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Seasonal Abundance of *Culicoides* Latreille and *Dasyhelea* Kieffer (Diptera : Ceratopogonidae) in an Agricultural Farm, West Bengal, India

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Abstract Seasonal abundance of biting midges, *Culicoides* Latreille and *Dasyhelea* Kieffer has been studied with correlation of the abundance of the biting midges with respect to temperature and relative humidity in the University Campus. A comparative study of attraction of *Culicoides* and *Dasyhelea* to both UV and white light has also been made.

Keywords Seasonal abundance, Burdwan, *Dasyhelea, Culicoides.*

Introduction

Ceratopogonidae, commonly known as biting midges is a diverse group of nematocerous Diptera which includes 111 extant genera comprising more than 6270 species worldwide (Borkent 2016. Brahma et al. 2016, Saha et al. 2017), of them, *Culicoides* Latreille (1809) and *Dasyhelea* Kieffer (1911) are cosmopolitan genera encompassing more than 1369 (Borkent 2016, Saha et al. 2017) and 624 (Brahma et al. 2016) worldwide species respectively. The members of *Culicoides* are one of the smallest hematophagous flies of the tribe Culicoidini Kieffer (1911) of the subfamily Ceratopogoninae Newman (1834) transmitting pathogens of medical and veterinary importance (Mellor et al. 2000). Severe and repeated biting attacks of *Culicoides* are reported to give rise allergic reactions and secondary infections in humans leading to medical and pest problem (Hase 1934, Bellis 2013). In Southeast Asia, the members of the genus transmit the diseases caused due to protozoans and viruses (Wirth and Huber 1989). The *Dasyhelea* is also one of the species rich and complex genera of the subfamily Dasyheleinae Lenz (1934) with diverse morphological and biological adaptations. It is widely distributed and known from all the biogeographical regions except Antarctica (Grogan and Wieners 2006). On account of minute and hairy body, they are good pollinators and efficient in pollen collection from the flower (de Meillon and Wirth 1991). The adults are fugacious and are prevalent in and around the vegetation near the breeding sites.

In this paper, the abundance of these two genera has been reflected in the University of Burdwan campus during the pre-monsoon, monsoon and post-monsoon periods. The relative abundance of the species has also been provided in respect to meteorological data and the relative attraction to white and UV light through ANOVA.

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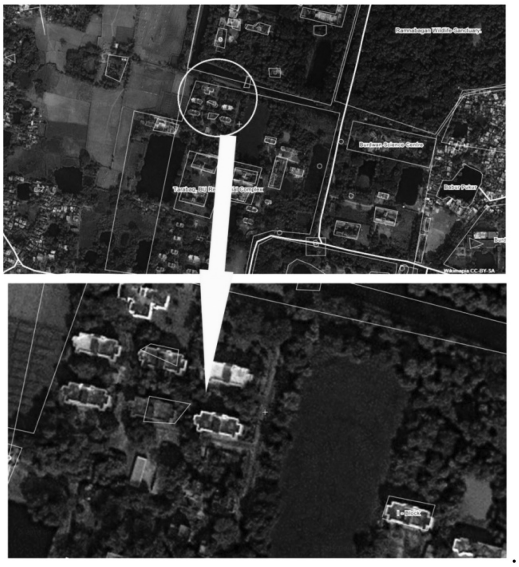

Fig. 1. Collection site of biting midges.

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Materials and Methods

Operation of light trap

The open type (15W white CFL bulb) and fabricated UV light (8W lamp) traps were operated at the site ($23^{0}15`03.5``$ N $87^{0}50`44.9``$E) adjoining to the Burdwan University Farm House (Fig. 1). Both shrubs and herbaceous vegetation are predominant in the collection site. Two ecological parameters, temperature and relative humidity of the location were recorded using Google Weather, Version : 3.4.8 (182006750). The collection were made twice a week from February 2017 to January 2018 in pre-monsoon, monsoon and post-monsoon seasons each of four months. The light traps were operated for overnight from 6.00 pm to 6.00 am. The specimens were brought to the laboratory for sorting and slide-mounting (Borkent and Spinelli 2007) followed by identification to the generic levels of *Culicoides* and *Dasyhelea* with the aid of CARL ZEISS Stemi 2000-C Stereo Zoom Trinocular microscope, Germany after relevant literature (Borkent 2004). Species level identification was made after mounting some samples in glass slides and identifying in Wild Leitz GMBH Trinocular microscope, Portugal.

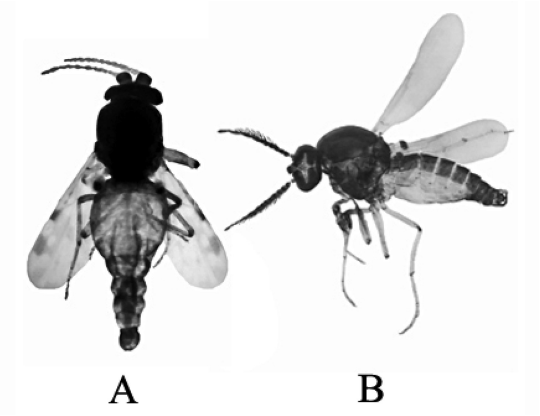

Fig. 2. Adult male individuals : A. *Culicoides* Latreille and B. *Dasyhelea* Kieffer.

Statistical analysis

The regression analyses were made after Zar (1991) and application of Microsoft® office excel® 2007. The relationship between temperature and relative humidity with the total number of collected individuals are presented through the regression equation using one way ANOVA.

Results

Approximately 2400 adult specimens of Ceratopogonidae of the four different genera, *Culicoides, Dasyhelea, Atrichopogon* Kieffer (1906) and *Forcipomyia* Meigen (1818) were caught. Among them, *Culicoides* and *Dasyhelea* comprised 98% with *Atrichopogon* was 1.5% and *Forcipomyia* 0.5%. Here, seasonal abundance of only first two genera was considered. Biting midges of the species of *Culicoides* are relatively larger in size with spotted wing and females with well developed mandibles whereas *Dasyhelea* are small-bodied, having sculptured flagellomeres, frontal sclerite in head and reduced venation in wing. Total individuals of both the genera were 2356 of which 1267 belonged to *Culicoides* and 1089 to *Dasyhelea* (Fig. 2). During the per-monsoon,

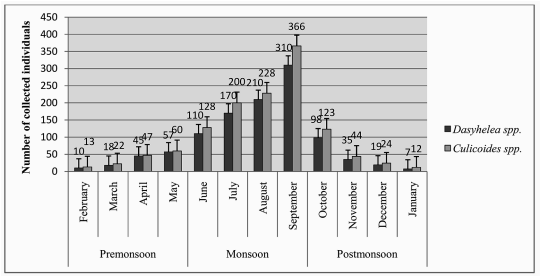

Fig.3. Number of collected *Culicoides* and *Dasyhelea* in three seasons.

monsoon and post-monsoon periods, the number of *Culicoides* spp. and *Dasyhelea* spp.collected are represented in Fig. 3. The species of *Culicoides* were found to outnumber those of *Dasyhelea* with a difference of 3-5%.

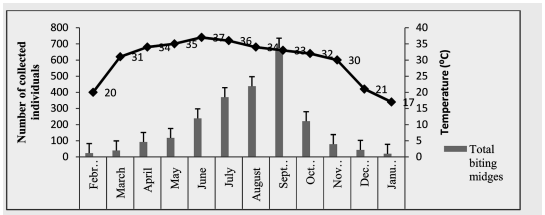

Fig. 4A. Total number of collected biting midges with respect to temperature (°C).

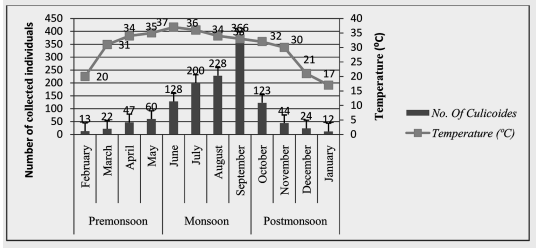

Fig. 4B. Number of collected *Culicoides* spp. with respect to temperature (°C).

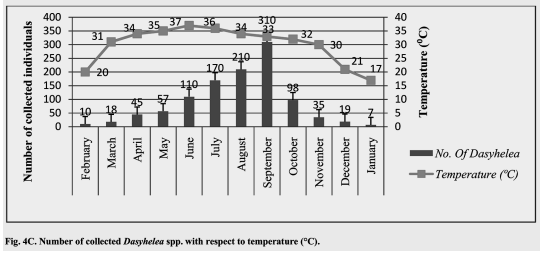

Fig. 4C. Number of collected *Dasyhelea* spp. with respect to temperature (°C).

Fig. 4A. Total number of collected biting midges with respect to temperature (^{0}C). **Fig. 4B.** Number of collected *Culicoides* spp. with respect to temperature (^{0}C). **Fig. 4C.** Number of collected *Dasyhelea* spp. with respect to temperature (^{0}C).

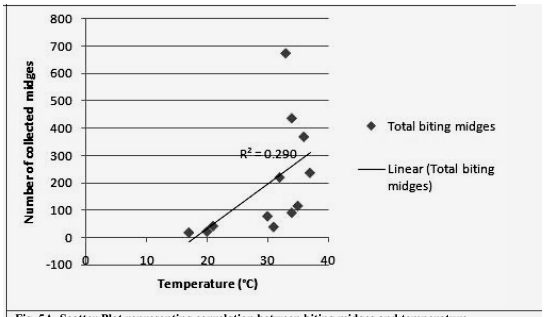

Fig. 5A. Scatter Plot representing correlation between biting midges and temperature.

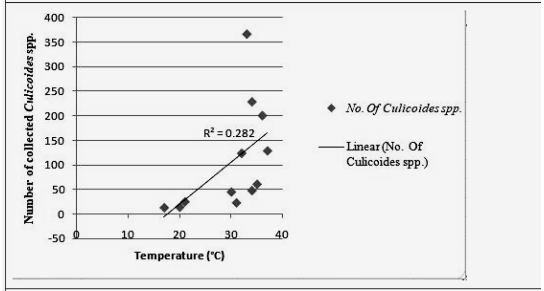

Fig. 5B. Scatter Plot representing correlation between collected *Culicoides* and temperature.

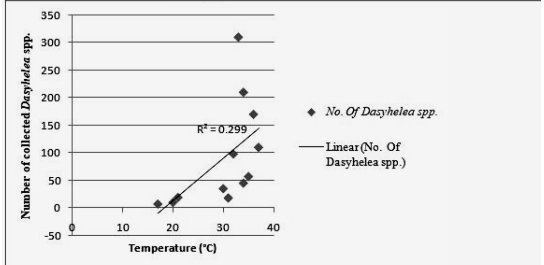

Fig. 5C. Scatter Plot representing correlation between Collected *Dasyhelea* and temperature.

Fig. 5A. Scatter plot representing correlation between biting midges and temperature. **Fig. 5B.** Scatter plot representing correlation between collected *Culicoides* and temperature.**Fig. 5C.** Scatter plot representing correlation between collected *Dasyhelea* and temperature.

Regression analyses

The multiple regression analyses were performed to get the following descriptive models. Analyses between the abundance of individuals of both the *Culicoides* and *Dasyhelea* genera and the meteorological variables showed the abundance of population of both the genera was significantly correlated in respect to relative humidity ($R^2 = 0.48$, $p = 0.011353$). However, abundance was not found significantly correlated with temperature ($R^2 = 0.29$, $p = 0.0705$).

From Figs. 4A–C and 5A–C it became evident that the biting midges were less in number in the pre-monsoon season especially in March when the mean air temperature was 31^0C. The number steadily increased from April with gradual rise of mean air temperature. At the late pre-monsoon in the month of June, the number reached 238 comprising 10.1% of the total catches. From the beginning of the monsoon the midges increased in number accounting 15.7% of the total collections in July. The highest number of midges appeared in the late monsoon period i.e. in September when the mean air temperature was 33^0C. The number of midges was at the peak being 28.6% of the total 676 individuals. The flies began to drop to 9.3% in October with the fast fall of mean temperature (32^0C). A severe reduction in the number of the midges of *Culicoides* (0.8%) and *Dasyhelea* (0.9%) was evidenced in the late post-monsoon period in the month of January and February when the mean air temperature became was 17^0C and 20^0C

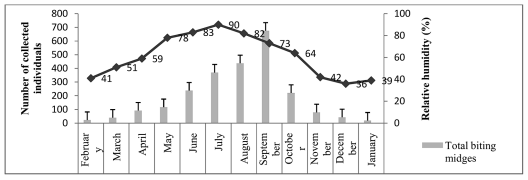

Fig. 6A. Total number of collected biting midges with respect to relative humidity (%).

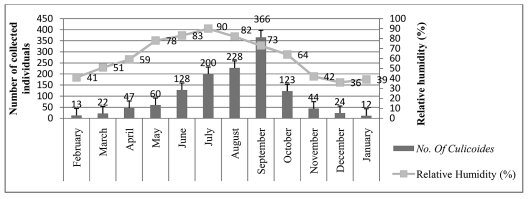

Fig. 6B. Total number of collected *Culicoides* spp. with respect to relative humidity (%).

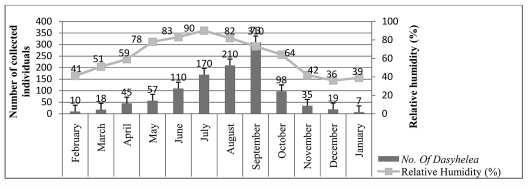

Fig. 6C. Total number of collected *Dasyhelea* spp. with respect to relative humidity (%).

Fig. 6A. Total number of collected biting midges with respect to relative humidity (%). **Fig. 6B.** Total number of collected Culicoides app. with respect to relative humidity (%). **Fig. 6C.** Total number of collected *Dasyhelea* spp. with respect in relative humidity (%).

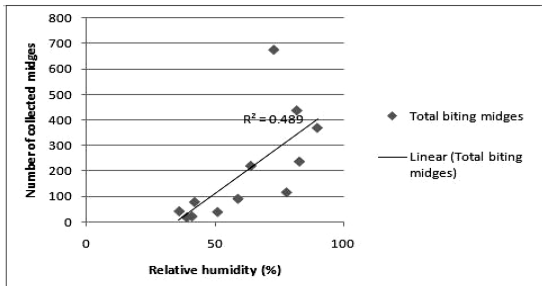

Fig. 7A. Scatter Plot representing correlation between the biting midges and relative humidity.

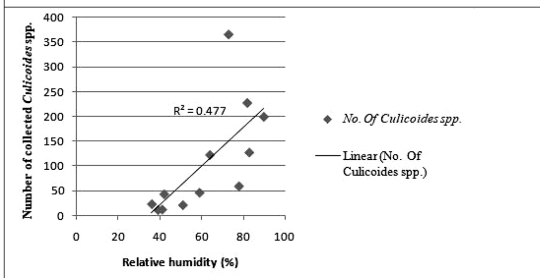

Fig. 7B. Scatter Plot representing correlation between collected *Culicoides* and relative humidity.

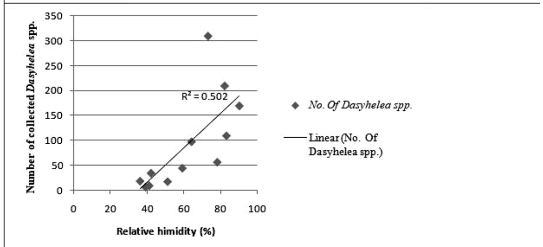

Fig. 7C. Scatter Plot representing correlation between collected *Dasyhelea* and relative humidity.

Fig. 7A. Scatter plot representing correlation between the biting midges and relative humidity. **Fig. 7B**. Scatter plot representing correlation between collected *Culicoides* and relative humidity. **Fig. 7C.** Scatter plot representing correlation between collected *Dasyhelea* and relative humidity.

respectively. Similar pattern of abundance of the species of both the genera in relation to temperature was also observed. However, the greater number of *Culicoides* spp. was found than those of *Dasyhelea* in the early pre-monsoon when the temperature was raised from 20^0C to 31^0C.

In case of relative humidity (RH), the scenario is more or less similar type (Fig. 6). In the premonsoon period less number of individuals was obtained in the months of March and April when the mean RH was

Table 1. Correlation data between abundance of *Culicoides* and *Dasyhelea* with respect to temperature and humidity.

Genera	Correlation	
	Temperature	Humidity
Culicoides	R^2=0.28, p <0.07	R^2 = 0.47, p<0.01
Dasyhelea	R^2 =0.29, p <0.06	R^2 =0.50, p=0.009

between 41% and 51%. The highest number appeared in the month of September when the mean RH was around 82%. The number of the midges was found to decrease slowly again along with the mean RH value in the post-monsoon period.

Both the genera showed same type of abundance pattern with relation to relative humidity (%) (Figs. 6A–C and 7A–C). In the early monsoon period *Cullcoides* spp. encountered less than *Dasyhelea* spp. when the relative humidity ranged from 78% to 83%. However, from the late monsoon to early post-monsoon, the difference in decline in number of individuals was greater in *Culicoides* than *Dasyhelea.* The pattern was noticed similar to early post-monsoon to late post-monsoon when the relative humidity dropped from 64% to 39%. Here, both the genera are positively correlated with relative humidity (p<0.05) but in case of temperature the p value is greater than 0.05 leading to infer that temperature is not positively correlated with the abundance (Table 1).

Comparative study of attraction towards both

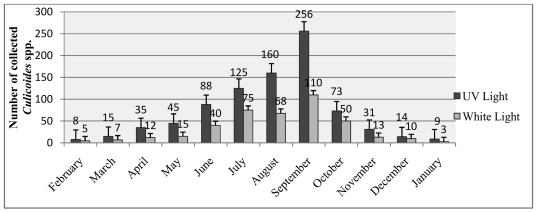

Fig. 8A. Comparison of attraction of *Culicoides* spp. towards UV and white light.

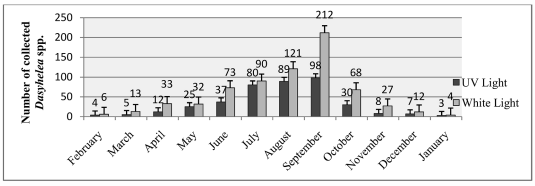

Fig. 8B. Comparison of attraction of *Dasyhelea* spp. towards UV and white light.

Fig. 8A. Comparison of attraction of *Culicoides* spp. towards UV and white light. **Fig. 8B**. Comparison of attraction of *Dasyhelea* spp. towards UV and white light.

UV and white light in *Culicoides* and *Dasyhelea* is shown in Figs. 8A–B and Table 2. It has been observed that the adult midges of *Culicoides* spp. were more attracted towards the UV light than white light. In September, highest number of *Culicoides* spp. was caught in UV light (Fig. 8A) while the number of *Dasyhelea* spp. (Fig. 8B) was highest in white light in the same month. However, the differences in number of midges collected in UV and white light of both the genera is much less in the early pre and late post-monsoon.

Table 2. Descriptive statistics of comparison of attraction of *Culicoides* and *Dasyhelea* towards UV and white light.

Culicoides spp.				*Dasyhelea spp.*			
UV light		White light		UV light		White light	
Mean	71.58333	Mean	34	Mean	33.16667	Mean	57.58333
Standard error	21.86753	Standard error	10.03705	Standard error	10.2712	Standard error	17.63582
Median	40	Median	14	Median	18.5	Median	32.5
Mode	#N/A	Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard deviation	75.75134	Standard deviation	34.76937	Standard deviation	35.58047	Standard deviation	61.09227
Sample variance	5738.265	Sample variance	1208.909	Sample variance	1265.97	Sample variance	3732.265
Kurtosis	2.110819	Kurtosis	0.348951	Kurtosis	-0.54752	Kurtosis	2.880272
Skewness	1.533688	Skewness	1.134324	Skewness	1.043404	Skewness	1.64644
Range	248	Range	107	Range	95	Range	208
Minimum	8	Minimum	3	Minimum	3	Minimum	4
Maximum	256	Maximum	110	Maximum	98	Maximum	212
Sun	859	Sun	408	Sun	398	Sum	691
Count	12	Count	12	Count	12	Count	12

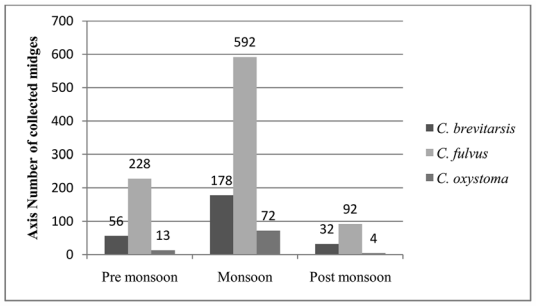

Fig. 9. Species wise abundance data of the genus *Culicoides.*

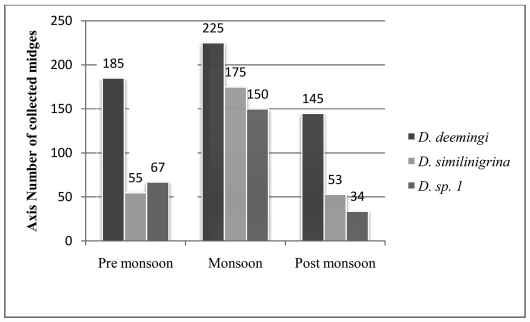

Fig. 10. Species wise abundance data of the genus *Dasyhelea.*

Species wise abundance data

Three species of *Culicoides* viz., *Culicoides brevitarsis* Kieffer (1917), *C. fulvus* Sen and Das Gupta (1959) and *C. oxystoma* Kieffer (1910) had been found throughout the study. Three species of *Dasyhelea* like *D. deemingi* Boorman and Van Harten (2002). *D. similinigrina Navai* (1994) and *Dasyhelea* sp. 1 (Unidentified) were more or less ample in the site throughout the year (Figs. 9, 10 and Table 3). *Culicoides fulvus* was found in maximal abundance in the study area throughout the year reaching its peak in the post-monsoon period. *Culicoides* was in greater number in the monsoon season only. *Culicoides oxystoma* recorded in less number in the pre- and post-monsoon seasons. *Dasyhelea deemingi* was found greater in number than *D. similinigrina* and *Dasyhelea* sp. 1 in the area of investigation throughout the year. All the species were found in large number in every season except *Dasyhelea* sp. 1 which was more prevalent than *D. similinigrina* in the pre-monsoon season.

Table 3. Specieswise abundance data of the genera *Culicoides* and *Dasyhelea.*

No.	Species	Percentage of individuals collected
1.	*Culicoides brevitarsis*	21%
2.	*C. fulvus*	72%
3.	*C. axystoma*	7%
4.	*Dasyhelea deemingi*	51%
5.	*D. similinigrina*	26%
6.	*Dasyhelea* sp. 1	23%

Discussion

Most members of biting midges require environments with high humidity for their development. According to Mancini et al. (2016) the humid season appeared more appropriate to complete their life cycle. The available food resources such as cattle for *Culicoides* and vegetable food sourees like floweres and fruits for *Dasyhelea* in the study area should be considered influencing factors for the growth and multiplication of the above midges. Semiaquatic habitats are preferred by some species of *Dasyhelea* (Waugh and Wirth 1976, Wirth 1978) and *Culicoides* (Bakhoum et al. 2016).Thus, optimum air temperature and relative humidity rather than water temperature seemed essential for growth of the midges. From the above, the relation of the abundance of biting midges with temperature is evident and positively correlated which also corroborates with the study of Veggiani Aybar et al. (2012) in case of the genus *Culicoides*. However, less number of midges was encountered owing to high temperature of the pre-monsoon season than the moderate temperature of the monsoon which might be conducive to maturation and multiplication. The development of the midges ceased in high temperature due to desiccation of the habitat resulting arrest of the development. Therefore, very few numbersS of individuals was encountered in the pre-monsoon period during this venture. There was roughly two fold increase in trend of collected individuals in spite of increased in air temperature in the early months of monsoon. This might be the increment of relative humidity during the monsoon than the pre-monsoon. Diarra et al. (2014) also showed increased trend in

abundance of *Culicoides* from the end of month May. However, maturation and emergence of the midges in large number in August and September appeared to be due to moderate temperature with high amount of relative humidity. *Dasyhelea* spp. were noted to less attracted to UV light than those of *Culicoides* probably because they pollinate different plants having diverse colors of the flowers requiring sensitivity of longer visible range of wavelength to get attracted than the UV light. However, females of *Culicoides* spp. are generally hematophagous (Mellor et al. 2000) usually feeding on cattle and sheep at night and do not require visible light for attraction.

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