.

Materials and methods

The prevalence of *Culicoides* sp. was studied in 11 different farms of cattle, buffalo, sheep and goats in

Bangalore rural and urban districts. The flies were collected with UV-light traps (Onderstepoort Veterinary Institute, ARC, LNR) during rainy, winter and summer seasons. The insects were collected in the light traps, kept from 6.00 p.m. to 6.00 a.m., and positioned within close proximity of 25 m where the livestock were kept at night at 1.5–2.0 m above the ground level and a glass collecting beaker containing 200–300 ml of water (to which a drop of detergent was added to reduce surface tension) and was placed at the base of each trap. The collected insects were transported to the laboratory and preserved in 90 % ethanol. Ceratopogonid flies were first separated from other insects. Identification of *Culicoides* was initially based upon wing pattern and confirmed subsequently by mounting different parts of the specimen in drop of phenol–balsam mixture on microscope slides after clearing in liquefied phenol solution for 12 h (Wirth and Marston 1967).

Morphological identification of *Culicoides* spp. was done by using keys of Wirth and Hubert (1989), Glick (1990), Sen and Dasgupta (1959), Dasgupta (1995), Kitaoaka (1984), Wirth and Hubert (1961) and Pires et al. (2010). The characters for morphological identification of *Culicoides* spp. included wing markings, presence and distribution of macrotrichia, lengths of flagellar segments 3–15, length of five palpal segments, antennal ratio and palpal ratio, distribution of antennal coeloconica, form of sensory pit on third palpal segment, form of whole third palpal segment, proboscis–head ratio, number and form of spermathecae, form of male genitalia, appearance of leg and thorax, number (sometime absence) of teeth of mandible, number of hind tibial comb and largest spine among them (i.e. on third pair of legs), length of body, length and breadth of wing and costal ratio.

Table 1 Composition of different species of *Culicoides* spp.

Species	Number of female	Number of male	Total	%
<i>C. imicola</i>	38,369	1,751	40,120	47.97
<i>C. oxystoma</i>	35,880	3,486	39,366	47.07
<i>C. actoni</i>	2,265	239	2,504	2.99
<i>C. peregrinus</i>	945	200	1,145	1.37
<i>C. huffi</i>	129	16	145	0.17
<i>C. innoxius</i>	125	5	130	0.16
<i>C. palpifer</i>	80	10	90	0.11
<i>C. anopheles</i>	60	7	67	0.08
<i>C. circumscriptus</i>	32	5	37	0.04
<i>C. arakawae</i>	21	4	25	0.03
Total	77,906	5,723	83,629	

Table 2 Morphometric measurements of *Culicoides* species

Species	Antennal ratio	Antennal sensillar pattern	Palpal ratio	P/H ratio	Wing length (mm)	Wing width	Costal ratio	Mandible teeth	Hind tibial spine (largest spine from spur)
<i>C. imicola</i>	1.04 (1.0–1.09)	3, 12–15	2.4 (2.1–2.6)	0.87	0.93 (0.8–0.99)	0.45 (0.42–0.5)	0.54 (0.5–0.57)	13	5(I)
<i>C. oxystoma</i>	1.04 (1.0–1.13)	3, 8–10	1.99 (1.88–2.2)	0.66	1.0 (0.9–1.06)	0.46 (0.44–0.5)	0.53 (0.51–0.55)	12	4(I)
<i>C. peregrinus</i>	1.18 (1.12–1.3)	3, 11–15	2.9 (2.5–3.44)	0.92	1.19 (1.06–1.26)	0.54 (0.45–0.57)	0.64 (0.62–0.67)	14	6(II)
<i>C. actoni</i>	1.1 (1.06–1.15)	3, 12–15	2.18 (2.0–2.33)	0.73	0.83 (0.78–0.87)	0.4 (0.37–0.41)	0.56 (0.54–0.56)	13	5(I)
<i>C. huffi</i>	1.36 (1.3–1.46)	3, 5, 7–10	2.0 (1.8–2.1)	0.58	0.92 (0.87–1.02)	0.44 (0.43–0.5)	0.53 (0.53–0.55)	10	4(I)
<i>C. innoxius</i>	1.1 (1.06–1.16)	3, 11–15	2.76 (2.5–3.0)	0.8	1.18 (1.1–1.28)	0.53 (0.48–0.57)	0.68 (0.66–0.68)	19	6(II)
<i>C. anopheles</i>	0.96 (0.93–0.99)	3, 11–15	2.2 (2.2–2.3)	0.38	1.1 (1.07–1.12)	0.54 (0.45–0.57)	0.71 (0.69–0.72)	15	4(II)
<i>C. palpifer</i>	1.0 (0.98–1.07)	3, 11–15	2.1 (2–2.25)	0.56	0.97 (0.9–1.04)	0.44 (0.42–0.48)	0.68 (0.67–0.69)	7	4(II)
<i>C. circumscriptus</i>	1.12 (1.1–1.16)	3–14	2.07 (2.0–2.1)	0.91	1.18 (1.06–1.3)	0.53 (0.5–0.57)	0.57 (0.55–0.58)	15	4(I)
<i>C. arakawae</i>	1.36 (1.32–1.42)	3–14	2.4 (2.33–2.6)	0.96	1.12 (1.03–1.23)	0.5 (0.43–0.54)	0.6 (0.58–0.62)	12	4(I)

Fig. 1 Head of *Culicoides* species under 10×

Fig. 2 Third maxillary palp of *Culicoides* species, arrow indicating sensory pit

Results and discussion

Morphologically 10 different species of *Culicoides* were found to be prevalent in 11 different farms of cattle, buffalo, sheep and goats in Bangalore rural and urban

districts (Table 1). In the present study, the morphology (Table 2; Figs. 1, 2, 3, 4, 5, 6, 7) of different *Culicoides* spp. were described based on the keys provided by Wirth and Hubert (1989); Dasgupta (1995) and Sen and Dasgupta (1959).

Fig. 3 Hind tibial comb of *Culicoides* species under 40×

In a total of 83,629 *Culicoides* midges collected from different farms of rural and urban districts of Bangalore 77,906 (93.16 %) were females and 5,723 (6.84 %) were males. Could be probably due to the obligate blood

feeding nature of the female midges which is required for their egg production and oviposition. Whereas males are not blood feeders and usually die after mating. Similar, sex wise prevalence pattern were also reported by

Fig. 4 Mandibular teeth of *Culicoides* species under 40×

Fig. 5 Wing of *Culicoides* species under 10×

C. imicola

C. oxystoma

C. actoni

C. peregrinus

C. anophelis

C. palpifer

C. huffi

C. innoxius

C. circumscriptus

C. arakawae

Fig. 6 Spermathecae of *Culicoides* species

Satheesha et al. (2006), Reddy and Hafeez (2008), Deniz et al. (2010), Foxi and Delrio (2010) and Kim et al. (2012).

During this study, 10 different *Culicoides* spp. were prevalent in Bangalore rural and urban districts of Karnataka state (Table 1). Similar findings were also reported by Wirth and Hubert (1989) from South east Asia and Dasgupta (1995) from Kolkata. Whereas *C. oxystoma*, *C. peregrinus*, *C. actoni*, *C. anophelis*, *C. palpifer* and *C. innoxius* were reported by Sen and Dasgupta (1959) from Kolkata. However, *C. oxystoma*, *C. peregrinus*, *C. actoni* and *C. anophelis* were reported by Sen and Fletcher (1962) from Assam and Bengal and other parts of India, whereas *C. peregrinus* and *C. actoni* reported by Narladkar et al. (1993) from Marathwada region of Maharashtra.

Culicoides imicola, *C. oxystoma*, *C. peregrinus* were reported by Ganesh Udupa (2001) from Tamil Nadu. *C. actoni*, *C. anophelis*, *C. innoxius*, *C. oxystoma* and *C. peregrinus* were reported by Reddy and Hafeez (2008) from Chittoor and Prakasam districts of Andhra Pradesh. *C. imicola* and *C. oxystoma* were recorded by Bhoyar et al. (2009) from Bidar and Mandakanahalli of Karnataka. Satheesha et al. (2006) reported *C. imicola* and *C. oxystoma* from Bidar district of Karnataka. *C. imicola*, *C. oxystoma* and *C. peregrinus* species were found to be commonly prevalent in most of the regions in India.

In the present study, *C. imicola* and *C. oxystoma* were the most predominant species. Similar observations were also made by Ganesh Udupa (2001) from Tamil Nadu, Satheesha et al. (2006) from Bidar, Karnataka, and Bhoyar et al. (2009) from Bidar and Mandakanahalli of Karnataka. Jayalakshmi (1966) from Chennai and Narladkar et al. (1993) from Marathwada of Maharashtra reported that *C. schultzei* was the most predominant spp. However, Reddy and Hafeez (2008) reported that *C. oxystoma* was the predominant species in Chittoor and Prakasam districts of Andhra Pradesh.

The variations in the occurrence of different species in different localities may be due to the differences in the agro climatic and seasonal conditions in different localities/states etc. (Reddy and Hafeez 2008). The different agroclimatic factors of Bangalore districts is given in Table 3.

Culicoides species have also been recorded worldwide. Musuka et al. (2001) reported from Zimbabwe, Kline (1986) from Salt Marsh in Florida, USA, Deniz et al. (2010) from Thrace Region of Turkey, Kim et al. (2012) from Southern part of the Republic of Korea, Aybar et al. (2012) from Salta, Northwestern Argentina, Oem et al. (2013) in Korea. The species composition in different countries varied which could be probably due to the prevailing different agroclimatic and seasonal conditions.

C. imicola (aedeagus) (10X)

C. imicola (parameres) (40X)

C. oxystoma (basistyle) (10X)
arrow-aedeagus) (40X)

C. oxystoma (above arrow-9th sternum, below

C. oxystoma (dististyle) (10X)

C. oxystoma (parameres) (40X)

Fig. 7 Male genitalia of *Culicoides* species

C. actoni (aedeagus) (10X)

C. actoni (parameres) (40X)

C. peregrinus (10X)

C. peregrinus (aedeagus) (40X)

C. peregrinus (parameres) (40X)

C. anophelis (aedeagus) (10X)

Fig. 7 continued

C. anophelis (parameres) (40X)

C. anophelis (apicolateral process) (40X)

C. palpifer (10X) (parameres)

C. palpifer (40X) (parameres)

C. huffi (10X) (parameres)

C. huffi (10X) (dorsal and ventral root of basistyle)

Fig. 7 continued

C. huffi (40X) (aedeagus)

C. innoxius (10X) (aedeagus)

C. innoxius (40X) (aedeagus)

C. innoxius (40X) (parameres)

C. circumscriptus (10X)

C. circumscriptus (10X) (aedeagus)

Fig. 7 continued

C. circumscriptus (10X) (parameres)

C. arakawae (10X) (aedeagus)

C. arakawae (10X) (parameres)

C. arakawae (40X) (parameres)

Fig. 7 continued

Table 3 Agroclimatic factors of Bangalore 2012–2013

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Max	Min	Max	Min	
June (2012)	30.9	20.3	87	44	26.6
July (2012)	28.7	19.6	93	52	97.2
August (2012)	28.3	19.3	93	53	100.1
September (2012)	29.2	19.4	92	51	29.2
October (2012)	28.3	18.7	90	53	71.2
November (2012)	27.2	16.2	88	53	150
December (2012)	27.4	15.7	88	52	11.2
January (2013)	28.8	14.8	87	43	0
February (2013)	30.5	16.4	87	40	2.2
March (2013)	32.7	19.2	87	37	0
April (2013)	34.6	21.8	85	35	56.8
May (2013)	33.5	21.1	87	44	92.8

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