DIVERSITY OF NON-*APIS* BEES IN RICE ECOSYSTEMS — A CASE STUDY FROM KERALA

Bijoy C.[1], Rajmohana K.[2]*, Jobiraj T.[3] and Gnanakumar M.[4]
[1]Department of Zoology, Christ College (Autonomous) Irinjalakuda, Thrissur
[2]Zoological Survey of India, Kolkata 700053
[3]Western Ghat Regional Centre, ZSI , Calicut, Kerala
[4]Department of Zoology, Government College, Kodanchery
Corresponding author Email: mohana.skumar@gmail.com

INTRODUCTION

Agricultural intensification, along with conventional use of pesticides has resulted in biodiversity losses worldwide (Stoate *et al.* 2001; Butler *et al.* 2007). Biodiversity decline in agricultural landscapes is of increasing concern (Matson *et al.* 1997; Krebs *et al.* 1999) in the recent. Meanwhile several studies have proven that organic farming has the ability to foster biodiversity, thereby enhancing ecosystem services including pollination and pest control (Letourneau *et al.* 2008). Though organic systems are known to enhance species richness and abundance, the effects are not the same for all organisms and landscapes (Hole *et al.* 2005; Bengtsson *et al.* 2005).

Nearly 80% of pollination is performed by insects. Since 80% of the insect pollinators are bees, they are often regarded as the best pollinators (Robinson & Morse 1989). The most important non *Apis* species significant with regard to pollination are the solitary bees (Adamson 2011). Though the bees don't have a direct role in the pollination of self pollinating crops like paddy, the crop also benefits from insect pollination, that, yield could go up by 30 % from pollinator visits (Pratap 2001). Here lies the importance of insect flower visitors in rice. As per Pu *et al.* 2014, the importance of insects in pollination is underestimated in anemophilous plants.

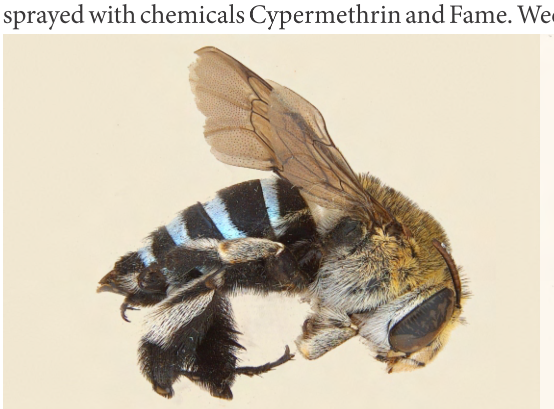
Both landscape heterogeneity and farm management have impact on biodiversity in agroecosystems (Krebs *et al.* 1999). Surrogative plants and weeds on bunds offer floral rewards to the native bee fauna. Decisions at the landscape and farm level often influences the management of wild pollinators, since they need floral resource provisions, breeding areas and nesting habitats, all within their flying range (Kevan & Imperatriz Fonseca 2002; Kremen 2008). Insecticide exposure can have profound effects on solitary bee populations, a female solitary bee dying while foraging often leaves her nest incomplete (Hopwood *et al.* 2012).

MATERIALS AND METHODS

a. Study area:

This study was conducted in Chittur Taluk, one of the major paddy producing regions of Palakkad district, central Kerala. About 60% of the net cultivated area in the district are of paddy. Organic and Conventional paddy fields, with different cultural practices were selected for this study. Both the study areas had black soil (KAU 2011) and important climatic parameters, of temperature and rainfall being same in both the sites.

The site with Conventional paddy (Cp) (10.68N and 76.72E) had a hybrid variety, *'Palakkadan matta', ('Jyothi')*, developed by Kerala Agricultural University, Thrissur (Kerala, India). Organochlorine pesticides like Metacid and Monocrotophos were employed to control the pests. Potash, Urea and NPK fertilisers were added. On the bunds pigeon pea was grown, but all were sprayed with chemicals Cypermethrin and Fame. Weedicides like Roundup were used to clear the plants on the bunds.



Amegilla zonata (Linnaeus)

Braunaspis cupulifera (Vachal)

Nomia aurifrons Smith

The site with Organic paddy (Op) (10.692N and 76.72E), had 'Navara', one of the traditional varieties of medicinal rice. No chemical pesticides or synthetic fertilizers were applied for the past 5 years and only farm manures were used as the nutrient supplement. Bunds had plenty of weed plants like *Biophytum sensitivum, Leucas* sp. and a variety of flowering plants like chrysanthemum along with *Cassia fistula.*

Insect collections were made when the crops were in the flowering stage.

b. Collection Methodology:

Insect sampling: Malaise traps were used for insect collection. These traps are efficient in trapping flying insects (Ganho *et al.* 2003), especially those coming under Diptera and Hymenoptera (Selfa *et al.* 2003). Malaise traps give a standardized data (Mason & Bordera 2008), that can be used for statistical analyses. Two malaise traps were deployed in the two study sites, for 3 weeks, from Feb- April, 2011. The trap was serviced once a week, 3 subsets of data could be generated from both the fields.

The specimens collected were preserved in 70% alcohol, and later examined, studied and identified using Olympus SZ 61. Imaging was under Leica M 205-A stereomicroscope. The bees collected were identified with the help of Bingham (1897) and Michener (2000).

Diversity indices like Alpha Diversity/Simpson's Diversity Index (SDI) and Beta Diversity/ the Jaccard index (JI) were calculated.

RESULTS AND DISCUSSION

Altogether 37 individuals of solitary non *Apis* bee species belonging to 19 species in 7 genera and 3 families were collected using malaise trap during the study period (Table 1). A total of 26 individuals with 15 species belonging to 6 genera could be collected from Op, whereas only 11 specimens identified as 7 species belonging to 5 genera could be documented from Cp.

Pu *et al.* 2014 documented more than 510 insect species that visited rice flowers in China and also documented gene flow due to flower-visiting insects, of which pollinators included 40 species of bees and 28 species of syrphid hoverflies. Their study documented that *Megachile* sp., *Halictus* spp., *Lasioglossum* sp., *Nomia* sp., *Apis* spp. bees, carried large amount of rice pollen, while *Pithitis* sp. and the dipteran hover flies, *Eristalsis* spp., carried lesser amounts. Such studies are however lacking in the Indian context. However, the present study on non *Apis* bees, recorded 19 species from rice fields.

Holzschuh *et al.* 2007, stated that bee diversity was generally higher in organic than in conventional fields, the present study corroborates this finding. While 15 species of non *Apis* bees were recorded from Op, only 7 species could be recorded from Cp. The solitary ground nesting sweat bee *Nomia,* represented by 4 species in Op was altogether absent in Cp. Similarly, while 6 species of *Halictus* bees were present in Op, only 2 species could be recorded from Cp. Not just the species number, but the total number of bees recorded too in Op was almost double compared to Cp (Table 1). Simpson's Diversity Index was higher in organic farming compared to the conventional one (0.908>0.782). The Jaccard similarity index value was less, with only 16% similarity between the species community of the solitary non-*Apis* bees of the two study sites.

CONCLUSION

Rice ecosystem hosts good diversity of non *Apis* bee species. Their pollination role in rice as well as for the surrogate vegetation needs to be assessed. Surrogate vegetation, habitat diversity and semi-natural areas are vital in organic farming systems, in order to maintain temporary retreats and refuges, especially to the pollinators and natural enemy complexes.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, Zoological Survey of India (ZSI), Kolkata and the Officer-in-Charge, ZSI, Western Ghat Regional Centre, Calicut, Kerala, for support and encouragement. Thanks are due to Dr. Girish Kumar, ZSI for his valuable suggestions for the work. We extend our thanks to the farmers of the study site for their willingness and cooperation for the periodical study in their farms.

REFERENCES

Adamson NL (2011). An Assessment of Non-*Apis* Bees as Fruit and Vegetable Crop Pollinators in Southwest Virginia. Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University.

Bengtsson J, Ahnström J and Weibull AC (2005). The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology* 42: 261–269.

Bingham CT (1897). Fauna of British India: Hymenoptera Vol. 1. Wasps and Bees (W. T. Blanford Ed.). London: Taylor and Francis Ltd. London. 564.

Butler SJ, Vickery JA and Norris K (2007). Farmland biodiversity and the footprint of agriculture. *Science* 315: 381–84.

Ganho NG and Marinoni RC (2003). Fauna de Coleoptera no Parque Estadual de Vila Velha, Ponta Grossa, Parana, Brasil. Abundancia e riqueza das familias capturadas atraves de armadilhas malaise. *Revta Bras. Zool* 20**:** 727–736.

Hole DG, Perkins AJ, Wilson JD, Alexander IH, Grice F and Evans AD (2005). Does organic farming benefit biodiversity? *Biological Conservation* 122: 113–130.

Holzschuh, A., Steffan-Dewenter, I., Kleijn, D., and Tscharntke, T. (2007). Diversity of flower visiting bees in cereal fields: effects of farming system, landscape composition and regional context. *Journal of Applied Ecology* 44:41–49.

Hopwood J, Vaughan M, Shepherd M, Biddinger D, Mader E, Black SH and Mazzacano C (2012). Are neonicotinoids killing Bess? A review of research into the effect of neonicotinoid insecticides on bees, with recommendations for action. *Xercus society for invertebrate conservation.*

KAU (2011). Rice Info. Genetic Database on rice [online]. [Accessed on 15.08.2011]. Available at http://kaubic.in/rice%20info/html/kau.html

Kevan PG and Imperatriz-Fonseca VL (2002). *Pollinating Bees: The Conservation Link between Agriculture and Nature*, Ministry of Environment, Brasília, Brazil.

Krebs JR, Wilson JD, Bradbury RB and Siriwardena GM (1999). The second silent spring. *Nature* 400: 611–612.

Kremen C (2008). *Crop pollination services from wild bees*. In: James RR and Pitts-Singer T L (Eds) Bee Pollination in Agricultural Ecosystems, Oxford University Press, US, pp10–26.

Letourneau DK and Bothwell SG (2008). Comparison of organic and conventional farms: challenging ecologists to make biodiversity functional. *Frontiers in Ecology and the Environment* 6(8): 430–438.

Mason, M. and Bordera, S. (2008). Effectiveness of two sampling methods used for collecting Ichneumonidae (Hymenoptera) in Cabaneros national park (Spain). *European Journal of Entomology* 105: 879–888.

Matson PA, Parton PJ, Power AG and Swift MJ (1997). Agricultural intensification and ecosystem properties. *Science* 277: 504–509.

Michener CD (2000). The bees of the world. Baltimore and London (*The John Hopkins University Press*). 913 pp.

Partap T (2001). Mountain agriculture, marginal land and sustainable livelihoods: Challenges and opportunities. International Symposium on Mountain Agriculture in HKH Region (21-24 May 2001). ICIMOD, Kathmandu, Nepal.

Pu D, Shi M, Wu Q, Gao M, Liu J, Ren S, Yang F, Tang P, Ye G, Shen Z, He J, Yang D., Bu W, Zhang C, Song Q, Xu D, Strand MR, Chen X (2014). Flower-visiting insects and their potential impact on transgene flow of rice. *Journal of applied Entomology* 51: 1357–1365.

Robinson WE and Morse RA (1989). The value of honeybees as pollinators of US crops. *American Bee Journal* 129 (1): 477–487.

Selfa J, Motilla F, Ribes A, Rosello J and Dominguez A (2003). Abundancia de los ordenes de insectos en cuatro sistemas agronomicos mediterraneos. *Phytoma España* 151: 24–30.

Stoate C, Boatman ND, Borralho RJ, Carvalho CR, de Snoo GR and Eden P (2001). Ecological impacts of arable intensification in Europe. *Journal of Environmental Management* 63: 337–365.

Table 1. Solitary bee species collected from Organic and Conventional paddy

Sl. no.	Family	Species	Organic (Op)	Conventional (Cp)
1	Apidae	*Braunsapis cupulifera* (Vachal)	2	3
2	Apidae	*Ceratina binghami* Cockerell	1	–
3	Apidae	*Ceratina heiroglyphica* Smith	–	1
4	Halictidae	*Halictus* **sp. nr.** *Agrestis*	3	–
5	Halictidae	*Halictus* **sp. nr.** *gutturosus*	4	–
6	Halictidae	*Halictus serenus* Cameron	2	–
7	Halictidae	*Halictus tristis* (Vachal)	1	–
8	Halictidae	*Halictus* **sp. nr.** *liodomus*	1	1
9	Halictidae	*Halictus invidus* Cameron	1	–
10	Halictidae	*Halictus catullus*	–	1
11	Halictidae	*Nomia albofasciata* Smith	1	–
12	Halictidae	*Nomia carinata* Smith	2	–
13	Halictidae	*Nomia aurifrons* Smith	2	–
14	Halictidae	*Nomia combusta* Smith	2	–
15	Halictidae	*Sphecodes rubripes* Spinola	2	–
16	Halictidae	*Sphecodes* **sp. nr.** *rubripes*	–	3
17	Halictidae	*Sphecodes apicatus* Smith	1	1
18	Halictidae	*Lassioglossum* sp.	1	–
19	Megachilidae	*Chelostoma* sp.	–	1