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Review on dynamics of *Culicoides* spp. (Diptera: Ceratopogonidae) and its nuisance on body movements and milk yield in cows

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Abstract

Haematophagous insects involving different species of dipteran flieseg. *Culicoides* midges or *Simulium* flies or *Phlebotomus* flies or mosquitoes, causes three way trouble to livestock i.e., a) annoyance and worries and blood loss from direct biting and feeding, b) disease transmission, c) losses incurred on their control. In the livestock shed, amongst the four nematoceros flies biting throughout night and producing other ill effects *Culicoides* midges stands first. Their population is greatly higher in number than population of any other haematophagus fly species in the shed. *Culicoides* spp have great influence on livestock health due to their tiny nature and enormous number in the shed biting throughout night leading to psychological disturbances and compels them to make enumerable body movements for ward-off these midges. As per the Law of Physics, for undertaking any body movement huge energy is spent, resulting in reduction of milk yield which has been estimated to the extent of 18.97 percent. Being very dynamic misges the economic losses from *Culicoides* are of great magnitude and thus needs attention of policy makers and entomologists.

Keywords: *Culicoides* spp, body movements, dynamics, economic losses

Introduction

It is well known fact that different species of dipteran flies eg. *Culicoides* midges or *Simulium* flies or *Phlebotomus* flies or mosquitoes are the major insect pests, causing great trouble to livestock. In the livestock shed, amongst these four nematoceros insect pests biting throughout night and producing other ill effects, *Culicoides* midges stands first. Their population is greatly higher in number than population of any other haematophagus fly species in the shed. According to Narldkar and Shivpuje^[1], *Culicoides* spp have great influence on livestock health due to their tiny nature and enormous number in the shed biting throughout night leading to psychological disturbances and compels them to make enumerable body movements for ward-off these midges. As per the Law of Physics, for undertaking any body movement huge energy is spent, resulting in reduction of milk yield which has been estimated to the extent of 18.97 percent by Narldkar and Shivpuje^[1]. At International level different species of *Culicoides* have been proved as the vectors of blue tongue virus^[2, 3]. Bovine ephemeral fever which is very common in India is also transmitted by *Culicoides* species. These midges also transmits viruses of epizootic haemorrhagic disease, Akabane, Aino, Chuzan, Vesicular stomatitis virus, Equine Encephalitis virus (EEV), Schmallenberg virus, protozoa like *Haemoproteus* spp., *Leucocytozoon* spp., *Hepatozoon*, avian Trypanosomes, *Plasmodium* in lizard, helminths like filarid worms *Onchocerca cervicalis* in horses, *Dipetalonema* spp, *Mansonella perstans* and *Mansonella ozzardi* in humans and various filarid worms of birds and mammals. *Culicoides impunctatus* the Scottish highland midge is a significant factor in limiting tourism in Western Scotland and has been estimated to cause losses upto 20% man hours in the forest industry^[4]. *Culicoides* transmitted diseases i.e. Blue Tongue and African Horse sickness are of international significance and have been allocated OIE list 'A' status i.e. 'Communicable diseases of national borders, which are of socio-economic or public health consequences and which are of major importance in the international trade of livestock and livestock products'^[5]. Therefore, present review was taken with a sole objective to highlight all such issues related to dynamics of *Culicoides* midges.

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Species of *Culicoides* prevalent in India

Culicoides spp. midges are the important human and animal pests with great economic significance. These are the one of the world's smallest haematophagous flies measuring from 1 to 3 mm in size. Importance of *Culicoides* (Diptera: Ceratopogonidae) as a livestock Pest is of high significance owing to facts that *Culicoides* are small midges (1-3 mm) presenting a huge diversity with more than

1300 species described worldwide [5] of which some 96% are hematophagous. Of these genera, four are known to contain species that suck the blood of vertebrates viz. *Austroconops*, *Culicoides*, *Forcipomyia* (subgenus *Lasiohelea*), and *Leptoconops*. More than 1400 species of genus *Culicoides* have been identified worldwide of which about 96% are obligate blood feeders attacking mammals (including humans) 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 4000m [6]. In India 63 species of *Culicoides* were identified morphologically and their prevalence reported by many authors from Kolkata and the neighbouring areas, Assam, Bengal, Chennai (Tamil Nadu), Marathwada region of Maharashtra, Chittoor and Prakasam districts of Andhra Pradesh and Northern Karnataka region and many parts of India [7].

In India citing the works of [8-11] enumerated 28 *Culicoides* species in India. Of these 28 species, most of them belonged to Calcutta, whereas one species *Culicoides pattoni* was collected from Calcutta, Assam/Puri. Sen and Fletcher [11] also reported the species of *Culicoides oxystoma* from Bombay Veterinary College. Sen and Dasgupta [12] reported 31 *Culicoides* species and one variety, while Dasgupta [13, 14] and added few more species from Calcutta. Of these 31 species, *C. pattoni* and *Culicoides indianus* were reported from Coimbatore and Dharwar (Sen and Dasgupta) [12], *Culicoides alatus* from Pune Dasgupta and Ghosh (1961 and three

species, i.e., *Culicoides fulves*, *Culicoides clavipalpis* and *Culicoides similis* were reported from Madras [15], from India total of around 50 species and one variety are documented. These include *C. actoni*, *Culicoides autumnalis*, *C. alatus*, *Culicoides albipennis*, *Culicoides anophelis*, *Culicoides bimaculicosta*, *Culicoides brevimanus*, *Culicoides certus*, *C. clavipalpis*, *Culicoides candidus*, *Culicoides daleki*, *Culicoides dumdumi*, *Culicoides distinctus*, *Culicoides definitus*, *Culicoides fortis*, *C. fulvus*, *Culicoides fulvithorax*, *Culicoides himalayae*, *Culicoides innoxius*, *Culicoides iniquus*, *C. indianus*, *Culicoides imperceptus*, *Culicoides inexploratus*, *Culicoides kamrupi*, *Culicoides macrostoma*, *Culicoides macfieii*, *Culicoides molestus*, *Culicoides minutus*, *Culicoides magnificus*, *Culicoides nitidulus*, *C. oxystoma*, *Culicoides orientalis*, *Culicoides odiosus*, *Culicoides opacus*, *C. peregrinus*, *Culicoides palpifer*, *Culicoides paivai*, *Culicoides pictiventris*, *Culicoides pseudoturgidus*, *Culicoides paralini*, *C. pattoni*, *Culicoides quadrilobatus*, *Culicoides raripalpis*, *C. schultzei*, *Culicoides shortti*, *C. similis*, *Culicoides setiger*, *Culicoides scapularis*, *Culicoides superfulvus* and *Culicoides sturgidus* and one variety as *C. peregrinus* var. *assamensis*. From Darjeeling region of India [16] reported *Culicoides spinulosus* and *Culicoides majorinus* species. *Culicoides* species reported in the literature from Maharashtra state predominantly belonging to three species namely *Culicoides peregrines* Kieffer, 1910, *Culicoides schultzei* Enderlein, 1908 and *Culicoides actoni* Smith, 1929 [17].

Udupa [18] and Bhoyar *et al.* [19] did the work on various aspects of species of *Culicoides* at Chennai and Bidar, respectively. Archana *et al.* [7] studied different species of *Culicoides* in Bangalore rural and urban districts of South India. Flies were collected with UV-light traps during rainy season. The fly species reported were *Culicoides imicola*, *C. oxystoma*, *C. peregrinus*, *C. actoni*, *C. anopheles*, *C. palpifer*, *C. huffi*, *C. innoxius*, *C. arakawae* and *C. circumscriptus*.

Table 1: Zeist of species of *Culicoides* prevalent across the globe

Country	Author	Species of <i>Culicoides</i> responsible
America	[20]	Sixteen species of <i>Culicoides</i> from Gold coast area providing distinguishing characters and keys to identify the males and females of 17 species of <i>Culicoides</i> .
America	[21]	ceratopogonids of the genus <i>Lasiohelea</i>
America	[22]	<i>Culicoides actoni</i> and <i>C. raripalpis</i>
America	[23]	<i>C. Insignis</i> and <i>C. varipennis</i>
Australia	[24]	<i>C. brevitarsis</i>
Africa	[25]	16 <i>Culicoides</i> species from Karoo region of South Africa of which <i>C. pycnostictus</i> was the most predominant
Africa	[26]	<i>C. imicola</i> , <i>C. zuluensis</i> , <i>C. pycnostictus</i> , <i>C. schultzei</i> group, <i>C. bolitinos</i> , <i>C. magnus</i> , <i>C. leucostictus</i> , <i>C. nivosus</i> , <i>C. bedfordi</i> , <i>C. similis</i> , <i>C. macintoshi</i> , <i>C. neavei</i> , <i>C. gulbenkiani</i> , <i>C. onderstepoortensis</i> , <i>C. kobae</i> , <i>C. ravus</i> , <i>C. milnei</i> , <i>C. tropicalis</i> , <i>C. engubandei</i> , <i>C. glabripennis</i> , <i>C. brucei</i> , <i>C. micheli</i> , <i>C. dutoiti</i> and <i>C. coarctatus</i> .
Africa	[27]	<i>C. imicola</i> , <i>C. zuluensis</i> , <i>C. pycnostictus</i> , <i>C. schultzei</i> group, <i>C. bolitinos</i> , <i>C. magnus</i> , <i>C. leucostictus</i> , <i>C. nivosus</i> , <i>C. bedfordi</i> , <i>C. similis</i> , <i>C. macintoshi</i> , <i>C. neavei</i> , <i>C. gulbenkiani</i> , <i>C. onderstepoortensis</i> , <i>C. kobae</i> , <i>C. ravus</i> , <i>C. milnei</i> , <i>C. tropicalis</i> , <i>C. engubandei</i> , <i>C. glabripennis</i> , <i>C. brucei</i> , <i>C. micheli</i> , <i>C. dutoiti</i> and <i>C. coarctatus</i> .
Turkey	[28]	<i>C. circumscriptus</i> , <i>C. punctatus</i> , <i>C. odibilis</i> , <i>C. puncticollis</i> , <i>C. riouxi</i> , <i>C. cubitalis</i> (<i>C. kibunensis</i>), <i>C. cataneii</i> , <i>C. newsteadii</i> , <i>C. simulator</i> , <i>C. longipennis</i> , <i>C. achrayi</i> , <i>C. riethi</i> , <i>C. obsoletus</i> , <i>C. truncorum</i> , <i>C. dzhafarovi</i> , <i>C. odiatus</i> , <i>C. shanklawensis</i> , <i>C. pulcaris</i> and <i>C. geigelensis</i> .
Europe	[29]	<i>C. kingi</i> and <i>C. Imicola</i> were most predominant. <i>C. schultzei</i> and <i>C. Obsoletus</i>
Europe	[30]	20 species of <i>Culicoides</i> from Mainland
Italy	[31]	<i>C. paolae</i>
Spain and Portugal	[32]	21 species of <i>Culicoides</i>
USSR	[33]	<i>C. riethi</i> , <i>C. circumscriptus</i> , <i>C. desertorum</i> , <i>C. maritimus</i> , <i>C. karagiensis</i> , <i>C. punctatus</i>
Indonesia	[34]	<i>C. orientalis</i> , <i>C. peregrinus</i> , <i>C. peregrinus</i> , <i>C. actoni</i> , <i>C. peregrinus</i> , <i>C. oxystoma</i> , <i>C. oxystoma</i> and <i>C. peregrinus</i> ,
China	[35]	documentation of 78 species of <i>Culicoides</i>
China	[36]	<i>C. oxystoma</i> and <i>C. homotomus</i>
China	[37]	<i>C. desytoculus</i> , <i>C. pulchellus</i> , <i>C. gymnopterus</i> , <i>C. parabarnetti</i> , <i>C. pikongkoi</i>
China	[38]	<i>C. arakawae</i> , <i>C. schultzei</i> , <i>C. amaniensis</i> (<i>C. sumatrae</i>), <i>C. okumensis</i> (<i>C. actoni</i>), <i>C. erairai</i> , <i>C. palpifer</i> among which

		<i>C. arakawae</i> and <i>C. schultzei</i>
Island	[39]	<i>C. paragarctai</i>
Morocco	[40]	<i>C. imicola</i> , <i>C. obsoletus</i> <i>C. Pulicaris</i>
Argentina	[41]	<i>C. insignis</i> , <i>C. venezuelensis</i> , <i>C. leopoldoi</i> , <i>C. liamai</i> , <i>C. flinti</i> , <i>C. debilipalpis</i> , <i>C. paraensis</i> and <i>C. guttatus</i>
Spain	[42]	<i>Culicoides imicola</i> and <i>C. obsoletus</i>
Republic of Korea	[43]	<i>C. punctatu</i> , <i>C. arakawae</i> , <i>C. tainanus</i> , <i>C. oxystoma</i> , <i>C. circumscriptus</i> , <i>C. homotomus</i> , <i>C. erairai</i> , <i>C. kibunensis</i> , and <i>C. nipponensis</i>
Namibia	[44]	<i>Culicoides imicola</i>
Grog	[45]	<i>Culicoides obsoletus</i> and <i>Culicoides pulicaris</i>
Belgium	[46]	<i>C. obsoletus</i> / <i>C. scoticus</i> species, <i>C. chiopterus</i> , and <i>C. dewulfi</i> , <i>C. impunctatus</i> , <i>C. sphagnumensis</i> , <i>C. clintoni</i> and <i>C. comosioculatus</i>
Korea	[47]	<i>Culicoides punctatus</i> , <i>C. maculates</i> , <i>C. arakawae</i> , <i>C. oxystoma</i>
Korea	[48]	<i>Culicoides insignis</i>
South Africa	[49]	<i>Culicoides oxystoma</i> , <i>Culicoides kingi</i> , <i>C. enderleini</i> and <i>C. nevillei</i>
Timis	[50]	<i>Culicoides obsoletus</i> , <i>C. pulicaris</i> and <i>C. nubeculosus</i>
South Bengal	[51]	<i>Culicoides schultzei</i> , <i>C. palpifer</i> and <i>C. definitus</i> .

Population dynamics and metrological factors responsible

It is evident from the literature that the population dynamics of *Culicoides* midges varies from place to place and country to country and is solely dependent on the climatic factors.

Due to variation in climatic factors, calendar months of a particular season differ in different continents of the world. In view of this fact the literature on seasonal abundance of *Culicoides* spp. in different countries are documented.

Table 2: Population dynamics and metrological factors responsible

Country	Author	Meteorological factor responsible for dynamics
Nigeria	[52]	Wind force and rainfall were believed to be important factors influencing the populations of <i>Culicoides</i> .
Nan Kang Taipei	[53]	Climatic factors especially temperature and precipitation and observed population peak of all species in the region in the month of May.
USSR	[54]	phenology and seasonal course of blood sucking midges of the genus <i>Culicoides</i> in the Western Pamir USSR
Southeast Queensland	[25]	population of <i>Culicoides</i> was dependent on windspeed, temperature, vapour pressure and sunlight
South Africa	[26]	season and rainfall greatly influenced the population of <i>Culicoides</i> species
Taiwan	[55]	that <i>Culicoides</i> population in central was significantly influenced by temperature and rainfall
New York	[56]	population size tended to increase through season and was highest in July and August which coincided with the emergence of adults from overwintered 3 rd and 4 th instar larvae
USA	[24]	Population of <i>Culicoides insignis</i> persisted throughout the year in Florida USA except during cold winter months.
Israel	[57]	Observed that <i>C. imicola</i> showed peak populations from mid-summer to onset of winter which was peak season of Blue Tongue disease occurrence.
Georgia	[58]	Noted that <i>C. hollensis</i> and <i>C. melleus</i> were abundant during winter and summer and correlated with the bimodal spring-autumn seasonal abundance of these two species
Paris	[59]	<i>Culicoides</i> could grow in the temperature range of 10 to 35°C and they required adequate moisture. Movement of the <i>Culicoides</i> was found to be affected by mainly wind. Lastly author has highlighted two important factors in the <i>Culicoides</i> ecology i.e. temperature and wind.
India	[60]	Seasonal abundance of three <i>Culicoides</i> species i.e. <i>C. schultzei</i> , <i>C. peregrinus</i> and <i>C. actoni</i> from Marathwada region of India. During monsoon season with second peak during winter, while during summer the depression in <i>Culicoides</i> population occurs (peak during September and second peak in January, while lowest population during December and May).

Losses estimated

It is well known fact that different species of *Culicoides* midges causes trouble to livestock by several ways such as a) blood feeding, b) psychological disturbances) allergy,

d) disease transmission all leading to economic losses from livestock. These facts have been reported through observations by scientists across the globe.

Table 3: Losses estimated

Country	Author	Losses estimated
USA	[6]	Transmission of Bovine ephemeral fever (Loss of draught work), Blue Tongue outbreaks results in six million US dollar loss
Scotland	[4]	hampering agricultural and forestry activities, as well as tourism development
India	[1]	<i>Culicoides</i> midges causes psychological disturbances and body movements forward-off these midges, as a results energy spent in movements results in reduction of milk yield to the extent of 18.97 percent.

Narladkar (2018) based on the estimates mentioned in the literature worked out the projected economic losses from

Culicoides midges in terms of milk loss as detailed in the below

Direct losses estimated	Total milkproduction in India [§]	Projected loss of milk production [#]	Projected loss in ₹
Transmission of Bovine ephemeral fever (Loss of draught work), Blue Tongue outbreaks results in six million US dollar loss # Total 18.97% loss of milk production (Narladkar and Shivpuje,2012)	Total 132.43 million tons during 2012-13 in India	@18.97% 25.12 million tones	@ Rs 38 liter/Kg = ₹ 95463 crore per annum
	7.02 liter/day Crossbred cow	@18.97% -1.33 liter/day loss	₹ 50.54 cow/day
	2.36 liter/day Indigenous/ND cow	@18.97% -0.45 liter/day loss	₹ 17.10 cow/day
	4.80 liter/day Indian buffalo	@18.97% -0.91 liter/day	₹ 35.48 buffalo/day
	7.02 liter/day CB cow	@23% -1.61 liter/day loss	₹ 61.18 cow/day
	2.36 liter/day/ Indigenous /ND cow	@23% -0.54 liter/day loss	₹ 20.52 cow/day
	4.80 liter/day/ Indian buffalo	@23% -1.10 liter/day loss	₹ 41.80 buffalo/day

Conclusions

From the present review article conclusions can be drawn that a) *Culicoides* species midges are the pests of livestock importance world-wide, b) their nuisance to livestock results in heavy economic losses they being, blood suckers, causing body movements as a result of their painful bites in enormous numbers which resulting in milk loss to the extent of 18.97%, c) potent vectors for viral and helminthic diseases, and d) owing to all these facts needs attention for their control.

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