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Research Article

Distribution of *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) in Citrus Orchards of Naushahro Feroze, Sindh, Pakistan

Javed Ahmed Malik[1], Imtiaz Ahmed Nizamani[1], Muhammad Ali Khanzada[1], Arfan Ahmed Gilal[1*], Muhammad Ishaque Mastoi[3]

[1]*Department of Plant Protection, Sindh Agriculture University, Tando Jam, Pakistan.*
[2]*Department of Plant Entomology, Sindh Agriculture University, Tando Jam, Pakistan.*
[3]*Pakistan Agricultural Research Council, Islamabad, Pakistan.*

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Authors' Contributions
JAM conducted and supervised the study. IAN and MAK conceived the idea and supervised the study. AAG helped in data analysis and finalised the manuscript. MIM analysed the data and wrote the manuscript.

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Citrus, Distribution, Huanglongbing, Preference, Psylla, Sindh

Abstract | Asian citrus psylla, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) is a globally severe pest of citrus plants, mainly because it vectors threatening phloem-restricting bacterium Huanglongbing disease. Considering there is no cure for Huanglongbing disease, management of psylla is the only option to lower the losses in citrus orchards. Moreover, Naushahro Feroze district is the main citrus producing district in Sindh, Pakistan, but no basic study has been done in the entire Sindh on psylla where it has caused serious yield losses. Therefore, studies were conducted on the distribution and relative preference of psylla on various citrus plants (lemon, grapefruit, oranges, and musambi) in five talukas of Naushahro Feroze i.e., Naushahro Feroze, Moro, Bhria, Kandiaro, and Mehrabpur. Three locations per taluka were visited during March to July, the active psylla population period, as twenty-five plants of each citrus fruit were observed to count the number of adults and nymphs of psylla per young flush with five leaves. Weather parameters of the sampling talukas were also recorded for the correlation of psylla distribution. Results indicated wide distribution of psylla in all four citrus fruits in five talukas of the district with significant differences among them. The highest mean population of psylla was observed in lemons (8.68±0.45 psylla per flush), followed by grapefruits (6.81±0.35 psylla per flush), whereas the lowest population was recorded in musambi (1.12±0.06 psylla per flush). Kandiaro (6.44±0.39 psylla per flush) and Moro (3.52±0.20 psylla per flush) suffered the highest and lowest distribution of psylla in all four citrus fruits. Moreover, weather parameters, i.e., temperature (maximum and minimum), relative humidity, and wind velocity exhibited weak to moderate and a mixed (positive and negative) influence on the population of psylla in lemon, grapefruit, oranges, and musambi trees in the surveyed talukas. Therefore, it is suggested that further basic studies on psylla dispersion and biology should be conducted to devise proper management of psylla to restrict its distribution and damage.

Novelty Statement | This is first detailed study on the distribution of Diaphorina citri in Sindh focusing on main citrus growing areas of Naushahro Feroze district. Althought D. citri was found on lemon, grapefruit, oranges and musambi, but with significant difference, lemon being the most favourite host and Kandiaro being the most susceptible taluka. This information could help growers and policy makers to take appropriate measures for D. citri management.

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Corresponding author: Arfan Ahmed Gilal
aagilal@sau.edu.pk

Introduction

Huanglongbing (HLB) or citrus greening disease is a severe threat to global citrus production as it can result in complete loss of orchard orchards within few years of its first infestation (Silva *et al.*, 2023). Asian citrus psyllid or psylla, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) is primarily responsible for the spread of HLB (Hall and McCollum, 2011). The citrus psylla is an oligophagous pests of citrus and closely associated fruit species whose development and growth is greatly dependent on the young developing shoots of the citrus (Halbert and Manjunath, 2004; Bov´e, 2006), hence they strongly affect the population fluctuation of psylla among citrus fruits (Sétamou *et al.*, 2016; Cifuentes-Arenas *et al.*, 2018). Moreover, presence of young flush on the citrus trees also have a profound influence on the rapid reproduction of citrus psylla and its ability to disperse from infested to un-infested orchards (Kobori *et al.*, 2011; Pelz-Stelinski and Killiny, 2016; Zorzenon *et al.*, 2021; Sétamou *et al.*, 2022). The citrus psylla also have a great capability to colonize residential citrus trees, abandoned and poorly managed orchards along with wild citrus plants (Halbert and Manjunath, 2004; de C Felisberto *et al.*, 2019; Sétamou *et al.*, 2022).

HLB disease is responsible for huge losses to citrus production in the world and the situation has become worsen because so far, no adequate management tool is available for its control (Silva *et al.*, 2023). The situation become worsen because of the inability of the laboratory rearing of causal organism of HLB i.e., *Candidatus Liberibacter* spp., and its interaction within its vector, *D. citri* (Jiang *et al.*, 2019; Guo *et al.*, 2024). Although, a lot of research have done to understand epidemiology of HLB disease and its effective management because there is a huge complexity involved in HLB disease evolving the pathogen, its vector (*D. citri*), the host plant, and environmental factors (Fan *et al.*, 2025; Hussain *et al.*, 2025; Primiano *et al.*, 2023, 2025). Among such complex interactions, the age of trees and the role of endosymbiotic bacterial communities within the *D. citri* have been the key factors for the successful HLB management (Primiano *et al.*, 2023, 2025).

Hence, the only option to minimize losses of HLB is to control its vector i.e., citrus psylla, that is mostly dependent on the use of synthetic insecticides (Yuan *et al.* *et al.*, 2021; Leong *et al.*, 2022; Hu *et al.*, 2024; Amorós *et al.*, 2025). However, effectiveness of these insecticides to manage citrus psylla is greatly challenged due to seasonal population variation of psylla (Zorzenon *et al.*, 2021), high cost of insecticides (Tansey *et al.*, 2017), and development of resistance in psylla (Tian *et al.*, 2018; Naeem *et al.*, 2019; Chen *et al.*, 2021). Moreover, the use of synthetic insecticides also has determinant impact to natural enemies of the *D. citri* and other non-targeted organisms including humans beings, besides deteriorating the natural ecosystems (Wang *et al.*, 2019; Avery *et al.*, 2021; Shrestha *et al.*, 2021). Moreover, in some regions of the world, due to higher costs of insecticides, small subsistence farmers cannot afford to spray on their citrus orchards, hence they become harbors of citrus psylla for its fresh infestation to large commercial citrus orchards (Singerman and Rogers, 2020). Therefore, growers are always looking for alternative tools to manage psylla populations below threshold levels (Antolínez *et al.*, 2022, 2023).

In Pakistan, citrus are the main exporting fruits of the country as majority of the production is contributed by Punjab province, followed by Sindh. During 2020-21, total production of citrus in Pakistan was 2,599,689 tons showing an increase of 10% as compared to the production of 2019-20. Province-wise, Sindh produce 33,555 tons of citrus during 2020-21 which mainly includes lemon, grapefruit, and oranges as Naushahero Feroze district is considered as the hub of lemon production in Pakistan (GoP, 2022). Considering the major cultivation of citrus in Punjab, most of the studies on HLB and citrus psylla have been done in the province, which mostly focused on its management strategies (Fiaz *et al.*, 2018; Khan *et al.*, 2018; Naeem *et al.*, 2020; Iqbal *et al.*, 2020, 2022), however, no systematic research has been carried out on citrus psylla in Sindh province so far. Therefore, considering the major contribution of Sindh regarding lemon in the country, it become necessary to conduct basic research regarding the distribution and preference of citrus psylla on major citrus fruits at Naushahero Feroze district. The result obtained could help to minimize the spread and losses of psylla to citrus trees to restrict the spread of HLB disease and maximize their yield potential.

Materials and methods

The sampling for data collection was made from all five talukas of Naushahro Feroze district i.e., Bhria, Kandiaro, Mehrabpur, Moro, and Naushahro Feroze. The sampling for citrus psylla population was done from trees of lemon, oranges, grapefruit, and musambi orchards which were managed by the local growers with traditional management tools. The sampling procedure was adopted from Leong *et al.* (2022) with partial modifications. Three orchards of each citrus species were sampled from the individual taluka once during the active population period of psylla i.e., March-July. Each selected orchard was divided into 5 blocks and stratified sampling was used in the study. Young flush (about 10–15 mm in length) with five selected young leaves was selected as the sampling unit as 25 random samples of young flushes were observed to count the number of adults and nymphs in situ with the help of 10x hand-held lens and described as number of psylla per flush. Farmers were advised not to use any

synthetic chemical treatments during the month of data collection so that actual population of psylla can be assessed. Average monthly data for various weather parameters such as temperature, relative humidity, and wind velocity was obtained from Meteorological Department, Government of Pakistan to determine their effect on the appearance of citrus psylla.

The data collected was analyzed using Analysis of Variance (ANOVA) to determine the differences of psylla population in various citrus fruits among various talukas of Naushahro Feroze as the means with significant difference were separated using the Least Significant Difference (LSD). Pearson's correlation was performed to determine the impact of various weather parameters on the appearance of citrus psylla on different host fruits at various talukas of Naushahro Feroze.

Results

The population of citrus psylla was observed on all the citrus orchards of lemon, grapefruit, oranges, and musambi at all the locations of five talukas i.e., Bhria, Kandiaro, Mehrabpur, Moro, and Naushahro Feroze. However, the level of psylla population on various citrus fruits showed a great variation among different survey locations of five talukas (Figure 1). According to results, the highest population of citrus psylla (14.20±0.54 psylla per flush) was recorded on lemon at Kandiaro, followed by 11.23±0.81 and 10.51±0.65 psylla per flush recorded on grapefruit at Bhria and lemon at Mehrabpur, respectively. Among orange and musambi orchards, the highest population was recorded at Kandiaro (5.46±0.40 psylla per flush) and Naushahro Feroze (1.75±0.15 psylla per flush), respectively. Statistically, a highly significant ($F= 42.39$, $P < 0.0001$) difference was recorded in the population of citrus psylla among various citrus fruits orchards at five talukas of Naushahro Feroze district.

Overall, among various citrus fruit orchards surveyed at all five talukas of Naushahro Feroze district, significantly ($F= 280.11$, $P < 0.001$) the highest mean population of citrus psylla was recorded in lemons (8.68±0.45 psylla per flush), followed by grapefruits (6.81±0.35 psylla per flush), and oranges (4.10±0.21 psylla per flush). The lowest overall population of citrus psylla in Naushahro Feroze district was observed on musambi fruit trees (1.12±0.06 psylla per flush) (Figure 2).

Figure 3 describes results for the taluka-wise overall citrus psylla population observed on various citrus fruit trees that confirmed a highly significant ($F = 22.82$, $P < 0.001$) difference in psylla population recorded at various talukas. According to results, Kandiaro taluka significantly suffered the highest population (6.44±0.39 psylla per flush) of citrus psylla on citrus, whereas the lowest population (3.52±0.20 psylla per flush) was observed at Moro taluka. Moreover, the citrus psylla population recorded on citrus at Naushahro Feroze (5.48±0.28 psylla per flush), Bhria (5.24±0.3 psylla per flush), and Mehrabpur (5.20±0.28 psylla per flush) talukas was not significantly different from each other.

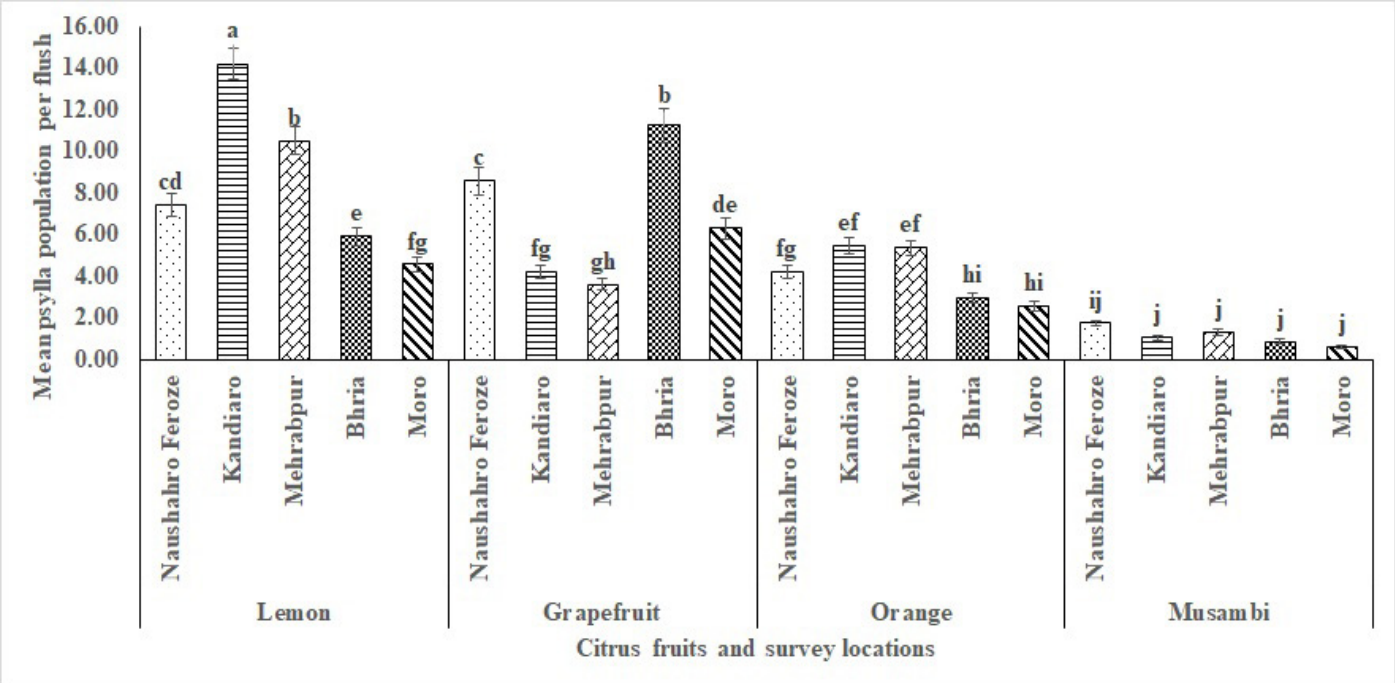

Figure 1: Mean population of citrus psylla on different citrus fruits at various survey talukas of Naushahero Feroze district.

*Means followed by same letters are not significantly different from each other (LSD = 1.2209, P < 0.05)

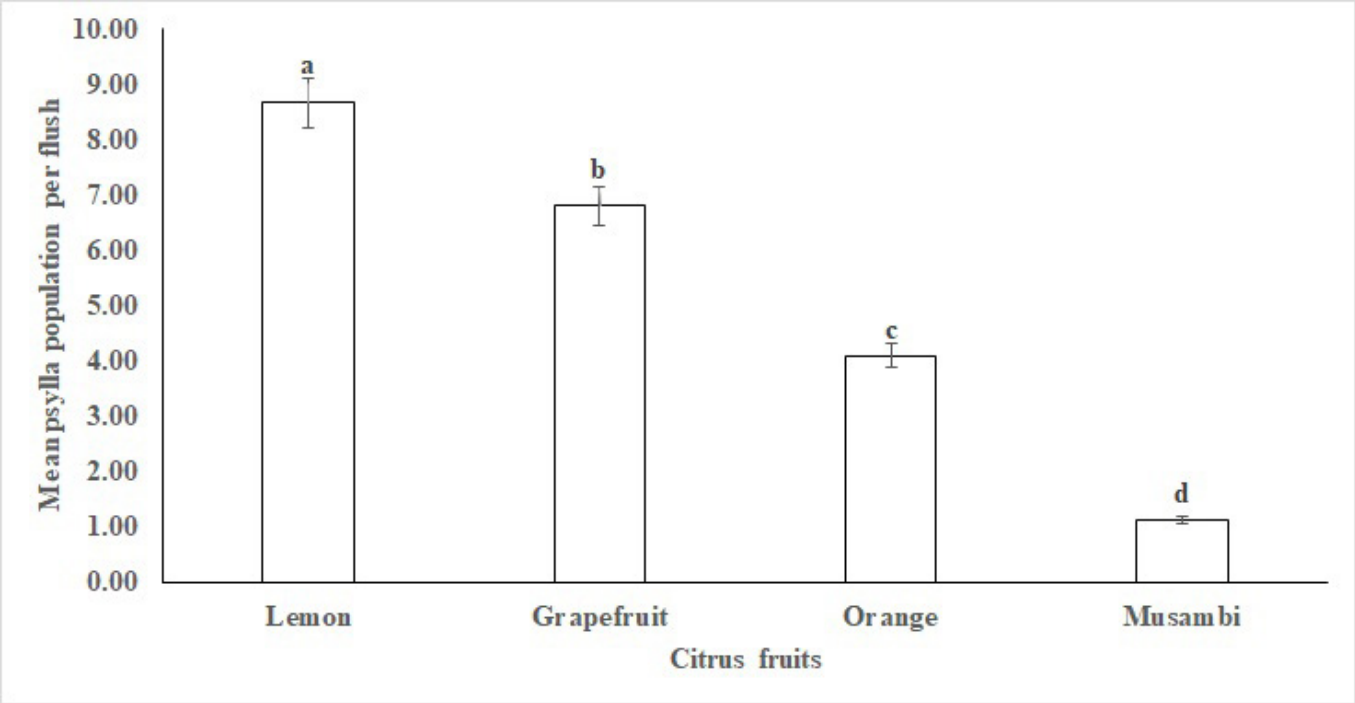

Figure 2: Overall mean population of citrus psylla on different citrus fruits at Naushahro Feroze district.
*Means followed by same letters are not significantly different from each other (LSD = 0.5460, P < 0.05)

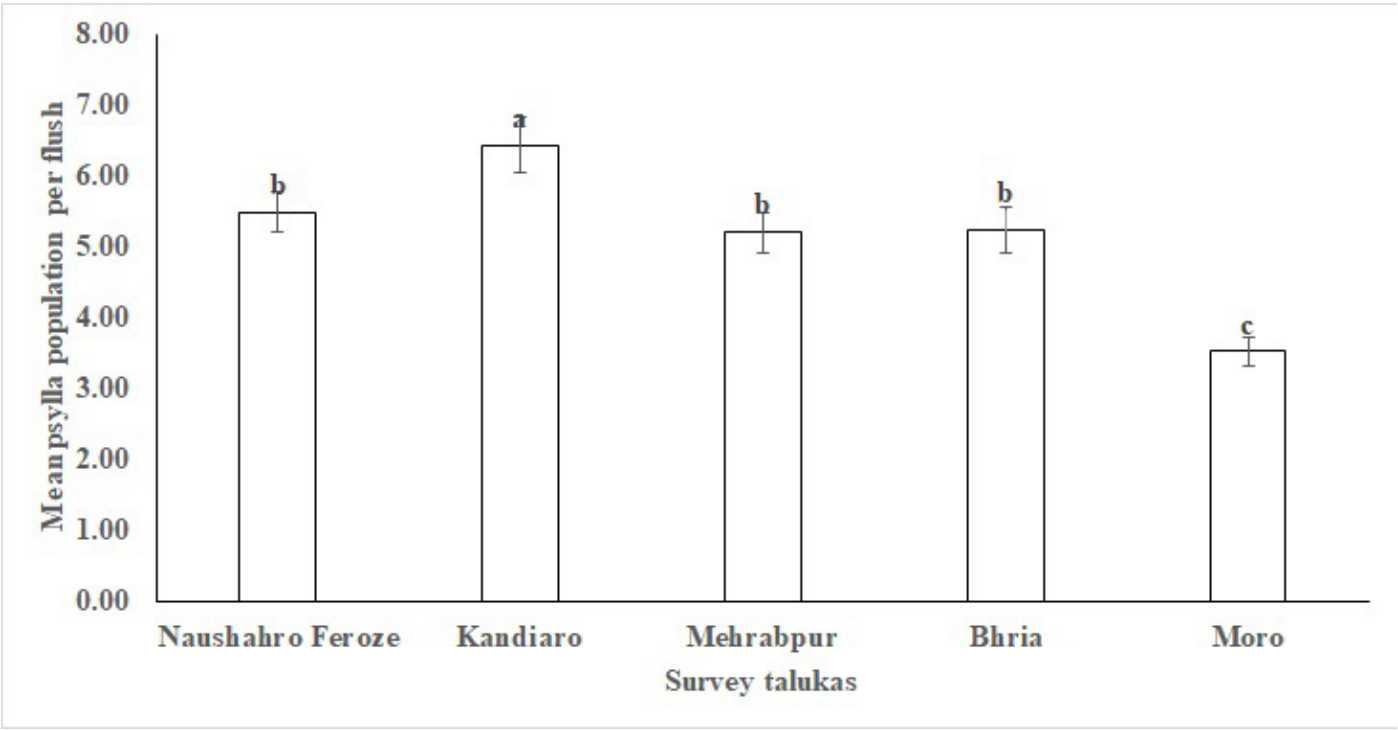

Figure 3: Overall mean population of citrus psylla infesting citrus fruits\ at different talukas of Naushahro Feroze district.
*Means followed by same letters are not significantly different from each other (LSD = 0.6104, P < 0.05)

The Pearson's correlation regarding the population of citrus psylla on various citrus fruit trees with average prevailing weather parameters of the surveyed talukas of district Naushahro Feroze are given in Table 1. According to the results, psylla population on all the fruits showed a significant, positive, and weak to moderate relationship with the minimum temperature, whereas maximum temperature have a significant and negative but weak effect with only on grapefruits and musambi. Moreover, relative humidity also exhibited a weak to moderate and significant effect on the population of citrus psylla as its relationship was positive with lemons and orange, whereas negative association with grapefruits and musambi. The citrus psylla population also showed a weak, significant, and positive relationship with wind velocity on lemons and grapefruit only.

Table 1: Pearson's correlation of citrus psylla populations of different citrus hosts at various talukas of Naushahro Feroze district.

	Maximum temperature	Minimum temperature	Relative humidity	Wind velocity
Lemon	r = 0.0073 P = 0.8883	r = 0.3300 P < 0.001	r = 0.3675 P < 0.001	r = -0.2370 P < 0.001
Grape-fruit	r = -0.2390 P < 0.001	r = -0.1956 P < 0.001	r = -0.3363 P < 0.001	r = -0.2182 P < 0.001
Orange	r = -0.0272 P =0.5990	r = 0.1255 P < 0.05	r = 0.1322 P < 0.05	r = -0.0886 P = 0.0866
Musam-bi	r = -0.2549 P < 0.001	r = -1889 P < 0.05	r = -0.1792 P < 0.05	r = -0.0905 P = 0.0806

Discussion

The citrus psylla was found greatly distributed in all citrus growing areas of district Naushahro Feroze on all the citrus fruits grown there. However, citrus psylla not only showed a significant variation in its preference towards various citrus fruits i.e., lemon, grapefruit, orange, and musambi grown in the district, but it also exhibited differences in its distribution at various talukas. Lemon and grapefruit were highly infested with citrus psylla in the study, whereas musambi suffered the lowest population of the psylla. Moreover taluk-wise, Kandiaro and Moro talukas showed great distribution of citrus psylla, with no significant difference in its distribution at Bhria, Naushahro Feroze, and Mehrabpur talukas. Thus, such variation in the population of psylla on different citrus trees of lemons, grapefruits, oranges, and musambi may be either the availability of more young leaves on them during the time of data collection or the management practices used by the growers in their orchards along with relative preference of psylla towards the particular host.

The studies of Fiaz *et al.* (2018) in central Punjab, Pakistan reported that orchards of kinnow mandarin, and musambi in Sargodha district were heavily effected with citrus psylla as compared to Faisalabad and Toba Tek Singh districts with comparatively more psylla population recorded on musambi than kinnow mandarin. The studies in other regions of the world also confirmed that the appearance of new shoots (flush) have a significant impact on the availability and damage of psylla on citrus plants (Sétamou *et al.*, 2016; Cifuentes-Arenas *et al.*, 2018). The citrus psylla is a highly polyphagous insect pest having a broad host range in Aurantiodea subfamily of citrus plants, whereas it can infest almost all members of Rutaceae family (Meng *et al.*, 2018, 2019; Stelinski, 2019). However, *D. citri* have also shown exhibited strong preference towards some of the plants such as sweet orange (*Citrus sinensis*), orange jasmine (*Murraya paniculata*), curry tree (*Murraya koenigii*) (Sétamou *et al.*, 2016; Bragard *et al.*, 2021; Meng *et al.*, 2022). The studies also suggested that some of the rutaceous plants such as certain mandarins and trifoliate orange are unattractive for feeding and oviposition of the citrus psylla (Borgoni *et al.*, 2014; George and Lapointe, 2019; Meng *et al.*, 2022). Mostly, these plants produce certain volatiles that deter the egg-laying and development of the immature psylla (Hall *et al.*, 2015). Similar to above-studies, the relative preference of citrus psylla in this study on the available fruit plants i.e., lemon, grapefruit, oranges, and musambi may be because of the availability of essential plant volatiles that have determined its preference towards lemon and grapefruit as compared to musambi and oranges.

Generally, in this study, a very weak to moderate effect of various weather parameters was recorded on the occurrence of citrus psylla in various citrus fruit plants. The temperature and relative humidity exhibited a negative impact on psylla attack in grapefruit and musambi plants, whereas a positive influence was observed in lemon and orange plants. However, wind velocity showed a negative impact on the prevalence of psylla in all citrus fruit plants. The studies of Iftikhar *et al.* (2017) observed a significant relationship of psylla population on citrus orchards of Sargodha, Pakistan with minimum temperature and rainfall in all the study talukas, whereas maximum temperature at only two of the talukas. Fiaz *et al.* (2018) also observed a significant effect of average temperature and relative humidity on the population fluctuation of citrus psyllid in sweet mandarin and musambi orchards at Sargodha, Faisalabad, and Toba Tek Singh districts of central Punjab, Pakistan. Tsai *et al.* (2002) also confirmed that along with development of fresh flush, weekly minimum temperature and rainfall exhibited a significant relationship with the population development of psylla in orange jasmine in Florida. Moreover, significant and positive role of solar radiation and wind direction have also been reported in the dispersion of citrus psylla, whereas relative humidity showed a negative impact on its dispersal (Johnston *et al.*, 2019). The studies of Hernandez-Landa *et al.* (2018) also found a positive role of new flushes and temperature in the population development of citrus psylla population in commercial *Murraya paniculata* and Persian lime orchards in Veracruz, México as temperature and relative humidity regimes of 26 to 28°C and 75 to 85% were found optimum for its population growth. In comparison to most of the above-mentioned studies, Rakhshani and Saeedifar (2013) observed a negative effect of both high and low temperatures, high rainfall, and low relative humidity on the population of citrus psylla.

Although, studies confirmed variable role of weather parameters in the population growth of citrus psylla in various citrus orchards, but most of the studies confirmed that appearance of new fresh flush (shoots) is the single most important factor that not only determined its population development, but also its dispersion pattern

(Sétamou *et al.*, 2016; Cifuentes-Arenas *et al.*, 2018; Hernandez-Landa *et al.*, 2018; Leong *et al.*, 2022; Silva *et al.*, 2023).

Conclusion

The citrus psylla, *D. citri* was widely distributed among available fruit orchards plants of lemon, grapefruit, oranges, and musambi in all five talukas of district Naushahro Feroze, Sindh. However, citrus psylla showed comparatively more population on lemon and grapefruit plants, whereas musambi plants showed the least population. The highest and lowest distribution in all citrus fruit plants was recorded at Kandiaro and Moro talukas, respectively. Therefore, it is suggested that further basic studies such as dispersion pattern, availability of natural enemies of citrus psylla in the district, comparative growth and development of citrus psylla may be conducted in the district that could help to reduce its distribution and population in citrus orchards.

Declarations

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IRB approval

Ethical approval for this study was granted by the Institutional Review Board (IRB) of Department of Plant Protection, Sindh Agriculture University, Tandojam, Pakistan.

Ethical statement

All procedures performed in this study involving human/animal subjects were in accordance with the ethical standards of the Institutional Research Committee.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

References

Amorós, M.E., Pereira Das Neves, V., Galván, V., Rodríguez, A., Pechi, E., Amaral, J., Asutin, V., Rivas, F., Buenahora, J. and Rossini, C., 2025. Control of *Diaphorina citri* (Hemiptera: Liviidae) using environmentally friendly chemical alternatives. *Int. J. Pest Manage.*, **71**: 84-96. https://doi.org/10.1080/09670874.2024.2418011

Antolínez, C.A., Byrne, F.J., Wasantwisut, S., Rohula, T., Aziz, K.L.G.A. and Rivera, M.J., 2023. Assessment of renewable compounds as biopesticides for Asian citrus psyllid, *Diaphorina citri* (Kuwayama) (Hemiptera: Psyllidae). *J. Pest Sci.*, **96**: 663-670. https://doi.org/10.1007/s10340-022-01542-z

Antolínez, C.A., Martini, X., Stelinski, L.L. and Rivera, M.J., 2022. Wind speed and direction drive assisted dispersal of Asian citrus psyllid. *Environ. Entomol.*, **51:** 305-312. https://doi.org/10.1093/ee/nvab140

Avery, P.B., Duren, E.B., Qureshi, J.A., Adair Jr, R.C., Adair, M.M. and Cave, R.D., 2021. Field efficacy of *Cordyceps javanica*, white oil and spinetoram for the management of the Asian Citrus Psyllid, *Diaphorina citri*. *Insects*, **12:** 824. https://doi.org/10.3390/insects12090824

Borgoni, P.C., Vendramim, J.D., Lourencão, A.L. and Machado, M.A., 2014. Resistance of Citrus and related genera to *Diaphorina citri* Kuwayama (Hemiptera: Liviidae). *Neotrop. Entomol.*, **43:** 465-469. https://doi.org/10.1007/s13744-014-0230-0

Bové, J.M., 2006. Huanglongbing: A destructive, newly-emerging, century-old disease of citrus. *J. Pl. Pathol.*, **88(1):** 7-37. https://doi.org/10.2903/j.efsa.2021.6357

Bragard, C., Dehnen-Schmutz, K., Di Serio, F., Gonthier, P., Jacques, M.A., Jaques Miret, J.A., Justesen, A.F., Magnusson, C.S., Milonas, P. and Navas-Cortes, J.A., 2021. Pest categorisation of Diaphorina citri. *EFSA J.*, **19:** e06357.

Chen, X.D., Neupane, S., Gill, T.A., Gossett, H., Pelz-Stelinski, K.S. and Stelinski, L.L., 2021. Comparative transcriptome analysis of thiamethoxam susceptible and resistant Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Liviidae), using RNA- sequencing. *Ins. Sci.*, **28:** 1708-1720. https://doi.org/10.1111/1744-7917.12901

Cifuentes-Arenas, J.C., de Goes, A., de Miranda, M.P., Beattie, G.A.C. and Lopes, S.A., 2018. Citrus flush shoot ontogeny modulates biotic potential of *Diaphorina citri*. *PLoS One*, **13:** p.e0190563. https://doi.org/10.1371/journal.pone.0190563

de C Felisberto, P.A., Girardi, E.A., Peña, L., Felisberto, G., Beattie, G.A. and Lopes, S.A., 2019. Unsuitability of indigenous South American Rutaceae as potential hosts of *Diaphorina citri*. *Pest Manage. Sci.*, **75:** 1911-1920. https://doi.org/10.1002/ps.5304

Fan, J., Pan, H., Yuan, C., Liu, T., Shang, F., Zhou, Y., Gao, Y., Yi, L., Wang, J. and Dou, W., 2025. The relationship between the Huanglongbing pathogen and *Diaphorina citri* with body color polyphenism: Field dynamics, acquisition efficiency, and immunity response. *Pest Manage. Sci.*, **81:** 3750–3761. https://doi.org/10.1002/ps.8743

Fiaz, M., Afzal, M. and Majeed, M.Z., 2018. Influence of abiotic weather factors on population dynamics of Asian citrus psyllid, *Diaphorina citri* Kuwayama

(Hemiptera: Psyllidae) in central Punjab, Pakistan. *J. Agric. Res.,* **56:** 35-40.

George, J. and Lapointe, S.L., 2019. Host-plant resistance associated with *Poncirus trifoliata* influence oviposition, development and adult emergence of *Diaphorina citri* (Hemiptera: Liviidae). *Pest Manage. Sci.,* **75**: 279-285. https://doi.org/10.1002/ps.5113

GoP, 2022. Area, production and yield of important crops. Ministry of National Food Security & Research, Government of Pakistan.

Guo, C.F., Kong, W.Z., Mukangango, M., Hu, Y.W., Liu, Y.T., Sang, W. and Qiu, B.L., 2024. Distribution and dynamic changes of Huanglongbing pathogen in its insect vector *Diaphorina citri*. *Front. Cell. Infect. Microbiol.*, **14:** 1408362. https://doi.org/10.3389/fcimb.2024.1408362

Halbert, S.E. and Manjunath, K.L., 2004. Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: a literature review and assessment of risk in Florida. *Fl. Entomol.*, **87**: 330-353. https://doi.org/10.1653/0015-4040(2004)087[0330:ACPSPA]2.0.CO;2

Hall, D.G. and McCollum, G., 2011. Survival of adult Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Psyllidae), on harvested citrus fruit and leaves. *Fl. Entomol.*, **94:** 1094-1096. https://doi.org/10.1653/024.094.0459

Hall, D.G., George, J. and Lapointe, S.L., 2015. Further investigations on colonization of *Poncirus trifoliata* by the Asian citrus psyllid. *Crop Prot.*, **72:** 112-118. https://doi.org/10.1016/j.cropro.2015.03.010

Hernandez-Landa, L., Lopez-Collado, J., González-Hernández, H., Vargas-Mendoza, M., Osorio-Acosta, F., and Nava-Tablada, M.E., 2018. Fluctuation and synchronization of adults catches of *Diaphorina citri* Kuwayama (Hemiptera: Liviidae) in urban backyards and commercial citrus plantations. *J. Asia-Pac. Entomol.*, **21**: 745-753. https://doi.org/10.1016/j.aspen.2018.05.005

Hu, W., Wang, K., Zhong, X., Jiang, P., Zhang, S., Lu, Z., Zhang, Z., Yi, L. and Zhang, N., 2024. Enhanced control efficacy of different insecticides mixed with mineral oil against Asian citrus psyllid, *Diaphorina citri* Kuwayama, under varying climates. *Insects*, **16:** 28. https://doi.org/10.3390/insects16010028

Hussain, M., Zhong, Y., Tao, T., Xiu, B., Ye, F., Gao, J. and Mao, R., 2024. Effect of tree height and spraying methods on *Diaphorina citri* Kuwayama endosymbionts in the context of Huanglongbing disease management in citrus orchards. *Pest Manage. Sci.*, **80**:1484-1500. https://doi.org/10.1002/ps.7880

Iftikhar, Y., Haq, I.U., Raza, W., Ullah, M.I., Ali, S., Khoso, F.N. and Mubeen, M., 2017. seasonal fluctuation of Asian citrus psylla populations in the citrus orchards infected with huanglongbing in Sargodha, Pakistan. *Pak. J. Phytopathol.*, **29:** 175-179. https://doi.org/10.33866/phytopathol.029.01.0328

Iqbal, J., Hussain, H.N., Latif, M., Baig, M.B., Owayss, A.A., Raweh, H.S. and Alqarni, A.S., 2020. A field study investigating the insecticidal efficacy against *Diaphorina citri* Kuwayama on Kinnow mandarin, *Citrus reticulata* Blanco trees. *Saudi J. Biol. Sci.*, **27**: 1237-1241. https://doi.org/10.1016/j.sjbs.2020.02.006

Iqbal, M., Ahmad, S., Gogi, M., Atta, B. and Nisar, M.J., 2022. Comparative efficacy of synthetic insecticides against Citrus psylla, *Diaphorina citri* kuwayama (Homoptera: Psyllidae) under laboratory and field conditions. *Plant Prot.*, **6**: 43-50. https://doi.org/10.33804/pp.006.01.4094

Jiang, Y., Zhang, C.X., Chen, R. and He, S.Y., 2019. Challenging battles of plants with phloem-feeding insects and prokaryotic pathogens. *Proc. Nat. Acad. Sci.*, **116:** 23390-23397. https://doi.org/10.1073/pnas.1915396116

Johnston, N., Stelinski, L.L. and Stansly, P., 2019. Dispersal patterns of *Diaphorina citri* (Kuwayama) (Hemiptera: Liviidae) as influenced by citrus grove management and abiotic factors. *Fl. Entomol.*, **102**: 168-173. https://doi.org/10.1653/024.102.0127

Khan, A., Shah, S., Zaman, M. and Habib, K., 2018. Management of Asian citrus psyllids, *Diaphorina citri* Kuwayama, the direct and vector pest of citrus via synthetic insecticides in Khyber Pakhtunkhwa, Pakistan. *Pak. J. Agric. Res.* **31**: 300-305. https://doi.org/10.17582/journal.pjar/2018/31.4.300.305

Kobori, Y., Nakata, T., Ohto, Y. and Takasu, F., 2011. Dispersal of adult Asian citrus psyllid, *Diaphorina citri* Kuwayama (Homoptera: Psyllidae), the vector of citrus greening disease, in artificial release experiments. *Appl. Entomol. Zool.* **46**: 27-30. https://doi.org/10.1007/s13355-010-0004-z

Leong, S.S., Leong, S.C. and Beattie, G.A., 2022. Integrated pest management strategies for Asian citrus psyllid *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) and huanglongbing in citrus for Sarawak, East Malaysia, Borneo. *Insects*, **13**: 960. https://doi.org/10.3390/insects13100960

Meng, L., Cheng, X., Xia, C. and Zhang, H., 2022. Effect of host plants on development and reproduction of *Diaphorina citri* and their host preference. *Entomol. Exper. Appl.*, **170**: 700-707. https://doi.org/10.1111/eea.13188

Meng, L., Li, X., Cheng, X. and Zhang, H., 2019. *16S rRNA* gene sequencing reveals a shift in the microbiota of *Diaphorina citri* during the psyllid life cycle. *Front. Microbiol.*, **10:** 1948. https://doi.org/10.3389/fmicb.2019.01948

Meng, L., Wang, Y., Wei, W.H. and Zhang, H., 2018. Population genetic structure of *Diaphorina citri*

Kuwayama (Hemiptera: Liviidae): host-driven genetic differentiation in China. *Sci. Rep.*, **8**: 1473. https://doi.org/10.1038/s41598-018-19533-5

Naeem, A., Afzal, M.B.S., Freed, S., Hafeez, F., Zaka, S.M., Ali, Q., Anwar, H.M.Z., Iftikhar, A. and Nawaz, M., 2019. First report of thiamethoxam resistance selection, cross resistance to various insecticides and realized heritability in Asian citrus psyllid *Diaphorina citri* from Pakistan. *Crop Prot.*, **121:** 11-17. https://doi.org/10.1016/j.cropro.2019.03.004

Pelz-Stelinski, K.S. and Killiny, N., 2016. Better together: association with '*Candidatus* Liberibacter asiaticus' increases the reproductive fitness of its insect vector, *Diaphorina citri* (Hemiptera: Liviidae). *Ann. Entomol. Soc. Am.*, **109:** 371-376. https://doi.org/10.1093/aesa/saw007

Primiano, I.V., Eduardo, W.I., Amorim, L., Bergamin Filho, A., Montesino, L.H. and Bassanezi, R.B., 2023. The effect of citrus planting orientation on the gradient and incidence of huanglongbing. *Plant Pathol.*, **72:** 686-695. https://doi.org/10.1111/ppa.13704

Primiano, I.V., Monteferrante, E.C., Ferreira, L., Adami, A.C.D.O., Miranda, S.H.G.D., Behlau, F. and Bassanezi, R.B., 2025. Epidemiological and economic model to estimate the optimal edge width of citrus block to be weekly sprayed with insecticide for huanglongbing management. *Sci. Agricol.*, **82:** 20240240. https://doi.org/10.1590/1678-992x-2024-0240

Rakhshani, E. and Saeedifar, A., 2013. Seasonal fluctuations, spatial distribution and natural enemies of Asian citrus psyllid *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) in Iran. *Entomol. Sci.*, **16:** 17-25. https://doi.org/10.1111/j.1479-8298.2012.00531.x

Sétamou, M., Da Graça, J.V. and Sandoval, J.L., 2016. Suitability of native North American Rutaceae to serve as host plants for the Asian citrus psyllid (Hemiptera: Liviidae). *J. Appl. Entomol.*, **140:** 645-654. https://doi.org/10.1111/jen.12300

Sétamou, M., Tarshis Moreno, A. and Patt, J.M., 2022. Source or sink? the role of residential host plants in Asian citrus psyllid infestation of commercial citrus groves. *J. Eco. Entomol.*, **115:** 438-445. https://doi.org/10.1093/jee/toab249

Shrestha, B., Martini, X. and Stelinski, L.L., 2021. Population fluctuations of Diaphorina citri and its natural enemies in response to various management practices in Florida. *Flor. Entomol.*, **104:** 178-185. https://doi.org/10.1653/024.104.0306

Silva, M.S., Patt, J.M., de Jesus Barbosa, C., Fancelli, M., Mesquita, P.R.R., de Medeiros Rodrigues, F. and Schnadelbach, A.S., 2023. Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Liviidae) responses to plant-associated volatile organic compounds: A mini-review. *Crop Protection*, pp. 106242. https://doi.org/10.1016/j.cropro.2023.106242

Singerman, A. and Rogers, M.E., 2020. The economic challenges of dealing with citrus greening: The case of Florida. *J. Int. Pest Manage.*, **11:** 3. https://doi.org/10.1093/jipm/pmz037

Stelinski, L.L., 2019. Ecological aspects of the vector-borne bacterial disease, Citrus Greening (Huanglongbing): Dispersal and host use by Asian Citrus Psyllid, *Diaphorina citri* Kuwayama. *Insects*, **10:** 208. https://doi.org/10.3390/insects10070208

Tansey, J.A., Vanaclocha, P., Monzo, C., Jones, M. and Stansly, P.A., 2017. Costs and benefits of insecticide and foliar nutrient applications to huanglongbing-infected citrus trees. *Pest Manage. Sci.*, **73:** 904-916. https://doi.org/10.1002/ps.4362

Tian, F., Mo, X., Rizvi, S.A.H., Li, C. and Zeng, X., 2018. Detection and biochemical characterization of insecticide resistance in field populations of Asian citrus psyllid in Guangdong of China. *Sci. Reports*, **8:** 12587. https://doi.org/10.1038/s41598-018-30674-5

Tsai, J.H., Wang, J.J. and Liu, Y.H., 2002. Seasonal abundance of the Asian citrus psyllid, *Diaphorina citri* (Homoptera: Psyllidae) in southern Florida. *Fl. Entomol.*, **85:** 446-451. https://doi.org/10.1653/0015-4040(2002)085[0446:SAOTAC]2.0.CO;2

Wang, R., Yang, H., Luo, W., Wang, M., Lu, X., Huang, T., Zhao, J. and Li, Q., 2019. Predicting the potential distribution of the Asian citrus psyllid, *Diaphorina citri* (Kuwayama), in China using the MaxEnt model. *PeerJ*, **7:** e7323. https://doi.org/10.7717/peerj.7323

Yuan, C.Y., Jing, T.X., Li, W., Liu, X.Q., Liu, T.Y., Liu, Y., Chen, M.L., Jiang, R.X., Yuan, G.R., Dou, W. and Wang, J.J., 2021. NADPH-cytochrome P450 reductase mediates the susceptibility of Asian citrus psyllid *Diaphorina citri* to imidacloprid and thiamethoxam. *Pest Manage. Sci.*, **77:** 677-685. https://doi.org/10.1002/ps.6143

Zorzenon, F.P., Tomaseto, A.F., Daugherty, M.P., Lopes, J.R. and Miranda, M.P., 2021. Factors associated with *Diaphorina citri* immigration into commercial citrus orchards in São Paulo State, Brazil. *J. Appl. Entomol.*, **145:** 326-335. https://doi.org/10.1111/jen.12851