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Bio-ecological aspects and density of *Haematobia exigua* species in cattle and buffaloes of Maharashtra state

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Abstract
The present research was carried out to study the bio-ecological aspects and density of *Haematobia exigua* flies in cattle and buffaloes. The total length of life cycle from laying of eggs to emergence of adult was recorded as 10 days, 15 days and 12 days respectively during monsoon, winter and summer season. Cattle from Konkan region having highest fly density followed by North Maharashtra, lower in Vidarbha, Western Maharashtra and lowest in Marathwada. Buffaloes from Konkan region were having highest fly density followed by North Maharashtra, Western Maharashtra and lowest in Vidarbha and Marathwada. Studies on density of the flies according to colour and breed of the cattle revealed significantly higher density of flies on non-descript cattle and lower in Deoni. The totally white colored cattle breed such as Kankrej, Gaolav and Khillar were free from biting of these flies. Amongst the two-host studied, significantly higher fly density was observed on the body of buffaloes as compared to cattle.

Keywords: *Haematobia exigua*, bio-ecology, cattle, buffalo, density

1. Introduction
Haematobia flies feeding on animals are responsible for large scale energy expenditure in defensive behaviour by the host. The energy is spent in the form of movement of different body parts to ward off the flies. It results in less attention towards grazing, decreased feeding efficiency, decreased weights and reduced milk production in cows and buffaloes (Byford *et al.*, 1992) [3]. Each fly takes between 24 to 38 blood meals per day (Foil and Hogsette, 1994) [8] and this extensive feeding habit can cause substantial blood loss and severe damage to cattle hides results in poorer quality leather. *Haematobia irritans* and *H. exigua* act as biological vector for the filarial nematode *Stephanofilaria* spp. including *S. stilesi* and *S. assamensis* (Foil and Hogsette, 1994; Shaw and Sutherland, 2006; Saparov *et al.*, 2014) [8, 24, 22]. The role of these flies as pest causing economic losses and having potent vector capacity, the present research work was undertaken to study the bio-ecological aspects and density of *Haematobia exigua* flies in cattle and buffaloes.

2. Material and Methods
The present research was carried out from January 2019 to December 2019 comprising all the three seasons. Requisite number of flies were collected from cattle and buffaloes from each centre using insect hand net. During collection intensity of flies per animal was recorded. The collected fly specimens were preserved in the vials containing 90% ethanol and labelled properly. Preliminary identification of flies was done under stereo-zoom microscope by standard identification keys described in books (Smart, 1943; Soulsby, 1982; Walker, 1994; Roy and Brown, 2003).[27, 29, 21]
For studying the bio-ecological aspects and life table of *Haematobia exigua*, the flies were collected with the help of insect net from buffalo farms in and around Parbhani. Flies were collected live in the glass test-tubes and these freshly collected flies were released in the insectary, facility available in the Department of Parasitology, College of Veterinary and Animal Sciences, Parbhani.

Freshly voided faeces were instantly collected from buffalo farm with due care to ensure that any type of insect had not laid the eggs on it. Such faeces were used for breeding in the insectary where flies were released for oviposition. Faecal mass was observed continuously to note the oviposition time at 2 hrs interval. After oviposition, faecal media containing eggs were transferred to rectangular plastic boxes covered with lid. Lid has a quadrangular (10 cm x 10 cm) opening duly covered with fine 40 mm mesh. Regularly time was noted for hatching of the eggs, eggs to larval development, larva to pupal development and from pupa to adult eclosion. Moisture content of the faecal media was maintained throughout the experiment by frequently adding water with pasture pipette. The data obtained from various parameters was analysed by employing suitable statistical design.

3. Results and Discussion

3.1 Identification on the basis of morphological characters

Adult flies collected during the present study were identified on the basis of morphological description in the literature, belongs to the genus *Haematobia* (Smart, 1943; Walker, 1994; Roy and Brown, 2003). [27, 29, 21] Similarly, after thorough morpho-metric observations of large number of specimens of adult flies from the five region of Maharashtra State, flies were further identified as *Haematobia exigua*. Species identification was done on the basis of characters described by Kano *et al.* (1972) [11] and Moon (2019).[17]

3.2 Life cycle table of *Haematobia exigua* fly during three different seasons

The total length of life cycle from laying of eggs to emergence of adult was recorded as 10 days, 15 days and 12 days respectively during monsoon, winter and summer season. The time required for completion of one generation was shortest during monsoon, moderate during summer and quite delayed during winter season. Similar pattern has been observed for hatching of eggs, duration of larval stages, duration of pupal stages etc. It indicates that monsoon season is the most favorable season for *Haematobia exigua* fly and therefore can complete maximum number of generations during the monsoon followed by second favorable as summer and least as winter. Although during summer development appeared as fast and required lesser duration as compared to winter, but due to too dry environment with low humidity levels (being tropical climate, the place of present study experiences dry and hot summer with no rain), egg laying and emergence of number of flies has been recorded as lowest (Table 1). Therefore, on the basis of present study, it can be firmly said that warmth (21-31°C) and humidity (55-82%) both are prerequisite conditions to occur the life cycle of *H. exigua*.

Table 1: Mean time required for development of different life cycle stages of *Haematobia exigua* flies in different seasons (n= 6)

Particulars	Monsoon (Hrs.)		Winter (Hrs.)		Summer (Hrs.)		CD
	Mean ±SE	Range (Min-Max)	Mean ±SE	Range (Min-Max)	Mean ±SE	Range (Min-Max)	
Hatching of Eggs	19.3^{b}±0.6	18-20	26.6^{a}±1.3	24-28	22.6^{b}±1.3	20-24	Significant at 5% level of significance CD (0.05) =3.99
Larval period	104.0^{c}±8.0	96-120	152.0^{a}±4.0	144-156	128.0^{b}±4.0	120-132	Significant at 1% and 5% level of significance CD (0.01) = 29.65 CD (0.05) = 19.57
Pupal stage	120.0^{b}±6.9	108-132	184.0^{a}±8.0	168-192	132.0^{b}±6.9	120-144	Significant at 1% and 5% level of significance CD (0.01) = 38.28 CD (0.05) = 25.27
Total life table (Egg to Adult)	243.3^{c}±11.2 ~10 days	222-260	362.6^{a}±5.8 ~15 day	352-372	282.6^{b}±3.5 ~12 day	276-288	Significant at 1% and 5% level of significance CD (0.01) = 39.69 CD (0.05) = 26.20

Means showing different superscripts shows significant difference in a row.

The observations recorded on duration of life cycle stages in the present study are in accordance and within the range of life cycle duration of buffalo flies studied by the Cook (1980) [4] and Doube *et al.* (1982) [5] at Queensland, Australia and Natal, South Africa respectively. Showler *et al.* (2014) [26] studied life cycle aspects of *H. irritans irritans* at Texas, USA and concluded that the eggs hatchs within 20–24 hours. Development from egg to pupa generally requires 4–8 days, dependent upon temperature. These observations are in harmony with the present study findings. Whereas, Lysyk (1999) [14] conducted a study on *H. irritans* at Alberta, Canada described contrast observations to present study. He described egg hatching period of few days, larval development period of 7-11 days and pupal development period of 8-14 days showing significant influence of temperature during rearing. The justification for this contrast is that Canada being a temperate region has very low temperature throughout year hence development of juvenile stages is slow whereas location of present study comes under tropical zone of warmer region where juvenile stages develop fast. In cool temperate areas, six to nine generations can occur per year, and 12–14 generations are completed in warmer temperate and subtropical regions (Showler *et al.* 2014). [26]

3.2.1 Density of *Haematobia exigua* fly population on cattle body: The density (number of flies observed on the one side of body of cattle/buffaloes) was significantly differing among the cattle belonging to different regions of Maharashtra state. The cattle from Konkan region having highest fly density as 53.6 followed by North Maharashtra as 43.8, still lower in Vidarbha as 32, Western Maharashtra as 31.4 and lowest in Marathwada region as 30 flies per animal. It indicates, density of the flies feeding on the cattle body varies, according to climatology and other local factors like network of irrigation, breed etc. (Table 2).

Table 2: Density of *Haematobia exigua* on body of cattle of different regions of Maharashtra

Region	Fly density Mean ±SE	Range	Significance
Marathwada	30.00^{b}±5.77	12-42	Significant at 5% level of Significance CD(0.05)= 16.061
Konkan	53.60^{a}±8.09	39-67	
Western Maharashtra	31.40^{b}±6.24	21-42	
Vidarbha	32.00^{b}±13.61	0-56	
North Maharashtra	43.8^{ab}±1.50	42-45	

Means showing different superscripts shows significant difference within column.

3.2.2 Density of *Haematobia exigua* fly population on buffalo body: Like cattle, density of flies feeding on the body of buffaloes was significantly varied in the different regions

of Maharashtra state. The buffaloes from Konkan region were having highest fly density as 59.0, followed by North Maharashtra as 53.4, Western Maharashtra as 46.8 and lowest in Vidarbha and Marathwada region as 40.4 (Table 3).

Table 3: Density of *Haematobia exigua* on body of buffaloes of different regions of Maharashtra

Region	Fly density Mean ±SE	Range	Significance
Marathwada	40.40^{c}±2.67	34-45	Significant at 1% and 5% level of significance CD (0.01) = 11.510 CD (0.05) = 8.439
Konkan	59.00^{a}±5.89	46-65	
Western Maharashtra	46.80^{bc}±5.81	37-57	
Vidarbha	40.40^{c}±4.64	32-53	
North Maharashtra	53.40^{ab}±0.00	56-56	

Means showing different superscripts shows significant difference within column. Factors responsible for variation in fly densities were earlier reported by many scientists (Hargette and Goulding, 1962; Kaufman *et al.*, 1999; Parra *et al.*, 2013) [9, 12, 19]. Hillerton and Bramley (1984) [10] cited the density of flies as 44.5 on the half of the body of animal cattle.

Close view to the Table 2 and 3 informs that the highest fly density on both the host occurred in Konkan region followed by Northern Maharashtra followed by Western Maharashtra and comparatively lowest in Vidarbha and Marathwada region. All five regions of Maharashtra state experiences different sets of climatological conditions and hold the population of different breeds of cattle and buffaloes acclimatised to local climatic conditions. Konkan region being sea-shore experiences fair amount of humidity and optimum range of temperature mostly suitable for growth and propagation of any type of insects, hence experiences high density of *H. exigua* flies. The next geographic area in the descending order of density is Northern Maharashtra experiencing high density of flies attributed to the fact that some part of the area is in close proximity to the Konkan region and remaining part of area having good network of irrigation received from catchment area of Tapi river, helping for maintenance of fair amount of humidity in the environment. Due to good irrigation network and large population of host cattle, third important geographic area-Western Maharashtra also experiences sizeable density. The rest of the two regions i.e. Vidarbha and Marathwada regions are having comparatively poor irrigation network and much part of the year experiences dry hot environment making it less favourable for growth and propagation of flies. The regional variation reported in the state of Maharashtra is in accordance with Shevchenko and Slobodian (2017) [25]. According to them, different species of the flies belonging to family Muscidae and in particular like *Haematobia* have considerable species diversity, life cycle and distribution places, which are happening due to the specific climatic conditions of individual geographic zones and also due to the presence of aquatic and biological resources and animals. Elevation of the geographic area can also be a factor deciding the density of flies on the host body. According to Kaufman *et al.* (1999) [12] highest density of flies on the body of cattle occurs at 1800 meter as against 800 meters and least density of flies were observed when elevation was 2400 meters (density below 90 flies per side).

3.3 Fly density according to host

Amongst the two hosts studied during present study, significantly higher fly density was observed on the body of buffaloes as compared to cattle. The density recorded was 45.11 on buffaloes and 34.35 on cattle (Table 4). Significant variation in the host species can be attributed to two grounds, one as colour and another as body temperature of the host species.

Table 4: Comparison of density of *Haematobia exigua* on the body of cattle and buffaloes (n=17)

Host	Fly density Mean ±SE	Range	't' Value	't' Table (0.05)	't' Table (0.01)	Significance at 5%
Cattle	34.35±4.49	0-67	-2.18	2.12	2.92	Significantly different at 5% level of significance
Buffalo	45.11±2.44	32-65				

3.3.1 Density of the flies according to color and breed of the cattle

From the present study data gathered in Table 5, it can be assessed that, flies showed favoritism towards specific color of the host body and according to the color of particular breed of cattle, number of flies feeding on them varies. In the present study significantly, higher density of flies observed on non-descript cattle as 54.66, Dangi 46.0, Holstein Friesian 43.0, Red Kandhari and Frieswal as 21.33 and Deoni as 13.66. The totally white color cattle breed such as Kankrej, Gaolav and Khillar were free from biting of these flies.

Table 5: Density of *Haematobia exigua* flies on the body of different breeds of cattle belonging to different regions of Maharashtra State and having various body colors

Breed of cattle	Fly density Mean ±SE	Range	Significance
Red Kandhari	21.33^{c}±0.33	21-22	Significant at 1% and 5% level of significance CD (0.01) = 13.421 CD (0.05) = 9.741
HF	43.00^{b}±5.56	36-54	
Deoni	13.66^{c}±0.88	12-15	
ND	54.66^{a}±7.21	42-67	
Frieswal	21.33^{c}±0.33	21-22	
Kankrej	0.00^{d}±	0-0	
Gaolao	0.00^{d}±	0-0	
Khillae	0.00^{d}±	0-0	
Dangi	46.00^{ab}±0.57	45-47	

Means showing different superscripts shows significant difference within column.

According to McLintock and Depner (1954) [16], it is difficult to predict exact factors or stimuli which attract the horn flies to a particular host, but many predictions and observations cited in the literature. Present study revealed that buffaloes were more attacked by flies with higher density as compared to cattle, indicating buffaloes as principal host for buffalo flies. The reason could be the higher hide temperature (Thomsen, 1938) [28]; buffaloes being black in colour which absorbs the sunlight and thus hide temperature is more. In concurrence to our study, Du Toit (1938) [6] and Krijigsman and Windred (1933) [13] stated that buffaloes are the principal attraction of *Haematobia irritans exigua* flies. On similar analogy cattle with black spots *viz*. HF crossbred were more attacked as compared to white and other coloured cattle *viz.* Gaolao, Kankrej etc. It agrees with the observations of Morgan (1962) [18] who noted the significant difference between the number of horn flies on HF as against on Guernsey and Jersey heifers and further they observed that on HF cattle, horn flies preferred the dark coloured areas. According to Marlatt (1910) [15] and Bruce (1940) [1] the dark-coloured breeds were attacked more than the lighter-coloured breeds of cattle. Hargett and Goulding (1962) [9] opined that more flies get congregated on dark places compared to white colour of host. Perotti and Bachmann (1999) [20] observed that only 192 (10%) of 1949 flies were counted on the white spots while rest of the 90 percent flies counted on black colour of the cows. Bruce (1964) [2] has well explained the justification for colour preferences of horn flies. According to them coloured skins and hairs absorb heat, while it is reflected from white or unpigmented areas. Further Schreiber and Campbell (1986) [23] and Fava *et al.*, (1994) [7] have opined that horn flies are thermotropic and colour preference could be the influence of thermoregulation mechanism. In this context Hargett and Goulding (1962) [9] observed that horn flies get attracted to a surface temperature range of 70 ºF-107 ºF and get repelled at temperature of 110 ºF. According to Thomsen (1938) [28] on black and white cattle, horn flies usually seeks out the black spots, where the hide temperature is undoubtedly higher.

4. Conclusion

Thus, on the basis of observations recorded in the present study regarding *Haematobia exigua* flies, following general conclusions can be drawn for planning of control measures.

Warmer the country but problem of humidity during warm/summer season like India, the emergence of flies gets delayed or no emergence occurs. During hot climate faecal pods gets dried off even before the completion of larval period and thus in the present study during summer months fly population declined to lower count though life cycle duration required was shorter than winter season. There is upper and lower limit of temperature for growth and propagation (not < 10 ℃ and > 36 ℃), at below and above this range neither hatching of eggs, development of larvae nor emergence of flies takes place. Temperature works in both ways. To less or too high temperature are detrimental for growth. Too cold and too hot seasons are also not suitable for the growth and development of insects. In the present study, due to non-availability of the humidity during too hot temperature and non-availability of the warmth during winter were found as detrimental. Humidity helps in dissolving so many metabolites from the environment which is absorbed through cuticle and warmth helps in gearing up metabolic rate of insects, as a result humidity and warmth are required for completion of life cycle in all the types of insects. *H. exigua* is no exception to it. The temperature range and duration of life cycle studies help to suggest control measures to be adopted during a particular period of the year e.g. the tropical country like India no necessity of applying control measures during the summer months.

Host buffaloes compared to host cattle, shall be attended more and efforts shall be concentrated on host buffaloes for control of *Haematobia exigua* flies. Cattle particularly HF crossbred or cattle with dark colour rather than white colour shall be more cared and be protected from attack of *Haematobia exigua* flies.

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