Indian Journal of Ecology (2025) 52(6) (SI): 1808-1814
DOI: https://doi.org/10.55362/IJE/2025/4734

Manuscript Number: 4734
NAAS Rating: 5.38

Foraging Activity and Nesting Behaviour of Leafcutter Bees, *Megachile lanata* (F.) and *Megachile disjuncta* (F.)

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Abstract: This study investigated the nesting behaviour, nest architecture, substrate acceptance, and foraging activity of *Megachile lanata* and *Megachile disjuncta* during 2023–2024 at the Agricultural Research Station, Vijayarai, Andhra Pradesh, India. Both species exhibited distinct temporal foraging patterns and differential visitation rates across crops. Nesting occurred in pre-existing cavities, with both species constructing linear series of brood cells i.e., *M. lanata* used leaf material and red earth, whereas *M. disjuncta* employed wax-propolis mixtures. Mid-range substrate diameters (0.8–1.0 cm) were preferentially accepted, with species-specific differences in optimal diameters. Overall, this research helps to fill significant knowledge gaps in the nesting ecology of *M. lanata* and *M. disjuncta*, and supports further studies on their role as pollinators in diverse ecosystems.

Keywords: Nesting, Pollinators, Cells, Domiciliation, *Megachile lanata, Megachile disjuncta*

Megachilid genera are most commonly known as mason bees and leafcutter bees within the family Megachilidae (Hymenoptera) reflecting the materials from which they construct their nest cells i.e., soil or leaves respectively. Due to their long tongue, oligolectic foraging behaviour, faster foraging trips, and scopa on ventral side for collecting pollen, non- Apis bees are regarded as more effective pollinators than Apis pollinators of a large number of cultivated and wild flowering plants (Raina et al., 2023). *Megachile* species are solitary and highly adaptive and build their nests in pre-existing cavities, e.g., wooden logs, hollow stems of bamboo and roses, burrows in the soil, cracks and crevices, and slits in rocks or man-made structures. Some species use plant resins in nest construction and are correspondingly called resin bees which are also recognized as potential pollinators of the number of crops. Globally, the family Megachilidae is one of the largest families of bees, comprising over 50 subgenera and more than 3,000 angiosperm host species. Their ecological role and high pollination efficiency highlight the importance of conservation. The late 1950s saw the recognition of the benefits of employing leaf cutter bees as pollinators (Stephen et al., 1969, Bohart 1972). The genus *Megachile* and the family Megachilidae include several non-native imported bees, many of which are well represented in terms of species numbers. This is largely because they can be readily transported within vegetative portions as they nest in stems, twigs, and wood cavities (Russo 2016). *Megachile* is known to build its nest in bamboo reeds and use a mud and resin mixture to seal the cells (Osaka Museum collection 2017).

Each female constructs cells made from pieces of leaves and petals, hence the name leafcutter bee. These cells are placed in any of a wide variety of situations such as in hollow weed stalks, in curled leaves, or in holes in the ground. They may occur singly or in series, placed end to end. Each cell is provisioned with a viscous mass of honey and pollen, sufficient to provide food for the entire larval development. An egg is then laid on top of the food mass and the cell is closed with a cap made from additional pieces of petals and leaves. There are two types of favorable habitats which cause concentrations of the bees. One is called a nesting habitat as it provides nesting sites and pollen sources as well as nectar. So far as is known, all plants utilized for pollen also provide nectar, bees thrust their proboscices into the flowers to suck nectar while collecting pollen. The others called a nectar habitat, which provides flowers that are highly attractive as nectar sources but are not used for pollen, and may not have nesting sites in the vicinity (Young et al., 2016). Within this context, the present study focuses to document the nesting biology of *M. lanata* and *M. disjuncta* including describing the structure of their nests, the materials employed for construction of brood cells, and record the pollen resources used by females.

Pollination services provided by bees are vital for terrestrial ecosystems and agricultural productivity (Roig Alsina, 2008). However, intensification and expansion of agriculture remain two of the greatest global threats to biodiversity (Donald and Evans, 2006). Habitat destruction, fragmentation, reduced floral diversity, and the introduction of competing species pose significant challenges to native bee populations (Kremen et al., 2002, Silveira, 2004, Freitas et al., 2009, Medan et al., 2011). Studies from agro-ecosystems, such as those in the Inland Pampa (Durante and Torretta 2010), highlight the need for ecological research on bee diversity and nesting biology of leaf cutter bees.

MATERIAL AND METHODS

Study area: The study was conducted during 2023-2024 at Agricultural Research Station(ARS), Vijayarai (16.8121^{0}N and 81.0327^{0} E). A total of three pollinator sheds were erected at different locations at ARS, Vijayarai (Fig. 1). Bamboo nodes and *Saccharum spontaneum* sticks with diameters ranging from 0.5-1.5 cm and lengths ranging from 3-4 feet were installed in the pollinator sheds (Fig. 1). The bundles of Saccharum sticks and Bamboo nodes were stacked in a bundle of twenty-five each and were placed in pollinator shed (Table 2). The percent acceptance of *Saccharum* sticks and bamboo nodes by *M. disjuncta* and *M. lanata* was standardized and recorded. The observations on foraging activities of all the pollinators were recorded on sunny days undernormal temperature conditions. The activity of *M. lanata* and *M. disjuncta* was observed in the pollinators sheds to understand the nest preference by leaf cutter bees. The number of bees entering into and exiting out of bamboo nodes and saccharum sticks were recorded at three different intervals in a day i.e., 9 am, 1 pm and 3 pm. The sticks were cut longitudinally to observe various stages of young ones and to study the pattern of cell construction.

Floral hosts: The foraging activity of *M. lanata* and *M. disjuncta* was recorded during monthly visits to the study area (3–4 days per visit) by observing the foraging activity of adults on flowers of diancha (*Sesbania spinosa*), niger (*Guizotia abyssinica*) and sunhemp (*Crotalaria juncea*) at ARS, Vijayarai. These observations were made between 9:00 h and 16:00h on sunny days undernormal temperature on days when conditions were favorable for bee activity. The data for foraging activities of leaf cutter bees were recorded from initiation to cessation of blooms at three different intervals in a day *i.e*., 9 am, 1 pm and 3 pm. Furthermore, all plant species having entomophilous flowers were recorded during each visit.

RESULTS AND DISCUSSION

Foraging Activity of *Megachile lanata* and *Megachile disjuncta* on Various Crops

Foraging activity on Sesbania: *M. lanata* showed peak foraging activity at 1:00 PM, with an average of 0.62 visits per 2 minutes. However, the maximum number of flowers visited was at 3:00 PM, with 1.41 flowers visited per 2 minutes. Similarly, *M. disjuncta* also exhibited its highest foraging

a

b c

Fig. 1. a. Pollinators' shed with systematically arranged *Saccharum* sticks and Bamboo nodes to serve as nesting structures for leaf cutter bees; b. Bamboo nodes; c: Saccharum sticks

activity at 1:00 PM (0.62 visits/2 min), but demonstrated significantly greater flower visits, visiting 3.52 flowers/2 min at the same hour. This indicates that *M. disjuncta* is potentially a more efficient forager on Diancha than *M. lanata* during peak activity periods.

Foraging activity on Niger: For *M. lanata*, both peak foraging activity (0.67 visits/2 min) and maximum flower visits (2.89 flowers/2 min) occurred at 3:00 PM, suggesting a strong preference for afternoon foraging on this crop. *M. disjuncta* also exhibited its highest foraging rate on Niger at 3:00 PM, with 0.83 visits/2 min. Interestingly, the number of flowers visited was relatively low at this time, with only 0.46flowers/2 min. (Table 1).

Foraging activity on Sunhemp: *M. lanata* displayed peak activity at 1:00 PM (0.33 visits/2 min), while the highest flower visitation was recorded at 9:00 AM (1.60 flowers/2 min**).** This suggests a possible early morning preference for floral rewards, despite more frequent activity later in the day. *M. disjuncta* showed its highest activity at 9:00 AM (0.31 visits/2 min), with the number of flowers visited peaking at 3:00 PM (2.21 flowers/2 min). These findings indicate a broader temporal foraging range for *M. disjuncta* compared to *M. lanata*, especially on sunhemp (Table 1).

Overall, *M. disjuncta* demonstrated higher flower visitation rates than *M. lanata* on diancha and sunhemp, while *M. lanata* showed greater efficiency on Niger (Fig. 2). These patterns suggest crop-specific preferences and temporal variations in foraging behavior between the two species, which could be influenced by floral morphology, nectar availability, and environmental conditions.

Nest, cell structure and biology of *M. lanata*: The nests of *Megachile lanata* were constructed in alinear series, with each occupied *Saccharum* stick or bamboo node containing six to eight brood cells. Cell construction typically began at

Table 1. Foraging activity of *Megachile* sp. on sesbania, niger and sunhemp flowers at ARS, Vijayarai

Time	No of bees / 2 min	No of flowers visited / 2 min	Time spent (sec)	No of bees / 2 min	No of flowers visited / 2 min	Time spent (sec)
	Megachile lanata			*Megachile disjuncta*		
Sesbania						
9.00 AM	0.14	0.62	2.20	0.31	1.33	4.41
1.00 PM	0.62	1.33	4.45	0.56	3.52	6.60
3.00 PM	0.35	1.41	4.20	0.54	2.54	6.02
Niger						
9.00 AM	0.25	1.23	2.96	0.50	1.44	2.71
1.00 PM	0.41	2.21	4.87	0.55	2.25	6.12
3.00 PM	0.67	2.89	6.33	0.83	3.46	6.80
Sunhemp						
9.00 AM	0.29	1.60	1.41	0.31	2.21	4.96
1.00 PM	0.33	1.29	1.08	0.16	0.58	0.50
3.00 PM	0.18	0.62	0.75	0.12	0.31	0.56

Table 2. Percent acceptance of Saccharum and bamboo nodes of different diameters *M. disjuncta* and *M. lanata*

Megachile disjuncta			*Megachilelanata*		
Treatments	Percent acceptance		Treatments	Percent acceptance	
	Saccharum	Bamboo		Saccharum	Bamboo
T1 (0.7-0.8cm)	12.51	21.35	T1 (0.8-0.9 cm)	23.38	19.33
T2 (0.8-0.9 cm)	28.15	28.97	T2 (0.9 to 1 cm)	31.94	25.21
T3 (0.9 to 1 cm)	20.43	16.40	T3 (1.0 to 1.1 cm)	19.82	19.53
T4 (1.0 to 1.1 cm)	17.60	10.76	T4 (1.1 to 1.2 cm)	12.43	14.51
T5 (1.1 to 1.2 cm)	10.80	9.29	T5 (1.2 to 1.3 cm)	6.56	8.57
T6 (1.2 to 1.3 cm)	7.72	7.64	T6 (1.3 to 1.4 cm)	3.63	7.79
T7 (1.3 to 1.4 cm)	3.36	5.52	T7 (1.4 to 1.5 cm)	2.20	5.01
CD (p=0.05)	2.66	2.65	CD (P=0.05)	4.96	4.01

the nodal septum of the nesting substrate. Nests were built using both leaf material and red earth, with plant species such as redgram (*Cajanus cajan*), roselle (*Hibiscus sabdariffa*), sunhemp (*Crotalaria juncea*), and rose (*Rosa* spp.) serving as leaf sources. In nests where red earth was used for construction, the nestentrance was sealed with a mixture of red earth and saliva. All nests, regardless of the building material, were ultimately closed using this red earth–saliva mixture. Each brood cell measured between 0.9 to 1.4 cm in length and 0.4 to 0.5 cm in diameter. The developmental stages included: Early stage grub hatched from egg in 03 days, the grub period was 9 days and pupal period was 22 days (Fig. 3).

Nest, cell structure and biology of *M. disjuncta:* Nests of *Megachile disjuncta* were also arranged in a linear series, with each *Saccharum* stick or bamboo node containing six to eight cells. Like *M. lanata*, construction generally began at the nodal septum of the nesting substrate. However, unlike *M. lanata*, the nest entrances of *M. disjuncta* were left open, without any form of sealing. The cells were constructed using

d e f

Fig. 2. D. Foraging activity of *M. lanata* on flowers of Sunhemp; E. Foraging activity of *M.* F *disjuncta* on flowers of sesbania; F. Foraging activity of *M. disjuncta* on flowers of Niger

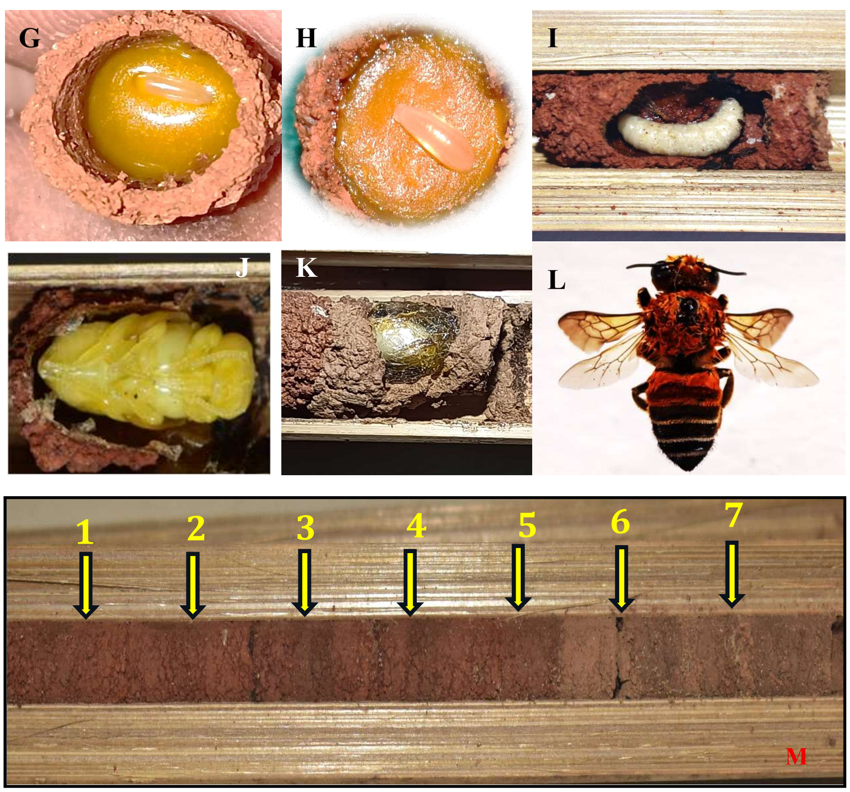

Fig. 3. Biology of *Megachile lanata* in Saccharum sticks& Bamboo nodes. G. Egg laid in provisioned food (pollen + nectar); H. Hatched egg; I. Grub; J. Pupa (inside view); K. Pupa (outside view); L. *Megachile lanata* (adult); M. Cells made of red earth constructed by *M. lanata*

a mixture of wax and propolis, and the interior walls of the sticks were polished with wax, giving them a smoother finish. Each brood cell measured 0.5-0.6 cm in length and 0.4-0.5 cm in diameter. The developmental stages followed the same pattern as in *M. lanata* (Fig. 4).

Pollen provisions: The pollen provisions inside the brood cells were yellow, moistened with nectar, and typically occupied about half of the cell volume. The egg was deposited in a slanting position on the pollen mass. After pupation, the cocoon filled the entire inner dimension of the cell and was composed of a thin silk layer embedded within a thicker, dark brown matrix. In cells constructed with red earth, brown fecal material was observed adhering to the external surface of the cocoon (Eickwort et al., 1981).

Nest Substrate Preferences of *M. lanata* and *M. disjuncta*

Percent acceptance of *Saccharum* sticks with different diameters: The selection of *Saccharum* sticks of varying diameters by leafcutter bees was assessed during 2023–24 to determine substrate preferences for nesting. For *Megachile disjuncta*, the highest acceptance was observed in T2 (0.8–0.9 cm diameter) sticks, with acceptance of 28.15%, followed by T3. In *Megachile lanata*, the highest preference was for T2 (0.9–1.0 cm), with an acceptance rate of 31.94%, followed by T1. These results suggest that *M. disjuncta* prefers slightly narrower sticks (0.8–0.9 cm), whereas *M. lanata* shows a higher preference for slightly wider sticks (0.9–1.0 cm). This difference may be attributed to variations in body size and nesting behavior between the two species (Table 2).

Percent acceptance of bamboo nodes with different diameters: Similar trends were observed in the acceptance of bamboo nodes as nesting substrates. For *Megachile disjuncta*, the highest acceptance was in T2 (0.8–0.9 cm) nodes with 28.97%, followed by T1. For *M. lanata*, the highest acceptance was again in T2 (0.9–1.0 cm) at 25.21%, followed by T3. These findings indicate that while both species show a strong preference for mid-range diameters (0.8–1.0 cm), *M. lanata* tends to prefer slightly larger diameters than *M. disjuncta*. The preference could be influenced by nesting requirements such as space for brood cells, ease of entry, or thermal insulation (Table 2). Mid-range diameters between 0.8 to 1.0 cm appear to be most suitable for both *M. lanata* and *M. disjuncta*. The slight variation in optimal diameters between the two species should be considered in conservation strategies and artificial nesting programs, especially if these species are to be used for pollination services in agricultural landscapes.

Kunjwal et al. (2021) reported that *Megachile (Eutricharea) studiosa* Bingham females constructed 1–6 brood cells per nest and used leaf pieces of three different sizes to build each cell. Female emergence occurred after 29 days. Kunjwal et al. (2021) observed that *M. disjuncta*, visited 30 species for nectar/pollen and 19 species for leaf material from 17 plant families. Dos Santos et al. (2020) analyzed the larval diet of *Megachile zapotlana* and concluded that the species was polylectic, with pollen sourced from 19 plant species, predominantly from the families of Asteraceae, Rubiaceae, Plantaginaceae, and Fabaceae. Similar nest-lining behaviors was observed in *Megachile cephalotes*, where females apply resin and other secretions to fortify cell walls and protect brood from desiccation and pathogens (Akram et al., 2022). Heroldvê et al. (2021) and Bogo et al. (2024) also reported the use of plant-derived materials in other groups, such as *M. ligniseca* and *M. sculpturalis*, both

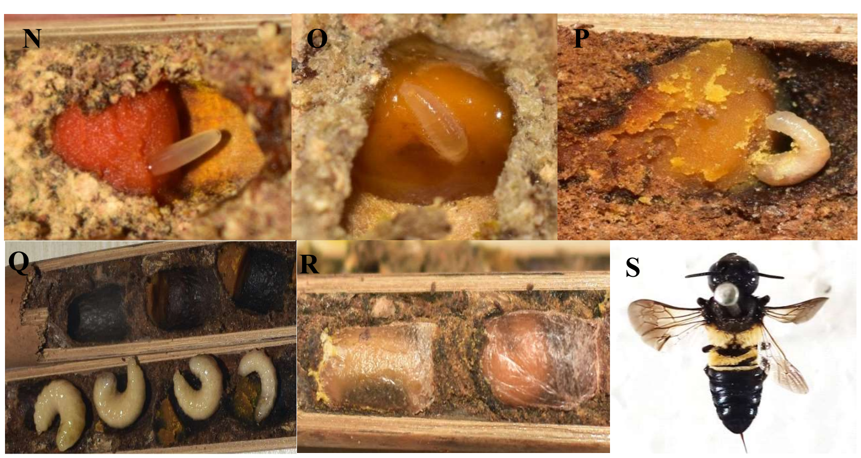

Fig. 4. Biology of *Megachile disjuncta* in Saccharum sticks and Bamboo nodes. N. Freshly laid Egg; O. Hatched egg; P. *M. disjuncta* grub feeding upon provisioned food(pollen + nectar);Q. Various grub stages; R. Pupal stages of *M. disjuncta;*S. *M. disjuncta* (Adult)

of which exhibit species-specific nest-building behaviors that enhance brood protection and structural stability. The brood-cell dimensions recorded in the present study (0.5–0.6 cm length, 0.4–0.5 cm diameter) fall within the lower size range reported for smaller-bodied *Megachile* species. Dos Santos et al. (2020) documented similarly compact cells in *M. zaptlana*, whereas larger species such as *M. sculpturalis* construct substantially wider and deeper cells due to their greater body size (Bogo et al., 2024). These variations demonstrate the strong morphological constraints that shape nest architecture across the genus. Comparable larval and pupal durations have also been reported in *M. cephalotes* and *M. zaptlana*, although slight variations occur depending on temperature, resource availability, and cell size (Dos Santos et al., 2020, Akram et al., 2022).

CONCLUSION

This study elucidated distinct foraging and nesting patterns in *M. lanata* and *M. disjuncta*. *M. disjuncta* generally showed higher visitation rates on *Sesbania* and sunhemp, while *M. lanata* displayed greater efficiency on Niger, indicating species−specific and temporally variable foraging behaviour. Both species built linear nests in Saccharum sticks and bamboo nodes, but differed in construction materials and brood cell dimensions. *M. lanata* used leaf fragments and red earth with sealed entrances, whereas *M. disjuncta* used wax propolis mixtures with open entrances. Brood cell provisioning and development patterns were consistent with those reported in other *Megachile* studies, in which linear brood chambers are provisioned with pollen and nectar mixtures and eggs are laid on the provision mass. The preference for mid−range nesting diameters (0.8–1.0 cm) reflects species−specific nesting requirements potentially linked to body size, a pattern also seen in related research where cavity diameter corresponded to bee morphology. These findings enhance understanding of the reproductive ecology of these leafcutter bees and necessitate conservation and artificial nesting strategies aimed at sustainable pollination services in agricultural landscapes.

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to ICAR- All India Coordinated Research Project on Honey bees & Pollinators, New Delhi for providing, funding and support for study.

AUTHOR'S CONTRIBUTION

Mohan Rao K contributed to investigation, data curation, implementation, and writing and editing of the manuscript. Alekhya G assisted in investigation, literature collection, review, and editing. Kumar Naga provided supervision and validation. Sachin Suresh Suroshe was involved in conceptualization, project administration, and validation. Srinivas T contributed to review and editing. All authors have read and approved the final manuscript.

REFERENCES

Akram W, Sajjad A, Ghramh HA, Ali M and Khan KA 2022. Nesting biology and ecology of a resin bee, *Megachile cephalotes* (Megachilidae: Hymenoptera). *Insects* **13**(11): 1058.

Bogo G, Fisogni A, Iannone A, Grillenzoni FV, Corvucci F and Bortolotti L 2024. Nesting biology and nest structure of the exotic bee *Megachile sculpturalis*. *Bulletin of Entomological Research* **114**(1): 67-76.

Bohart GE 1972. Management of wild bees for the pollination of crops. *Annual Review of Entomology* **17**: 287-312.

Donald PF and Evans AD 2006. Habitat connectivity and matrix restoration: the wider implications of agri environment schemes. *Journal of Applied Ecology* **43**: 209-218.

Dos Santos A, Parizotto D, Schlindwein C and Martins, C F. 2020. Nesting biology and flower preferences of *Megachile (Sayapis) zaptlana*. *Journal of Apicultural Research* **59**(4): 609-625.

Durante SP and Torretta JP 2010. First description of male of *Megachile* (*Pseudocentron) gomphrenoides* Vachal and redescription of female (Hymenoptera, Megachilidae). *Transactions of the American Entomological Society* **136**: 235-240.

Eickwort George C, Matthews Robert W Carpenter, James 1981. Observations on the nesting behavior of *Megachile rubi* and *M. texana* with a discussion of the significance of soil nesting in the evolution of Megachilid Bees (Hymenoptera: Megachilidae). *Journal of the Kansas Entomological Society* **54**(3): 557-570.

Freitas BM, Imperatriz-Fonseca VL, Medina LM, de MP, Kleinert A, Galetto L, Nates-Parra G and Quezada Euán JJG. 2009.Diversity, threats and conservation of native bees in the Neotropics. *Apidologie* **40**: 332–346.

Heroldovê M, Zejda J, Raus P and Gregor F 2021. New localities and nesting behaviour of the solitary bee *Megachile ligniseca* (Hymenoptera, Megachilidae). *Acta Musei Moraviae Scientiae Biologicae* **106**(2): 357-363.

Kremen C, Williams NM and Thorp RW 2002. Crop pollination from native bees at risk from agricultural intensification. **In**: *Proceedings of National Academy of Sciences*. USA **99**: 16812-16816.

Kunjwal N, Khan MS, Kumar G and Srivastava P 2021. Notes on the nesting ecology of the Megachile bees from North India. *Journal of Apicultural Research* **60**(5): 807-816.

Kunjwal N, Khan MS and Srivastava P 2021. Nesting biology of *Megachile (Eutricharea) studiosa* Bingham, a leafcutter bee. *Journal of Apicultural Research* **60**(3): 491-502.

Medan D, Torretta JP, Hodara K, de la Fuente, EB and MontaldoN. 2011.Effects of agriculture expansion and intensification on the vertebrate and invertebrate diversity in the Pampas of Argentina. *Biodiversity Conservation* **20:** 3077-3100.

Osaka Museum Collection. 2017- *Chalicodomadis junctiformis*. (accessed December 2017).

Raina RH, Pathak P, Kumar K and Jangid T 2023. The family Megachilidae (Hymenoptera: Apoidea) in pollination ecology: A review. *Indian Journal of Entomology* 1-7.

Roig A 2008. Apiformes. **In**: Claps LE, Debandi G, Roig-Juñent S (eds.) Biodiversidad de artrópo dos argentinos. Sociedad Entomológica Argentina ediciones. *Mendoza* **2:** 373-390.

Russo L 2016. Positive and negative impacts of non-native bee species around the world. *Insects* **7**(4): 69.

Silveira FA 2004. Monitoring pollinating wild bees. **In**: Freitas BM, Pereira JOP (eds.) *Solitary bees: Conservation, rearing and management for pollination*. p. 73-76.

Stephen WP, Bohart GE and Torchio PF 1969. *The Biology and external morphology of bees.* Agricultural Experiment Station, Oregon State University, Corvalllis, Oregon. p135.

Young BE, Schweitzer DF, Hammerson GA, Sears NA, Ormes MF and Tomaino AO 2016. *Conservation and Management of North American Leafcutter Bees.* Nature Serve, Arlington, VA.

Received 20 September, 2025; Accepted 10 December, 2025