Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(3): 983-990

Received: 10-03-2020
Accepted: 12-04-2020

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Seasonal abundance of horseflies (Diptera: Tabanidae) in the Western Ghats of Karnataka

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Abstract
The aim of the present study was to explore the seasonal activity of tabanids in the Western Ghats of Karnataka. The study was carried out during all the seasons of the flight period March, 2019 to February 2020. A total of 912 specimens of tabanids were collected and identified belong to 5 different genera grouped into 20 species. The horse flies began flying during March-2019 and its flight period lasted until February-2020 with difference in number and species composition. The peak of seasonal abundance was observed during the last week of June. The most abundant species in the horse fly assemblages in the Western Ghats of Karnataka was *Tabanus diversifrons* Ricardo comprising of 18.64%, followed by *Tabanus indianus* Ricardo (9. 21%), *Atylotus virgo* Wiedemann (8.33%), *Tabanus biannularis* Philip (8.11%), *Tabanus dorsilinea* Wiedemann (7.13%), *Tabanus rubidus* Wiedemann (7.02%), *Tabanus jucundus* Walker (5.81%), *Haematopota montana* Ricardo (5.37%), *Tabanus gertrudae* Philip and *Tabanus triceps* Thunberg 5.04% each, *Chrysops dispar* Fabricius 3.84%, *Haematopota javana* Wiedemann 3.51%, *Haematopota Longipennis* Stone and Philip (2.96%), *Haematopota brevis* Ricardo (2.52%), *Tabanus sexcinctus* Ricardo and *Philoliche taprobanes* Walker 2.08% each, *Tabanus tenebrosus* Walker (1.43%), *Tabanus auristriatus* Ricardo (1.21%), and least abundance was observed in *Haematopota albimedia* Stone and Philip and *Chrysops pellucidus* Fabricius with 0.33% each. The largest number of specimens of *Tabanus diversifrons* Ricardo was collected during the peak of seasonal abundance of horse flies in the Western Ghats of Karnataka. Among the 20 species recorded in the present study, 7 species were proven vector for Surra, Anthrax, Blackleg and Haemorrhagic septicaemia in domestic and wild animals.

Keywords: Seasonal activity, tabanids, dominant species, Western Ghats, Karnataka

1. Introduction
The family Tabanidae includes horse flies, deer flies, and yellow flies, all of which have veterinary and medical importance. Large tabanid populations have a significant economic impact on livestock production and outdoor activities because of the blood-feeding habits of the females of most species (Foil and Hogsette 1994) [1]. They are a serious nuisance to livestock and can mechanically transmit several animal pathogens (Mullen and Durden, 2002) [2]. In India, tabanids transmit more than 35 diseases of cattle and humans including *surra* or trypanosomiosis (Basu *et al*., 1952) [3]. In other parts of the World**,** tabanids are responsible for the transmission of more than 80 viral, bacterial and protozoan diseases (Krinsky, 1976) [4]. Among them trypanosomiosis, anthrax is a prevalent fatal disease of Livestock, if infected animals left untreated.

Just like any other insect groups, tabanids do interact with environment and show seasonal variations. But, the factors affecting their population may vary as they are dependent on hosts for their blood meal, required for the development of eggs. Tabanid life cycle is dependent on various biotic and abiotic factors. Egg laying requires suitable substrates nearby water sources. Larval development requires appropriate soil conditions and availability of other larvae and small invertebrates as food, since they are carnivorous and predate on other larvae. Pupal emergence also requires appropriate dampness of soil. Finally, adults require nectar from flowers as energy source and blood from vertebrate hosts for the development of eggs. Host seeking activity is again controlled by various environmental factors as they are more active in sunny days with an elevated humidity. Hence, at any of the above steps, population may be regulated.

Tabanid ecology is one of the least addressed topics in tropical countries and India as well. According to (Veer, 2004) [5] in India, neither any research article that addresses the seasonality and abundance of these flies has been published so far, nor there is any detailed study on seasonal variations in their populations.

In nature, the emergence of horse flies depends on season and latitude (Chvala *et al.* 1972) [6]**.** According to (Vasudeva, 2007) [7] in Karnataka tabanids began flying in early Monsoon and peak was observed in June and July. Whereas least flight was observed in December, January and February. The Tabanid fauna were abundant throughout the study area and can be seen throughout the year with a little decline at during winter (Maity *et al.*, 2016) [8]. As in any insect populations, tabanids are also affected by various abiotic factors like temperature, rainfall, humidity and biotic factors predators, parasites, availability of hosts etc. It is generally believed that their population peaks usually coincide with rainfall (Barros, 2001) [9], though there are few exceptions.

This study was a part of the research, conducted on the fauna and activity of the horse flies of the Tabanidae family in the Western Ghats Belagavi division, Karnataka.

2. Materials and Methods

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) 2019 and 2020 from different locations *viz.*, Three talukas (Hukkeri, Belagavi and Khanapur) of Belagavi and eleven talukas (Haliyal, Supa, Yellapur, Mundagod, Sirsi, Siddapur, Kumta Bhatkal, Honnavar, Ankola and Karwar) of Uttar Kannada districts (Fig. 1). Tabanid flies especially females were collected easily by handpicking method while blood-feeding on cattle, buffalo and bullocks from March 2019 to February 2020. 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. After catching, adults were killed in killing jars as it contains benzene and they were taken to pin the specimen through one side of the thorax and proper labelling was done. 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 insides and the cotton ball dipped in carbolic acid at bottom of the box. Then pinned specimens were identified following a proper taxonomic keys of (Kapoor *et al*., 1990; Veer, 2004; Burton, 1978; Stone and Philip, 1974; Burger and Chainey, 2000) [10, 5, 11, 12,13].

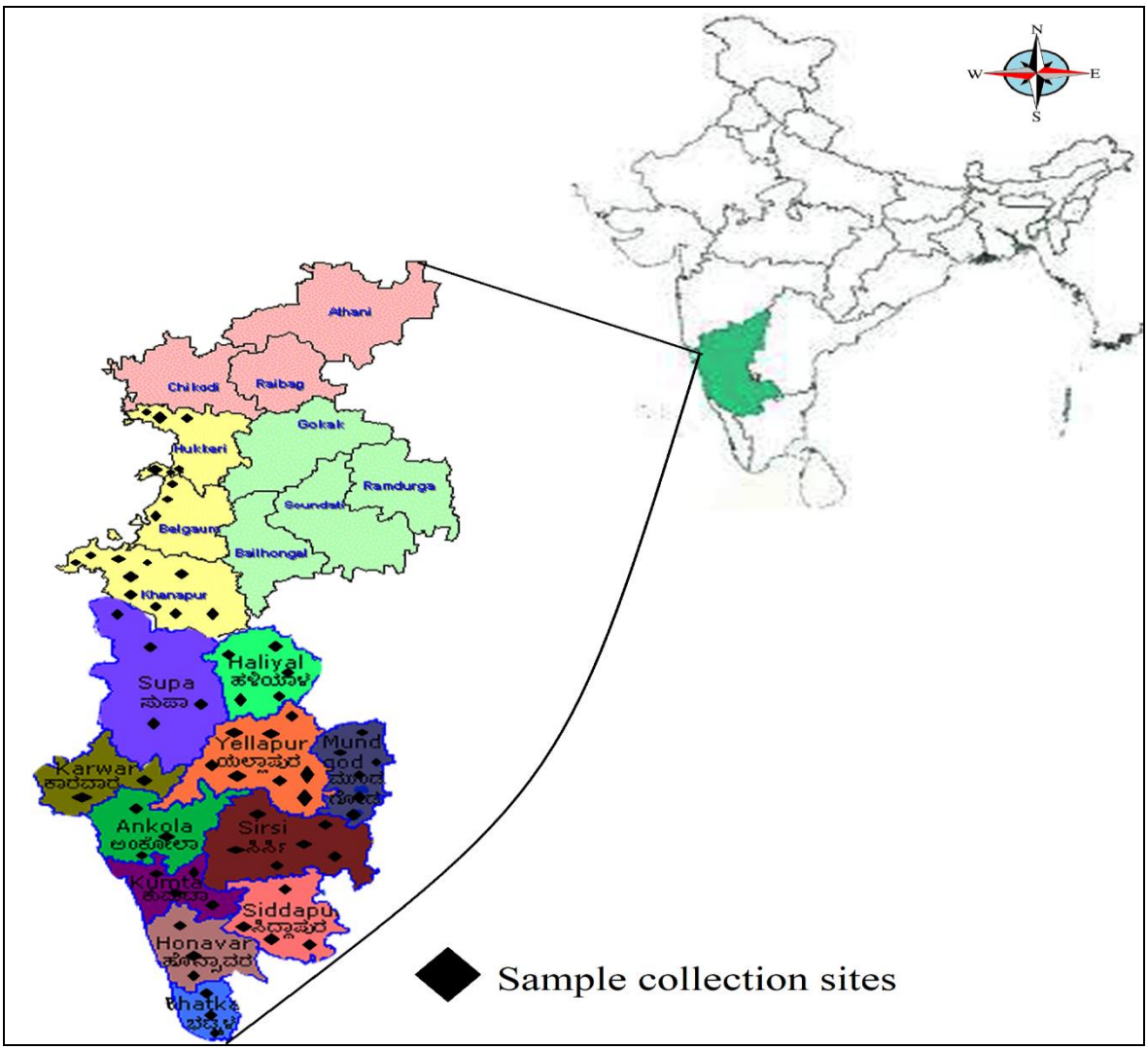

Fig 1: Map showing sampling sites at Belagavi and Uttar Kannada Districts of Western Ghats of Karnataka

Table 1: Physical data of 67 sampling sites at Belagavi and Uttar Kannada Districts Western Ghats Karnataka from March 2019 to February 2020.

	Sampling sites	Latitude	Longitude	Altitude (m)	Host
Hukkeri					
1	Daddi	16° 3' 38.4156"N	74° 26' 46.284"E	650	Buffalo
2	Maranholi	16° 3' 25.7292"N	74° 22' 44.22"E	650	Buffalo
3	Modga	16° 3' 22.4784"N	74° 24' 36.144"E	650	Cattle
4	Bhairapur	16° 18' 30.1788"N	74° 22' 13.9728"E	650	Buffalo
5	BugteAlur	16° 18' 17.6796"N	74° 21' 14.544"E	650	Buffalo
6	Shippur	16° 20' 47.0904"N	74° 23' 6.5616"E	650	Buffalo
Belagavi					
7	Sutagatti	16° 2' 35.6604"N	74° 29' 31.1964"E	752	Buffalo
8	Handiganur	15° 57' 41.8824"N	74° 27' 8.802"E	752	Buffalo
9	Bhutramahatti	15° 59' 7.7028"N	74° 30' 46.5156"E	752	Cattle
Khanapur					
10	Maan	15° 40' 57.8784"N	74° 10' 15.6396"E	651	Cattle, Buffalo
11	Kankumbi	15° 41' 51.9864"N	74° 13' 55.38"E	651	Cattle
12	Ckikale	15° 40' 12.738"N	74° 17' 12.6996"E	651	Cattle
13	Jamboti	15° 40' 59.7036"N	74° 21' 37.0224"E	651	Buffalo
14	Kapoli K.C	15° 39' 49.7124"N	74° 22' 25.0284"E	651	Buffalo, Cattle
15	Chapoli	15° 38' 58.2144"N	74° 20' 34.4112"E	651	Buffalo
16	Kusumalli	15° 43' 31.692"N	74° 22' 58.3932"E	651	Buffalo
17	Nersa	15° 35' 51.2664"N	74° 25' 49.7532"E	651	Buffalo
18	Navage	15° 35' 3.5376"N	74° 31' 41.7396"E	651	Buffalo
19	Gunji	15° 32' 3.9624"N	74° 28' 57.2376"E	651	Buffalo, Cattle
Mundagod					
20	Tibetan colony	14° 59' 21.3324"N	74° 59' 51.3456"E	634	Cattle
21	Bachanaki	15° 0’ 52.776”N	75° 39’ 6.3564”E	634	Buffalo, Cattle
22	Indoor	15° 1' 37.1568"N	75° 1' 8.5548"E	634	Buffalo, Cattle
23	Ugginakere	15° 1’ 34.3164”N	74° 57’36.7632”E	634	Buffalo, Cattle
24	Nandikatta	15° 2' 45.9744"N	74° 59' 2.1768"E	634	Cattle
25	Malagi	14° 45' 26.5716"N	74° 1' 3.7812"E	634	Bullocks
Sirsi					
26	Isloor	14° 41' 47.166"N	74° 54' 57.4884"E	576	Cattle
27	Bommahalli	14° 40' 49.4328"N	74° 49' 46.4772"E	576	Cattle
28	Hirebail	14° 35' 48.4368"N	74° 47' 34.3032"E	576	Cattle
29	Sonda	14° 44' 6.09"N	74° 48' 42.1524"E	576	Cattle
30	Hulagol	14° 42' 46.656"N	74° 49' 0.9942"E	576	Cattle
31	Manchikere	14° 51' 41.472"N	74° 48' 55.188"E	576	Cattle
Siddapur					
32	Kanasur	14° 31' 6.9276"N	774° 50' 0.8916"E	576	Cattle
33	Bankuli	14° 20' 30.084"N	74° 50' 5.2296"E	576	Cattle
34	Tumbargod	14° 25' 22.5372"N	74° 52' 41.4732"E	576	Cattle
35	Adakalli	14° 31' 2.4888"N	74° 48' 37.7892"E	576	Cattle
Kumta					
36	Katagal	14° 28' 59.5308"N	74° 29' 1.5324"E	20	Cattle
37	Hebbailu	14° 29' 17.8044"N	74° 33' 8.7948"E		Cattle
38	Alkod	14° 29' 16.4868"N	74° 29' 7.7604"E	20	Cattle
39	Antravalli	14° 28' 27.1488"N	74° 27' 53.5608"E	20	Cattle
Ankola					
40	Adlur	14° 40' 23.502"N	74° 23' 33.7164"E	17	Cattle
41	Navagadde	14° 41' 8.5632"N	74° 21' 50.7384"E	17	Cattle
42	Aversa	14° 44' 0.6828"N	74° 16' 28.4016"E	17	Cattle
Karwar					
43	Katar	14° 53' 10.4388"N	74° 16' 11.1324"E	14	Cattle
44	Virje	14° 53' 54.2508"N	74° 20' 9.4848"E	14	Cattle
Honnavar					
45	Kavalakki	14° 17' 39.7464"N	74° 29' 55.914"E	48	Cattle
46	Hadinbal	14° 17' 19.1544"N	74° 30' 32.6448"E	48	Cattle
47	Hosakere	14° 13' 25.3416"N	74° 29' 27.96"E	48	Cattle
Bhatkal					
48	Haliyani	14° 2' 29.2668"N	74° 37' 32.2032"E	16	Cattle
49	Hudil	14° 2' 42.3816"N	74° 35' 21.858"E	16	Cattle
50	Mavalli	14° 3' 42.2712"N	74° 32' 4.6752"E	16	Cattle
Supa					
51	Jagalbet	14° 59' 42.45"N	74° 21' 51.0408"E	254	Cattle
52	Joida	15° 19' 29.4708"N	74° 30' 23.8824"E	254	Cattle
53	Anshi	15° 10' 29.4672"N	74° 29' 9.978"E	254	Cattle

54	Badagund	15° 16' 33.4416"N	74° 32' 50.3376"E	254	Buffalo
Haliyal					
55	Malawadi	15° 11' 11.2668"N	74° 44' 55.8276"E	567	Buffalo
56	Bhagavati	15° 9' 2.322"N	74° 45' 33.1992"E	567	Buffalo
57	Kyatangera	15° 17' 15.9036"N	74° 44' 28.1832"E	567	Buffalo
58	Usoda	15° 18' 54.3312"N	74° 32' 50.4672"E	567	Buffalo
59	Karlakatta	15° 15' 44.2476"N	74° 44' 33.2772"E	567	Cattle
Yellapur					
60	Jodagali	15° 0' 47.7396"N	74° 43' 15.6828"E	637	Cattle
61	Arabailu	14° 50' 36.8052"N	74° 38' 32.7012"E	637	Cattle
62	Ramanguli	14° 47' 15.0828"N	74° 34' 59.718"E	637	Cattle
63	Ubegali	14° 58' 16.7016"N	74° 45' 38.8872"E	637	Cattle
64	Yerakambail	14° 56' 35.9304"N	74° 23' 58.884"E	637	Cattle
65	Gullapur	14° 56' 35.9304"N	74° 44' 23.8884"E	637	Cattle
66	Idagundi	14° 54' 50.0076"N	74° 39' 12.1716"E	637	Cattle
67	Ummachagi	14° 48' 38.7324"N	74° 49' 58.2888"E	637	Cattle

3. Results

A total of 912 specimens belonging to 5 genera and 20 species were collected and determined in two localities at the Western Ghats of Belagavi division Karnataka (Table 1). During the study it was observed that *Tabanus diversifrons* Ricardo most diverse species comprising of 18.64% (170 out of 912 specimens), followed by *Tabanus indianus* Ricardo comprising of 9. 21% (84 out of 912 specimens), *Atylotus virgo* Wiedemann with 8.33% (76 out of 912 specimens), *Tabanus biannularis* Philip with 8.11% (74 out of 912 specimens), *Tabanus dorsilinea* Wiedemann with 7.13% (65 out of 912 specimens), *Tabanus rubidus* Wiedemann with 7.02% (64 out of 912 specimens), *Tabanus jucundus* Walker with 5.81% (53 out of 912 specimens), *Haematopota montana* Ricardo with 5.37% (49 out of 912 specimens), *Tabanus gertrudae* Philip and *Tabanus triceps* Thunberg with 5.04% each (46 each out of 912 specimens), *Chrysops dispar* Fabricius with 3.84% (35 out of 912 specimens), *Haematopota javana* Wiedemann 3.51% (32 out of 912 specimens), *Haematopota Longipennis* Stone and Philip with 2.96% (27 out of 912 specimens), *Haematopota brevis* Ricardo with 2.52% (23 out of 912 specimens), *Tabanus sexcinctus* Ricardo and *Philoliche taprobanes* Walker with 2.08% each (19 each out of 912 specimens), *Tabanus tenebrosus* Walker with 1.43% (13 out of 912 specimens), *Tabanus auristriatus* Ricardo with 1.21% (11 out of 912 specimens), and least percent of prevalence was observed in *Haematopota albimedia* Stone and Philip and *Chrysops pellucidus* Fabricius with 0.33% each (3 each out of 912 specimens) Table 2 and figure 3.

3.1 Month wise abundance of tabanid flies (March 2019 to February 2020) in Western Ghats Karnataka

The highest number of flies were observed in June with 16% (142 out of 912 flies) followed by April with 14% (124 out of 912 flies), July with 13% (123 out of 912 flies), May 12% (106 out of 912 flies), August with 11% (102 out of 912 flies), September with 9% (85 out of 912 flies), October with 7% (66 out of 912 flies), March with 5% (43 out of 912 flies), November with 4 (40 out of 912 flies), January 2020 with 4% (38 out of 912 flies), February 2020 with 3% (23 out of 912 flies) and least abundance of flies were observed in December with 2% (20 out of 912 flies).

The active flight period of tabanid flies commenced last week of March-2019. A total of 43 specimens and 3 species *viz.*, *T. biannularis*, *T. tenebrosus* and *T. gertrudae* were recorded. The dominant species in March was *T. biannularis.*

In April a total of 124 specimens and 3 species *viz.*, *T. indianus* with highest number of flies followed by *T. biannularis T. gertrudae* and *T. tenebrosus* were recorded. Summer season peak flight was observed in April. In March activity was reported for 3 species of tabanids. All of these 3 continued to fly in April. The analysis of phenological data shows that 1 new species (*T. indianus*) was included in the tabanid assemblages in April. The dominant species in April was *T. indianus.*

There was slight decline in number of flies, though there was emergence of two more genera (Chrysops and Haematopota) during May with 106 specimens and 7 species *viz., C. dispar* and *T. biannularis* with highest number followed by *T. indianus, T. diversifrons. T. triceps, T. rubidus* and *H. brevis.* In April activity was reported for 4 species of tabanids. Only 2 of these continued to fly in May. The analysis of phenological data shows that 5 new species (*T. diversifrons, T. triceps, T. rubidus, H. brevis* and *C. dispar*) were included in the tabanid assemblages in May. The flight activity of *T. tenebrosus* and *T. gertrudae* were nil. The dominant species in May was *T. dispar.* A total of 273 specimens and 9 species were recorded during summer season.

South-west monsoon began in June with variation in the meteorological conditions was characterized by scattered clouds, unstable wind and decline in temperature, increased relative humidity. Highest number of specimens i.e., 142 with 8 species. *T. diversifrons* with highest number of specimens followed by *T. triceps, H. montana, H. brevis, C. dispar, T. indianus, T. rubidus and T. auristriatus* included in the composition of the horsefly assemblages in June.

In May activity was reported for 7 species of tabanids. Only 6 of these continued to fly in June. The analysis of phenological data shows that 2 new species (*H. montana* and *T. auristriatus*) were included in the tabanid assemblages in June. The flight activity of *T. biannularis* was nil. The dominant species in June was *T. diversifrons.* It was characterized by pronounced peak in early June, due to the relatively high activity of tabanids almost until mid-July, after which drop in their number was recorded till December.

In June activity was reported for 8 species of tabanids. Only 5 of these continued to fly in July. The analysis of phenological data shows that 2 new species (*H. longipennis* and *A. virgo*) were included in the tabanid assemblages in July. The flight activity of *T. indianus, H. brevis* and *C. dispar* was nil. The dominant species in July was *T. diversifrons.*

In July activity was reported for 7 species of tabanids. Only 5 of these continued to fly in August. The analysis of phenological data shows that 3 new species (*T. dorsilinea, T. jucundus* and *C. pellucidus*) were included in the tabanid

assemblages in August. The flight activity of *T. triceps*, and *T. rubidus* were nil. The dominant species in August was *T. diversifrons.*

In August activity was reported for 8 species of tabanids. Only 5 of these continued to fly in September. The analysis of phenological data shows that 2 new species (*H. javana* and *P. taprobanes*) were included in the tabanid assemblages in September. The flight activity of *T. auristriatus, H. montana* and *H. longipennis* were nil. The flight activity of *T. diversifrons* was nil. The dominant species in September was *H. javana.*

In September activity was reported for 7 species of tabanids. Only 5 of these continued to fly in October. The analysis of phenological data shows that 2 new species (*T. sexcinctus* and *H. albimedia*) were included in the tabanid assemblages in October. The flight activity of *T. diversifrons* was nil. The dominant species in October was *T. dorsilinea.*

In October activity was reported for 7 species of tabanids. Only 3 of these continued to fly in November. The analysis of phenological data shows that re-emergence of new species (*T. rubidus*) was included in the tabanid assemblages in November. The flight activity of *T. jucundus* and *P. taprobanes* were nil. The dominant species in November was *T. rubidus*.

In November activity was reported for 4 species of tabanids. Only 3 of these continued to fly in December. The analysis of phenological data shows that no new species were included in the tabanid assemblages in October. The flight activity of *T. sexcinctus* was nil. The dominant species in December was *A. virgo.* A total of 578 specimens and 17 species were recorded during rainy season.

In December activity was reported for 3 species of tabanids. All of these 3 continued to fly in January-2020. The analysis of phenological data shows that re-emergence of new species (*T. jucundus*) was included in the tabanid assemblages in January. The dominant species in January was *T. rubidus.*

In January-2020 activity was reported for 4 species of tabanids. All of these 4 continued to fly in February. The analysis of phenological data shows that no new species were included in the tabanid assemblages in February. The dominant species in February was *T. rubidus.* A total of 61 specimens and 4 species were recorded during winter season.

Thus, on the basis of the monitoring on the seasonal activity of tabanids, it can be concluded that in Western Ghats of Belagavi division Karnataka the flight activity of tabanids began in the last week of March and ended until the mid-February, with a peak in the seasonal abundance during the first week of June.

3.2 Seasonal abundance of number of flies

It was observed that highest number of flies were collected during rainy season with 63% (578 flies out of 912 flies from June to December 2019), followed by summer season with 30% (273 flies out of 912 flies from March to May 2019) and least number of flies were observed during winter season with 7% (61 flies out of 912 flies from January and February 2020).

3.3 Seasonal wise abundance of number of Species of flies

The flies were collected and recorded the prevalence in all the three seasons of the year (Table 2). During the study, season wise observation was made about the number of species of flies prevalent in that particular season. A total of 9 species were prevalent during summer season. *Tabanus* was the most diverse genus represented by 77% (7 out of 9 species), followed by the genus *Haematopota* and *Chrysops* with 11% each (1 out of 9 species each) collected in summer. It was also observed that some species of flies were prevalent during summer season and as soon as monsoon begins they disappear viz., *T. biannularis, T. tenebrosus and T. gertrudae.* Whereas, *T. diversifrons, T. triceps, T. auristriatus, T. dorsilinea, T. jucundus, T. rubidus, H. montana* were emerge just before monsoon and they were present in rainy season.

A total of 17 species were prevalent during rainy season. *Tabanus* was the most diverse genus comprising 47% (8 out of 17 species), followed by the genus *Haematopota* with 29% (5 out of 17 species), *Chrysops* with 12% (2 out of 17 species), *Atylotus* with 6% (1 out of 17 species) and *Philoliche* with 6% (1 out of 17 species). A total of 4 species were prevalent during winter season. *Tabanus* was the most diverse genus comprising 75% (3 out of 4 species), followed by the genus *Atylotus* with 25% (1out of 4 species).

The study also revealed that the most diverse genus of the Western Ghats of Belagavi division was *Tabanus,* with 55% (11 out of 20 species), followed by *Haematopota* with 25% (5 out of 20 species), *Chrysops* with 10% (2 out of 20 species), *Atylotus* and *Philoliche* with 5% each (1 each out of 20 species).

It was observed that the highest number of species were prevalent during rainy (17 species) followed by summer season (9 species) and winter season (4 species). It indicates that the tabanid flies were more prevalent during rainy season than the other seasons.

Table 2: Species and season wise prevalence of number of tabanid flies in different places Western Ghats of Belagavi division, Karnataka

Seasons	Summer				Rainy				Winter					
Species	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**Species total**	**RA (%)**
T. indianus	0	55	19	10	0	0	0	0	0	0	0	0	84	9.21
T. biannularis	21	32	21	0	0	0	0	0	0	0	0	0	74	8.11
T. tenebrosus	5	8	0	0	0	0	0	0	0	0	0	0	13	1.43
T. gertrudae	17	29	0	0	0	0	0	0	0	0	0	0	46	5.04
T. diversifrons	0	0	19	43	51	39	18	0	0	0	0	0	170	18.64
T. triceps	0	0	12	25	9	0	0	0	0	0	0	0	46	5.04
T. auristriatus	0	0	0	6	3	2	0	0	0	0	0	0	11	1.21
T. dorsilinea	0	0	0	0		12	15	11	7	6	9	5	65	7.13
T. jucundus	0	0	0	0		15	13	9	0	0	10	6	53	5.81
T. rubidus	0	0	9	10	6	0	0	0	12	7	11	9	64	7.02
T. sexcinctus	0	0	0	0	0	0	0	10	9	0	0	0	19	2.08
H. montana	0	0	0	16	20	13	0	0	0	0	0	0	49	5.37
H. longipennis	0	0	0	0	19	8	0	0	0	0	0	0	27	2.96

H. brevis	0	0	5	18	0	0	0	0	0	0	0	0	23	2.52
H. javana	0	0	0	0	0	0	21	11	0	0	0	0	32	3.51
H. albimedia	0	0	0	0	0	0	0	3	0	0	0	0	3	0.33
C. dispar	0	0	21	14	0	0	0	0	0	0	0	0	35	3.84
C. pellucidus	0	0	0	0	0	2	1	0	0	0	0	0	3	0.33
A. virgo	0	0	0	0	15	11	9	11	12	7	8	3	76	8.33
P. taprobanes	0	0	0	0	0	0	8	11	0	0	0	0	19	2.08
Total no. specimens	43	124	106	142	123	102	85	66	40	20	38	23	912	
Month total no. of species.	3	4	7	8	7	8	7	7	4	3	4	4		
Season total no. of species.	9			17							4			

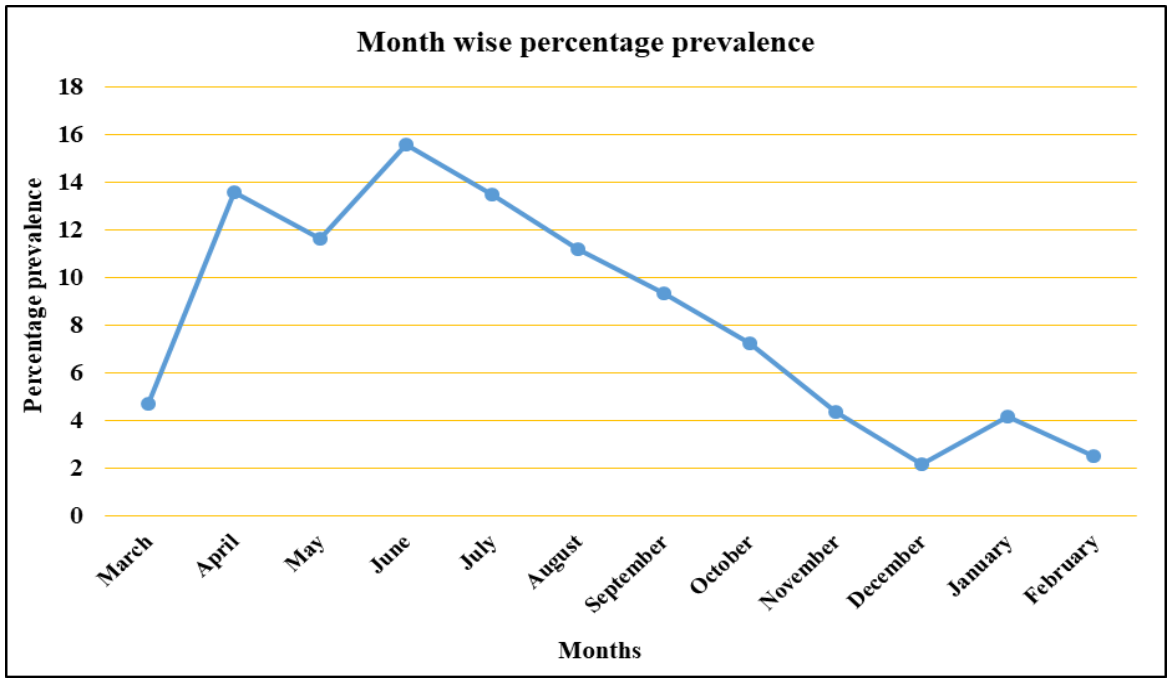

Fig 2: Graph showing month wise percentage prevalence of tabanid species during March 2019 to February 2020

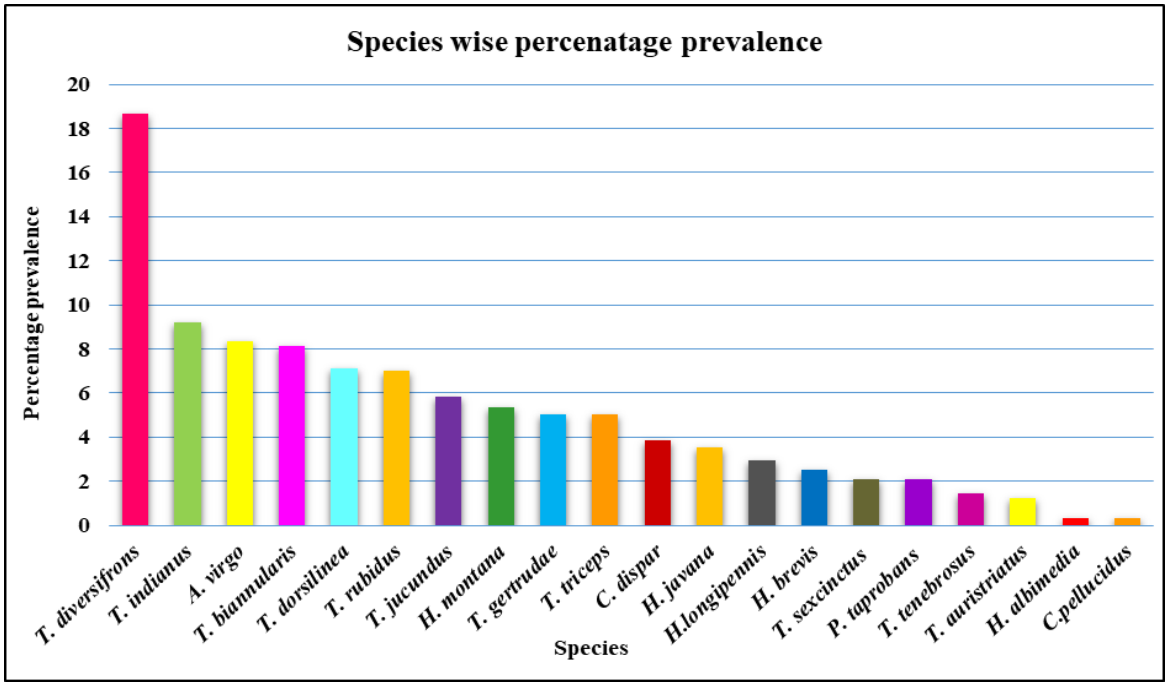

Fig 3: Graph showing the Species wise percentage prevalence of tabanid flies in different places of Western Ghats of Belagavi division

4. Discussion

The abundance of tabanid populations is influenced by meteorological conditions, especially temperature, relative humidity and the beginning of the rainy season (Barros, 2001; Parra *et al.*, 2008) [9, 14]. In general, tabanid populations are highest when the temperature is high and during the rainy season. However, there may be a seasonal succession of the more abundant species, with different species peaking at different times of the year (Barros, 2001) [9].

In the present study, it was observed that, both number of

adult flies caught (578 of 912 flies) and number of species recorded were highest during rainy (17 of 20 species) followed by summer season (273 flies and 9 species) and least was observed in winter season (61 flies and 4 species). It was observed that the number of adult flies caught and number of species were more prevalent during rainy season than the other seasons. The present study was in concurrence with Vasudeva (2007) [7] observed maximum tabanid activity during monsoon period from Rajiv Gandhi National Park, Karnataka, India. However, Maity *et al.* (2017) [15] reported that the abundance was more during the rainy season and declined during winter season. Tabanidae are abundant mainly throughout the year with a little decline in mid to higher elevations during winter (Maity *et al.,* 2015) [16].

In the present study it was observed that an increase in the number of adult flies were noticed in beginning of the rainy season, high numbers during the rainy season (April to September), and there was decline in the winter season. These findings were in concurrence with (Phasuk *et al.,* 2011) [17] numbers of flies caught increased with the beginning of the rainy season in May month, remained high until September, and declined in the winter season (October to February). Whereas (Croof *et al.,* 2017) [18] collected more tabanids flies during the wet season than the dry season. However, the peak populations of tabanid fly was observed from mid-June to early August and the abundance (catches) were more influenced by previous winter temperatures when compared to the spring or summer season temperatures as observed by (Suh *et al.,* 2015) [19]. Moreover, (Choi *et al.,* 2020) [20] reported the highest numbers of tabanids from June-August. In contrast to present study, (Lucas *et al.,* 2020) [21] reported that the horse fly season started in September and ended in May. No horse flies were caught during winter. This difference in emergence of fly might be attributed to availability of climatic conditions in different geographical area. (Krcmar, 2005) [22] reported that the seasonal meteorological variability significantly influenced the abundance of adult tabanids. Seasonal abundance and emergence pattern reflects breeding pattern for a specific species and its response to its surrounding physical and biotic environment (Al-Talafha *et al.,* 2005) [23]. (Kruger and Krolow 2015) [24] reported that, the richness and abundance may be increased more than two and a half times if there is an increase of 2 °C in MT and of 8% in mean RH. The pattern of association between hot and dry climates for the growth of adult populations may be associated with an increased need for higher humidity and temperature for the development of the larvae, of which most are aquatic.

The present study recorded sudden peak fly population in April after the beginning of the first rain fall in March. However, this peak was primarily the result of the capture of large numbers of *T. indianus* Ricardo, *T. biannularis* Philip and *T. gertrudae* Philip in Western Ghats of Belagavi division. Tabanid populations remained relatively high from April through September 2019, and approximately similar numbers of species were collected in each month. In our study it was observed that, decline in number of tabanids from November 2019 through February 2020 is probably related to the drier conditions and lower temperatures during the winter months (Barros, 2001) [9], but further studies are needed. The high abundance of tabanid species during the rainy season (April through September), increases their potential importance as mechanical vectors of *T. evansi* infection. The time between from the mid-June to the third week of July could be considered as the potentially higher-risk period of mechanical transmission of pathogens by tabanids in Turkey (Altunsoy and kilic 2012) [25]. (Sudhakar *et al*., 2014) [26] and (Muraleedharan, 2015) [27] reported high infection rates of cattle and buffalo by *T. evansi* during the rainy season in Karnataka. Among the 20 species recorded in the present study, 7 species were proven vector for Surra, Anthrax, Blackleg and *Haemorrhagic septicaemia* in domestic and wild animals.

5. Conclusion

Summarized data from annual observations on tabanids on the Western Ghats of Belagavi division Karnataka show that under appropriate weather conditions tabanids in the area become active during the last week of March and fly to mid-February with a peak in the seasonal abundance during the first week of June.

T. diversifrons, T. indianus, T. rubidus. C. dispar and *A. virgo* were the dominant species in the area and *T. diversifrons* population was the most numerous in the peak of tabanid seasonal abundance (early June).

In a seasonal aspect a change of the most common species in the tabanid assemblages on the Western Ghats of Belagavi division Karnataka was established. The basic composition of the tabanid assemblages in March and April was determined by the early summer species *T. biannularis, T. gertrudae, T. indianus*. *T. auristriatus, H. montana, H, longipennis, H. javana, C. pellucidus* and *P. taprobanes* were the rainy season species. *T. rubidus, A. virgo, T. diversifrons, T. dorsilinea* and *T. jucundus* were the poly seasonal species.

6. Acknowledgement

I would like to express my heartfelt gratitude to Retired Professor Viraktamath, C. A. and Yashavanth, H. M. Department of Agriculture Entomology, GKVK, Bengaluru for providing relevant literature and help in identification. Further, I deeply acknowledge the help of all the staffs of ICAR-NBAIR Institute, Bengaluru. The facilities and funding by the ICAR, New Delhi through the Centre of Advanced Faculty Training in Veterinary Parasitology is gratefully acknowledged. I am extremely thankful to officers and staff, department of AH&VS Government of Karnataka for assisting me in field for sample collection.

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