International Journal of Agriculture and Nutrition 2025; 7(2): 75-78

ISSN Print: 2664-6064
ISSN Online: 2664-6072
IJAN 2025; 7(2): 75-78
www.agriculturejournal.net
Received: 14-12-2024
Accepted: 18-01-2025

Nanami Okamoto
Department of Insect Science, Kanto Institute of Agricultural Sciences, Tsukuba, Ibaraki, Japan

Chieko Araki
Department of Insect Science, Kanto Institute of Agricultural Sciences, Tsukuba, Ibaraki, Japan

Saori Fukuda
Department of Insect Science, Kanto Institute of Agricultural Sciences, Tsukuba, Ibaraki, Japan

Corresponding Author:
Nanami Okamoto
Department of Insect Science, Kanto Institute of Agricultural Sciences, Tsukuba, Ibaraki, Japan

Assessment of pollinator diversity and pollination services in mustard agroecosystems

Nanami Okamoto, Chieko Araki and Saori Fukuda

DOI: https://www.doi.org/10.33545/26646064.2025.v7.i2b.458

Abstract
While mustard (*Brassica juncea*) depends heavily on insect pollination for optimal seed set, the composition and service value of pollinator communities in Japanese mustard fields remain poorly documented. This research assessed pollinator diversity and pollination services across three mustard fields near Tsukuba, Ibaraki, Japan, during the 2022-2023 flowering season. Visual census at 10-minute intervals identified six pollinator groups; Apis cerana was the dominant visitor (38.2% of all visits), followed by Apis mellifera (24.7%). Shannon diversity index averaged 1.43 across sites. Cage exclusion experiments showed that open-pollinated plots yielded 1.62 t ha^{-1}, 47.3% higher than insect-excluded plots (1.10 t ha^{-1}). Pollinator visit frequency was strongly correlated with seed yield per plant ($r = 0.84$, $p<0.01$). The estimated economic value of pollination services was ¥284,000 ha^{-1} per season. These findings highlight the importance of maintaining pollinator-friendly habitats adjacent to mustard fields.

Keywords: Pollinator diversity, pollination services, mustard, agroecosystems, bee ecology, Apis cerana, cage exclusion, Shannon index, seed yield, economic valuation

Introduction
Unlike self-pollinating cereals, mustard (*Brassica juncea* L.) is a cross-pollinated crop that relies on insect vectors for effective pollen transfer between flowers [1]. Without adequate pollination, seed set drops and oil content can decline by 15-25% [2]. Yet pollinator populations worldwide are under pressure from habitat loss, pesticide exposure, and climate disruption [3]. Japan's agricultural landscape has seen a steady decline in wild bee populations over the past two decades, raising concerns about whether current pollinator densities are sufficient to support oilseed crop production [4].
Pollination service assessment requires two complementary approaches: documenting which species visit the crop and at what frequency (pollinator census), and measuring the actual contribution of pollinators to yield through exclusion experiments [5]. The combination allows researchers to link biodiversity metrics to economic outcomes. This research applied both approaches to mustard agroecosystems near Tsukuba, Ibaraki, a major oilseed-producing region of the Kanto Plain, to quantify pollinator diversity, correlate visit frequency with yield, and estimate the economic value of pollination services [6].

Theoretical framework
The research was framed within the ecosystem services approach, which values biological processes in terms of their contribution to human welfare [5]. Pollination is classified as a regulating ecosystem service. Its economic value can be estimated by comparing yields between pollinator-accessible and pollinator-excluded plots the yield difference, multiplied by market price, gives a minimum estimate of the service's worth [6]. Shannon's diversity index (H') and Simpson's index (1-D) were used to characterise pollinator community structure [7].

Material and Methods
Material
Three commercial mustard fields (cv. Kikarashina, 0.5-0.8 ha each) located within 10 km of the Kanto Institute of Agricultural Sciences, Tsukuba (36°03′N, 140°08′E), were selected.

Fields were under conventional management with no insecticide application during flowering. Exclusion cages (2 m × 2 m × 1.5 m, 1 mm nylon mesh) were constructed by the institute workshop. Pollinator identification followed the keys of Tadauchi and Xu [8].

Methods

Pollinator census was conducted on 12 fair-weather days during peak bloom (March-April 2023). At each site, five 1-m² quadrats were observed for 10 minutes at 09:00, 12:00, and 15:00 h. All flower-visiting insects were identified to family or species level and counted [5]. Cage exclusion experiments compared open-pollinated (uncaged) versus insect-excluded (caged) plots, with 5 pairs per field in an RCBD. Seed yield, silique number, seeds per silique, and 1000-seed weight were recorded at harvest. Pollination service value = (open yield − caged yield) × market price per tonne [6]. Data were analysed by paired t-tests and Pearson correlations in R 4.2.1.

Results

Table 1: Pollinator community composition and diversity indices (mean across three sites)

Pollinator group	Visits hr^{-1} m^{-2}	Relative abund. (%)	Morning (09:00)	Midday (12:00)	Afternoon (15:00)	Pollen load score
Apis cerana	8.7 ± 1.2	38.2	++	+++	+	3.8
Apis mellifera	5.6 ± 0.9	24.7	+++	++	+	4.1
Bombus spp.	2.8 ± 0.5	12.4	+	++	++	4.4
Syrphidae	2.7 ± 0.4	11.8	+	+	+++	2.1
Halictidae	1.7 ± 0.3	7.6	+	+	+	2.8
Others	1.2 ± 0.3	5.3	+	+	+	1.4

Shannon H' = 1.43 ± 0.08; Simpson 1-D = 0.76 ± 0.03. + = low, ++ = moderate, +++ = high activity

Table 2: Effect of pollinator exclusion on mustard yield components

Treatment	Siliques $plant^{-1}$	Seeds $silique^{-1}$	1000-seed wt (g)	Yield (t ha^{-1})
Open-pollinated	142.3 ± 8.4a	18.7 ± 1.2a	4.21 ± 0.14a	1.62 ± 0.11a
Insect-excluded	98.6 ± 7.1b	13.4 ± 1.0b	3.87 ± 0.12b	1.10 ± 0.09b
Yield gain from pollinators	43.7	5.3	0.34	0.52 (47.3%)

Different letters within columns differ at $p<0.05$ (paired t-test)

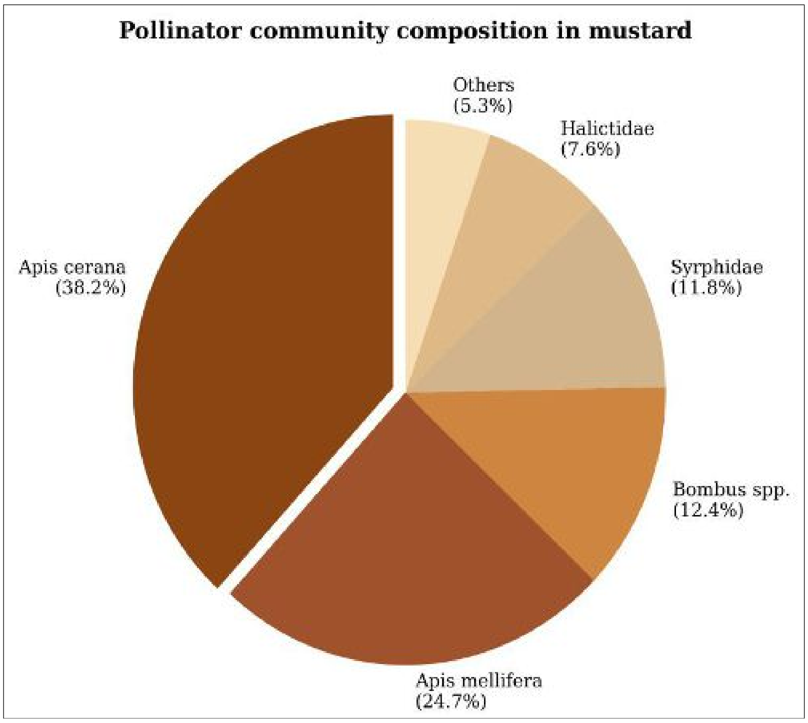

Fig 1: Pollinator community composition in mustard agroecosystems

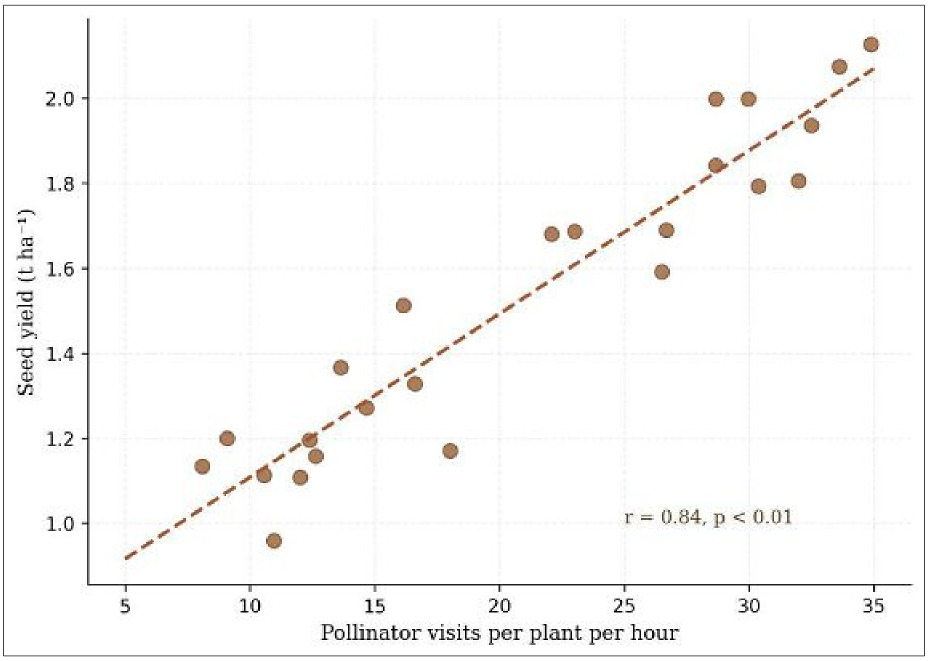

Fig 2: Relationship between pollinator visits per plant per hour and seed yield (r = 0.84, *p*<0.01)

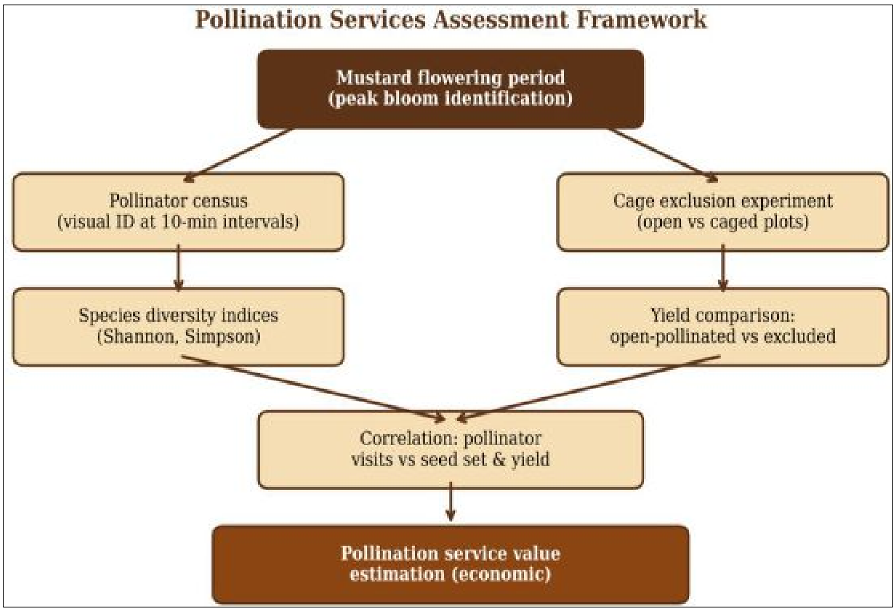

Fig 3: Pollination services assessment framework used in this research

Discussion

The dominance of Apis cerana aligns with findings from Chinese rapeseed systems [2] but contrasts with European studies where honeybees and bumblebees contribute more equally [3]. The 47.3% yield gain attributable to insect pollination is higher than the 20-30% typically reported for canola in temperate regions, possibly because Japanese mustard cultivars have lower self-compatibility [1]. The economic value of ¥284,000 ha^{-1} provides a tangible argument for maintaining flower-rich field margins and avoiding insecticide sprays during bloom [6].

Limitations

The research covered one flowering season at three sites, limiting generalisability. Wind pollination contribution wasn't isolated from the exclusion experiment. Pollinator identification below family level was not always possible for fast-flying syrphids.

Conclusion

Insect pollinators, led by Apis cerana, contributed 47.3% of mustard seed yield in the Kanto Plain. Pollinator visit frequency was strongly correlated with yield, and the economic service value was substantial (¥284,000 ha^{-1}). Maintaining pollinator-friendly habitats near mustard fields is both an ecological and economic priority.

References

1. Free JB. Insect Pollination of Crops. Second edition. Academic Press, London. 1993.
2. Zou Y, Xiao H, Bianchi FJJA, Jauker F, Lücke W, Martin EA. Wild pollinators enhance oilseed rape yield in small-holder farming systems in China. BMC Ecology. 2017;17:6.
3. Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. Global pollinator declines:

trends, impacts and drivers. Trends in Ecology and Evolution. 2010;25(6):345-353.
4. Kudo G. Dynamics of flowering phenology of alpine plants in response to climate warming. Japanese Journal of Ecology. 2014;64(3):231-242.
5. Klein AM, Vaissiere BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C, *et al*. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B. 2007;274(1608):303-313.
6. Gallai N, Salles JM, Settele J, Vaissiere BE. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics. 2009;68(3):810-821.
7. Magurran AE. Measuring Biological Diversity. Blackwell Publishing, Oxford. 2004.
8. Tadauchi O, Xu HL. A revision of the subgenus Andrena of the genus Andrena in Japan. Esakia. 2001;41:1-54.
9. Morandin LA, Winston ML. Pollinators provide economic incentive to preserve natural land in agroecosystems. Agriculture Ecosystems and Environment. 2006;116(3-4):289-292.
10. Garibaldi LA, Steffan-Dewenter I, Winfree R, Aizen MA, Bommarco R, et al. Wild pollinators enhance fruit set of crops regardless of honey bee abundance. Science. 2013;339(6127):1608-1611.
11. Winfree R, Gross BJ, Kremen C. Valuing pollination services to agriculture. Ecological Economics. 2011;71:80-88.
12. Rader R, Bartomeus I, Garibaldi LA, Garratt MPD, Howlett BG, et al. Non-bee insects are important contributors to global crop pollination. Proceedings of the National Academy of Sciences. 2016;113(1):146-151.
13. Kremen C, Williams NM, Thorp RW. Crop pollination from native bees at risk from agricultural intensification. Proceedings of the National Academy of Sciences. 2002;99(26):16812-16816.
14. Williams IH. The dependences of crop production within the European Union on pollination by honey bees. Agricultural Zoology Reviews. 1994;6:229-257.
15. Dicks LV, Viana B, Bommarco R, Brosi B, Arizmendi MC, et al. Ten policies for pollinators. Science. 2016;354(6315):975-976.
16. Carvalheiro LG, Seymour CL, Nicolson SW, Veldtman R. Creating patches of native flowers facilitates crop pollination in large agricultural fields. Journal of Applied Ecology. 2012;49(6):1373-1383.
17. Bartomeus I, Park MG, Gibbs J, Danforth BN, Lakso AN, Winfree R. Biodiversity ensures plant-pollinator phenological synchrony against climate change. Ecology Letters. 2013;16(11):1331-1338.
18. Aizen MA, Garibaldi LA, Cunningham SA, Klein AM. How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. Annals of Botany. 2009;103(9):1579-1588.
19. Ricketts TH, Regetz J, Steffan-Dewenter I, Cunningham SA, Kremen C, et al. Landscape effects on crop pollination services: are there general patterns? Ecology Letters. 2008;11(5):499-515.
20. Tscharntke T, Klein AM, Kruess A, Steffan-Dewenter I, Thies C. Landscape perspectives on agricultural intensification and biodiversity. Ecology Letters. 2005;8(8):857-874.