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POPULATION DYNAMICS OF SIX SPECIES OF *CULEX PIPIENS* L. GROUP (DIPTERA: CULICIDAE) FROM CHANDIGARH#

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ABSTRACT

During the present study, detailed mosquito surveys were carried out from various habitats of developed areas, gardens, slums and surrounding villages of Chandigarh from June 2017 to November 2019 to explore the mosquito fauna. Six species of *Culex pipiens* L group were recorded with maximum distribution of *Culex quinquefasciatus* Say (89.61%) followed by *Culex univittatus* Theobald (6.39%) while, rest of the species *viz; Culex vagans* Wiedemann, *Cx. hutchinsoni* Barraud, *Cx. theileri* Theobald and *Cx. fuscocephala* Theobald collectively formed only 3.99% in almost in all habitats. The population dynamics was analyzed from regular surveys to assess the relationship between abundance of six vector species of *Cx. pipiens* group with meteorological variables. The data revealed varied abundance of species of *Cx. pipiens* group in different seasons. Survey of literature revealed that no data is available on the species of *Cx. pipiens* group in the region with particular reference to weather parameters. Hence, the present study on the seasonal abundance and population dynamics of *Culex pipiens* group in Chandigarh and its surroundings has been carried out.

Key words: *Culex pipiens*, Chandigarh, species diversity, vectors, weather parameter, abundance, population dynamics, correlation coefficients, distribution, seasonal abundance

The earlier taxonomic workers differentiated the species of *Culex* into groups, subgroups and complexes. Edwards (1932) categorized the species of *Culex* into two groups namely the *pipiens* group and *sitiens* group in first catalogue of mosquitoes of the world. Later on Sirivanakarn (1976) arranged the species under *Culex pipiens* group into four subgroups i.e., *pipiens* subgroup, *trifilatus* subgroup, *theileri* subgroup and *univittatus* subgroup and placed the closely related species into these subgroups accordingly. The present studies are subjected to seasonal dynamics of six species i.e., *Culex quinquefasciatus* Say (*pipiens* subgroup), *Cx. vagans* Wiedemann and *Cx. hutchinsoni* Barraud (*trifilatus* subgroup), *Cx. theileri* Theobald (*theileri* subgroup), *Cx. univittatus* Theobald and *Cx. fuscocephala* Theobald (*univittatus* subgroup). The first catalogue of Indian mosquitoes given by Tyagi et al. (2015) also mentioned these six species of *Cx. pipiens* group out of 404 species collected from various geographical areas of India. The species under *Culex pipiens* group especially *Cx. quinquefasciatus* and *Cx. fuscocephala* are particularly important in public health in India due to their potential to transmit various diseases like Japanese encephalitis, periodic filariasis, West Nile Virus, St. Louis encephalitis, Rift Valley fever viruses, and Sindbis virus (National Center for Vector Borne Diseases Control, 2022; Amara et al. 2016). However, *Cx. univittatus* and *Cx. theileri* are responsible for carrying West Nile virus, Sindbis virus, bancrofti fever, Bagaza virus, Western Equine encephalitis virus and other viral pathogens globally (Walter Reed Biosystematics Unit 2022). It is worthwhile to mention that the environmental factors such as temperature, rainfall and relative humidity play a very significant role in the transmission of various pathogens. Hence, keeping in view the medical importance of species of *Cx. pipiens* group, the present study explored the species distribution and seasonal prevalence in Chandigarh and its adjoining areas.

MATERIALS AND METHODS

The survey cum collection of mosquitoes was carried out during morning as well as evening hours from June 2017 to November 2019 from different habitats in and around Chandigarh (30° 44' N, 76° 46' E). Hand collection method was followed in which hand sweep nets and oral aspirators were used. The collected samples were brought to laboratory, pinned and preserved in the insect storage boxes. The standard taxonomic keys of Barraud 1934, Sirivanakaran 1976

#Table 1-3 are supplementary and are available only in online version

and Reuben 1994 were used to identify mosquitoes. Further, slides of male genitalia were prepared using the method given by Siverly and Shroyer (1974) and photographed. Meteorological data was collected for the period June 2017 to November 2019 from Meteorology Department, Sector 39, Chandigarh, India. The standard parameters like temperature (maximum and minimum), rainfall and relative humidity were taken. The data was analyzed to know relationship of these weather factors with population density, using Pearson correlation coefficient. Regression analysis including p value and correlation coefficient (r) was performed to evaluate the statistical significance ($p< 0.05$) using SPSS® 16.0.

RESULTS AND DISCUSSION

During June 2017 to November 2019, a total of 2802 mosquitoes belonging to six species of *Culex pipiens* group namely *Cx. quinquefasciatus, Cx. univittatus, Cx. fuscocephala*, *Cx. vagans* and *Cx. hutchinsoni* and *Cx. theileri* were collected and studied. The results revealed that *Cx. quinquefasciatus* and *Cx. univittatus* were the most prevalent species. The density of *Cx. quinquefasciatus* was maximum in garden belts (37.6%) followed by developed urban areas (26.1%), villages (25%) and slum areas (10%) whereas, *Cx. univittatus* exhibited its highest density in villages (39.1%) followed by developed areas (25.6%), garden belts (20.1%) and slums (15%). The *Cx. vagans* was also prevalent mostly in villages (40.4%) followed by developed areas (33.3%), slums (21.4%) and garden belts (4.76%). *Cx. hutchinsoni* too was highest in villages (43.3%) followed by developed areas (20%), garden areas (20%) and then slums (16.6%). The *Cx. theileri* also showed its maximum density in villages (42.3%) followed by developed areas (23.07%), garden belts (23.07%) and slums (11.53%). *Cx. fuscocephala* showed its high abundance in villages (62.5%) followed by garden belts (18.75%), slums (12.5%) and urban areas (6.26%) (Fig. 1).

The seasonal incidence of both *Cx. quinquefasciatus* and *Cx. univittatus* were observed with peak in July to August, when maximum and minimum temperature was 33.39°C and 26.69°C, relative humidity 68% and rainfall 8.31mm. *Cx. vagans* showed its appearance in June, when temperature range was 27-35.2°C and reached at its highest peak in July to August, when maximum and minimum temperature was 33.41°C and 26.69°C, relative humidity was 68.05% with 8.31mm of rainfall and remained very low during September to November. *Cx. hutchinsoni* too started appearing with its highest peak in June to July when maximum and minimum temperature was 35.08°C and 26.88°C, relative humidity 54.4% and rainfall (5.61mm) and its abundance declined in August to September, but it again appeared in October and November. *Cx. theileri* was found with very low density in June to August and reached to highest peak in October and November when maximum and minimum temperature was 29.11°C and 18.32°C, relative humidity was 52.92% with 0.81mm rainfall. *Cx. fuscocephala* appeared in July with peak

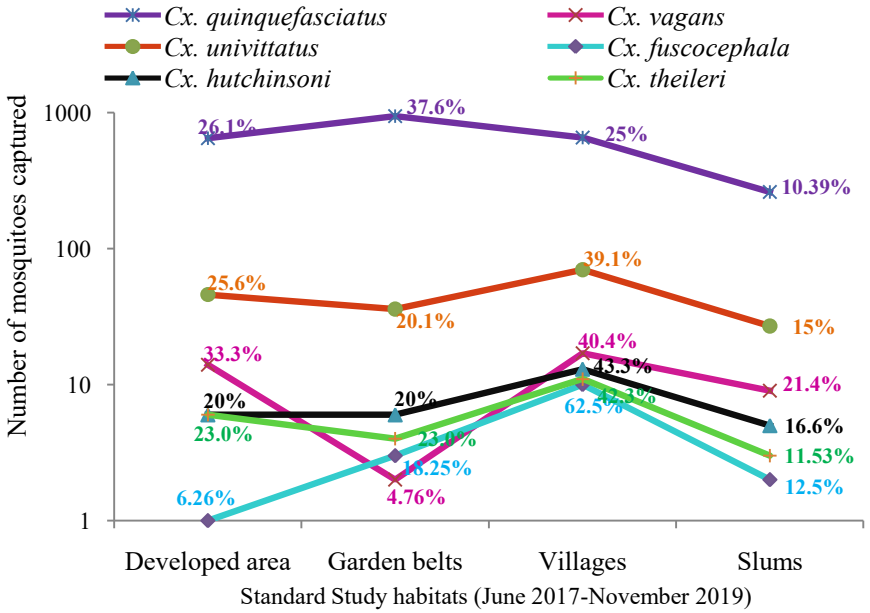

Fig. 1. Diversity of species of *Culex pipiens* group in habitats of Chandigarh (2017-2019)

in October, when maximum and minimum temperature was 31.83°C and 21.38°C, relative humidity 47.94% with 0.10 mm rainfall. Its density was observed very low in August with negligible appearance in June and September. The pooled data revealed that all the species were diversified in different habitats and its seasonal abundance in an area firstly appeared in June, gradually increased and reached to peak during July to August while, declined gradually in September to November (Fig. 2).

The coefficient of determination exhibited a negative correlation of *Cx. vagans* with relative humidity (r=-0.86) in 2017. In 2018, *Cx. hutchinsoni* was strongly positive correlated with relative humidity (r=0.81). While in 2019, it was found to be negatively correlated with maximum temperature (r=-0.79) and minimum temperature (r=-0.83). The incidence of *Cx. fuscocephala* was strongly negative correlated with minimum temperature (r=-0.84). *Cx. quinquefasciatus* and *Cx. vagans* found to be positively correlated with rainfall (r=0.9, r=0.82) (Fig. 3). However, no significant correlations were observed among species with weather parameters in remaining years of study. Hence, the present data revealed that the relative changes in population density of collected mosquito species is complex and can be affected by prevailing weather parameters.

Various other workers who worked on mosquito abundance in relation to climate factors also observed a similar pattern. Bhat and Kulkarni (1983), recorded *Cx. quinquefasciatus* and *Cx. fuscocephala* in October-November, while *Cx. theileri* and *Cx. vagans* in August-October from Jammu and Kashmir. Sharma (1997) and Fakoorziba and Vijayan (2006) found peak density of *Cx. quinquefasciatus* in July and August in Gurgaon (Haryana) and in Mysore (Karnataka) respectively. Kanojia and Geevarghesh (2005) observed first peak density of *Cx. quinquefasciatus* in March–April followed by September-October in Gorakhpur. However, in Saudi Arabia, Alahmed (2012) observed peak density of *Cx. quinquefasciatus* and *Cx. univittatus* in June, when temperature reached 36°C, its abundance started declining with decrease in temperature (15°C). It further increased in rainfalls during January to March. It could be due to increase in breeding sites in these months. Roiz et al. (2014) found abundance of *Cx. theileri* in April to August in Placibo, Mediterranean wetlands. They also revealed negative correlation of *Cx. theileri* with relative humidity. In Agra, Shad and Andrew (2016) during three years study, noticed peak larval density of *Cx. quinquefasciatus* from July to September during first year, August to October during the second year and August to September during the third year. Bashar et al. (2016), observed *Cx. hutchinsoni* along with dominant species *Cx. quinquefasciatus* during May to June months of Dhaka, Bangladesh in semi-urban areas. In Bareilly, Pantawane et al. (2017) too noticed two peak density months of *Cx. quinquefaciatus*, first in Feburary to March when temperature range was 12-29°C and second peak in September to October. They revealed that mosquito population increased with overall increase in maximum temperature (21-39°C), rainfall and relative humidity (40-60%). The *Cx. fuscocephala* was also seen highest in monsoon season i.e. July to September and in post-monsoon seasons. Mohamed et al. (2020), studied seasonal variation of both *Cx. quinquefasciatus* and *Cx. univittatus* from Khartoum state of Sudan, Saudi Arabia and found high peak incidence during pre-rainy season (April–July). Manzoor et al. (2020), studied *Cx. vagans* along with *Cx. quinquefasciatus,* and observed its maximum prevalence during September 2014 to August 2015 in Lahore, Pakistan in different breeding habitats.

Present study revealed that collected species marked their peak relative abundance majorly in garden belts, followed by villages, developed urban areas and then slums. It might be due to the availability of suitable breeding sites like vegetation, bamboo trees, ditches, flower pots, catch basins, water logs and puddles with diverse water quality in gardens. In villages, irrigated agricultural lands, cattle sheds, small water bodies with algal blooms provide more breeding habitats than in developed urban areas with semi water logs conditions during rainy seasons. The slums which contributed one fourth of its abundance could be due to the reason that majority of the species of *pipiens* group breeds in fresh water, whereas the polluted water bodies, garbage storage lands, waste muddy water bodies in slums provided less breeding sites. Hence, it can be inferred that out of all climatic parameters, the rainfall pattern has a strong influence on the breeding of *Cx. quinquefasciatus* and *Cx. vagans* whereas, population density of *Cx. fuscocephala* and *Cx. hutchinsoni* was strongly associated with temperature changes. The relative humidity influenced incidences of *Cx. vagans* and *Cx. hutchinsoni* in urban and rural areas of Chandigarh. The influence of climatic variables on the seasonal dynamics of vector species of *pipiens* group can be useful for predicting future transmission pattern and to strengthen vector control strategies with

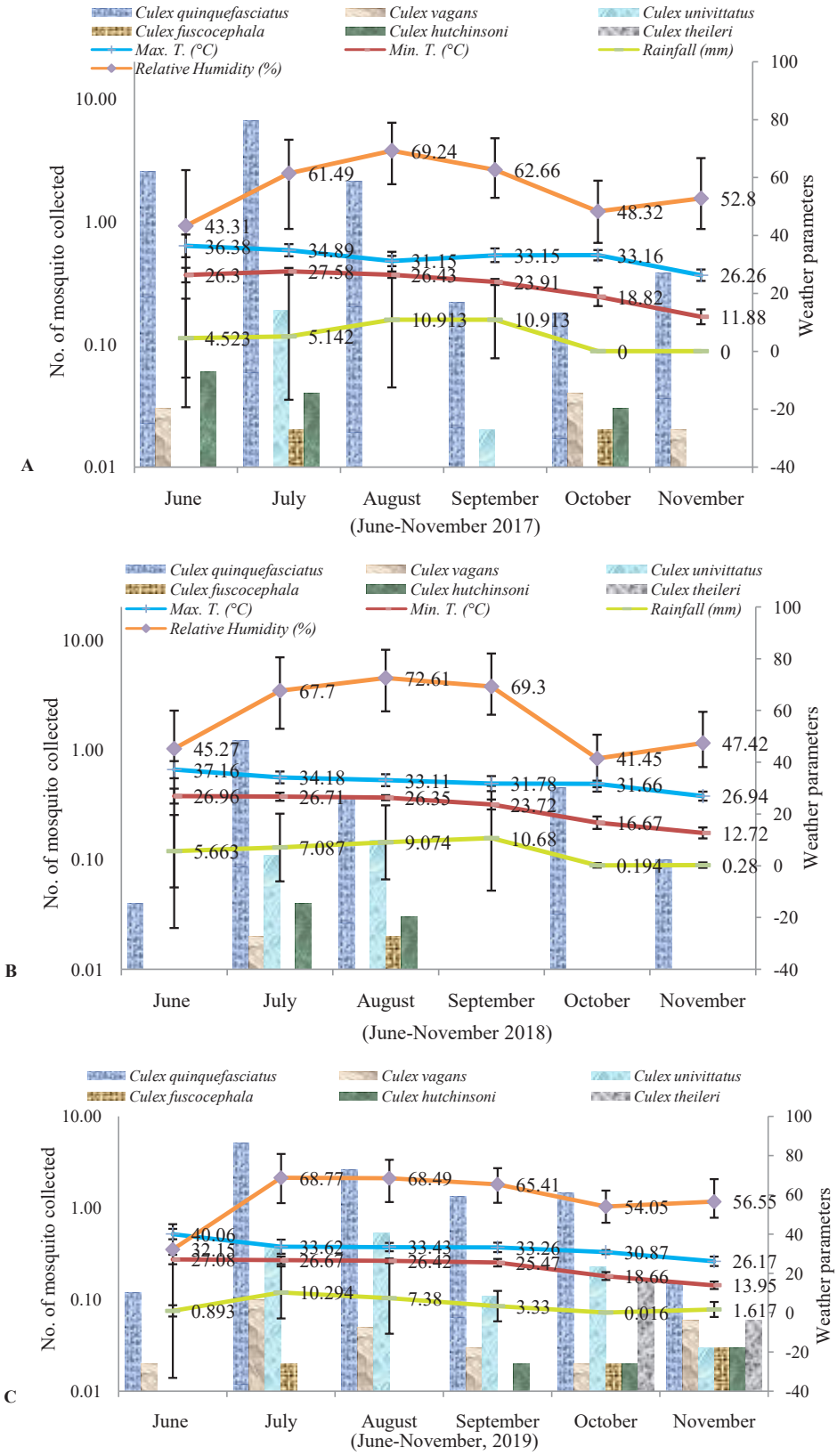

Fig. 2. Seasonal incidence of *Culex pipiens* group (pooled data)- Chandigarh (2017-2019)

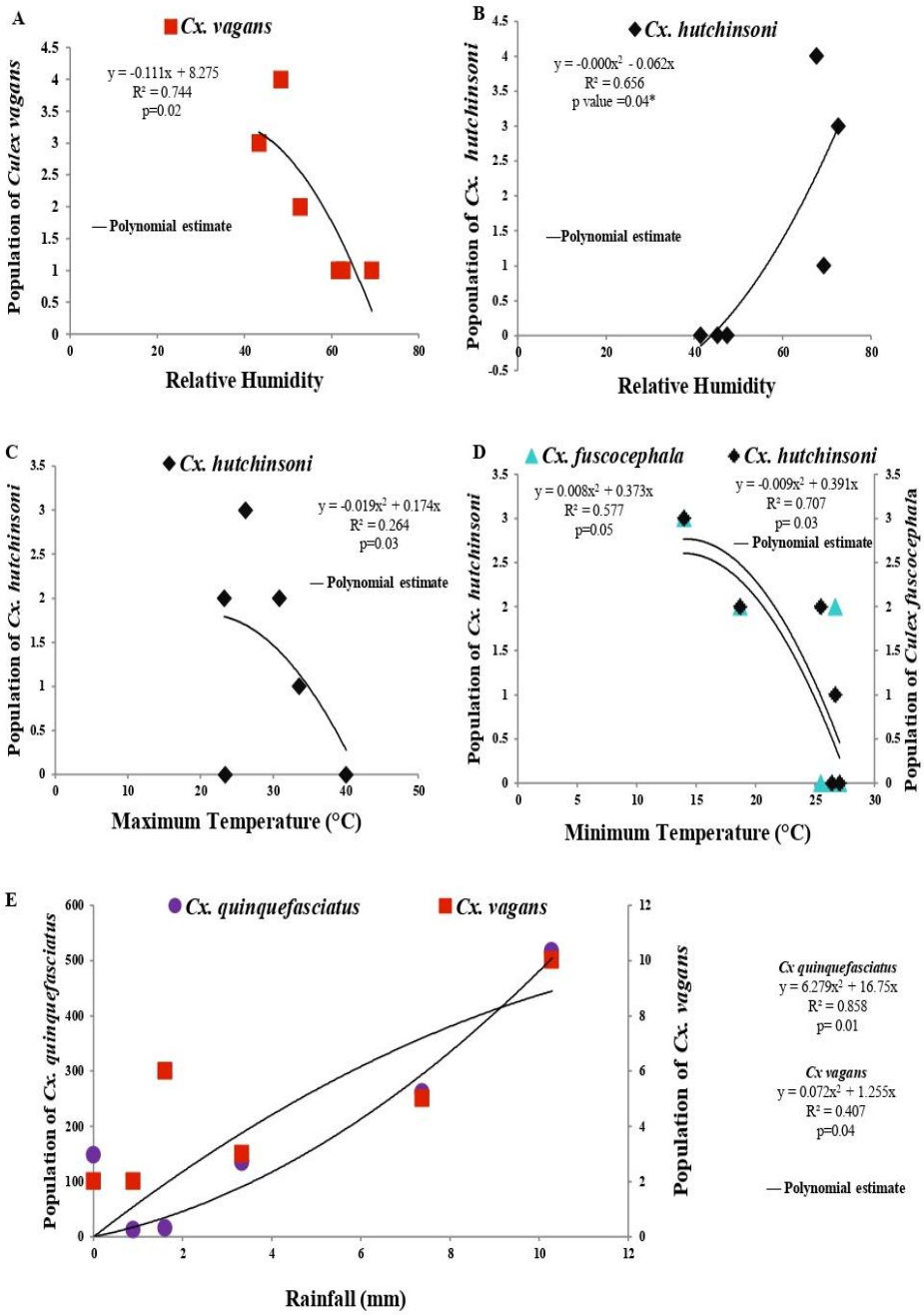

Fig. 3. Population dynamics of *Culex pipiens* group (Chandigarh- 2017 to 2019)

surveillance programme in and around Chandigarh proximities in an effective manner.

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AUTHOR CONTRIBUTION STATEMENT

AS and RR devised and designed research. AS and RR conducted surveys and experiments. SK suggested

statistical analysis. AS, RR, and SK analyzed data and wrote the manuscript. All of the authors read and approved the manuscript.

CONFLICT OF INTEREST

There are no conflicts of Interest.

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