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Research Article

Distribution and host plant associations of Megachile (*Pseudomegachile*) *lanata* (Fabricius, 1775) (Megachilidae) in Pothohar, Pakistan

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ABSTRACT

Solitary *Megachile lanata* (Fabricius) are important pollinator of a variety of plants including horticultural, ornamental, aromatic and agricultural crops based on their prevalence and floral host plant range. Their presence can greatly increase the yield and quality of the crops they pollinate. Explore the occurrence and floral host plant range of *Megachile* (Pseudomegachile) *lanata* within the Pothohar plateau, Punjab, Pakistan. The specimens of *Megachile lanata* (Fabricius) were collected on a monthly basis from various agricultural and all other types of landscapes, such as forests, urban areas and natural habitats in the Pothohar plateau of Punjab, Pakistan during 2021-2022. The individuals of this bee were collected with an aerial net. The present study investigates seasonal population and distribution range of *M. lanata*. Herein, we have observed twelve host plants in various localities of the study area. This is an invasive species, and one distinct feature is the inclusion of brief diagnostic information, details about host plants as well as information on ecology and current distribution in Pakistan. This data will contribute to a better understanding of solitary *Megachile lanata* (Fabricius) bee species diversity and abundance, which is crucial for maintaining the health of ecosystems, especially those in agro-ecosystems on Pothohar Plateau of Punjab, Pakistan.

Keywords: Biodiversity, Foraging behavior, Pollination ecology, Megachilidae, Pothohar, Pakistan.

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INTRODUCTION

Bees are globally recognized as a fundamental group of insects responsible for pollination (Greenleaf & Kremen, 2006; Winfree et al., 2007). Megachilid commonly known as leaf cutter bees within the family Megachilidae (Hymenoptera) and found to be potential pollinators of the number of crops (Gibbs et al., 2017). Most importantly, fruit orchards and vegetable farming under controlled environment requires bee population for maximum production due to their effective pollination activity (Klein., 2007). Megachilidae is one of the most diverse family of the order Hymenoptera, comprising 81 genera, 237 subgenera, 11 tribes, 4 subfamilies and 4110 described species worldwide (Ascher & Pickering, 2021). Genus *Megachile* is one of the speciose genera with 1500 valid species and considered cosmopolitan in nature (Wedmann et al., 2009; Gibbs et al. 2017). Memebers of this genus nests in rock crevices, pithy trees, pre-existing cavities, galls, arboreal termite nests, sand, mud, plant trichomes, petals, masticated plant material and leaf litters (Litman et al., 2011; AbdulAziz et al., 2014; Morato & Martins, 2006). The number of species in genus *Megachile* has been reported from different regions of the world including India (Gupta, 1993; Veeresh kumar, 2018; Ascher & Pickering, 2020), Europe (Rasmont et al., 2017); Southeast Asia (Ascher & Pickering, 2020); Kenya, Uganda and Tanzania (Eardley and Urban 2010) and Pakistan (Gonzalez, 2010).

In agricultural and all other types of landscapes, such as forests, urban areas and natural habitats, agricultural activities are not the primary focus. The genus *Megachile* contains seven species, including *Megachile (Eutricharaea) arachosiana*, *M. lanata*, *M. cephalotes*, *Megachile hera*, *M. bicolor, M. disjuncta and M. conjuncta* on different regions of Pakistan associated with diverse floral host plants (Gonzalez et al., 2010; Abdur et al., 2022; Sajjad et al., 2019; Rauf et al., 2021; Sumera et al*.,* 2020). To investigate the possibility of using additional native species, research was done to analyse the occurrence of *Megachile lanata* (Fabricius) in Rawalpindi, Islamabad and Chakwal.

The purpose of this study was to better understand the host range, natural occurrence and distribution of *Megachile lanata* (Fabricius) across various host plant surroundings, aiming to identify the most suitable species for our habitats. This ensures they are readily accessible and capable of effectively pollinating crops. Additionally, host plants were categorized based on their preference for bee pollination.

MATERIALS AND METHODS

The present study was planned to investigate the host plant association and distribution range of *Megachile* (*Pseudomegachile*) *lanata* (Fabricius, 1775) in various localities of Rawalpindi, Islamabad and Chakwal on monthly basis during the year 2021-22. *Megachile* (*Pseudomegachile*) *lanata* were observed from different natural habitats including University Park, Landscapes, Gardens and 10 different field localities of rangelands. Collected specimens of *Megachile lanata* with the help of Aerial net. The population was also observed in each selected site timely on monthly basis during study period. Coordinates of each sampling site were also noted using GPS devise. Key features of each specimen were recorded, and important taxonomic parts were measured with micrographs to ensure proper identification. The study on species diversity of *Megachile lanata* (Fabricius) was conducted through walking transect method (Pollard, 1977) during the early morning to early afternoon hours.

RESULTS

As a result of the present study, *Megachile lanata* (Fabricius) individuals were observed during July-September, however, population becomes maximum in early August-September and hibernate during the months of November-February. The population of *Megachile lanata* individuals started to increase and reached its peak from July to September (Figure 3). *Megachile lanata* were seen actively foraging in the morning and afternoon hours 12:45 pm and 5:30 pm to avoid the severe weather from October to February (Figure 3).

Distribution

The *Megachile lanata* (Fabricius) is the main solitary pollinator for a variety of agricultural crops (Udayakumar & Timalapur, 2018). *Megachile lanata* was observed for the first time in Multan (Abdur et al., 2022). *Megachile lanata* has been reported from different parts of the World including North-America (Henson, Campbell and Kaplan, 2019), Colombia (Gonzalez et al., 2019), India (Pasteels, 1965), Cuba, Jamaica, Puerto Rico, United States, southern Florida, Saint Vincent, Grenadines Bolivia, Guyana, French Guyana, Trinidad, Tobago and French West Indies (Moure, 1953; Genaro, 1996; Pauly, 2012; Moure et al., 2007; Raw, 2007; Meurgey, 2016; Ascher and Pickering, 2018).

Populations of studied bees were at their maximum with pollination activity in public-managed parks and floral environments in Rawalpindi (PMAS-Arid Agriculture University Rawalpindi, Iqbal Park, Ayub National Park and Jinnah Park), Islamabad (F-7 Avenue, National Agriculture Research Centre, Kachnar Park) and Chakwal (Sarpak, Muhallah Anwarabad and Koont Research Farm).

Megachile lanata specimens were obtained from multiple locations with varying climates and environmental conditions, resulting in a broad range of floral host plants. Weeds, decorative plants, horticultural plants, tall thick forest trees and cultivated crops served as the primary food sources for these insects (Table 1).

Diagnostic Characters

Body finely pubescent and punctured in overall view. Clypeus sub-lunate and transverse anteriorly. Head broad medially, Thorax basal abdominal segments are covered with dense hairs, antennae & legs are nigropiceous, Legs light fulvous-red, pubescence, apical margins thin, transverse fasciae white pubescence; pollen-brush white in color, Wings flavo-hyaline, apical Margin broadly fuscescent. Abdominal segment III and IV extending thin fulvous-red pubescence; Segment V with white fascia.

Table 1. Collection localities in Rawalpindi, Islamabad and Chakwal of Pakistan.

Location	Global Position	Major Floral host plant
PMAS Arid Agriculture University Rawalpindi	73.08134 E^0 33.64698 N^0	Butterfly Pea, Trumpet Bush, Niazbo, Mint, Crape myrtle, Fire Bush, Phalsa
Allama Iqbal Park	73.07444 E^0 33.64951 N^0	Trumpet Bush, Crape myrtle
Fatima Jinnah Park	73.0122 E^0 33.4207 N^0	Trumpet Bush, Crape myrtle, Butterfly Pea
Ayub National Park	73.07982 E^0 33.56596 N^0	Trumpet Bush
F-7th avenue Park	73.07244 E^0 33.69225 N^0	Trumpet Bush
National Agriculture Research Centre	73.1261 E^0 33.6701 N^0	Roses, weeds
Jinnah Park	73.07265 E^0 33.58491 N^0	Lantana, Trumpet Bush
Kachnar Park	73.0724 E^0 33.6807 N^o	Dense trees
Muhallah Anwarabad	72.8630 E^0 32.9328 N^0	*Acacia nilotica*
Sarpak	72.8622 E^0 32.9266 N^0	Weeds, Alfalfa
Koont research farm	73.0112 E^0 33.1165 N^0	Phalsa, Trumpet bush

Male similar to female but smaller in size; pubescence on the clypeus and front paler to golden tint. Female: Body length 14-15 mm; wings extend 26-28 mm. Male: Body length 12-13 mm; wings extend. 22mm.

Distribution: Rawalpindi (PMAS-Arid Agriculture University Rawalpindi, Iqbal Park, Fatima Jinnah Park, Ayub Park), Islamabad (Kachnar park, F-7th avenue park, National Agriculture Research Centre), Chakwal (Koont research farm, Muhallah Anwarabad and Sarpak) & Multan.

Host plants: *Pongamia Pinnata* (L.), *Tecoma stans* (L.), *Senna bicapsularis* (L.), *Clitoria ternatea* (L.), *Medicago sativa* (L.), *Ocimum basilicum* (L.), *Trifolium repens* (L.), *Rosa indica* (L.), *Solidago spp* (L.), *Gaillardia aristata* (Pursh), *Lagerstroemia indica* (L.), *Lamiaceae spp.* (L.), *Duranta erecta* (L.), *Helianthus annuus* (L.) and *Hamelia patens* (Jacq.).

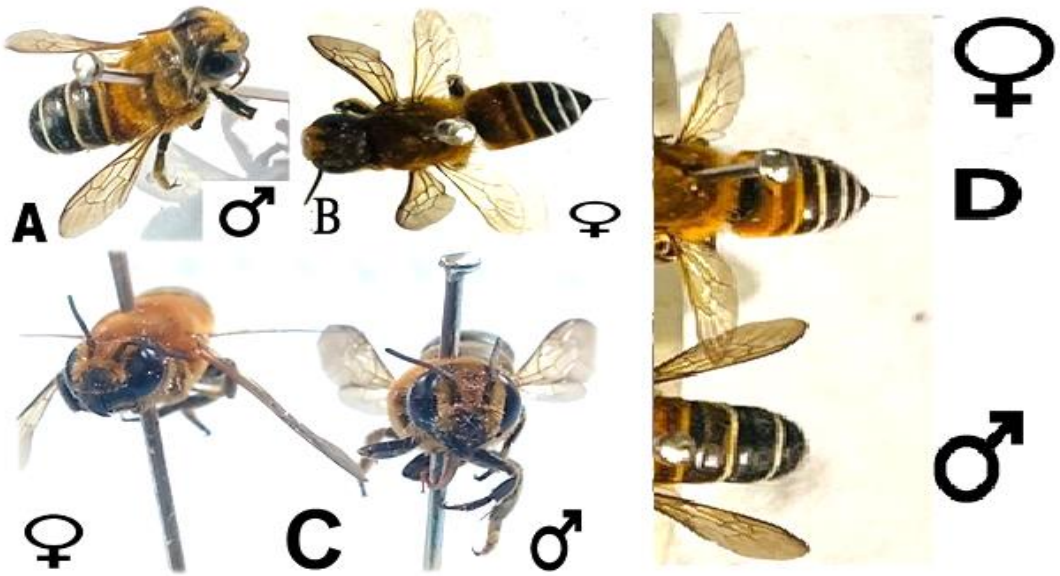

Figure1. (A-D) *Megachile lanata* (Fabricius), A. (Dorsal View (♂), B. (♀), C. (Frontal View (♀, ♂), D. (Abdominal View (♀,♂).

DISCUSSION

The intrinsic role of bees within ecosystems is indispensable, as they actively contribute to biodiversity maintenance by facilitating the growth and reproduction of various plant species. Moreover, their presence is vital for environmental health and human sustenance. However, the alarming decline in bee populations underscores the urgent necessity for enhanced protection measures. Understanding the relationship between bee populations and flowering patterns, as well as plant species composition and richness is essential for informing effective conservation strategies.

Megachile lanata was collected and monitored on a monthly basis inside the specified research area, which might reduce the chance of certain occurrences. Over time, *Megachile lanata* bees have cultivated a symbiotic relationship with their wild host plants to fulfill their needs for pollen and nectar. The feeding range of the *Megachile lanata* species has not before been studied. The objective of this research is to evaluate the prevalence of *Megachile lanata* species on both annual and perennial host plants at different monitoring locations, emphasizing their ability to adjust to a range of ecological niches in their native environment. *Megachile lanata* was observed to occur and be associated with floral hosts in twelve different species belonging to nine different plant families. Most commonly visited floral host plants families including Lamiaceae, Asteraceae, Rubiaceae, Bignoniaceae and Fabaceae. *Megachile lanata* (Fabricius) were reported active during early morning & afternoon hours and avoid the severe weather from October to February months**.**

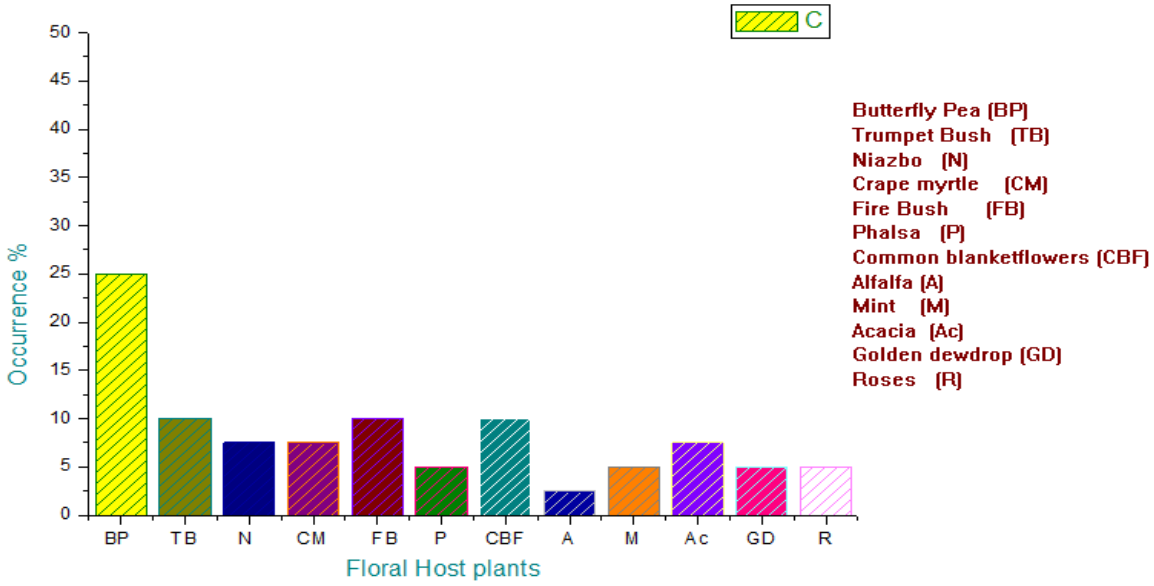

Figure 2. Occurrence and Floral host plant association.

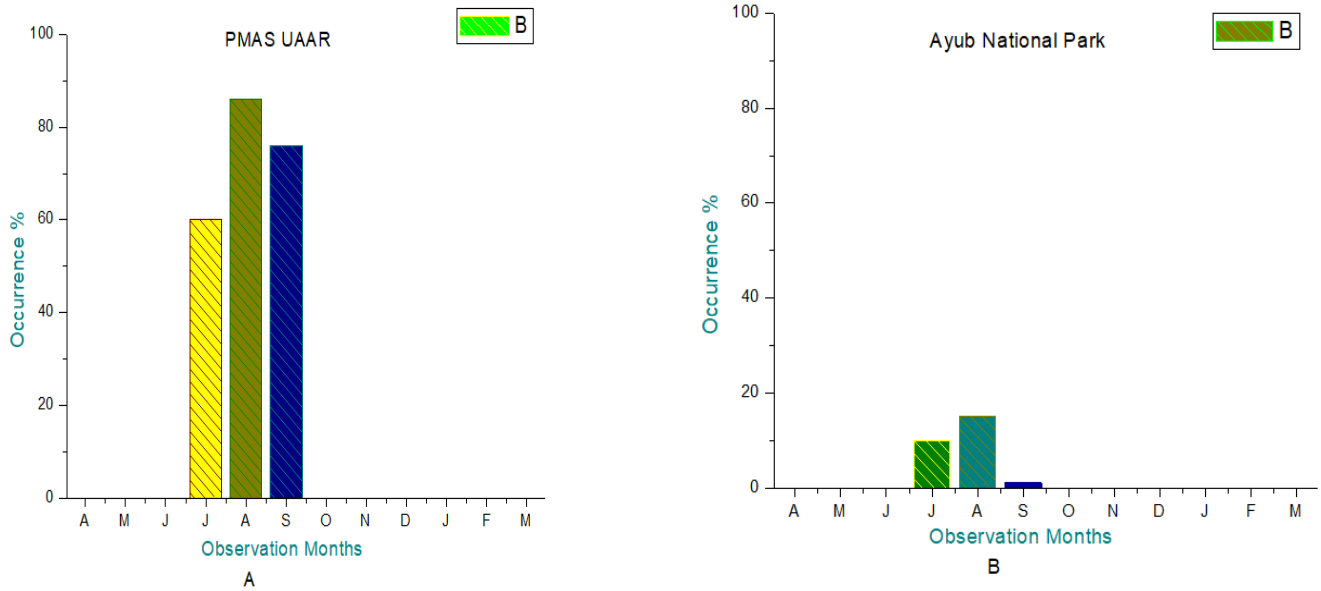

Figure 3 (a). Seasonal variation of *Megachile lanata* (Fabricius) under different landscapes for the year 2021-22.

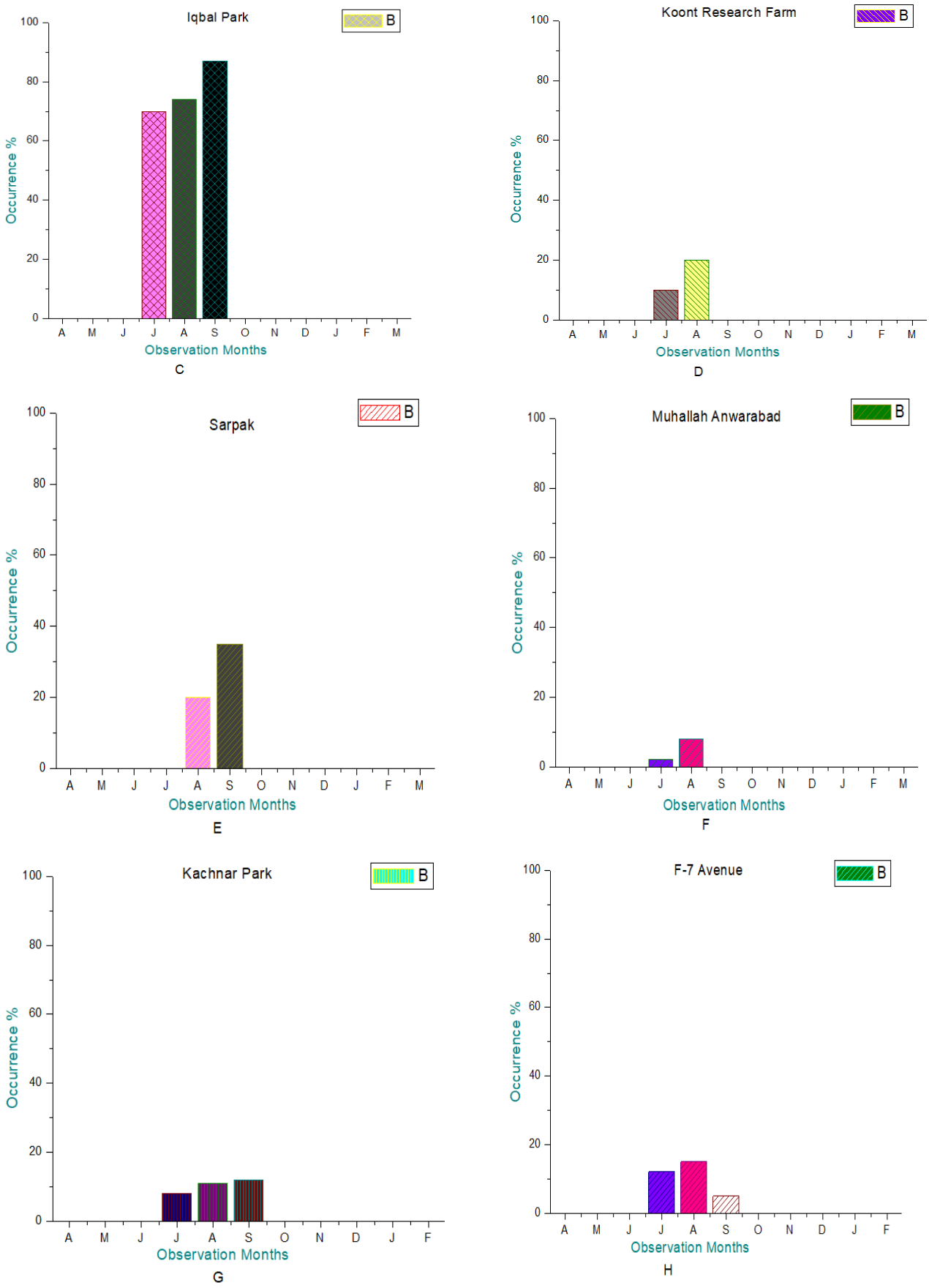

Figure 3 (b). Seasonal variation of *Megachile lanata* (Fabricius) under different landscapes for the year 2021-22.

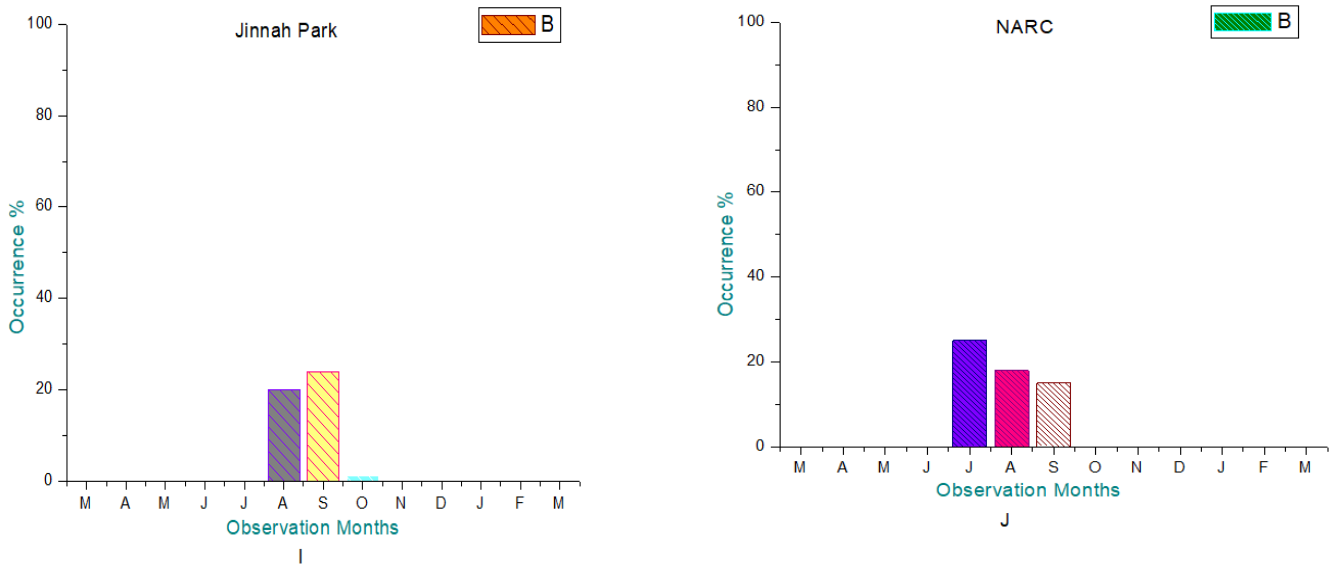

Figure 3 (c). Seasonal variation of *Megachile lanata* (Fabricius) under different landscapes for the year 2021-22.

Twelve plant species from nine different families were examined as host plants in ten new locations on the Pothohar plateau in Punjab, Pakistan (Table 2).The *Megachile lanata* species visited various plant families to collect nectar and pollens. These families included Fabaceae, Bignoniaceae, Lamiaceae, Lythraceae, Rubiaceae, Malvaceae, Asteraceae, Verbenaceae and Rosaceae. The five most commonly visited plant species were *Clitoria ternatea, Tecoma stans, Hamelia patens, Gaillardia aristata* and *Ocimum basilicum*. These plants belong to different families including Lamiaceae, Asteraceae, Rubiaceae, Bignoniaceae and Fabaceae (as listed in Table 2). The smallest quantity of *Megachile lanata* (Fabricius) bees were observed in the Chakwal and Islamabad areas including F-7th Avenue, Sarpak and Koont research farm, it may be a result of the bees' limited foraging options due to few flowering plants and dense forest areas.

Table 2. Plant species visited by *Megachile lanata* (Fabricius) form Localities of Rawalpindi, Islamabad and Chakwal, Pakistan during the year 2021-22.

Family	Plants	Scientific name	Status*	Flowering Time	Locations
Fabaceae	Butterfly Pea	*Clitoria ternatea*	High	Early August	PMAS-Arid Agriculture University Rawalpindi
Bignoniaceae	Trumpet Bush	*Tecoma stans*	High	August-September	Iqbal Park, Ayub National Park, F-7 Avenue, Koont research farm, Jinnah Park, Fatima Jinnah Park, PMAS-Arid Agriculture University Rawalpindi
Lamiaceae	Niazbo	*Ocimum basilicum*	Medium	Mid- August	PMAS-Arid Agriculture University Rawalpindi
Lamiaceae	Mint	*Mentha spp.*	Medium	Mid- August	PMAS-Arid Agriculture University Rawalpindi
Lythraceae	Crape myrtle	*Lagerstroemia indica*	Low	Early September	Iqbal Park, Ayub National Park, Fatima Jinnah Park, F-7th Avenue
Rubiaceae	Fire Bush	*Hamelia patens*	Medium	August-September	PMAS-Arid Agriculture University Rawalpindi
Malvaceae	Phalsa	*Grewia asiatica*	Low	Early August	PMAS-Arid Agriculture University Rawalpindi, National Agriculture Research Centre
Asteraceae	Common blanketflower	*Gaillardia aristata*	Medium	August-September	PMAS-Arid Agriculture University Rawalpindi, NARC, Islamabad
Fabaceae	Alfalfa	*Medicago*	Low	Early	Sarpak, Muhallah Anwarabad

		sativa		September	
Fabaceae	Acacia	*Acacia nilotica*	Low	Early September	Sarpak, Muhallah Anwarabad
Verbenaceae	Golden dewdrop	*Duranta erecta*	Low	Middle August	PMAS-Arid Agriculture University Rawalpindi, Iqbal Park, Ayub National Park
Rosaceae	Roses	*Rosa indica*	Low	Middle August	PMAS-Arid Agriculture University Rawalpindi, Iqbal Park, Ayub National Park

AAUR, Arid Agriculture University Rawalpindi Campus.
*High, medium and Low host classified on the basis of *Megachile lanata* (Fabricius) visitation rate.

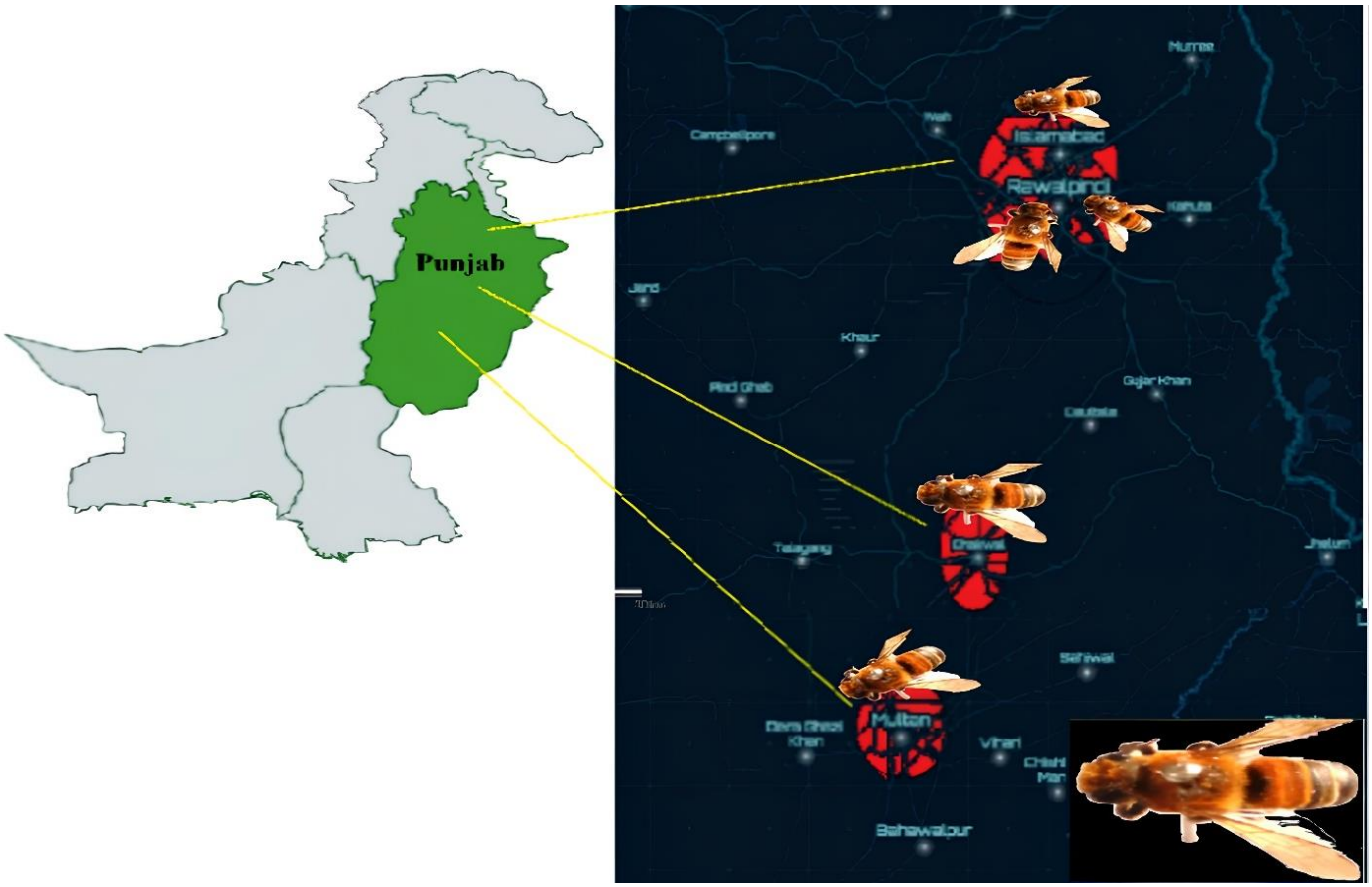

Fig-4 Occurrence of *Megachile* (*Pseudomegachile*) *lanata* (Fabricius, 1775) in Pakistan.

This map illustrates the presence and geographical distribution of *Megachile lanata* (Fabricius) in various areas of Punjab, Pakistan, including Rawalpindi, Islamabad, Chakwal and Multan (Fig-4).

CONCLUSION

In conclusion, *Megachile (Pseudomegachile) lanata* (Fabricius, 1775) is a widespread bee species found in Asia, Europe, North America and Africa. It associates with various host plants from the Asteraceae, Rosacea and Fabaceae families and has a distinctive large and hairy scopa for collecting and carrying pollen and nectar. The resource foraging ability of an organism is crucial for plant pollination, biodiversity and ecosystem stability. The species *Megachile lanata* (Fabricius) was seen visiting twelve different host plants from various plant families for their nectar and pollen resources. These floral plants were the primary source for these resources both in wild and managed parks. The range of *Megachile lanata* (Fabricius) was quite diverse, with the most frequently visited plants being from the Fabaceae family. However, plants that had longer lasting floral resources were visited more often than those that only had a short blooming season.

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STATEMENT OF CONFLICT

Authors have declared no conflict of interest.

REFERENCES

Abdulaziz, S., Hannan, M. A., Gonzalez, V. H., & Michael, S. E. (2014). Nesting biology of the leafcutting bee *Megachile minutissima* (Hymenoptera: Megachilidae) in central Saudi Arabia. *Annals of the Entomological Society of America, 107*(3), 635–640. DOI:10.1603/AN13165

Abdur, R., Shafqat, S., Mudassar, A., & Muhammad, H. N. T. (2022). Nest preference and ecology of cavity-nesting bees (Hymenoptera: Apoidea) in Punjab, Pakistan. *Journal of Asia-Pacific Entomology, 25*(2), 101–907. DOI:10.1016/j.aspen.2022.101907

Ascher, J. S., & Pickering, J. (2018). Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila)*.50*. DOI: http://www. discoverlife. org/mp/20q, 2011.

Ascher, J. S., & Pickering, J. (2020). Discover life bee species guide and world checklist (Hymenoptera: Apoidea). http://www. discoverlife. org/mp/20q, 2011.

Ascher, J. S., & Pickering, J. (2021). Discover life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). *Bees, Wasps & Ants Recording Society, 1*(2), 7. http://www. discoverlife. org/mp/20q, 2011.

Eardley, C. D., & Urban, R., (2010). Catalogue of Afrotropical bees (Hymenoptera: Apoidea: Apiformes). *Zootaxa, 2455*: 1–548. DOI:10.11646/zootaxa.2455.1.1

Eickwort, G. C., & Carpenter, J. M. (1981). Observations on the nesting behavior of *Megachile rubi* and *Megachile texana* with a discussion of the significance of soil nesting in the evolution of megachilid bees (Hymenoptera: Megachilidae). *Journal of the Kansas Entomological Society, 2*(5), 569–570. https://www.jstor.org/stable/25084194

Genaro, J. A. (1996). [1997] Key to the genus *Megachile, Chalicodoma* group (Hymenoptera: Megachilidae) in Cuba. *Revista de Biología Tropical, 44*(3), 193-198. https://www.researchgate.net/publication/267961076.

Gibbs, J., Ascher, J. S., Rightmyer, M. G., & Isaacs, R. (2017). The bees of Michigan (Hymenoptera: Apoidea: Anthophila), with notes on distribution, taxonomy, pollination, and natural history. Zootaxa, 4352(1), 1-160. DOI: 10.11646/zootaxa.4352.1.1.

Gonzalez, V., Guevara, D., Jaramillo-Silva, J., & Ospina-Torres, R. (2019). Discovery of Megachile (Pseudomegachile) lanata (Fabricius, 1775) (Hymenoptera, Megachilidae) in Colombia, an adventive bee species from the Old World. *Check List, 15*, 45-48. DOI: 10.15560/15.1.45.

Gonzalez, S. M., Victor, H. E., Ismael, A., & Entomological, K. (2010). A new species of Megachile from Pakistan, with taxonomic notes on the subgenus *Eutricharaea* (Hymenoptera: Megachilidae). *Journal of the Kansas Entomological Society, 83*(1), 58–67. DOI: 10.2317/JKES0905.16.1.

Greenleaf, S. S. & Kremen, C. (2006). Wild bees enhance honey bees´ pollination of hybrid sunflower. *Proc. Natl. Acad. Sci. USA103*, 13890–13895. DOI: 10.1073/pnas.0600929103

Gupta, R. K. (1993). Taxonomic studies on the Megachilidae of North-Western India. *Scientific Publishers (India),* 1–294. DOI: org/doi/full/10.5555/19990507103

Henson, K. A., Campbell, J. W., & Kaplan, D. A. (2019). Range extension of *Megachile lanata* (Fabricius) (Hymenoptera: Megachilidae), a non-native sunn hemp pollinator, in Florida. *Florida Entomologist, 102*(1), 259-261. DOI: .org/10.1653/024.102.0148

Klein, A. M., Vaisiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B, 274*, 303-313. DOI:org/10.1098/rspb.2006.3721

Litman, J. R., Danforth, B. N., Eardley, C. D., & Praz, C. J. (2011). Why do leafcutter bees cut leaves? New insights into the early evolution of bees. *Proceedings of the Royal Society, 278*(1724), 3593–3600. DOI:10.1098/rspb.2011.0365

Meurgey, F. (2016). Bee species and their associated flowers in the French West Indies (Guadeloupe, Les Saintes, La Désirade, Marie Galante, St Barthelemyand Martinique) (Hymenoptera: Anthophila: Apoidea). *Annales de la Société Entomologique de France, 52*(4), 209-232. DOI:10.1080/00379271.2016.1244490

Morato, E. F., & Martins, R. (2006). An overview of proximate factors affecting the nesting behavior of solitary wasps and bees (Hymenoptera: Aculeata) in preexisting cavities in wood. *Neotropical Entomology, 35*(2), 285-298. DOI:10.1590/S1519-566X2006000300001

Moure, J. S. (1953). Notas sobre Megachilidae de Bolivia, Perú y Chile. *Dusenia, 4*(2), 113-124. DOI:10.17161/jom.v0i5.4451

Moure, J. S., Melo, G. A. R., & DalMolin, A. (2007). *Megachilini Latreille,* 1802. In J. S. Moure, D. Urban, & G. A. R. Melo (Eds.), Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region. *Sociedade Brasileira de Entomologia,* 917-1001. ISBN: 978-85-85729-08-0

Pollard, E. (1977). A method for assessing changes in the abundance of butterflies. *Biological Conservation*, *12*(2), 115–134. https://doi.org/10.1016/0006-3207(77)90065-9

Pasteels, J. J. (1965). Revision des Megachilidae (Hymenoptera Apoidea) de l'Afrique noire. I. Les genres Creightoniella [sic], *Chalicodoma* et *Megachile* (s. str.). Annales, Serie IN-8, *Sciences Zoologiques, 137*, 1-579. https://openlibrary.org/works/OL5449936W

Pauly, A. (2012). Three new species of *Eupetersia* Blüthgen 1928 (Hymenoptera, Halictidae) from the Oriental Region. *European Journal of Taxonomy*, (14). DOI: 0.15298/euroasentj.20.4.03

Rasmont, P., Devalez, J., Pauly, A., Michez, D., & Radchenko, V. G. (2017). Addition to the checklist of IUCN European wild bees (Hymenoptera: Apoidea). *Annales de la Société entomologique de France, 53*, 17-32. DOI: 10.1080/00379271.2017.1307696.

Rauf, A., Saeed, S., Ali, M., & Nadeem Tahir, M. H. (2021). Comparative efficiency of native insect pollinators in reproductive performance of *Medicago sativa* L. in Pakistan. *Insects, 12*(11), 1029. https://doi.org/10.3390/insects12111029Raw, A. (2007). An annotated catalogue of the leafcutter and mason bees (Genus Megachile) of the Neotropics. *Zootaxa, 1601*, 1-127. https://doi.org/10.11646/zootaxa.1601.1.1

Sajjad, A., Bashir, M. A., Saeed, S., Khan, K. A., Ghramh, H. A., Shehzad, M. A., Mubarak, H., Mirza, N., Mahpara, S., Rehmani, M. I. A., & Ansari, M. J. (2019). Insect pollinator diversity in four forested ecosystems of southern Punjab, Pakistan. *Saudi Journal of Biological Sciences, 26*(7), 1835-1842. https://doi.org/10.1016/j.sjbs.2018.02.007

Sumera, A., Rafi, M. A., Zia, S. A., Munir, A., & Saljoki, A.-Ur-R. (2020). Faunistic study of Non-Apis bees (Hymenoptera: Apoidea) from Potohar Plateau of Pakistan. *International Journal of Bioscience, 16*(3), 221-230. http://dx.doi.org/10.12692/ijb/16.3.221-230

Udayakumar, A., & Timalapur, S. M. (2018). Trap-Nest Diameter Preference of *Megachile lanata* (Fabricius) (Hymenoptera: Megachilidae). *Journal of Entomological Science, 53*, 96-98. DOI:10.18474/JES17-88.1

Veeresh, K. (2018). Diversity and conservation of leaf cutter bees (Hymenoptera: Megachilidae). *Advances in Plants & Agriculture Research, 8*(1), 2. DOI:10.15406/apar.2018.08.00291

Wedmann, S., Wappler, T., Engel, M. S., & Michael, S. (2009). Direct and indirect fossil records of megachilid bees from the Paleogene of Central Europe (Hymenoptera: Megachilidae). *Naturwissenschaften, 96*(6), 703-712. DOI:10.1007/s00114-009-0525-x

Winfree, R., Williams, N. M., Dushoff, J. & Kremen, C. (2007). Native bees provide insurance against ongoing honeybee losses*. Ecol. Lett. 10*, 1105–1113. DOI: 10.1111/j.1461-0248.2007.01110.x