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# Species Composition, Meteorological and Zoogeographical Aspects of the Horsefly Fauna (Diptera: Tabanidae) in the Western Ghats, Karnataka, India

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**ABSTRACT**

A study was conducted to record the species composition, meteorological and zoogeographical aspects of horsefly fauna of Western ghats Belagavi division, Karnataka state, India from March 2019 to February 2020. A total of 912 flies were collected from 67 villages under 14 talukas in all the three seasons of the year. The study showed a total of 20 species of tabanids belonging to 5 genera of 3 subfamilies. The highest number of tabanid flies (55%) were collected from talukas covered by Sahyadri mountains with their habitats including moist deciduous, evergreen forests, followed by 34% flies were collected from talukas with habitats including plains, dry and moist deciduous forests, agricultural flatland and least number of flies (12%) were collected from talukas with their habitat including coastline with evergreen and moist deciduous forests. Tabanus was the most dominant genus recorded in all the three zones. The highest number of flies were collected from Khanapur taluka. The highest number of species were recorded from Hukkeri taluka. In the present study, investigated the effects of meteorological and zoogeographical factors on the abundance of tabanids in the Western ghats region Karnataka, India.

## Introduction

Tabanids have most described species of family Tabanidae of blood-feeding Diptera. It contains approximately 4,400 species and subspecies in 144 genera worldwide (Baldacchino *et al.*, 2014a; Morita *et al.*, 2016). In India Tabanidae family having 247 species and 1 subspecies belonging to 14 genera in 6 tribes and 3 subfamilies (Maity *et al.*, 2016). Kapoor *et al.*, (1990); Veer, (2004); Vasudev (2007) reported 46 species of tabanid flies belongs to 5 genera *viz.*, *Tabanus, Haematopota, Chrysops, Atylotus* and *Philoliche* and3 subfamilies *viz.,* Tabaninae, Chrysopsinae and Pangoniinae of Family Tabanidae from different parts of Karnataka. Tabanid flies are popularly known as gadflies or gnats in India (Datta, 1985). In the Hindi language, they are known as ‘Dance Makhi’ or ‘Dans’ (Veer, 2004). Whereas in Karnataka they are known as ‘Kurudu Nona’ or ‘Uri Nona’. Marathi and Konkani language they are called as ‘Andhala Maashi’ and ‘Sonda’ respectively.

Tabanid flies are large (9–33mm) robust colourful flies with a brilliant coloration of the eyes, sometimes having brilliant green or pink bands. Males having holoptic eyes whereas females having dichoptic eyes. Adults generally take rest on trees, all are diurnal and are often most active in sunny weather. Males feed on nectar from flowers and females are bloodsuckers on large animals like horses, cattle, mules, camels, deer, elephants, tigers and occasionally humans. Flies are abundant during monsoon; rainfall is the most affecting factor in deciding tabanid density (Vasudeva, 2007).

Tabanid flies attack on domestic animals has caused a loss of 40 million dollars to the livestock industry USA in 1965 (Steelman, 1976). However, there is no such estimate from this region but it is certainly quite higher. The abundance of tabanids is usually found higher during monsoon, especially in sunlight after rain (Datta, 1998). Occurrence of trypanosomosis high during monsoon, the higher load of flies causes severe mortality in animals. Among the carnivores, tigers are more susceptible to surradisease (Acharjyo, 2000). In India first case report of trypanosomosis in a human was reported in a farmer from Nagpur, Maharashtra (Joshi *et al.,* 2005).

In the temperate zone, horseflies are active only on warm, sunny days, generally during the summer (Chvala and Jezek 1997). Climatic conditions, such as temperature, humidity, atmospheric pressure, wind speed, and cloud coverage of the sky, strongly influence the daily activity of adult horseflies (Baldacchino *et al.,* 2014b). Higher air temperature generally accelerates flight activity, while higher wind speed reduces (Baldacchino *et al.,* 2013). Furthermore, low (<18°C) temperature may be a limiting factor for tabanid flight (Amano 1985). The present work reports about the meteorological parameters influencing tabanid catches in tropical semi-arid (steppe) climate zone Western ghats region of Karnataka, India.

## Materials and Methods

The study area included Western ghats of Belagavi division comprises of Sahyadri mountains with moist deciduous, evergreen forests (Khanapur, Supa, Yellapur, Sirsi and Siddapur), Plains with dry and moist deciduous forests, agricultural flatland (Hukkeri, Belagavi, Haliyal and Mundagod). The coastline with evergreen and moist deciduous forests (Karwar, Ankola, Kumta, Honnavar and Bhatkal). The details of meteorological details of study areas were tabulated intable-2.

Monthly collections were made during three different seasons, *viz.,* summer season (March, April and May) rainy season (south-west monsoon: June, July, August and September: north-west monsoon: October, November and December) and winter season (January, February) during 2019 and 2020 from different locations *viz.,* three talukas (Hukkeri, Belagavi and Khanapur) of Belagavi (Fig. 3) and eleven talukas (Haliyal, Supa, Yellapur, Mundagod, Sirsi, Siddapur, Kumta Bhatkal, Honnavar, Ankola and Karwar) of Uttar Kannada districts of Western ghats of Karnataka (Fig-4). Flies were collected by handpicking while feeding

on domestic cattle, buffalos. During peak season, flies were also collected from the car, while moving in the forest area with open window they were attracted and got trapped inside the car. Flies were also collected during dusk while moving on a bicycle by using sweep net sitting on the back seat of the rider. The air temperature was measured by a mercury thermometer during the field collections. Average rainfall, wind velocity humidity data were collected from website https://www.worldweatheronline.com.
Altitude (m) and geographical coordinates (Latitude and Longitude) were obtained through measurement with a Garmin GPS Navigator eTrex10 device.

Collected flies were placed in killing jar containing cotton soaked in ether as a narcotizing agent. Flies were pinned using entomological pin and kept in the collection box and preserved for further identification. All specimens were labelled with the location of the sampling along with date and time of collection.The label having the details of the date of collection, season, species and region of collection and collector's name. Pinned specimens were preserved carefully by keeping them in a wooden box with 1,4-Dichlorobenzene or D-L camphor and cotton at hollow spaces inside and the cotton ball dipped in carbolic acid at bottom of the box. Then pinned specimens were identified following taxonomic keys of Kapoor *et al*., 1990; Veer, 2004; Burton, 1978; Stone and Philip, 1974; Burger and Chainey, 2000.

## Results and Discussion

### Species composition

A total of 912 flies were collected from67 villages under14 talukas (Fig. 2). During present study it was observed that the flies were easily caught by hand picking method from the animal body, only female flies were collected, because they require blood meal for egg laying. The sweep net was not convenient to collect flies from grazing animals, but it was useful for collection of flies which were resting on grass blades, tree trunks and on vegetation.

The flies collected during the study included 20 species of tabanids of three subfamilies *viz.*, Tabaninae, Chrysopsinae and Pangoniinae. Following are the five genera of the above subfamilies: *Tabanus, Haematopota, Chrysops, Atylotus* and *Philoliche*. The species composition from different talukas was tabulated in table-1.

The highest number (9 species out of 20 species) were recorded from Hukkeri taluka which was followed by other talukas in decreasing order, Supa and Belagavi with 7 species each, Khanapur, Haliyal and Sirsi with 6 species each, Yellapur and Siddapur with 5 species each, Mundagod with 4 species, Karwar with 3 species and least number (2 species each) from Kumta, Bhatkal, Honnavar and Ankola.

### Talukawise percentage prevalence

The highest percentage of flies were collected in Khanapur taluka with 16% (143 flies out of 912), followed by decreasing order Yellapur with 13%, Haliyal with 12%, Supa with 11%, Hukkeri with 10%, Sirsi with 9%, Mundagod and Siddapur with 6% each, Belagavi with 6%, Kumta with 4%, Bhatkal with 3%, Honnavar and Ankola with 2% each and least percent of flies were collected in Karwar with 1% (Table 2 and Fig. 1).

In the present study the highest number of tabanid flies 55% (496 flies out of 912) were collected from talukas covered by Sahyadri mountains with their habitats including moist deciduous, evergreen forest. Altitude ranges between 550 m to 650 m a. s. l. average temperature ranging between 25º C to 28º C, humidity ranging between 55% to 75%, average rainfall ranging between 1400 mm to 2400 mm, wind velocity between 8kmph to 15kmph. These meteorological conditions were most favoured for the development and propagation of tabanid flies in this region. Farmers living at foothills of Sahyadri mountains involved in animal husbandry activity, rearing Malnad gidda cow which were left for grazing in forest area were the main source of blood meal for tabanid flies. The dominant genus found in this zone was *Tabanus* and followed by decreasing order *Haematopota*, *Chrysops* and *Atylotus*.

Followed by 34% (311 flies out of 912) flies were collected from talukas with habitats including plains, dry and moist deciduous forests, agricultural flatland. Altitude ranges between 550 m to 750 m a. s. l. average temperature ranging between 25º C to 30º C, humidity ranging between 65% to 75%, average rainfall ranging between 1200 mm to 2400 mm, wind velocity between 8kmph to 16kmph. These meteorological conditions were moderately favoured for the development and propagation of tabanid flies in this region. Farmers living in this region involved in agriculture and animal husbandry activity, rearing cow, buffalo, bullocks, which were left for grazing in the forest area were the main source of blood meal for tabanid flies. The dominant genus found in this zone was *Tabanus* and followed by decreasing order *Haematopota, Philoliche, Atylotus* and *Chrysops*.

Least number of flies 12% (105 flies out of 912) was collected from talukas with their habitat including coastline with evergreen and moist deciduous forests. Altitude range between 14 m to 48 m a. s. l. average temperature ranging between 27º C to 30º C, humidity ranging between 65% to 75%, average rainfall ranging between 3200 mm to 4500 mm, wind velocity between 10kmph to 14kmph. These meteorological conditions were slightly favoured for the development and propagation of tabanid flies in this region. Farmers living in this region involved in agriculture and animal husbandry activity, rearing Malnad gidda cow which were left for grazing in the forest area were the main source of blood meal for tabanid flies. The dominant genus found in this zone was *Tabanus* and no other genus was recorded during the present study (Table-2).

**Table.1** Species composition at taluka level Western ghats of Belagavi division, Karnataka

| Sl. no. | Name of the taluka | Species composition |
|---|---|---|
| **1** | Khanapur | *Tabanus indianus* Ricardo, *Tabanus biannularis* Philip, *Tabanus diversifrons* Ricardo, *Tabanus triceps* Thunberg, *Tabanus tenebrosus* Walker, *Haematopota montana* Ricardo. |
| **2** | Yellapur | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus rubidus* Wiedemann, *Tabanus auristriatus* Ricardo, *Atylotus virgo* Wiedemann. |
| **3** | Haliyal | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus gertrudae* Philip, *Tabanus triceps* Thunberg, *Haematopota albimedia* Stone and Philip, *Atylotus virgo* Wiedemann. |
| **4** | Supa | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus gertrudae* Philip, *Tabanus triceps* Thunberg, *Tabanus rubidus* Wiedemann, *Haematopota montana* Ricardo, *Chrysops dispar* Fabricius. |
| **5** | Hukkeri | *Tabanus diversifrons* Ricardo, *Tabanus sexcinctus* Ricardo, *Tabanus* |

| | | |
|---|---|---|
| | | *dorsilinea* Wiedemann, *Tabanus jucundus* Walker, *Haematopota javana* Wiedemann, *Haematopota albimedia* Stone and Philip, *Chrysops pellucidus* Fabricius, *Atylotus virgo* Wiedemann, *Philoliche taprobanes* Walker. |
| **6** | Sirsi | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus rubidus* Wiedemann, *Haematopota montana* Ricardo, *Haematopota Longipennis* Stone and Philip, *Chrysops dispar* Fabricius. |
| **7** | Belagavi | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus gertrudae* Philip, *Tabanus dorsilinea* Wiedemann, *Tabanus jucundus* Walker, *Haematopota montana* Ricardo, *Haematopota javana* Wiedemann. |
| **8** | Mundagod | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus rubidus* Wiedemann, *Haematopota brevis* Ricardo. |
| **9** | Siddapur | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus rubidus* Wiedemann, *Haematopota Longipennis* Stone and Philip, *Chrysops dispar* Fabricius. |
| **10** | Kumta | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo. |
| **11** | Bhatkal | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo. |
| **12** | Honnavar | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo. |
| **13** | Ankola | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo. |
| **14** | Karwar | *Tabanus indianus* Ricardo, *Tabanus diversifrons* Ricardo, *Tabanus rubidus* Wiedemann. |

**Fig.1** Graph showing taluka wise percentage prevalence of tabanid flies in Western ghats of Belagavi division

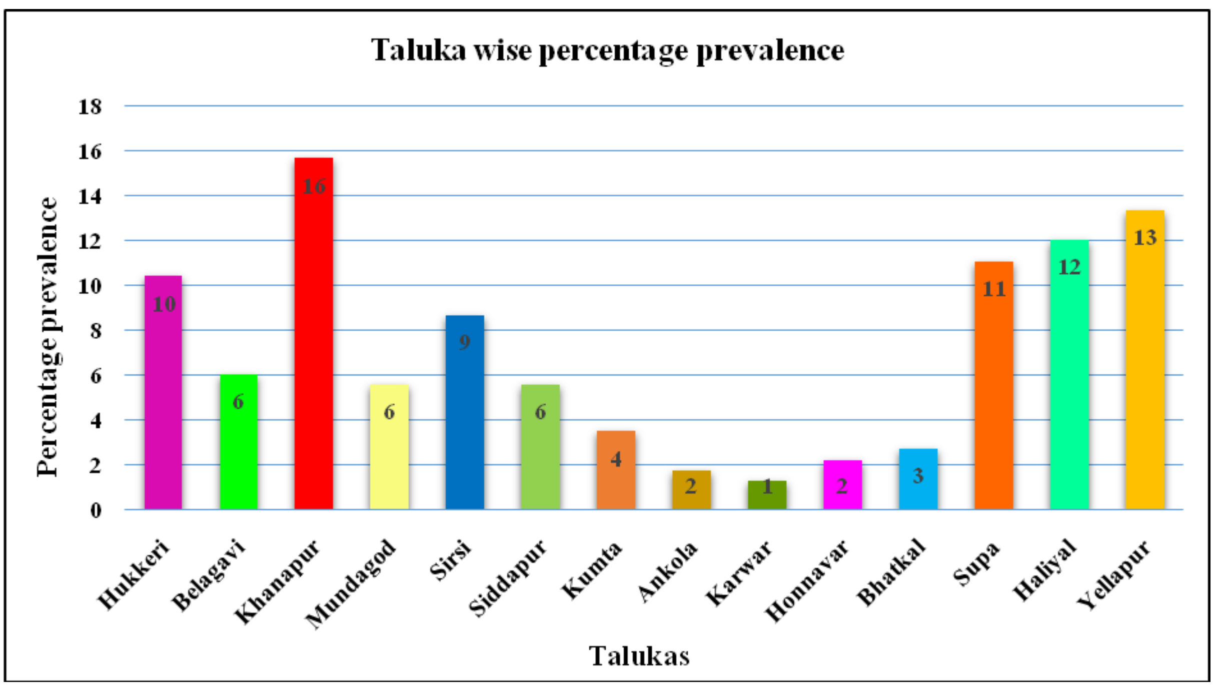


**Table.2** Taluka wise number of flies collected, prevalence, vegetation pattern and meteorological data from March 2019 to February 2020

| Sl. no. | Name of the taluka | No. of flies caught | Percentage prevalence | Vegetation pattern | Altitude (m) | Average T° | Humidity | Rainfall | Wind velocity |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Khanapur | 143 | 16% | Moist deciduous, Evergreen forests | 651 | 28 | 68% | 1592mm | 14kmpl |
| **2** | Yellapur | 122 | 13% | Moist deciduous, Evergreen forests | 637 | 27 | 72% | 1772mm | 8kmph |
| **3** | Haliyal | 110 | 12% | Dry and moist deciduous forests | 567 | 27 | 72% | 1772mm | 8kmph |
| **4** | Supa | 101 | 11% | Moist deciduous, Evergreen forests | 254 | 27 | 72% | 1775mm | 8kmph |
| **5** | Hukkeri | 95 | 10% | Dry and moist deciduous forests | 650 | 25 | 64% | 1055mm | 15kmph |
| **6** | Sirsi | 79 | 9% | Moist deciduous, Evergreen and evergreen scrub | 576 | 25 | 74% | 2383mm | 10kmph |
| **7** | Belagavi | 55 | 6% | Dry and moist deciduous forests | 752 | 26 | 68% | 1818mm | 14kmph |
| **8** | Mundagod | 51 | 6% | Dry and moist deciduous forests | 634 | 31 | 57% | 1210mm | 16kmph |
| **9** | Siddapur | 51 | 6% | Evergreen scrub | 576 | 26 | 74% | 1472mm | 12kmph |
| **10** | Kumta | 32 | 4% | Coastline with evergreen and moist deciduous forests | 20 | 28 | 79% | 3800mm | 10kmph |
| **11** | Bhatkal | 25 | 3% | Coastline with evergreen forests | 16 | 27 | 80% | 4419mm | 10kmph |
| **12** | Honnavar | 20 | 2% | Coastline with evergreen and moist deciduous forests | 48 | 30 | 75% | 3500mm | 14kmph |
| **13** | Ankola | 16 | 2% | Coastline with evergreen and moist deciduous forests | 17 | 28 | 78% | 3592mm | 13kmph |
| **14** | Karwar | 12 | 1% | Coastline with evergreen and moist deciduous forests | 14 | 28 | 76% | 3273mm | 14kmph |

**Fig.2** Map of the studied area, studied sites are described in materials and methods section

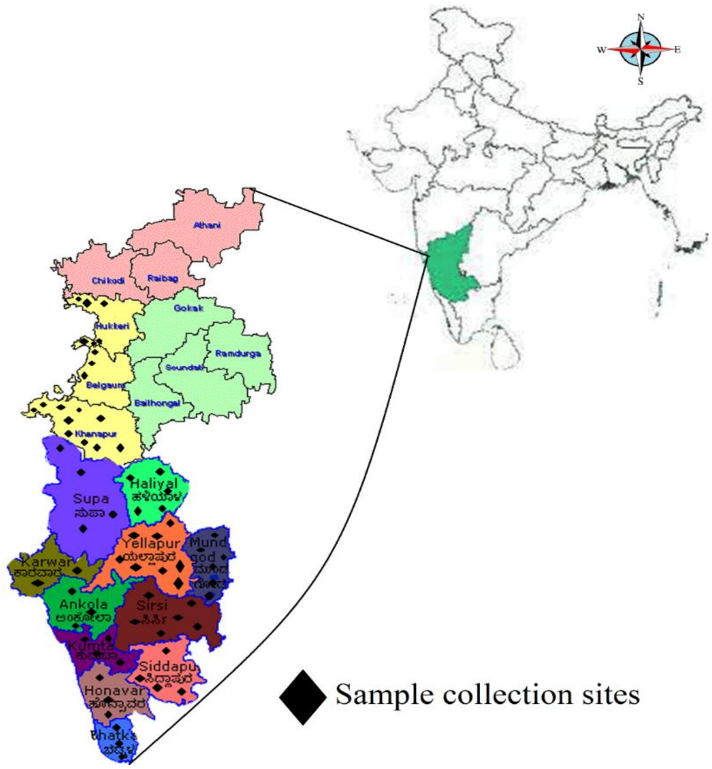



**Fig.3** Vegetation pattern in Belagavi district Karnataka, India

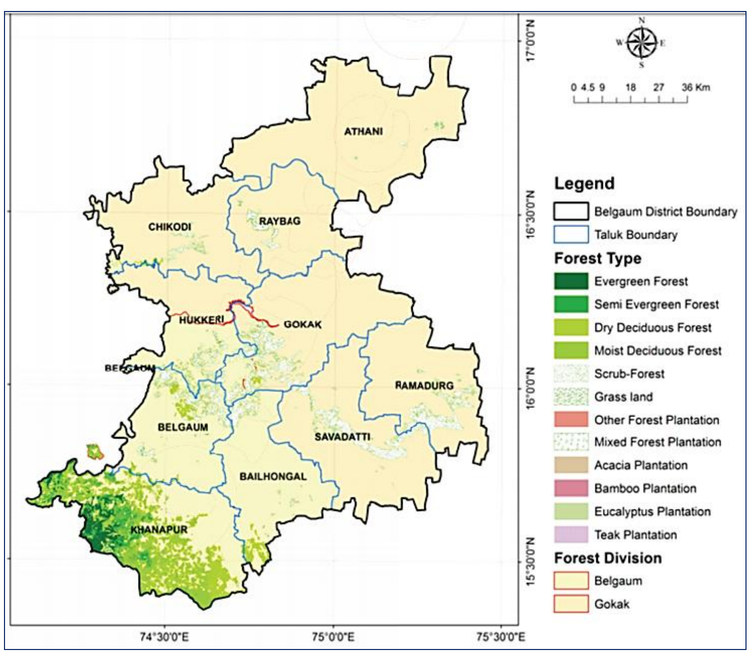
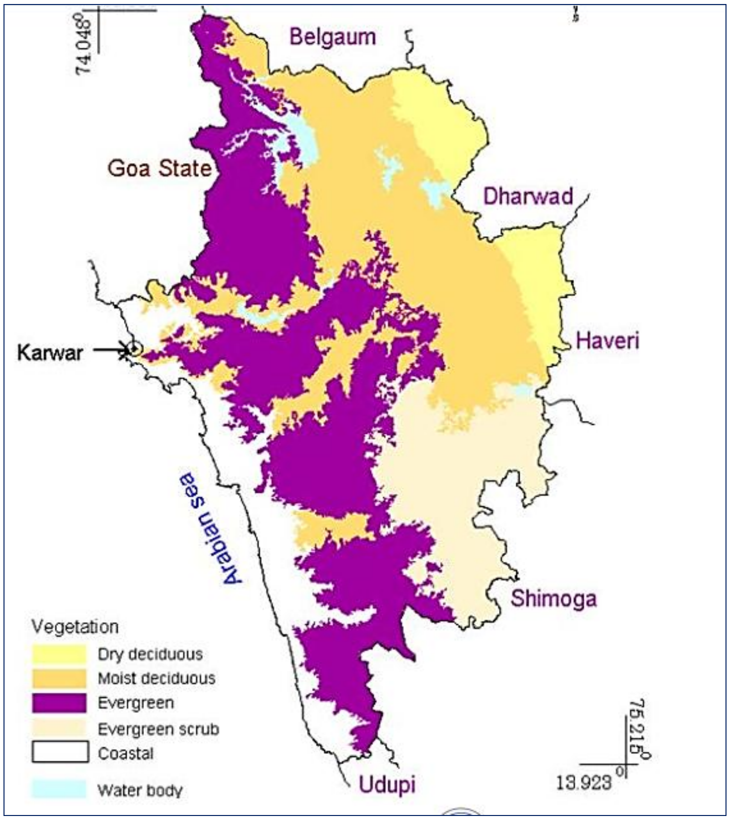


**Fig.4** Vegetation pattern in Uttara Kannada district Karnataka, India




Tabanid flies are holometabolous insects, continuation needs an encouraging environment which would support all stages of their life cycle *viz.*, egg, larva, pupa and adult. Suitable substrates for eggs, banks of water bodies for the larval and pupal development, proper adult resting sites, nectar sources for the survival of adult flies and blood sources for egg development are the elementary necessities.

Egg laying was seen on grasses and even on fallen bamboo/tree branches, nearby water sources. Larvae need sufficient food sources in the form of other Dipteran larvae, earthworms, snails, small fishes etc. Tabanids feed on nectar of flowers (Leprince and Lewis, 1983)and flowering plant species of the forest must have been the main nectar sources for male and female flies. A rich density of hosts must have provided blood sources for adult flies. Thus, different stage of tabanid life cycle is well supported by flora, fauna and edaphic factors of the Western ghats.

Other natural factors like temperature, humidity and rainfall, along with the said factors offer a suitable and conducive environment for the survival and continuation of these flies in the Western ghats. Thus, the forest supports a rich diversity. Five genera namely, *Tabanus*, *Haematopota, Atylotus*, *Chrysops* and *Philoliche* of three subfamilies were collected from different parts of the study area. *Tabanus* was the most diverse genus at all the three zones.

The rainfall is necessary for all stages of tabanidcycle and probably would have played a key role in deciding tabanid abundance. Humidity was another environmental parameter that was positively correlated with tabanid abundance in study areas. Humidity affects development and survivorship of insects, which must keep body water content within certain limits and that is influenced by the degree of cuticle permeability (Raghu *et al.,* 2004).

High relative humidity favours most metabolic processes in vectors like tabanids. So, a high humidity will tend to prolong survival, although increased susceptibility to fungal and bacterial pathogens may offset this to a variable degree. Low humidity causes a decrease in the daily survival rates of many arthropod vectors including tabanids. Because of dehydration, in some cases it may also cause an increase in the blood feeding rate, in an attempt to compensate for the high levels of water loss (Mellor and Leake, 2003). Hence, lesser number of tabanids and their activity could be attributed to both low temperature (McElligott and Galloway, 1991)and less humidity.

Temperature is another important environmental parameter affecting insect populations. Increase in the temperature decreases the interval between blood-meal and oviposition (Roberts, 1980).In a laboratory experiment, Hafez *et al.,* (1970)have shown a reduction in larval and pupal duration with an increase in temperature, clearly indicating the role of temperature in tabanid development. Lower temperature is also known to reduce activity and density of tabanids (Thibault and Harper, 1983).

Besides rainfall, humidity and temperature, many other factors have been shown to be responsible for abundance of tabanids. Flowering plants acting as the main source of energy in the form of nectar, flowers support and decide the duration of tabanid life cycle (Leprince and Poulin, 1990). Carbohydrates of flowers have been reported as important dietary components for tabanids (Magnarelli, 1981)apparently to restore depleted energy reserves during flight.

Numerous studies have investigated the effects of meteorological factors on seasonal abundance of tabanids all over the world (Roberts 1971; Strickman and Hagan 1986; Leprince *et al.,* 1991; Strickler and Walker, 1993; McElligot and Lewis 1998; Krcmar 1999; Barros 2001; Hribar *et al.,* 2003; Krcmar 2005). The studies of the seasonal abundance of tabanids are very important from the standpoint of medical and veterinary parasitology, because some species of tabanids participate in the transmission of agents of various diseases (Foil 1989; Vazzeille-Falcoz *et al.,* 1997; Thomson and Connor 2000).

In the present study highest number of flies were collected from the study area covered by Sahyadri mountains with moist deciduous, evergreen forests. These findings were in concurrence with Barros (2001) who reported higher number of tabanids in the wooded habitat than in grassland. Whereas number of flies caught in study area covered by plains with dry and moist deciduous forests, agricultural flatland was less than the Sahyadri mountains with moist deciduous, evergreen forests and more than the coastline with evergreen and moist deciduous forests. Tabanid flies were known to be abundant in different habitats (Harley, 1965; Mavoungou *et al*., 2012; Bitome Essono *et al.,* 2015; Suh *et al.,* 2015).seasonal meteorological variability that occurs periodically from one year to another has a significant influence on the duration of tabanid flight activity, on their emergence, and on their peaks of abundance. For instance, when temperature conditions were more favourable during spring (May), higher numbers of tabanids were caught in the pasture habitat than in the wooded habitat (Krcmar, 2005).

In the present study highest number of flies were collected from the study area covered by Sahyadri mountains with moist deciduous, evergreen forests and higher mean temperature and relative humidity. Mean temperature and relative humidity along with rainfall may be critical for the activity of flight of horse flies, as determined by Cardenas *et al.,* (2012). Thus, the richness and abundance may be increased more than two and a half times if there is an increase of 2° C in mean temperature and of 8% in mean relative humidity. This increase in mean temperature and relative humidity in the region could lead to an increased abundance of horse flies, which could lead to increased richness or expansion of the range of annual occurrence of species that are rare and of intermediate abundance Kruger and Krolow (2015). These findings were in contrast to one of our study area, wherein which least number of flies were caught in coastline with evergreen and moist deciduous forests with higher mean temperature and relative humidity. This may have attributed to the fact that one side of study area covered by shoreline of Arabian sea and other side with evergreen and moist deciduous forests of Western ghats. According to Korner (2007), precipitation, wind velocity and seasonality are not altitudinal-related because gradients can go in any direction depending on local topography and climatic conditions, but they may affect species distribution due to intraspecific adaptations to such conditions at precise sites and periods of the year. As indicated by Kettle (1995), the activity and dispersion of adult tabanids is influenced by meteorological factors, principally luminosity and temperature.

As a consequence of the global climate change (global warming), an increase in the annual average air temperature and a decrease in the average amount of precipitation can be expected during the summer seasons of the next few decades in the Western Ghats region. This climatic change may contribute to the appearance of new tabanid species in Western Ghats region and changes in the seasonal and daily activities and abundance of horseflies. The geographical distribution and the temporal activity of many vectors (e.g., mosquitos, ticks) have been influenced by the effects of climate change (Garza *et al.,* 2014; Ogden *et al.,* 2014). Like other parasites, tabanids can also appear and establish their populations in formerly uninfected areas, and they may introduce non-indigenous pathogens. Climate change may alter the host-vector interaction too. Tabanids are more active at higher air temperatures spending more time with blood sucking. For these reasons, females will lay more eggs and probably bigger populations of horseflies will attack animals and humans during the swarming periods. An increased frequency of bloodsucking gives a higher chance for the transmission of causative agents. This may cause not only economical losses and health problems of livestock but also public health consequences, depending on the pathogens. Climate change also alters the composition of plant ecosystems (Gehring *et al.,* 2014) serving food for herbivores. This may influence the persistence of tabanid hosts. A rainier weather, for example, results in more ponds, puddles, and mud, so the egg-laying areas of horseflies increase considerably. The follow-up study of the complex effects of the climate change on the activity and pathogen-transmission ability of tabanid flies could be performed by worldwide research teams.

In conclusion, the diversity of tabanids in the Western ghats region shows a high degree of adaptation. The highest abundance of flies was observed in the area covered by Sahyadri mountains with moist deciduous, evergreen forests and higher mean temperature and relative humidity. Least abundance was observed in the coastline with evergreen and moist deciduous forests with higher mean temperature and relative humidity. Also the research revealed that rainfall, air temperature, altitude, and wind velocity were the most important factors influencing the number of tabanids. Our data may serve as a reference for further investigations to study the effect of climate change on the tabanid activity in the Western ghats of Karnataka, India.

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