International Journal of Zoology Studies
ISSN: 2455-7269
Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 2; Issue 5; September 2017; Page No. 68-77

Climatic factors influences the ecology of the *Platynectes* sp. nov. Predator to the dengue and chikungunya vectors in the rubber plantations of Kerala, India

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Abstract
The population of the *Platynectes* beetles in the rubber plantations of Kerala, was found to be governed by the climatic factors - like rainfall and temperature. These Climatic factors were found to influence the prevalence of beetle population and its density as well in the study areas. The number of rainy days per month and temperature were found to influence prevalence (%) of beetle in the rubber plantation areas of Kerala. The rainfall showed a positive linear correlation with the prevalence of *Platynectes* beetles in all the three study areas included in the study viz., Aimcompu ($r = 0.609$, $p = 0.035$), Chethackal, ($r = 0.550$, $p = 0.063$) and in Pampady, ($r = 0.509$, $p = 0.090$). However temperature showed a negative linear correlation with prevalence of *Platynectes* beetles in Aimcompu, ($r = - 0.658$, $p = 0.019$), Chethackal, ($r = - 0.710$, $p = 0.096$) and in Pampady, ($r = - 0.806$, $p = 0. 001$). Also the rainfall showed a positive linear correlation with the density of *Platynectes* beetles in all the three study areas included in the study viz., Aimcompu ($r = 0.595$, $p = 0.041$), Chethackal, ($r = 0.785$, $p = 0.002$) and in Pampady, ($r = 0.589$, $p = 0.043$). However temperature showed a negative linear Correlation with density of *Platynectes* beetles in Aimcompu, ($r = - 0.586$, $p = 0.045$) Chethackal, ($r = - 0.682$, $p = 0.014$) and in Pampady, ($r = - 0.800$, $p = 0. 001$).

Keywords: *Platynectes* sp. nov. rubber plantations of Kerala. chikungunya. dengue climatic factors

1. Introduction
Fifteen States and Union Territories in India witnessed major outbreaks of Chikungunya virus (CHIKV) infection since 2005. During 2007, 3.6 million fever cases were recorded compared with about 1.38 million in 2006 and 1.2 million in 2005, most estimates drawn from, epidemiological, geographical and demographic data, (Kalantri *et al.* 2006), [3]. Chikungunya virus (CHIKV), is transmitted to humans through *Stegomyia* mosquitoes. Kerala was the worst affected State in India in 2007 with a total of 55.8% of the reported Chikungunya fever cases in the country from the State (NVBDCP, India). Almost all the districts of Kerala were affected with the infection during 2006-2007. The factors attributed to this outbreak were the crucial mutation "A226" acquired by the virus in 2007 and the abundance of the vector species *Stegomyia albopicta* in the region (Kumar *et al*. 2008), [4]. *St. aegypti* and *St. albopicta*, the vectors for CHIKV were widely distributed and abundant during the pre and post monsoon season. The prevailing climate, terrain and agricultural practices in these districts were conducive for the breeding of *St. albopicta/St. aegypti*, the vector of Chikungunya and Dengue in Kerala. The worst affected region was the mid-highland regions which harbour the vast rubber plantation sectors in the State. The hilly and semi-forested districts of Kottayam and Pathanamthitta were the most affected districts during 2007 epidemic, which constitutes the major portion in the rubber plantation sectors of Kerala. About 63.0% of people living in the rubber plantation areas (Kerala contributes 80.0% of the rubber production in India), was afflicted with this disease Kumar *et al* 2011, *St. albopicta* acted as main vector species (Kumar *et al*.2008), [4].

Incidence of Dengue fever, another mosquito borne arbo-viral disease is also on an increasing trend in Kerala (Kumar *et al.* 2013). *St. albopicta* (Skuse) 1894 (Diptera: Culicidae), the predominant *Stegomyia* species prevalent in Kerala was recorded as the vector species of both these arbo-viral diseases (Kumar *et al.* 2008; Thenmozhi *et al.* 2007), [4, 12]. Innumerable Discarded Latex Collection containers (DLCCs), unused Fixed Latex Collection Containers (FLCCs), and tree holes, leaf axils of pine-apple plants and fallen leaves of areca-nut tree etc. were recorded the key breeding habitats of this species in rubber plantation sectors in Kerala (Kumar *et al*. 2011; Sumodan, 2003), [5, 11].

About 28% of Kerala State remain forested. Topographically the State could be divided broadly into three regions, viz. High lands (48%), Mid-highlands (40%) and Coastal belt (12%). The Highlands slopes down from the Western Ghats (also known as the Sahyadri) which rise to an average height of 900m, with a number of peaks well over 1800 m in height. The midlands region mainly grows rubber, cashew, arecanut, banana, coconut etc. while coastal lands have mainly coconut and paddy cultivation. The total area under rubber cultivation in the State is 5.45 lakh hectares with an annual production of 6.9 lakh tonnes. The State produces over 80% of India's natural rubber. Rubber an exotic cash crop was introduced to Kerala State during 1902. Kottayam in Kerala State also is the national HQ of Rubber Board (Govt. of India). Currently most of the area belonging to the mid-highlands region had been converted to large scale rubber plantations. The plantation

practices favoured the abundance of *Stegomyia* breeding sources (unused or discarded latex collection containers) and *St. albopicta* was found to be the predominant species (62%) in the State.

Platynectes beetles are predatory insects inhabiting streams and riverine swamps as well as in irrigation ditches (Balke *et al.* 2002), [1]. They also inhabit springs and streams in foothill and lower mountain rainforests. Exposed streams and pools in peat and grasslands are occupied at higher altitudes. The known altitudinal range is from 300 to 2000 m (Hendrich and Balke 2000), [2]. *Platynectes* sp. nov. were recorded from the key breeding habitats of *St. albopicta*, in fixed latex collection containers and discarded latex collection containers from rubber plantation area of Aimcompu, Kottayam District (09^0 464.77' N; 76^0 41.113' E). Field surveys in other two study areas also recorded the natural occurrence of this beetle species in Pampady (09^0 32. 457′ N; 76^0 38.952′ E) in Kottayam District and Chethackal (09^0 26.241′ N 76^0 48.440′ E) in Pathanamthitta District. The prevalence, density and predatory role of the *Platynectes* beetles in the rubber plantations affects the density of immatures of *St. albopicta* in the latex collection containers of rubber plantations of Kerala.

2. Materials and Methods

The temperature and rainfall data was collected from Weather Stations installed by Rubber research institute of India (RRII), Kottayam Kerala, in the study areas Aimcompu and Chethackal on daily basis during the study period. The minimum temperature and rainfall was recorded at morning 8:30 am and maximum temperature and rainfall recorded at evening 5:30 pm. All the study areas were located in the regions of the rubber plantations. Since study was conducted in the study areas located in rubber plantations, therefore Weather Stations in these regions has been preferred. Relative humidity was calculated from the above data collected from Weather Stations in the study areas. Average temperature was calculated from differences between mean values of daily maximum and minimum temperatures and relative humidity.

2.1 Temperature

The monthly mean maximum and minimum temperature recorded during the study period in the study areas ranged from 32.52 to 21.62 ^{0}C during the study period. The variations observed in the mean maximum monthly temperature were between 29.11 (August 2011) and 35.44 ^{0}C (March 2012) and in the minimum temperature between 19.29 (February 2012) and 24.29 (May 2012) (Table 1).

2.2 Rainfall

The State enjoys tropical climate. Both southwest (June-September) and northeast monsoon (October- December) are active with an annual average rainfall of about 2991 mm (Table 3), about 50% of rainfall is contributed by southwest monsoon, pre-monsoon contributes 25-30% and northeast monsoon contributes 30% in the region of rubber plantation sectors. Relative humidity ranged from 63.89-87.92. The number of rainfall days recorded during the study period in the study areas. Almost all the months recorded rainfall (Table 2).

Table 1: Meteorological data of the study areas of rubber plantations of Kerala.

Years	Months	Temperature ^{0}C		
		Maximum	Minimum	Mean
2011	August	29.11	22.03	25.06
2011	September	29.38	21.95	25.17
2011	October	32.29	21.99	27.14
2011	November	32.24	20.69	26.47
2011	December	33.11	20.84	26.98
2012	January	34.13	19.42	26.78
2012	February	35.61	19.29	27.45
2012	March	35.44	20.04	28.74
2012	April	34.19	22.98	28.54
2012	May	33.81	24.29	28.50
2012	June	30.89	23.04	26.97
2012	July	30.16	22.78	27.47

Table 2: Number of rainfall days of the study areas of the rubber plantations of Kerala.

Years	Months	Number of rainfall days per month (mm)
2011	August	24
2011	September	12
2011	October	16
2011	November	10
2011	December	06
2012	January	02
2012	February	03
2012	March	09
2012	April	20
2012	May	10
2012	June	20
2012	July	21

Table 3: Total Rainfall Per Month of the study areas of the rubber plantations of Kerala.

Years	Months	Total Rainfall Per Month (mm)
2011	August	464.2
2011	September	367.8
2011	October	205
2011	November	250.7
2011	December	302.4
2012	January	17
2012	February	22.8
2012	March	129.4
2012	April	541.2
2012	May	88
2012	June	202.8
2012	July	399.7

Table 4: Prevalence and density of *Platynectes* sp. nov. in rubber plantations areas through different months.

Months	Average Prevalence in the three study areas	Average density in the three study areas
Aug	22.63	2.27
Sept	22.68	2.34
Oct	11.6	2.40
Nov	1.92	2.60
Dec	1.75	1.00
Jan	0	0
Feb	0	0
Mar	0	0
Apr	0	0
May	1.23	2.50
Jun	2.66	1.47
Jul	14.28	1.75

2.3 Ecology of the *Platynectes* sp. in the rubber plantations

An exploratory survey was carried out to find the natural habitats of the beetle in the rubber plantations, showed that the beetles were abundant in fresh water pools and streams amidst the plantations. Surveys were carried out on fortnightly intervals in these natural habitats by taking dips separated by about 10 m for studying the population of the beetles from these ponds. Different tools were used for the surveys. Two types of dippers and enamel trays were used for the survey of beetles in the natural habitats, long enamel dipper with '5' feet ladle length with capacity of 1 litre and small enamel dipper with '2' feet ladle length capacity of half a litre capacity (Service 1976), [9]. Long enamel dipper were used in the stream sides with water depth more than '2' metres and small enamel dip were used in the pools with water depth less than '2' meters. Beetles were collected from pools along with the water by using these dippers. After collecting from the pools and streams by using the dippers, these beetles were transferred to the enamel trays with length of '1' X '1' and '2' X '2' ft along with water. The beetles were observed in the enamel trays and poured into the containers with capacity of 500 ml of water and were transported to the laboratory (Service 1976; Nilsson and Sodersenberg 1996), [9, 7].

As these beetles invade in latex collection containers (LCCs), both fixed latex collection containers (FLCCs) and discarded latex collection containers (DLCCs), which are 3-5 meters above the ground level, containing various stages (first to fourth instars) of the mosquito larvae, acts as key breeding habitats of *St. albopicta* in the rubber plantations. Surveys were carried out in the 3 study areas in Kerala State, for a period of one year to understand its population parameters.

Population density of beetles in the latex collection containers was evaluated once in fortnightly in all the three study areas, Aimcompu, Chethackal and Pampady. Fixed latex collection containers and discarded latex collection containers in rubber plantations were surveyed to find out the beetle density. The number of wet containers which are positive for beetles in the study areas were observed. The whole content of water from positive FLCCs and DLCCs were transferred to the enamel trays for observing the density of the beetles in each containers, (Service 1976), [9]. Enamel trays and pipettes were used for the study of population density of the beetles in the rubber plantations.

The study was continued for a year covering 200 rubber trees were covered in each village, once in a fortnight. These were selected in 4 radials from a fixed point, covering about 50 trees on a radial (Southwood 1978), [10]. After completing the first row up to 50 trees (latex collection containers), second row of trees was surveyed in the opposite direction of the first row. The distance in all the four directions was same, as each rubber tree is fixed at same distance from each other. The trees were marked during the observation every fortnightly. Next fortnight survey, the density of the *Platynectes* sp. were observed in the next field area which were not surveyed in the previous survey. The total area covered using this sampling procedure was about 20 ha of rubber plantations in each village. These three villages were selected as these were worst affected by Chikungunya outbreak during 2007 and they represented both large and small scale rubber plantations.

3. Results and Discussion

Climatic factors such as number of rainfall days per month and temperature were found to influence population density of the beetle in the rubber plantation region. The rainfall showed a significant positive linear correlation with the density of *Platynectes* beetles in all the 3 study areas included in the study viz., Aimcompu, ($r = 0.595$, $p = 0.041$), Chethackal, ($r = 0.785$, $p = 0.002$) and in Pampady, ($r = 0.589$, $p = 0.043$). However temperature showed a negative linear correlation with density of *Platynectes* beetles in Aimcompu, ($r = - 0.586$, $p = 0.045$), Chethackal, ($r = - 0.682$, $p = 0.014$) and in Pampady, ($r = - 0.800$, $p = 0. 001$).

Also Climatic factors such as number of rainfall days per month and temperature were found to influence prevalence of the beetle in the rubber plantation region. The rainfall showed a positive linear correlation with the density of *Platynectes* beetles in all the 3 study areas included in the study viz., Aimcompu ($r = 0.609$, $p = 0. 0352$), Chethackal, ($r = 0.550$, $p = 0.063$) and in Pampady ($r = 0.509$, $p = 0. 090$). However temperature showed a negative linear correlation with density of *Platynectes* beetles in Aimcompu, ($r = - 0.658$, $p = 0. 019$), Chethackal, ($r = - 0.710$, $p = 0. 096$) and in Pampady, ($r = - 0.806$, $p = 0. 001$).

3.1 Prevalence of *Platynectes* sp. nov. in the rubber plantations.

3.1.1 Seasonal distribution

The seasonality of *Platynectes* beetles in the rubber plantations were studied in all the three study areas. It was found that the prevalence rate of *Platynectes* beetles in the

LCCs vary through different months, ranging from 1.0- 49.62 percentage (%) in the study areas. Highest prevalence of beetles in the latex collection containers were recorded from Aimcompu village (49.62%), during August month with a rainfall of 464.2 mm (peak monsoon season yearly). The average highest prevalence rate of beetles (22.68%) from all the study areas was recorded during the month September in the southwest monsoon season. The highest and maximum prevalence rate was recorded during the monsoon season. However the beetles were not found prevalent in the containers from January to April (summer season) in LCCs in all the three study areas. The re-occupation of beetles in containers commenced during the month of May pre monsoon season, when intermittent rainfall ensued prior to the onset of monsoon season. The minimum prevalence rate of beetles in the latex collection containers recorded during the month of June in all the study areas, as shown in (Table 4). However the average minimum prevalence rate of beetles in LCCS recorded during the month of May (May month is the transition between summer and monsoon seasons).

The prevalence (%) of wet containers (which supports the prolific breeding of *St. albopicta* in the rubber plantations) in Aimcompu ranged from 3 to 60 %, Chethackal area contributed 1 to 89 % of wet containers and Pampady area contributed 2 to 70 % of wet containers through different months. The prevalence (%) of *St. albopicta* pupae in the LCCs ranged from 1-5 %, in all the three study areas.

3.1.2 Temporal Distribution

The prevalence of beetles increases with the increase of rainfall in the pre monsoon and monsoon seasons. In Kerala, pre monsoon showers starts from April–May months which contributes 25-30% of rainfall, southwest monsoon contributes nearly half 50% of rain and northeast monsoon contributes 20% annually. The prevalence of the beetles starts form pre monsoon showers and reaches to maximum during southwest monsoon and again declines to minimum during northeast monsoon in the breeding habitats of *St. albopicta* LCCs. This indicates that the prevalence of *Platynectes* beetles increases with the increase of rainfall in the rubber plantation sectors. Beetles were found in Aimcompu, Chethackal and Pampady areas during the months, May to November, June to October and June to December respectively. From June to September southwest monsoon is active with an average rainfall 1434.5 mm (annual rainfall 2911 mm) and relative humidity 63.89-87.92 in the Kerala State. During this time period we recorded the highest prevalence (%) of beetles in the all three study areas (Table 4). Prevalence of *Platynectes* beetles recorded from Pampady area during pre-monsoon of month May and from Aimcompu area post monsoon month of December.

3.2 Density of *Platynectes* sp. nov. in the rubber plantations

3.2.1 Seasonal distribution

The seasonal density of *Platynectes* beetles in the rubber plantations was studied in all the three areas. *Platynectes* beetles were found in the latex collection containers in the rubber plantations and the population density of the beetles per latex collection container was found to be maximum during the south-west monsoon season which contributes 50% rainfall annually rubber plantations of Kerala. It was found that the maximum density of the beetles per latex collection container vary in different months, ranging from 1.0-3.8 per latex collection container in all the study areas. Maximum density was recorded at Aimcompu (3.8) during the month of September. The average density of *Platynectes* beetles per LCC was found (2.34) from all study areas, during the monsoon season. Beetles were not found in LCCs from January to April which contributes only 272 mm of rainfall (annual rainfall 2991 mm). The minimum density of beetles per latex collection container was recorded in the study areas, Aimcompu and Chethackal from months of November and October respectively (northeast monsoon which contributes 20% of rainfall) as shown in (Table 4). However minimum density of beetles per LCC in study area Pampady was recorded from months of June, October and December (during these months 1 beetle per LCC). During pre-monsoon month of May and post monsoon month of December, density of *Platynectes* beetles were recorded from Pampady and Aimcompu area. The beetles were found predatory on *St. albopicta* larvae abundant in the rubber plantations.

3.2.2 Temporal Distribution

The density of *Platynectes* beetles per latex collection container increases with the increase of rainfall in the monsoon seasons, starts from pre monsoon and reaches to maximum during southwest monsoon and again declines to minimum during northeast monsoon. The highest density of the beetles recorded in the all three study areas in the rubber plantation sectors of Kerala (Table 4) during June to September (southwest monsoon with an average rainfall 1434.5 mm (annual rainfall 2911 mm). The density of beetles in the LCCs were found during the months of May to November, June to October and June to December in Aimcompu, Chethackal and Pampady respectively.

4. Discussion

When the number of rainfall days increased, the *Platynectes* beetle population density per positive LCC also increased which reduced the density of immatures of *St. albopicta* in latex collection containers, results in the reduction of adult density of *St. albopicta* in the rubber plantation sectors of Kerala. Similarly when the temperature increased, the *Platynectes* beetle population density per positive LCC decreased, which increased the density of immatures of *St. albopicta* in latex collection containers results the enhances adult density of *St. albopicta* in the rubber plantation sectors of Kerala.

When the number of rainfall days increased, the prevalence of *Platynectes* beetles also increased in the LCC which reduces the density of immatures of *St. albopicta* in latex collection containers, results in the reduction of adult density of *St. albopicta* in the rubber plantation sectors of Kerala. Similarly when the monthly temperature increased, the prevalence of *Platynectes* beetle decreased in the LCC which increased the density of immatures of *St. albopicta* in latex collection containers results the enhanced adult density of *St. albopicta* in the rubber plantation sectors of Kerala.

The minimum temperature and maximum rainfall recorded in

the study areas during southwest monsoon, which contributes 50% rainfall annually. During this period, the prevalence and density of *Platynectes* beetle recorded highest in the LCCs in all the study areas in the rubber plantation sectors of Kerala. The highest temperature and lowest rainfall has recorded from January to April, when the beetles were not prevalent in the LCCs in the study areas. Statistically it has shown the rainfall and temperature are favourable for the prevalence and density (per positive LCC)) of *Platynectes* beetles in the key breeding habitats of *St. albopicta* in the rubber plantations during pre-monsoon, monsoon and post monsoon seasons.

The rainfall is the biologically favourable factor for the breeding of the *St. albopicta*. When rain water is accumulated in the LCCs, increases the probabilities of *St. albopicta* breeding in these habitats. Abundance of rainy water collections (LCCs) is suitable for *St. albopicta* breeding. However in the rubber plantation sectors of Kerala, monsoon seasons are active predominantly southwest monsoon which contributes the nearly 50% rainfall annually and provides maximum number of rainfall days constantly during this seasons. The same interval of time is the favourable season for *St. albopicta* breedings in the rubber plantations. Summer season which is not providing the constant rainy days for breeding of this species and contributes only 20% rainfall annually. Also the *St. albopicta* breeds only in forest edges tree holes, containers and natural reservoirs,
(Rezza 2012), [8].

Temperature is another biologically favourable factor for the breeding of *St. albopicta* and normal temperature is suitable for the breeding of *St. albopicta.* The lowest temperature (25.06 ^{0}C) was recorded during the monsoon seasons in the rubber plantations as related to summer season. When the temperature increase above normal the breeding chances for *St. albopicta* become less.

Number of rainfall days per month maintains constant water in the breeding habitats and provides suitable environment for breeding of *St. albopicta* in the LCCs in the rubber plantations of Kerala. Temperature also provides the suitable environment for the breeding of *St. albopicta.* Both these factors are favourable for the breeding of *St. albopicta* simultaneously during the monsoon seasons. Our studies showed that vector density is low during these monsoon seasons as compared to the summer season in the rubber plantations. This is due to the predominance of *Platynectes* beetles in the key breeding habitats of *St. albopicta*. Hence density of *St. albopicta* is checked by *Platynectes* beetles in this region during the monsoon seasons.

Climatic factors like number of rainfall days and temperature influences the ecology of the beetles which are predatory to the Dengue and Chikungunya vectors in the rubber plantations of Kerala. The climatic factors play a vital role of the interaction of *Platynectes* beetles and immatures of *St. albopicta* in the key breeding habitats, LCCs in the plantation sectors of Kerala. These climatic factors viz. rainfall showed positive a linear correlation and temperature showed negative linear correlation with the density and prevalence of beetles in the key breeding habitats.

The number of rainfall days varied 24 to 6 from August to December in the all the three study areas, during this period the density of the *Platynectes* beetles varied from 3 to 1.5 per LCC in Aimcompu, from 1.95 to 0 per LCC in Chethackal and from 1.5 to 1 per LCC in the Pampady. From January to March the number of rainfall days varied from 6 to 9 (minimum no. of rainfall days annually), during the same time period density remains zero in all the study areas. However when the number of rain fall days increases from 10 to 21 during May to July, the density of *Platynectes* beetles varied from 2.05 to 1.54 in Aimcompu (Fig. 1), from 0 to 2 in Chethackal (Fig. 2) and from 0 to 2.01 in Pampady (Fig. 3).

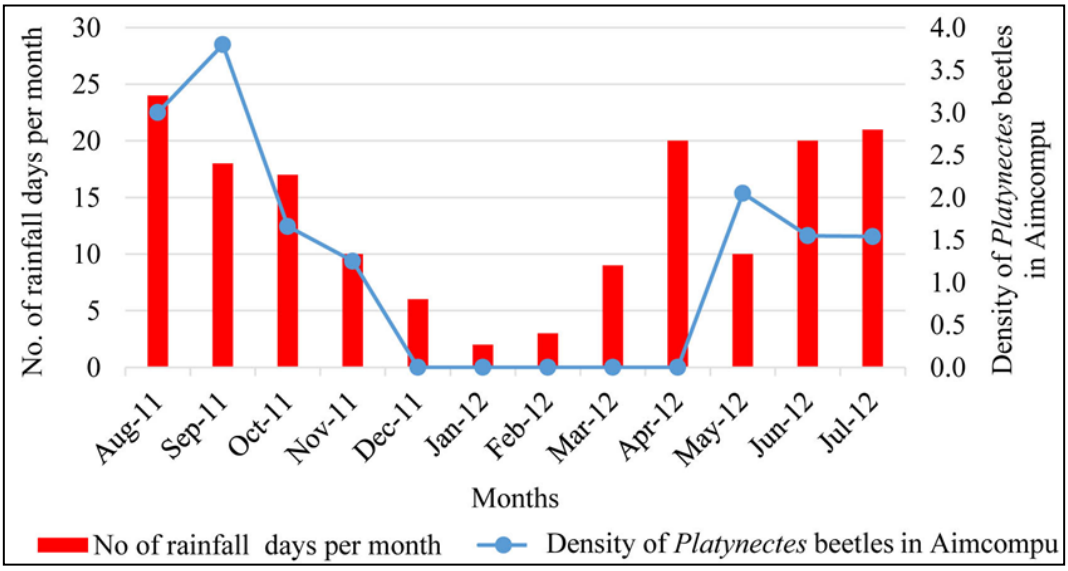

Fig 1: No. of rainfall days and density of *Platynectes* beetles in Aimcompu.

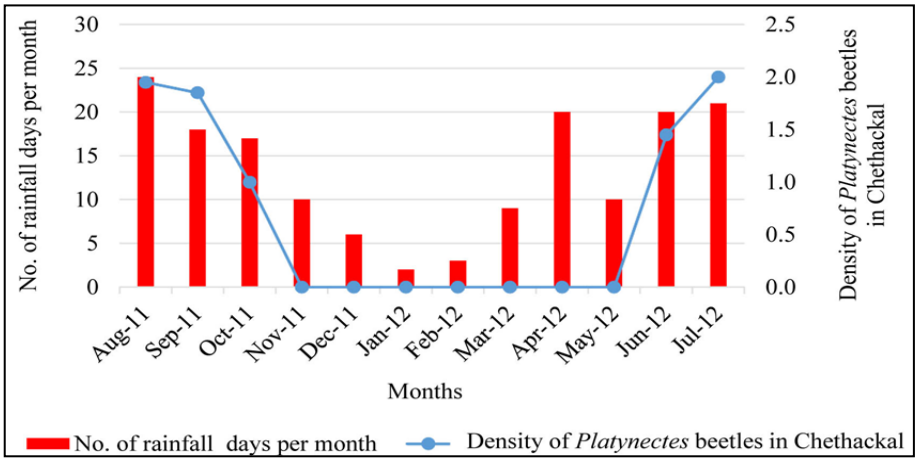

Fig 2: No. of rainfall days and density of *Platynectes* beetles in Chethackal.

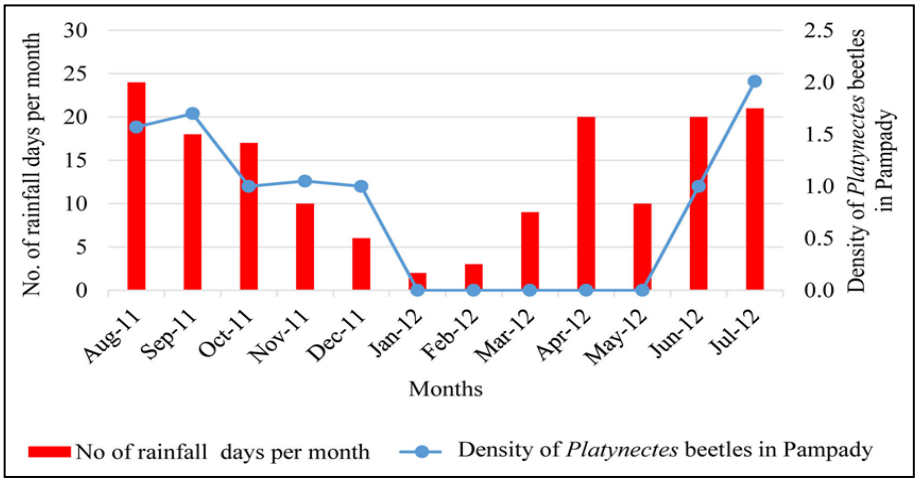

Fig 3: No. of rainfall days and density of *Platynectes* beetles in Pampady.

The temperature varied from 25.06 to 26.98 ^{0}C from August to December in the all the three study areas, in this period the density of the *Platynectes* beetles varied from 3 to 1.5 per LCC in Aimcompu, from 1.95 to 0 per LCC in Chethackal and from 1.5 to 1 per LCC in Pampady. From January to March the temperature varied from 26.78 to 28.74 ^{0}C (maximum temperature annually), during the same period of time density remains zero in all the study areas. However when the temperature decreases from 28.27 to 27.47 ^{0}C during May to July, the density of *Platynectes* beetles varied from 2.05 to 1.54 in Aimcompu (Fig. 4) from 0 to 2 in Chethackal (Fig. 5) and from 0 to 2.01 in Pampady (Fig. 6).

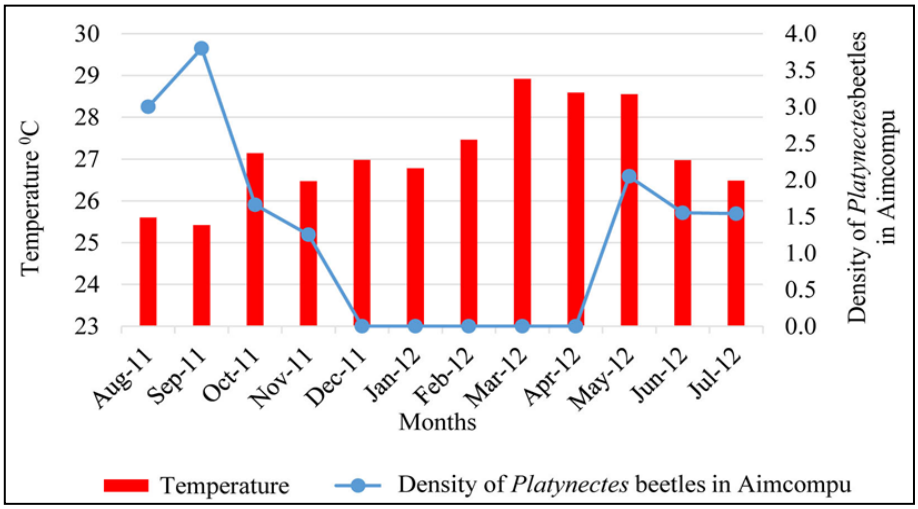

Fig 4: Temperature and density of *Platynectes* beetles in Aimcompu.

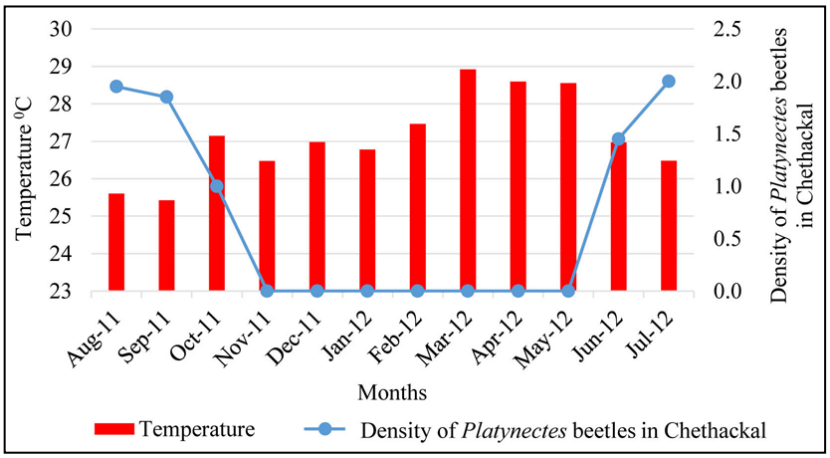

Fig 5: Temperature and density of *Platynectes* beetles in Chethackal.

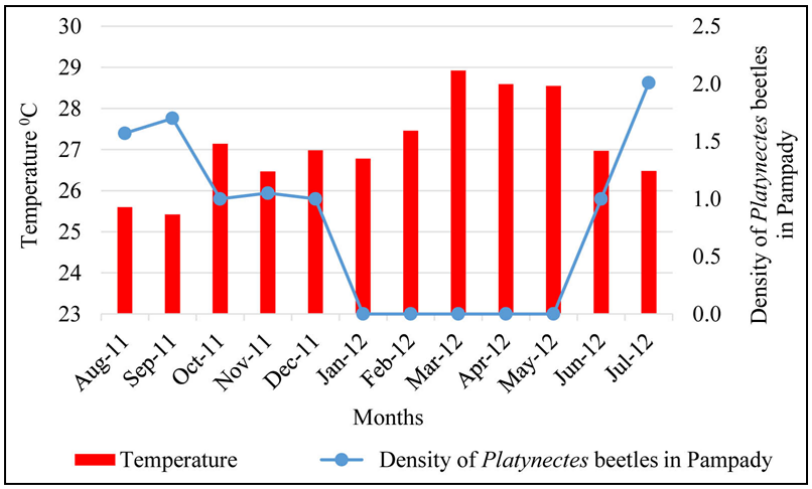

Fig 6: Temperature and density of *Platynectes* beetles in Pampady.

The number of rainfall days varied 24 to 6 from August to December in the all the three study areas, during this period the prevalence of the *Platynectes* beetles varied from 49.62 to 0 in LCC in Aimcompu, from 17.76 to 0 in LCC in Chethackal and varied from 15.38 to 1.81 in LCC in Pampady. From January to March the number of rainfall days varied only from 6 to 9 (minimum no. of rainfall days annually), in this time period prevalence remains zero again when the number of rain fall days increases from 10 to 21 during May to July, the prevalence of *Platynectes* beetles varied from 8 to 15.59 in Aimcompu (Fig. 7), from 0 to 3.12 in Chethackal (Fig. 8) and from 0 to 7.08 in the Pampady area (Fig. 9).

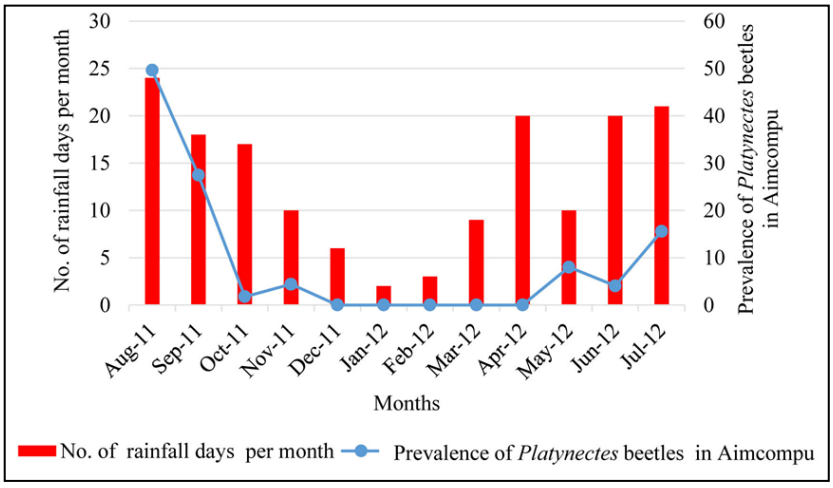

Fig 7: No. of rainfall days and prevalence of *Platynectes* beetles in Aimcompu.

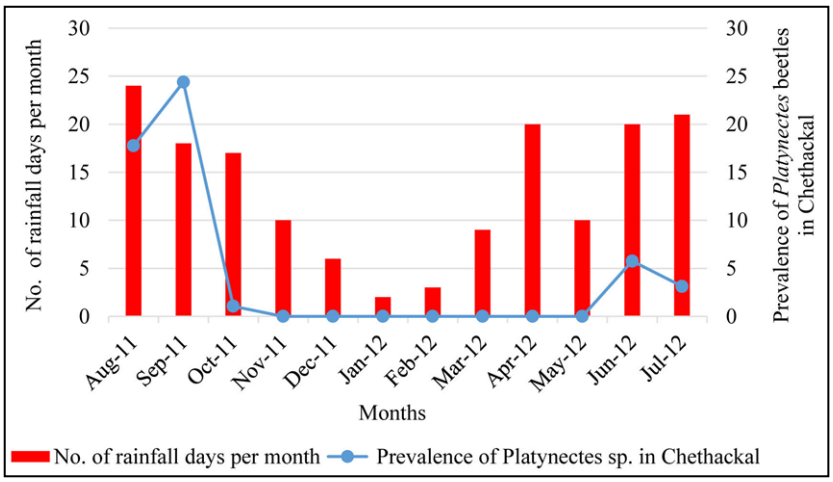

Fig 8: No. of rainfall days and prevalence of *Platynectes* beetles in Chethackal.

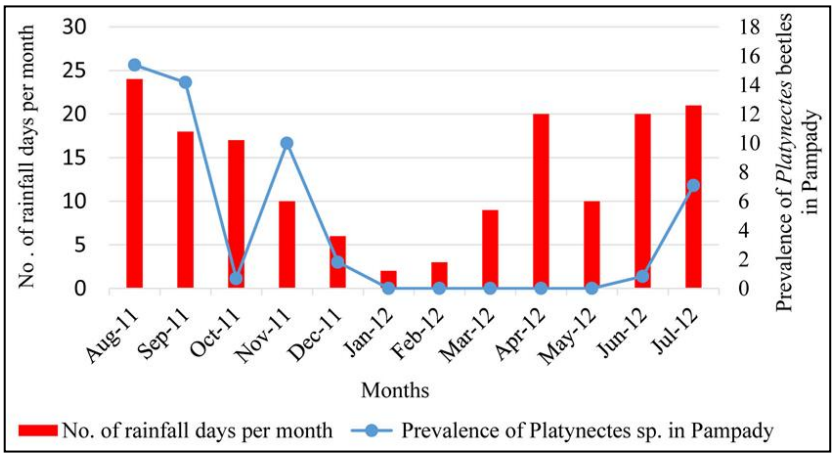

Fig 9: No. of rainfall days and prevalence of *Platynectes* beetles in Pampady.

The temperature varied from 25.06 to 26.98 ^{0}C from August to December in the all the three study areas during this period the prevalence of the *Platynectes* beetles varied from 49.62 to 0 in LCC in Aimcompu, from 17.76 to 0 in LCC in Chethackal and from 15.38 to 1.81 in LCC in Pampady area. From January to March the temperature varied from 26.78 to 28.7 ^{0}C (maximum temperature annually) in this time period prevalence remains zero again when the temperature decreases from 28.27 to 27.47 ^{0}C during May to July, the prevalence of *Platynectes* beetles varied from 0 to 15.59 in Aimcompu (Fig. 10), from 0 to 2 in Chethackal (Fig. 11) and from 0 to 2.01 in Pampady area (Fig. 12).

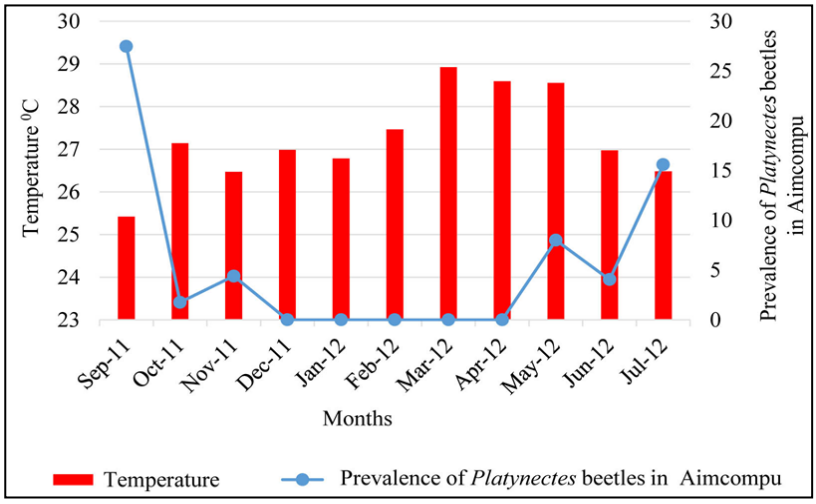

Fig 10: Temperature and prevalence of *Platynectes* beetles in Aimcompu.

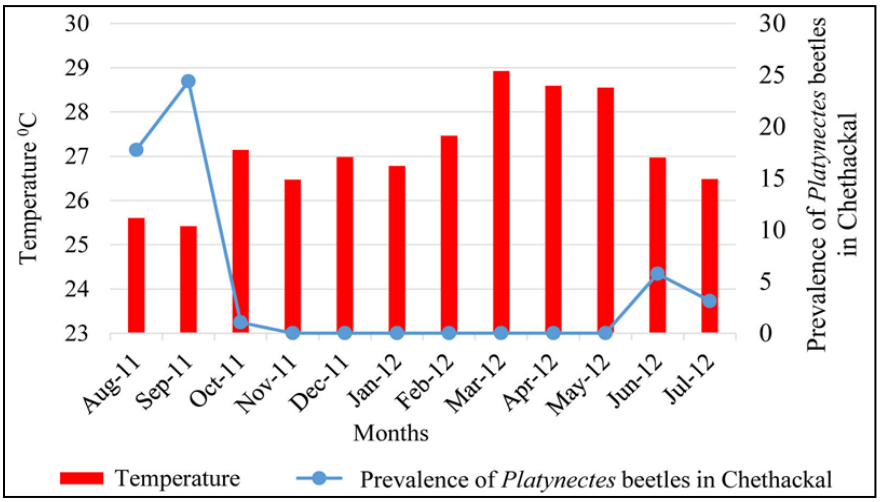

Fig 11: Temperature and prevalence of *Platynectes* beetles in Chethackal.

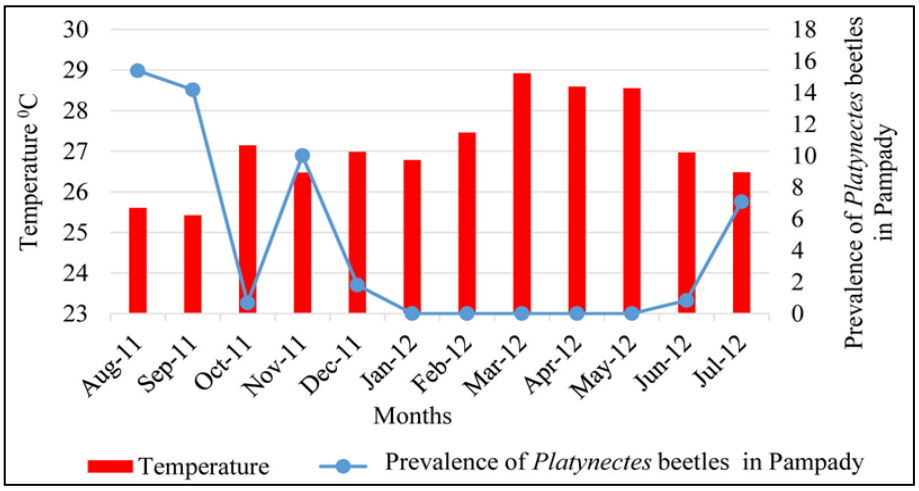

Fig 12: Temperature and prevalence of *Platynectes* beetles in Pampady.

Temperature in April month 28.54 ^{0}C and number of rainfall days 20 recorded, however prevalence and density (per positive container) of *Platynectes* beetles found zero in all the study areas of rubber plantations during this period. April is the only month in the summer season which contributes number of rainfall days above ten, on the other hand beetles were not found in the LCCs. Since April is the pre monsoon month, transition between summer and monsoon seasons in the Kerala. To overcome the summer season from January to April, the rainfall during this month is initiation of the monsoon seasons. This may be the reason beetles were not found prevalent in the LCCs even number of rainfall days were recorded above ten. Rest of the months in the year which contribute number of rainfall days ten and above annually, the density and prevalence of beetles in the latex collection containers was found in the study areas. However, in the month of December which contributes number of rainfall days only six, the density and the prevalence of beetles was recorded only from Pampady study area. It clearly indicates that the number of rainfall days per month (which maintain constant availability of water in the breeding habitats) is important for the prevalence of beetles in the latex collection containers in the rubber plantation sectors of Kerala. During the same time period which in otherwise is favourable for the breeding of *St. albopicta* in the LCCs, the density of the vectors remains low in the rubber plantations. Our statistical analysis also showed that prevalence of *Platynectes* beetles in the LCCs depends upon the number of rainfall days per month and the temperature in this region.

During summer season the *Platynectes* beetles in the streams and pools were found very less due to low rainfall. They were also found less prevalent in the breeding habitats of vectors. In this time period the vector density remains high throughout the rubber plantations of Kerala.

5. Acknowledgments

The authors gratefully acknowledge to the Mr. P. M. Ajaithlal, for his technical assistance rendered and Director, Vector Control Research Centre (ICMR), for providing great support by making the availability of various institutional facilities. Also thankful to Pondicherry central university for providing financial support.

6. Disclosure

The authors have no potential conflicts of interest, including specific financial interests and relationships and affiliations

relevant to the subject of the manuscript.

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