Host Landing And Diel Activity of Potent Vectors of Bluetongue Disease, *Culicoides Oxystoma* and *Culicoides Peregrinus*

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Research

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Abstract

Background The spread of bluetongue virus depends on the vectorial ability of *Culicoides* affecting the susceptible host. Animal farms in West Bengal have reported prevalence of potent vectors of BTV (*C. oxystoma*, *C. peregrinus* and *C. fulvus*). Besides, high seroprevalence of BTV was also reported from this cattle dense region. Henceforth host-seeking activity of two important potent vectors, *C. oxystoma* and *C. peregrinus* on cattle were studied in two farm sites of West Bengal, India.

Methods The study was done in 2018-19 comprising of total 297 hours of collection over 27 nights. A comparison was made between the catches obtained by mouth aspirator and light trap. Hourly collections of *Culicoides* were done directly from cattle (oral aspirator) as well as light trap was operated in close vicinity of cattle at a different shed.

Results A total of 11,462 *Culicoides* belonging to *C. oxystoma, C. peregrinus and C. fulvus* were collected in light trap and aspirator. In aspirator 4764 midges were collected whereas 6698 individuals were collected in light trap. The following species were aspirated: *C. peregrinus* and *C. oxystoma*; however the light trap catches consisted of *C. fulvus, C. oxystoma* and *C. peregrinus*. Light trap collection exhibited crepuscular activity whereas aspirator collection was maximum between 4.00 am and 5.00 am. Likewise maximum landing of midges was observed in neck and hump region of cattle.

Conclusion It was observed that the preferred time of feeding of *C. peregrinus* and *C. oxystoma* on cattle were early morning hours though midges were ubiquitous from dusk to dawn. Surprisingly the preferential landing of the two vectors were mostly restricted to the neck and hump region of the cattle. The results obtained during the study warrants further insight into the factors influencing the landing site by the vectors which may be useful biological data in disease management and draw effective deterrent strategies.

Background

Among the hematophagous genera, *Culicoides* have assumed significance and notoriety worldwide due to its ability to transmit a wide range of pathogens of public and veterinary importance [1]. Presently India records 535.78 million as major farm animals i.e cattle, buffalo, poultry, sheep and goat including indigenous and exotic breeds, with a total bovine population of 302.79 million (buffalo, cattle, mithun, yak) [2]. Such presence of large numbers and variety of livestock and density of livestock is at risk in transmission of an orbivirus bluetongue (BT) by *Culicoides* midges and which may lead to outbreak of BTD. Besides, This virus causes bluetongue disease (BTD) in goats, sheep, cattle and other small and wild ruminants [3]. Although the disease was dominant in temperate zones, introduction of non-native breeds in virus endemic tropical and subtropical zones also caused BT outbreak [4]. The spread of range of BT in the temperate was also attributed to global warming [5]. Presently seroprevalence of bluetongue virus (BTV) has been reported across all the Indian states [6]. The BTD outbreak has been witnessed frequently owing to the significant density of livestock, high prevalence of the *Culicoides* along with conducive climatic conditions helping in propagation of vectors and the virus [7, 8]. BTV was first recorded from the state of Maharashtra [9] and also occurrences of BTV from Indian states covering western, northern and southern regions followed [10, 11]. Although eastern and north eastern India is yet to witness an outbreak, high seroprevalence in livestock has appeared in several scientific articles [11, 12]. Presently 22 of the 28 serotypes (worldwide) have been recorded from India [13]. Moreover BT seropositivity in different animals depicts 34% in buffalo, 16% in camel, 38% in cattle, 43% in goat, 39% in sheep and 66% in mithun [13]. According to [2] state of West Bengal shares 6.9% of total livestock population comprising 8.25% cattle, 0.8% of sheep and 10.93% goats' population. The economy of West Bengal, especially in Burdwan district is agriculture based (mixed farming) in which livestock and animal husbandry plays a pivotal role. The villagers form a cluster of self help groups (SHG) which market livestock products to generate revenue [14]. The seroprevalence in goat (66.95%), sheep (57.66%) and cattle (52%) has been reported across 7 districts of West Bengal [15, 16]. Despite such high seroprevalence, BTD outbreak remains unreported from West Bengal [17]. BTD outbreak and its economic implications has been well documented from the southern Indian states, however, there remains critical knowledge gaps and understanding of biology of the potent vector species prevalent in this tropical region. Few studies on biology, ecology and taxonomy of the *Culicoides* spp were carried out [8, 17]. Besides, [18] has reported prevalence of 7 putative vectors *C.oxystoma*, *C. fulvus*, *C. orientalis*, *C. dumdumi*, *C. imicola*, *C. peregrinus* and *C. brevitarsis* from southern India. In the eastern state of West Bengal, *C. fulvus*, *C. peregrinus* and *C. oxystoma* were the prevalent species in mixed farms and cattle sheds [8, 17] thereby posing considerable risk in the spread of disease. Further a coloured LED light trap based extensive surveillance program was also conducted in the same site to ascertain the prevalence of the aforesaid species in the cattle sheds [8].

Information available on host seeking activity, ecology and biology of *Culicoides* are limited across the globe [19, 20]. The aforesaid information was imperative for implementation of control measures in disease epidemiology [20]. Although the disease causing pathogens vectored by *Culicoides* were a matter of concern, relatively scant information on its bionomics exists in India [18] and Europe [20, 21, and 22]. In the light of forecasting disease transmission, limited information on the host-vector association has led to assumptions that all the *Culicoides* species prevalent in the cattle sheds fed on host with equal facility on which various predictions were based [21]. Besides difficulty in aspirating *Culicoides* from the host body also limits studies on host seeking activity of the *Culicoides* [19].

In this study the catch data obtained by two different methods (light trap and aspirator) were evaluated and compared in order to separate two adult activity of *Culicoides* spp. in real time: flight activity and biting activity. The two study sites were selected at Burdwan district of West Bengal due to report of seroprevalence of BTV from this region [12] as well as high seasonal abundance of potent vector species of *Culicoides* associated with livestock from this district [17]. Moreover, the evaluation enables validation of the time and preferential landing of *Culicoides* on cattle body parts which is critical at farmer's level to reduce the host-vector contact.

Materials And Methods

Study site

This investigation was carried out in two rural villages of West Bengal 51 km apart i) Dharan (DH; 23°02'57.7"N, 87°51'47.5"E), ii) Sahibganj-Tantipara (ST; 23°44'29.14"N, 87°82'76.56"E). The biting midges were trapped throughout the seasons in DH during May to October, 2018 and in April to June, 2019; and in ST from May to October, 2018. In India, Indian Meteorological Department (IMD) recognizes the occurrences of four seasons: winter, December to February; summer or pre-monsoon season, lasting from March to May; monsoon or rainy season, lasting from June to September; Post-monsoon or autumn season, lasting from October to November. At ST village site, 12 night collections were made i.e., two catches/month, whereas in DH village site, monthly three collections were done (excepting for the months of October, April and June where single collections/every month). A total of 27 night catch data (297 hrs of collection) were considered for both the sites. In both the sites, the sheds housing the cattle were made of mud-brick adjoining to household. Geographically the villages are situated amidst agricultural fields in which extensive rice cultivation is practiced throughout the year, water logging even during dry seasons predominantly rice growing areas of West Bengal. Most households maintain livestock animals for their economic sustenance. It experiences tropical climate with annual rainfall of 1496 mm. The hygiene conditions are compromised within and outside the perimeter of the animal sheds as dung heaps and paddy straws were garbaged. In ST, the cattle sheds were located on the embankment of a pond. Moreover, the drainage system of the village was found to empty into the pond. For this study one cattle shed at DH and two cattle sheds at ST were chosen.

Description of collection

The adults that landed on the host body surface was retrieved by aspirators (oral & mechanical) and flying adults were trapped by LED based light traps installed at close vicinity of cattle within the shed. Adults were aspirated covering various parts of the body surface of a white coloured adult cow. For our convenience the entire body surface of the cattle was subdivided [23] following the studies of [20] and [21]. Catches made were labeled as follows: head (H1), neck (H2), hump (H3), back (H4), leg (H5), belly (H6), hip (H7) (Figure 1). Each catch duration was restricted to 10 minutes/hour the entire process of aspiration initiated on 18.00hrs in the evening that continued up to 6.00hr in the morning (12 hours per diem). The catch period (designated as T1 hr to T11 hr) was followed: T1: 18.00-19.00, T2: 19.00-20.00, T3: 20.00-21.00, T4: 21.00-22.00, T5: 23.00-00.00, T6: 00.00-01.00, T7: 01.00-02.00, T8: 02.00-03.00, T9: 03.00-04.00, T10: 04.00-05.00, T11: 05.00-06.00. During the process of aspiration all other cattle stationed within the sheds were evacuated at least half an hour prior to collection. 4W dim white light was used during the process of collection of the *Culicoides* from cattle. The LED light trap was operated within the cattle shed (ST), 200 m apart from the shed where aspiration based collections were done. Although a mechanical aspirator was also used for the purpose; however, the mouth aspirator was tedious but proved handy in aspirating the adults tucked within the fur.

Statistical Analysis

A logistic regression was done on the proportion of engorged and non engorged females to justify the effects of time and site on host landing. The logistic regression was carried following the binomial GLM with logit link, using time and site as the explanatory variables on the assumptions of generalized linear model (GLM). The logistic regression equation form: $(y) = 1/(1+\exp(-(a+b_1x_1+b_2x_2+b_3x_3))$; where the explanatory variables, x_1, x_2 and x_3, represented the time of landing of *Culicoides* on host, site of landing on host and interaction between the two components respectively and y was the response variable. The regression analysis was performed on the assumptions that the landing of non-engorged and engorged *Culicoides* follow binomial distribution (n, p) with n replicates for each set of independent variables (time of landing, site of landing on host and interaction between host landing and time). Maximum likelihood method has been used as a measure to estimate the logit linked parameters through statistical software. Using the value of Wald's Chi square, the parameter of the models were tested for the significance at P= 0.05 level.

Results

In this investigation, the trapped number of *C. oxystoma* females caught were 1924 individuals further categorized as 1315 non-engorged, 609 engorged and *C. peregrinus* females consisted of 2070 individuals of which 1192 non-engorged and 878 engorged (Table 1a). In ST, a total catch of *C. oxystoma* were 2119 individuals (899 engorged, 1220 non-engorged) and *C. peregrinus* were 2645 individuals (1630 engorged and 1015 non-engorged) respectively (Table 1b). In ST collections, the following species were aspirated: *C. peregrinus* and *C. oxystoma*; however the light trap catches consisted of *C. fulvus, C. oxystoma* and *C. peregrinus.* The total *Culicoides* caught through aspiration were 4764 compared to light trap catch of 6698 individuals (Figure 2a; 2b). Significant numbers of *Culicoides* individuals landed on the upper portion of the cow, while very few individuals landed on the belly and legs. Landing of *Culicoides* was limited to hip due to continuous tail whipping, licking and kicking reflexes of the cattle. It appeared that a period of 30-40 min i.e. between 4 am and 5 am (dawn) was the actual feeding window of the *C. oxystoma* and *C. peregrinus* attacking the cattle (Table 2). During the feeding interval usually the *Culicoides* females swarm on to the host althoughboth the species attacked the cattle with equal intensity, the proportion of engorged *C. peregrinus* aspirated were more (42.42%) compared to *C. oxystoma* (31.65%) (Figure 3). The results highlighted variation in abundance of the *Culicoides* analyzed through ANOVA with post hoc Tukey test considering the time of host-seeking activity and different body parts of cattle as the source of variations (Table 3a; Table 3b).

Dharan

GLM with logit link was done after aligning the data in binomial order to interpret the relation between specific age groups preferring particular landing sites on cattle bodies. In *C.oxystoma*, engorged (y)=1/(1+exp(-(-1.96+0.13*time-0.59*host landing + 0.025*time*host landing))). The parameters significantly were at $p<0.05$ (intercept= -1.961±0.59; Wald χ^2 = 11.44; host landing= -0.599±0.2; Wldχ^2 = 9.3). For non-engorged (y) = 1/(1+exp(-(-0.99+0.11*time – 0.49*host landing + 1.75 – 02*time*host landing))). Significance at level of $p<0.05$ has been observed for the following parameters (intercept= -0.991±0.4; Wald χ^2 = 6.2; time = -0.110±0.05; Wald χ^2 = 4.2; host landing = -0.498±0.12; Wald χ^2 = 17.15). Similarly in *C. peregrinus*, the equation of the models for input variables, engorged (y) = 1/(1+exp(-(-1.78+0.17*time-0.37*host landing – 3.48 – 03*time*host landing))). The parameters significant at $p<0.01$ (intercept= -1.78±0.46; Wald χ^2 = 14.75; time = 0.17±0.06; Wald χ^2 = 7.3; host landing = -0.37±0.14; Wald χ^2 = 7.08)

non-engorged (y) = 1/(1+exp(-(-2.07 + 0.18*time – 0.26*host landing – 1.32 – 02*time*host landing))). The model parameters considered significant at $p<0.05$ (intercept= -2.073±0.47; Wald χ^2 = 19.2; time = -0.184±0.06; Wald χ^2 = 8.6; host landing = -0.264±0.13; Wald χ^2 = 3.9).

Sahebganj-Tantipara (ST)

For *Culicoides oxystoma*, the binomial GLM with logit link was done after conversion of the data to binary (presence of the *Culicoides* has been considered 1 or else 0). The equation obtained was engorged (y) = 1/(1+exp(-(-0.985+0.069*time-0.59*host landing+0.02*time*host landing))). The following model parameters were significant at p<0.05 level (intercept= -0.985±0.5; Wald χ^2 = 3.976; host landing = -0.585±0.2; Wald χ^2 = 12.8). It was observed that the pattern of engorged *Culicoides oxystoma* landing on cattle was a time-dependent variable. The following equation has been noted for non-engorged (y) = 1/(1+exp(-(-0.76+8.49-02*time-0.51*host landing + 1.76 - 0.02*time*host landing))). The parameters significant at p<0.05 (host landing = -0.509±0.13; Wald χ^2 = 15.31). Likewise in *C. peregrinus*, engorged (y) = 1/(1+exp(-(-1.69+0.183*time-0.463*host landing+9.387-0.3*time*host landing))). The parameters observed were significant at p<0.05 (intercept= -1.690±0.5; Wald χ^2 = 10.81; host landing = -0.463±0.16; Wald χ^2 = 8.58). For non-engorged (y) = 1/(1+exp(-(-1.87+0.18*time-0.23*host landing-0.02*time*host landing))). The parameters observed significant were (intercept= -1.868±0.49; Wald χ^2 = 14.61; time = 0.182±0.07; Wald χ^2 = 7.59; host landing = -0.234±0.14; Wald χ^2 = 2.96).

Discussion

The *Culicoides* species investigated in this study was reported to be vectors of important diseases associated with farm animals' worldwide [17]. Shielding of animals from attack of female *Culicoides* may be adopted as a measure to interrupt disease transmission hence information on peak activity of *Culicoides* from this region of world will be useful in disease management strategies [17]. The landing time and site of females belonging to *C. oxystoma* and *C. peregrinus* on the cattle in the early morning for the purpose of obtaining blood meal was observed. However, *C. fulvus* has been reported only in a light trap from one of the study sites thereby raising doubts on the host preference of the species. The aspirator based study validated the diel activity of the *C. oxystoma* and *C. peregrinus*. Significant proportion of engorged females in the study justified the usage of aspirator to intercept the host-seeking females. Moreover the present study ascertained that cattle not only attracted *Culicoides* but constituted one of the significant hosts. *C. oxystoma* and *C. peregrinus* were known to be one of the most prevalent species across India, from which the BTV serotypes have been isolated [24, 25] and also were enlisted as potent vectors of BTV from the subcontinent [18]. Moreover both the species were reported to be most abundant in cattle sheds of West Bengal [17] thereby contributing to the significance of the study. High proportion of engorged *C. peregrinus* and *C. oxystoma* feeding on the cattle suggests active blood-seeking behaviour of the species, which agrees with the opinion regarding fierceness of *C. peregrinus* [26]. *C. oxystoma* has been recognized as potential vectors of BTV from India [24] and Indonesia [27]. Japan has reported *C. oxystoma* as potent vector of Akbane virus [28, 29] and of epizootic hemmorhagic disease virus from Israel [30]. Moreover [31] has reported involvement of *C. oxystoma* in transmission of African horse sickness virus (AHSV) from Senegal.

The proportion of engorged to non-engorged females aspirated ascertains landing of *Culicoides* on host but does not warrant feeding. It was noted that 30-40% of the total midges landing actually fed on the cattle; the finding substantiated the conclusion drawn on activity of *Culicoides* midges from Ireland [32].

A bimodal distribution of *C. oxystoma*, *C. peregrinus* and *C. fulvus* was observed in light trap based collections within the animal shed. The plausible explanation was that the resting adults within the cattle shed after completion of blood meal were also attracted towards the light traps. However, *Culicoides* were observed to be prevalent in resting conditions in the cracks, crevices, walls, and roof within the shed housing cattle throughout the 24 hour period. Mere prevalence of *Culicoides* within cattle sheds does not warrant their blood feeding activity.

Amongst the different portions of cattle body, the desired landing site of the *C. oxystoma* and *C. peregrinus* were neck, hump followed by the head of the cattle (mostly in and around the ear). Although various studies suggested temperature to be a significant factor influencing the landing of *Culicoides* [33], our observation suggests that the thickness of epidermis and degree of vascularization might be two of the most important criteria influencing the landing of female *Culicoides*. Likewise [32] reported on the preference of *C. obsoletus*, *C. dewulfi*, *C. pulicaris*, *C. punctatus* and *C. nebeculosus* for mane and lower legs of horse. [33] remarked that 72% of the total collections were from the belly whereas 28% from the dorsal surface. *C. puncticollis* and *C. schultzei* preferred the belly region whereas *C. imicola* preferred the dorsal surface. A comparative preferential landing study of *Culicoides* on dairy cows, Shetland pony and sheep has been done [21]. It was observed that C. *chiopterus* favoured legs, *C. punctatus, C. achrayi* landed on the belly. *C. obsoletus, C. dewulfi* and *C. pulicaris* landed on head, back and flanks respectively. Moreover *C. chiopterus, C. punctatus, C. obsoletus/scoticus* favoured the belly region of horses [35]. Anatomically, vascularization has been complex in the neck and hump region [23], henceforth correlating to the preferred landing of the *Culicoides* at these sites. Likewise the thickness of epidermis was found to be less in the aforesaid body parts. The difference in preference could not be attributed to body surface temperature as there was not much difference in temperature except belly and hip, where the difference was 1°C. However in the present study *Culicoides* on belly was less compared to that of neck and hump.

This investigation recorded diel activity and host-seeking activity of the potent vector species associated with cattle in the state of West Bengal. Most of the cattle sheds in West Bengal were open type and cattle were either herded in this shed or in open yard at night. In such a setup there exists a high risk of cattle being exposed to *Culicoides* bite during the early morning. The present study argues that in order to minimize the contact between *Culicoides* and cattle, the cattle should be housed in a closed shed for at least 1 hour (i.e., between 4.00 am and 05.00 am). In closed sheds the activity of *Culicoides* has been observed to be reduced by 14 fold (unpublished). Owing to absence of proper closed sheds in most of the rural areas, an alternative approach could also be adopted by farmers. Blankets, badges or jute bags could be placed over the hump and neck region of the cattle during the peak activity time (between 4 am and 5 am) of midges thereby interfering with the preferred landing and subsequent feeding of the *Culicoides* midges.

Declarations

ETHICS STATEMENT

No animals were harmed during the study

AUTHORS CONTRIBUTION: First author: The entire work from data collection to data analysis and writing of manuscript. Corresponding author: Ensuring that entire process was accurate. Second and third author: Aided in insect sampling

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CONFLICTS OF INTEREST

The authors declare no conflict of interest

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Tables

Table 1

a. Mean and S.E. of female C. oxystoma and C. peregrinus aspirated hourly from cattle (cow) body surface at Dharan (DH), West Bengal. Body part of cattle al H2, neck; H3, hump; H4, back; H5, leg; H6, belly; H7, hip.

			18.00-19.00	**19.00-20.00**	**20.00-21.00**	**21.00-22.00**	**23.00-00.00**	**00.00-01.00**	**1.00-2.00**	**2.00-3.00**	**3.00-4.00**	**4.00-5.0**
C. oxystoma	Non engorged	H1	0.0-7.0	0.0-2.0	0.0-2.0	0.0-1.0	0.0-1.0	0.0-2.0	0.0-0.0	0.0-1.0	0.0-4.0	0.0-31.0
			1.9±0.52	0.5±0.19	0.2±0.15	0.1±0.07	0.1±0.07	0.2±0.15	0.0±0.00	0.2±0.11	0.9±0.36	7.2±2.2
		H2	0.0-1.0	0.0-3.0	0.0-0.0	0.0-2.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-1.0	0.0-1.0	0.0-6.0
			0.1±0.09	0.2±0.2	0.0±0.0	0.3±0.16	0.1±0.09	0.1±0.07	0.0±0.00	0.1±0.07	0.2±0.11	1.3±0.5
		H3	0.0-10.0	0.0-7.0	0.0-2.0	0.0-2.0	0.0-2.0	0.0-2.0	0.0-1.0	0.0-5.0	0.0-6.0	0.0-151
			2.0±0.68	1.0±0.47	0.3±0.15	0.3±0.19	0.2±0.15	0.3±0.16	0.1±0.09	0.5±0.35	1.67±0.56	44.53±1
		H4	0.0-0.0	0.0-0.0	0.0-0.0	0.0-3.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-7.0
			0.0±0.0	0.0±0.0	0.0±0.0	0.2±0.2	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.07	0.0±0.00	0.53±0.
		H5	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-3.0
			0.0±0.0	0.0±0.0	0.0±0.0	0.1±0.07	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.09	0.33±0.
		H6	0.0-4.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-1.0	0.0-2.0	0.0-1.0	0.0-7.0	0.0-7.0
			0.5±0.29	0.1±0.07	0.1±0.09	0.1±0.07	0.0±0.00	0.1±0.07	0.1±0.13	0.1±0.07	0.5±0.47	1.47±0.
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0
			0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.07±0.
	Engorged	H1	0.0-3.0	0.0-0.0	0.0-2.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-2.0	0.0-0.0	0.0-7.0
			0.9±0.27	0.0±0.0	0.1±0.13	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.01	0.0±0.00	1.67±0.
		H2	0.0-0.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-7.0
			0.0±0.0	0.1±0.07	0.1±0.07	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.09	0.67±0.
		H3	0.0-16.0	0.0-4.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-5.0	0.0-8.0	0.0-94.0
			1.7±1.08	0.4±0.27	0.1±0.09	0.0±0.0	0.0±0.00	0.1±0.07	0.0±0.00	0.8±0.38	0.9±0.58	22.6±7.
		H4	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-5.0
			0.0±0.0	0.1±0.7	0.0±0.0	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.07	0.0±0.00	0.40±0.
		H5	0.0-2.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0
			0.13±0.13	0.0±0.0	0.1±0.07	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.07±0.
		H6	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-10.0
			0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.07	0.0±0.00	0.8±0.6
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.0
C. peregrinus	Non engorged	H1	0.0-4.0	0.0-2.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-8.0	0.0-11.0
			1.1±0.36	0.2±0.14	0.1±0.07	0.0±0.00	0.0±0.00	0.2±0.11	0.1±0.07	0.2±0.11	0.7±0.54	3.3±0.9
		H2	0.0-1.0	0.0-0.0	0.0-0.0	0.0-2.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-9.0	0.0-1.0	0.0-2.0
			0.1±0.09	0.0±0.0	0.0±0.00	0.1±0.13	0.0±0.00	0.1±0.07	0.0±0.00	0.6±0.60	0.1±0.09	0.27±0.
		H3	0.0-6.0	0.0-2.0	0.0-1.0	0.0-0.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-4.0	0.0-29.0	0.0-121.
			1.0±0.47	0.3±0.16	0.2±0.11	0.0±0.00	0.1±0.09	0.1±0.07	0.0±0.00	0.3±0.27	2.0±1.9	43.5±10
		H4	0.0-0.0	0.0-0.0	0.0-2.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-9.0	0.0-4.0	0.0-17.0
			0.0±0.0	0.0±0.00	0.2±0.15	0.1±0.07	0.0±0.00	0.0±0.00	0.0±0.00	0.6±0.60	0.3±0.26	1.2±1.1
		H5	0.0-0.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.0±0.0	0.1±0.07	0.1±0.1	0.0±0.00	0.1±0.07	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.0
		H6	0.0-3.0	0.0-0.0	0.0-0.0	0.0-4.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-8.0	0.0-1.0	0.0-4.0
			0.5±0.27	0.0±0.00	0.0±0.00	0.3±0.3	0.0±0.00	0.1±0.07	0.0±0.00	0.5±0.53	0.1±0.07	0.7±0.3

			18.00-19.00	19.00-20.00	20.00-21.00	21.00-22.00	23.00-00.00	00.00-01.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.0
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0
			0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.07±0.
	Engorged	H1	0.0-3.0	0.0-3.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-2.0	0.0-6.0	0.0-7.0
			0.4±0.21	0.3±0.21	0.1±0.09	0.1±0.09	0.1±0.07	0.1±0.09	0.0±0.00	0.3±0.18	1.13±0.5	2.13±0.
		H2	0.0-2.0	0.0-2.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-30.0	0.0-2.0	0.0-1.0
			0.3±0.16	0.0±0.15	0.0±0.00	0.1±0.07	0.0±0.00	0.0±0.00	0.0±0.00	2.0±2.0	0.13±0.13	0.07±0.
		H3	0.0-4.0	0.0-13.0	0.0-2.0	0.0-1.0	0.0-2.0	0.0-1.0	0.0-2.0	0.0-5.0	0.0-25.0	0.0-76.0
			0.5±0.3	1.1±0.86	0.3±0.16	0.1±0.07	0.2±0.15	0.1±0.07	0.13±0.13	0.6±0.38	2.07±1.7	25.6±6.
		H4	0.0-2.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-2.0	0.0-0.0	0.0-5.0
			0.1±0.13	0.0±0.00	0.0±0.0	0.1±0.07	0.0±0.00	0.0±0.00	0.0±0.00	0.13±0.13	0.0±0.0	0.4±0.3
		H5	0.0-1.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0
			0.1±0.07	0.1±0.07	0.0±0.0	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.0	0.2±0.1
		H6	0.0-1.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-1.0	0.0-4.0	0.0-6.0
			0.1±±0.09	0.0±0.0	0.0±0.0	0.1±0.09	0.0±0.00	0.0±0.00	0.1±0.07	0.1±0.07	0.47±0.29	0.5±0.4
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.07	0.0±0.00	0.0±0.00	0.0±0.0

Table 1

b. Mean and S.E. of female C. oxystoma and C. peregrinus aspirated hourly from cattle (cow) body surface at Sahebganj-Tantipara (ST), West Bengal. Body abbreviated: H1, head; H2, neck; H3, hump; H4, back; H5, leg; H6, belly; H7, hip.

			18.00-19.00	**19.00-20.00**	**20.00-21.00**	**21.00-22.00**	**23.00-00.00**	**00.00-01.00**	**1.00-2.00**	**2.00-3.00**	**3.00-4.00**	**4.00-5.00**
C. oxyatoma	Non engorged	H1	0.0-4.0	0.0-1.0	0.0-0.0	0.0-3.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-11.0
			1.3±0.43	0.2±0.11	0.0±0.00	0.3±0.25	0.0±0.00	0.0±0.00	0.1±0.08	0.2±0.11	0.2±0.11	1.7±0.92
		H2	0.0-17.0	0.0-3.0	0.0-4.0	0.0-1.0	0.0-1.0	0.0-2.0	0.0-9.0	0.0-2.0	0.0-18.0	0.0-111.0
			4.0±1.51	1.0±0.35	0.6±0.34	0.1±0.08	0.3±0.13	0.3±0.17	1.3±0.78	0.6±0.23	3.3±1.69	53.3±10.8
		H3	0.0-7.0	0.0-4.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-2.0	0.0-1.0	0.0-3.0	0.0-20.0
			1.1±0.63	0.4±0.33	0.1±0.08	0.0±0.00	0.0±0.00	0.2±0.11	0.2±0.16	0.1±0.08	0.3±0.25	9.8±1.75
		H4	0.0-2.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-3.0
			0.2±0.17	0.0±0.00	0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.3±0.25
		H5	0.0-3.0	0.0-1.0	0.0-0.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-29.0
			0.3±0.26	0.1±0.08	0.0±0.00	0.1±0.08	0.1±0.08	0.1±0.08	0.1±0.08	0.1±0.08	0.1±0.08	5.8±3.02
		H6	0.0-1.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-4.0
			0.1±0.08	0.0±0.00	0.2±0.11	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.09	1.0±0.36
		H7	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00
	Engorged	H1	0.0-2.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-7.0
			0.6±0.19	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.9±0.58
		H2	0.0-13.0	0.0-21.0	0.0-29.0	0.0-2.0	0.0-0.0	0.0-6.0	0.0-1.0	0.0-2.0	0.0-33.0	0.0-99.0
			3.2±1.24	2.3±1.73	2.4±2.4	0.2±0.16	0.0±0.00	0.6±0.49	0.2±0.11	0.3±0.18	5.6±2.75	29.9±8.14
		H3	0.0-17.0	0.0-27.0	0.0-11.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-0.0	0.0-2.0	0.0-11.0	0.0-29.0
			3.17±1.56	2.9±2.26	1.0±0.91	0.1±0.08	0.1±0.08	0.1±0.08	0.0±0.00	0.3±0.17	1.2±0.90	6.5±3.13
		H4	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0
			0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08
		H5	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-12.0
			0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	1.3±0.98
		H6	0.0-0.0	0.0-0.0	0.0-2.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-7.0
			0.0±0.00	0.0±0.00	0.3±0.18	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.7±0.58
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00
C. peregrinus	Non engorged	H1	0.0-2.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-3.0
			0.5±0.23	0.0±0.00	0.0±0.00	0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.0±0.00	0.4±0.28
		H2	0.0-17.0	0.0-3.0	0.0-7.0	0.0-3.0	0.0-0.0	0.0-4.0	0.0-1.0	0.0-26.0	0.0-13.0	0.0-175.0
			4.7±1.74	0.3±0.25	1.3±0.78	0.3±0.25	0.0±0.00	0.3±0.33	0.1±0.08	2.6±2.13	2.3±1.18	50.3±16.5
		H3	0.0-2.0	0.0-2.0	0.0-0.0	0.0-1.0	0.0-2.0	0.0-1.0	0.0-1.0	0.0-12.0	0.0-10.0	0.0-25.0
			0.3±0.18	0.3±0.18	0.0±0.00	0.1±0.08	0.2±0.16	0.1±0.08	0.1±0.08	1.3±0.98	1.1±0.89	6.8±2.4
		H4	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-2.0	0.0-0.0	0.0-0.0
			0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.2±0.16	0.0±0.00	0.0±0.00
		H5	0.0-3.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-30.0
			0.7±0.31	0.2±0.11	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	4.4±2.53
		H6	0.0-1.0	0.0-2.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-2.0
			0.1±0.08	0.2±0.16	0.2±0.11	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.09	0.2±0.16

			18.00-19.00	19.00-20.00	20.00-21.00	21.00-22.00	23.00-00.00	00.00-01.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00
	Engorged	H1	0.0-5.0	0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-5.0	0.0-9.0
			0.5±0.42	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.7±0.46	1.0±0.73
		H2	0.0-3.0	0.0-3.0	0.0-16.0	0.0-9.0	0.0-0.0	0.0-3.0	0.0-1.0	0.0-8.0	0.0-111.0	0.0-167.0
			0.8±0.32	0.7±0.33	1.6±1.31	0.8±0.75	0.0±0.00	0.4±0.26	0.1±0.08	1.8±0.89	19.2±11.22	67.9±12.
		H3	0.0-26.0	0.0-41.0	0.0-1.0	0.0-6.0	0.0-1.0	0.0-3.0	0.0-1.0	0.0-4.0	0.0-29.0	0.0-29.0
			4.25±2.46	5.8±4.00	0.2±0.11	0.6±0.49	0.1±0.08	0.3±0.25	0.1±0.08	0.3±0.33	5.1±2.73	6.7±2.60
		H4	0.0-1.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-4.0
			0.1±0.08	0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.4±0.33
		H5	0.0-9.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-3.0	0.0-0.0	0.0-11.0
			0.8±0.75	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.0±0.00	0.0±0.00	0.3±0.25	0.0±0.00	2.4±0.94
		H6	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.0	0.0-0.0	0.0-5.0
			0.0±0.00	0.0±0.00	0.1±0.08	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.1±0.08	0.0±0.00	1.3±0.54
		H7	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
			0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00

Due to technical limitations, table 2 is only available as a download in the Supplemental Files section.

Table 3a. Results of ANOVA using the time, host landing of *Culicoides* as the source of variations for the **observed abundance** in the cattle sheds in the study area (Dharan). The values in bold indicate significance at P < 0.0001 level. T- time, H – Host body parts.

(a) Culicoides oxystoma

Source	SS	MS	DF	F
TIME	12813.434	1281.343	10	**17.546**
HOST LANDING	10408.242	1734.707	6	**23.754**
TIME*HOST LANDING	49505.948	825.099	60	**11.298**
Error	78725.333	73.029	1078	
Total	151452.958		1154	

Contrast	Difference	Contrast	Difference	Contrast	Difference
T10 vs T7	**11.629**	T11 vs T1	2.771	T2 vs T6	0.219
T10 vs T5	**11.610**	T1 vs T7	1.000	T2 vs T3	0.181
T10 vs T6	**11.562**	T1 vs T5	0.981	T2 vs T4	0.171
T10 vs T3	**11.524**	T1 vs T6	0.933	T2 vs T8	0.038
T10 vs T4	**11.514**	T1 vs T3	0.895	T8 vs T7	0.248
T10 vs T8	**11.381**	T1 vs T4	0.886	T8 vs T5	0.229
T10 vs T2	**11.343**	T1 vs T8	0.752	T8 vs T6	0.181
T10 vs T9	**11.019**	T1 vs T2	0.714	T8 vs T3	0.143
T10 vs T1	**10.629**	T1 vs T9	0.390	T8 vs T4	0.133
T10 vs T11	**7.857**	T9 vs T7	0.610	T4 vs T7	0.114
T11 vs T7	3.771	T9 vs T5	0.590	T4 vs T5	0.095
T11 vs T5	3.752	T9 vs T6	0.543	T4 vs T6	0.048
T11 vs T6	3.705	T9 vs T3	0.505	T4 vs T3	0.010
T11 vs T3	3.667	T9 vs T4	0.495	T3 vs T7	0.105
T11 vs T4	3.657	T9 vs T8	0.362	T3 vs T5	0.086
T11 vs T8	3.524	T9 vs T2	0.324	T3 vs T6	0.038
T11 vs T2	3.486	T2 vs T7	0.286	T6 vs T7	0.067
T11 vs T9	3.162	T2 vs T5	0.267	T6 vs T5	0.048

Contrast	Difference	Contrast	Difference	Contrast	Difference
H3 vs H7	**8.903**	H1 vs H5	1.485	H2 vs H6	0.006
H3 vs H5	**8.818**	H1 vs H4	1.418	H6 vs H7	0.412
H3 vs H4	**8.752**	H1 vs H6	1.158	H6 vs H5	0.327
H3 vs H6	**8.491**	H1 vs H2	1.152	H6 vs H4	0.261
H3 vs H2	**8.485**	H2 vs H7	0.418	H4 vs H7	0.152
H3 vs H1	**7.333**	H2 vs H5	0.333	H4 vs H5	0.067
H1 vs H7	1.570	H2 vs H4	0.267	H5 vs H7	0.085

(b) *Culicoides peregrinus*

Source		SS		MS	DF	F
TIME		12478.244		1247.824	10	**15.632**
HOST LANDING		12967.780		2161.297	6	**27.076**
TIME*HOST LANDING		58232.010		970.534	60	**12.159**
Error		86048.667		79.823	1078	
Total		169726.701			1154	
Contrast	**Difference**	**Contrast**	**Difference**	**Contrast**	**Difference**	
T10 vs T7	**11.105**	T11 vs T9	**4.210**	T1 vs T6	0.552	
T10 vs T5	**11.086**	T9 vs T7	0.952	T1 vs T4	0.505	
T10 vs T6	**11.067**	T9 vs T5	0.933	T1 vs T3	0.486	
T10 vs T4	**11.019**	T9 vs T6	0.914	T1 vs T2	0.314	
T10 vs T3	**11.000**	T9 vs T4	0.867	T2 vs T7	0.276	
T10 vs T2	**10.829**	T9 vs T3	0.848	T2 vs T5	0.257	
T10 vs T1	**10.514**	T9 vs T2	0.676	T2 vs T6	0.238	
T10 vs T8	**10.390**	T9 vs T1	0.362	T2 vs T4	0.190	
T10 vs T9	**10.152**	T9 vs T8	0.238	T2 vs T3	0.171	
T10 vs T11	**5.943**	T8 vs T7	0.714	T3 vs T7	0.105	
T11 vs T7	**5.162**	T8 vs T5	0.695	T3 vs T5	0.086	
T11 vs T5	**5.143**	T8 vs T6	0.676	T3 vs T6	0.067	
T11 vs T6	**5.124**	T8 vs T4	0.629	T3 vs T4	0.019	
T11 vs T4	**5.076**	T8 vs T3	0.610	T4 vs T7	0.086	
T11 vs T3	**5.057**	T8 vs T2	0.438	T4 vs T5	0.067	
T11 vs T2	**4.886**	T8 vs T1	0.124	T4 vs T6	0.048	
T11 vs T1	**4.571**	T1 vs T7	0.590	T6 vs T7	0.038	
T11 vs T8	**4.448**	T1 vs T5	0.571	T6 vs T5	0.019	
Contrast	**Difference**	**Contrast**	**Difference**	**Contrast**	**Difference**	
H3 vs H7	**9.915**	H1 vs H5	1.224	H2 vs H6	0.067	
H3 vs H5	**9.806**	H1 vs H4	1.067	H6 vs H7	0.339	
H3 vs H4	**9.648**	H1 vs H6	0.994	H6 vs H5	0.230	
H3 vs H6	**9.576**	H1 vs H2	0.927	H6 vs H4	0.073	
H3 vs H2	**9.509**	H2 vs H7	0.406	H4 vs H7	0.267	
H3 vs H1	**8.582**	H2 vs H5	0.297	H4 vs H5	0.158	
H1 vs H7	1.333	H2 vs H4	0.139	H5 vs H7	0.109	

Table 3b. Results of ANOVA using the time, host landing of *Culicoides* as the source of variations for the **observed abundance** in the cattle sheds in the study area (Sahebganj-Tantipra). The values in bold indicate significance at P < 0.0001 level. T- time, H – Host body parts.

(a) Culicoides oxystoma

Source	SS	MS	DF	F	
Time	17941.411	1794.141	10	**33.205**	
HOST LANDING	12727.071	2121.179	6	**39.258**	
Time*HOST LANDING	56263.952	937.733	60	**17.355**	
Error	45765.083	54.032	847		
Total	132697.518		923		
Contrast	**Difference**	**Contrast**	**Difference**	**Contrast**	**Difference**
T10 vs T5	**15.821**	T11 vs T1	1.345	T2 vs T6	0.810
T10 vs T4	**15.786**	T1 vs T5	1.952	T2 vs T8	0.774
T10 vs T6	**15.702**	T1 vs T4	1.917	T2 vs T7	0.738
T10 vs T8	**15.667**	T1 vs T6	1.833	T2 vs T3	0.333
T10 vs T7	**15.631**	T1 vs T8	1.798	T3 vs T5	0.595
T10 vs T3	**15.226**	T1 vs T7	1.762	T3 vs T4	0.560
T10 vs T2	**14.893**	T1 vs T3	1.357	T3 vs T6	0.476
T10 vs T9	**14.345**	T1 vs T2	1.024	T3 vs T8	0.440
T10 vs T1	**13.869**	T1 vs T9	0.476	T3 vs T7	0.405
T10 vs T11	**12.524**	T9 vs T5	1.476	T7 vs T5	0.190
T11 vs T5	3.298	T9 vs T4	1.440	T7 vs T4	0.155
T11 vs T4	3.262	T9 vs T6	1.357	T7 vs T6	0.071
T11 vs T6	3.179	T9 vs T8	1.321	T7 vs T8	0.036
T11 vs T8	3.143	T9 vs T7	1.286	T8 vs T5	0.155
T11 vs T7	3.107	T9 vs T3	0.881	T8 vs T4	0.119
T11 vs T3	2.702	T9 vs T2	0.548	T8 vs T6	0.036
T11 vs T2	2.369	T2 vs T5	0.929	T6 vs T5	0.119
T11 vs T9	1.821	T2 vs T4	0.893	T6 vs T4	0.083
Contrast	**Difference**	**Contrast**	**Difference**	**Contrast**	**Difference**
H2 vs H7	**11.008**	H3 vs H4	**3.136**	H5 vs H1	0.098
H2 vs H4	**10.970**	H3 vs H6	**2.939**	H1 vs H7	0.644
H2 vs H6	**10.773**	H3 vs H1	2.530	H1 vs H4	0.606
H2 vs H1	**10.364**	H3 vs H5	2.432	H1 vs H6	0.409
H2 vs H5	**10.265**	H5 vs H7	0.742	H6 vs H7	0.235
H2 vs H3	**7.833**	H5 vs H4	0.705	H6 vs H4	0.197
H3 vs H7	**3.174**	H5 vs H6	0.508	H4 vs H7	0.038

(b) Culicoides peregrinus

Source	SS	MS	DF	F
Time	29269.818	2926.982	10	**29.522**
HOST LANDING	23410.734	3901.789	6	**39.355**
Time*HOST LANDING	118813.742	1980.229	60	**19.973**
Error	83975.250	99.144	847	
Total	255469.544		923	

Contrast	Difference	Contrast	Difference	Contrast	Difference
T10 vs T7	**20.226**	T9 vs T11	1.738	T2 vs T6	0.929
T10 vs T5	**20.226**	T11 vs T7	2.274	T2 vs T4	0.821
T10 vs T6	**20.119**	T11 vs T5	2.274	T2 vs T3	0.619
T10 vs T4	**20.012**	T11 vs T6	2.167	T2 vs T8	0.119
T10 vs T3	**19.810**	T11 vs T4	2.060	T8 vs T7	0.917
T10 vs T8	**19.310**	T11 vs T3	1.857	T8 vs T5	0.917
T10 vs T2	**19.190**	T11 vs T8	1.357	T8 vs T6	0.810
T10 vs T1	**18.464**	T11 vs T2	1.238	T8 vs T4	0.702
T10 vs T11	**17.952**	T11 vs T1	0.512	T8 vs T3	0.500
T10 vs T9	**16.214**	T1 vs T7	1.762	T3 vs T7	0.417
T9 vs T7	4.012	T1 vs T5	1.762	T3 vs T5	0.417
T9 vs T5	4.012	T1 vs T6	1.655	T3 vs T6	0.310
T9 vs T6	3.905	T1 vs T4	1.548	T3 vs T4	0.202
T9 vs T4	3.798	T1 vs T3	1.345	T4 vs T7	0.214
T9 vs T3	3.595	T1 vs T8	0.845	T4 vs T5	0.214
T9 vs T8	3.095	T1 vs T2	0.726	T4 vs T6	0.107
T9 vs T2	2.976	T2 vs T7	1.036	T6 vs T7	0.107
T9 vs T1	2.250	T2 vs T5	1.036	T6 vs T5	0.107

Contrast	Difference	Contrast	Difference	Contrast	Difference
H2 vs H7	**14.886**	H3 vs H4	3.386	H5 vs H1	0.318
H2 vs H4	**14.803**	H3 vs H6	3.265	H1 vs H7	0.538
H2 vs H6	**14.682**	H3 vs H1	2.932	H1 vs H4	0.455
H2 vs H1	**14.348**	H3 vs H5	2.614	H1 vs H6	0.333
H2 vs H5	**14.030**	H5 vs H7	0.856	H6 vs H7	0.205
H2 vs H3	**11.417**	H5 vs H4	0.773	H6 vs H4	0.121
H3 vs H7	3.470	H5 vs H6	0.652	H4 vs H7	0.083

Figures

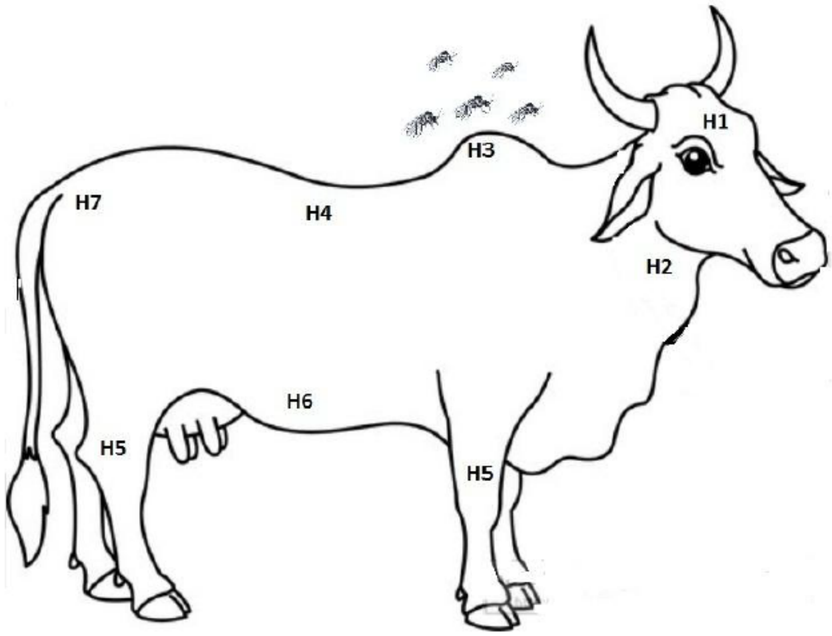

Figure 1

The body of cow was divided into head (H1), neck (H2), hump (H3), back (H4), leg (H5), belly (H6), hip (H7)

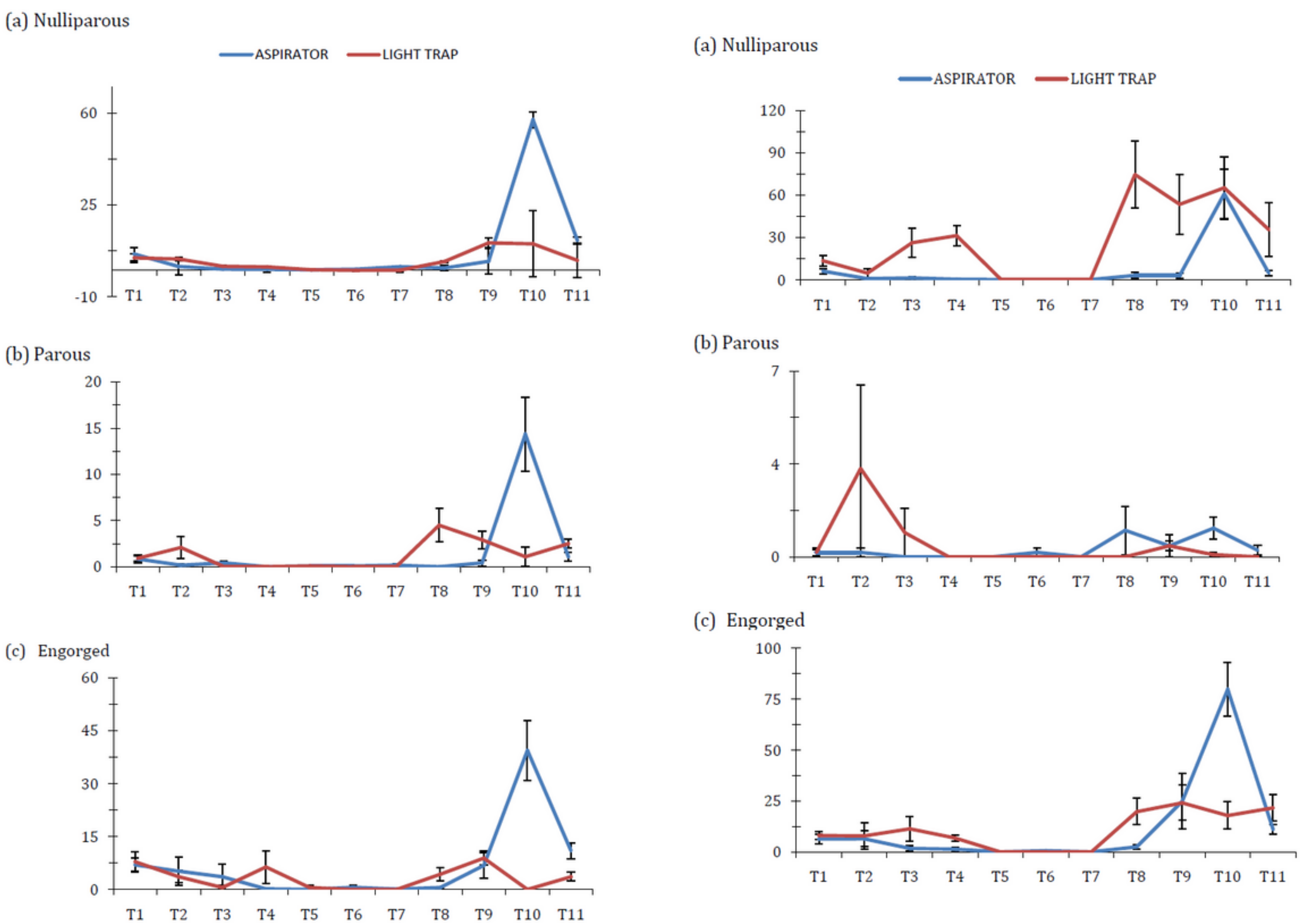

Figure 2

a Comparative graphical representation on sampling of Culicoides oxystoma by two trapping methods (aspirator; light trap) during May-October, 2018 from Sahebganj-Tantipara b Comparative graphical representation on sampling of Culicoides peregrinus by two trapping methods (aspirator; light trap) during May-October, 2018 from Sahebganj-Tantipara

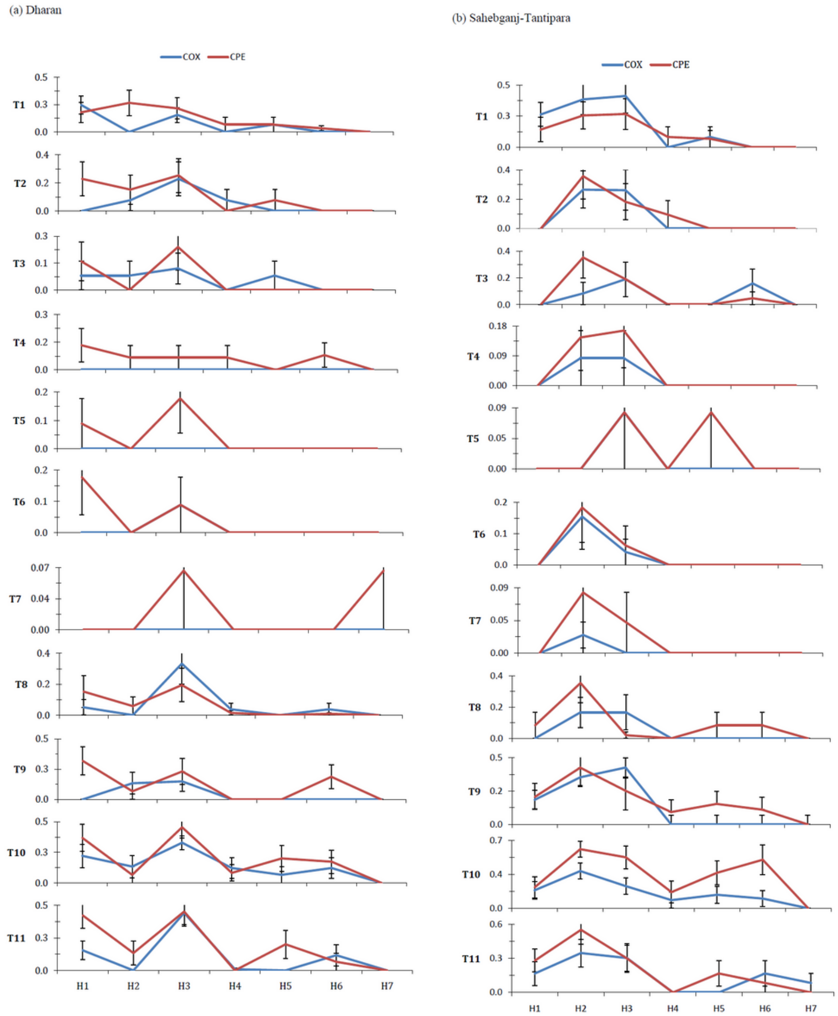

Figure 3

Graph represents the proportion of engorged females, Culicoides oxystoma (COX) and Culicoides peregrinus (CPE) trapped on different body surfaces of cow at two collection sites: a). Dharan, b). Sahebganj-Tantipara respectively. Region of body surface abbreviated as H1, head; H2, neck; H3, hump; H4, back; H5, leg; H6, belly; H7, hip. Duration of collection (T1-T11) hours, T1: 18.00-19.00; T2: 19.00-20.00; T3: 20.00-21.00; T4: 21.00-22.00; T5: 23.00-00.00; T6: 00.00-01.00; T7: 01.00-2.00; T8: 02.00-03.00; T9: 03.00-04.00; T10: 04.00-05.00; T11: 05.00-06.00.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table2.docx
- Graphicalabstract.jpg