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Ecological Implications on Insect Biodiversity

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Insects are important group of organisms that are diverse forming an important component of food web. They play vital ecological functions like nutrient recyclers, soil decomposers, pollinators, biocontrol agents, soil builders and scavengers. Anthropogenic factors like habitat destruction, land fragmentation, deforestation, climate change, monocropping and urbanization threaten the native diversity of the insects with possible loss in their abundance, richness and extinction. There is a growing need to conserve the diversity of insects using tactics like maintenance of crop diversity amidst the crop areas to serve as refugia and breeding grounds for the beneficial insects, creating of breeding habitats for natural multiplication of beneficials. Adoption of minor agronomic practices leading to crop and habitat diversification benefits native insect population for their natural proliferation in agro-ecosystems.

Insect Biodiversity–A Crucial Factor for Ecological Balance

Insect are largest and diverse group of organisms in Earth that constitutes to around 75% of all described animal species. The abundance of the insects is contributed by factors like flight ability, faster rates of multiplication, plasticity in their behavior and increased fecundity. Insects like butterflies, bees, dragonflies are referred as 'bio-indicator' species as they their occurrence and abundance rapidly respond to anthropogenic disturbances in ecosystem (Pollard, 1991). Many groups of insects are vital components of food web by serving as pollinators, nutrient recyclers, decomposers and biocontrol agents that regulate insect pest populations. The role of insects as scavengers is of paramount importance as they are first to visit organisms on carcass that aids in its faster degradation. Anthropogenic interventions directly threaten the diversity of insects resulting in species extinction. According to the Zoological Survey of India, 1,318 species of butterflies in the country, of which, according to the International Union for Conservation of Nature (IUCN), 35 species are critically endangered. There is a need to conserve the insect diversity with an aim to keep the food web intact in any ecosystem.

Vital Ecological Role Played by Insects

Insects in Nutrient Recycling

Insects plays a major role in nutrient recycling through degradation of leaf litters and organic matter. Dung beetles and few species of flies are referred as 'coprophages (faeces eaters) as they oviposit in the fecal matter of other animals. There are three different functional types of dung beetles (Doube, 1990),

a. Tunnelers (paracoprids) – they build tunnels under the pile of dung and move the dung into the tunnels, oviposits on it and develops inside the tunnel.
b. Dwellers (endocroprids) – they construct burrows or develops just underneath the fresh dung piles.
c. Rollers (telecoprids) – they remove a ball of dung roll in to tunnels far away from the dung pile.

The tunnelers group of dung beetles were reported to improve aeration to the roots of pasture plants and aiding in soaking of water at the root zones improves aeration to the crops. During the process of decomposition of the dung, the beetles feed upon the dung converting it into nitrogen that gets assimilated by the plants for their growth and development. The physical and chemical properties of soil was influenced by the dung relocation and burrowing activities of the dung beetles. The decomposition process of the dung aids in the homogenization of microbial communities during the course of action (Slade *et al*., 2016).

Insects as Pollinators

Pollination is an ecosystem process that has evolved over millions of years to benefit both flowering plants and pollinators. Pollinators visit flowers for many reasons, including feeding, pollen collection, and warmth. When pollinators visit flowers, pollen rubs or drops onto their bodies. The pollen is then transferred to another flower

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or a different part of the same flower as the pollinator moves from one location to the next. This process is a vital stage in the life cycle of all flowering plants and is necessary to start seed and fruit production in flowers. Animals pollinate approximately 75 percent of the crop plants grown worldwide for food, fiber, beverages, condiments, spices, and medicines. The principal pollinators are bees. Approximately 73 % of the world's cultivated crop such as cashew, squash, mango, cocoa, cranberries and blueberries were pollinated by a variety of bees, 19% by flies, 6.5% by bats, 5% by wasps and beetles, 4% by birds, butterflies and moths. Of the hundred principal crops that accounts for world's food supply, only 15 % was pollinated by domestic bees (mostly honeybees and bumble bees) and at least 80% are pollinated by wild non-apis pollinators (mostly leaf cutter bees, sweat bees, mason bees, flies, butterflies).

Insects as Soil Builders

Collembolans are the major group of microarthropods referred as 'key indicator species' of richness of soil biota as they feed on decaying organic substances, plant litters and that feed upon the soil microbiota viz., algae, bacteria and actinomycetes (Chen 1995). Deposition of frass during feeding on plants were reported to increase soil nitrogen and carbon pools with increasing the rate of soil respiration and leaching of nitric oxide that has direct and indirect effect on nutrient dynamics of the edaphic ecosystem (Frost and Hunter, 2004). Ground beetles belonging to the family Carabidae are important group of insects which are reported as predators as well as weed killers. The larvae of the ground beetles are voracious feeders of soil dwelling insects like wireworms, grubs, maggots resulting in curbing of the population of soil insects. Adult beetles were also reported to feed on the seeds of notorious weeds helping in regulation of weed population in crop fields (Liebman & Gallandt, 1997).

Insects as Scavengers

Insects play a vital role as scavengers by feeding in the dead matter helping in the breakdown of the decaying organic material and recycling them into the soil. The carrion feeding insects provide a natural sanitation to the environment through decomposition of dead organism's time to time. Blow flies (Calliphoridae) and bottle flies are the first to visit insects on any dead organisms. They oviposit in the decaying flesh and the hatching larvae feed upon the decaying matter. The occurrence of flies in the dead matter is of immense importance in forensic studies that helps in investigations to figure out the time of death of the organism. In addition to flies, social insects like termites decomposes decaying plant material in soil during their nest construction process. The decomposed plant material is used as food material inside their nests. Hydrophilids commonly referred as 'water scavenger beetles' play a vital role in feeding and recycling of larvae /maggots of insects and snails in water bodies (Inoda *et al*., 2014). They are active feeders of mosquito larvae that directly beneficial to contain the immature stages of the vector. This important ecosystem service rendered by different insects like flies, beetles in the form of scavengers form a component of food web.

Biocontrol – Predators and Parasitoids

Natural enemies *viz.,* predators and parasitoids provide a very vital pest regulatory service effecting natural reduction of harmful insects through natural predation and parastitization. The natural enemies keep the insect pest population under the economical threshold levels and prevent them from flaring up causing the total crop destruction. The concept of natural biological control holds good in case of invasives where a natural enemy (parasitoid/predator) specific to the invasive pest would occur to contain it.

Factors Threatening the Insect Biodiversity

Habitat destruction

Destruction of natural breeding grounds or dwelling habitats of insects is a major cause for loss of biodiversity of insects as it negatively impacts their abundance and distribution in the natural ecosystem (Kruess & Tscharntke, 2000). Among the different group of insects, butterflies belonging to the order Lepidoptera were reported to be worst affected through habitat destruction by anthropogenic factors (Warren & Dennis, 2004). The butterflies need floral rich habitats to meet the nectar requirement of the adults with sufficient host plants to complete their larval stage in their natural breeding places (Thomas *et al*., 2001).

Deforestation

Forest ecosystem serves as undisturbed buffer zone for insects where anthropogenic interventions to threat insect diversity is at minimal levels. Deforestation results in loss of habitats for a wide group insect negatively impacting their diversity and abundance in the natural ecosystems (Chilima *et al*., 2016). The extinction of forest dwelling dung beetles was correlated with the

deforestation in Madagascar (Hanski *et al*., 2007). The plant-pollinator community interactions were reported to be affected through deforestation that challenges the reproductive success of many plants in the forest ecosystem (Mccain, 2005).

Monocropping

Monocropping is a practice of cultivating single crop over a larger area. The practice of monocropping narrows down the food choice for the insects which has an innate preference to select and forage upon the plants/flowers. The survival and multiplication of bee pollinators largely on polyfloral diet rather than monofloral diet as the collected pollen influence the brood development in the colonies. Monocrop also provides nutrient inferior pollen that negatively impacts the fitness of the pollinators.

Climate Change

Predictions reveal an increase in precipitation across the globe owing to climate change that might cause change in cropping pattern which will affect the species composition of insect herbivores in different crops. Change in day length might alter the overwintering phase of insects (Dhillon *et al*., 2017). The more predicted impacts of climate change on insect herbivores were i) faster rates of development ii) increased risk of invasive insects iii) increased number of generations of insect iv) extended geographical range of insect pests v) increase in overwintering stage of insects (Porter *et al*., 1991). Studies conducted across the globe indicated that there occurs a temporal mis-synchrony between the flowering of plants and pollinators that negatively impacts their abundance and diversity across the ecosystem.

Urbanization

Urbanization is a phenomenon that affects the diversity and richness of insect population in long term. The ecological traits of insects and plants are directly impacted by the process in terms of shift in niches (Kamdem *et al*., 2012), phenology changes in crop that affects the visitation of insects (Diamond *et al*., 2014). With urbanization and rise in environmental pollution, drastic changes in insect behavior were predicted over a period of time that might impact the plant-insect interactions at the trophic levels. The insects were also reported to extend their geographical range of distribution and possibly invade newer areas.

Land Fragmentation

Land fragmentation is a rising concern in the current era owing to the urbanization factors Land fragmentation is a factor that may threat the insect diversity through reduction in the area that cause a habitat loss to the insects, edge effect that impact the insect species distribution and richness in the ecosystem. The increased distance between the fragmented habitats demand an additional energy toll for the bees to access the floral resources that might hinder the movement of bees to the detached habitats in a long run.

Measures to Boost up Insect Diversity

Creation of Crop Diversity and Semi-natural Habitats

The role of creation of semi-natural habitats to support the diverse arthropods like parasitoids, predators (Thomas *et al*., 1997) and pollinators (Lagerlof *et al*., 1992; Meek *et al*., 2002) was reported as a vital component of agricultural landscaping in the recent times. The easiest way to attract native pollinators is to plant gardens or meadows that contain a diversity of native wildflowers, trees, and shrubs. A variety of wildflowers and native grasses will provide native pollinators with food (nectar, pollen, and/or larval host plants). Trees and dense shrubbery provide important shelter, nesting, and overwintering areas for beneficial insects. To maximize food and shelter, landowners can include gardens, fruit-bearing trees and shrubs, thickets and hedgerows of flowering shrubs, and set-asides (areas that are not mowed) in their plans. Due to differing preferences among pollinator species, planted areas should contain varying levels of vegetation and areas of sun, partial shade, and full shade.

Plants native to the region should be selected. Native plants are adapted to the local climate, soils, and the native pollinators with which they co-evolved. Native plants should comprise at least 75 percent of a habitat area. Invasive species should not be planted because they will degrade pollinator and other wildlife habitat by interfering with the natural structure and composition of the ecosystem.

Mowed lawn area should be minimized in favor of patches of native wildflowers, shrubs, and grasses. Lawn areas that do exist should be mowed less frequently to allow the vegetation to provide habitat for pollinators.

Perennials can be chosen over annuals. Perennials are generally richer in nectar and, because they bloom year after year, provide a more dependable food source than annuals. Both nectar and pollen flowers should be available throughout the growing season.

In high value perennial crops, narrow bands of inter-cropped resource-rich plants can be planted within fields to create permanent patches for beneficial insects. This will not only increase the stability of insect populations in the field, it will provide resources for a large number of other beneficial insects. These crops can be chosen with other farm goals in mind also, for example, to improve soil quality.

Creation of Habitats for Breeding of Beneficials

Beetle Banks

Ground beetles are soil inhabiting generalist predators that plays a major role in reduction of harmful insect pests. Beetle banks includes the concept of raising field strips with typically with grasses running through the middle of the field that serves as refugia for the overwintering stages of predatory beetles like carabids, coccinellids that can shift to the main crop during appropriate stages of insect pest infestation (Woodcock *et al*., 2005). Such habitats also serve as hiding spots for the beneficials protecting them from pesticidal sprays in the main crop. The increased abundance and activity of ground beetles and rove beetles in the beetle banks during the winter period which later shifts to the cultivated crop causing natural suppression in farmlands (Varchola & Dunn, 1999). Carabids get an additional advantage of protection in the field strips during the agricultural field preparations like tillage, weeding etc.

Butterfly Gardens

Butterflies are important group of model insects that indicates healthiness of an environment. 'Butter fly garden' concept is a classical approach to conserve butterflies and maintain their diversity. The butter fly garden should contain nectar rich flowering plants for their survival. The larvae of butterflies require suitable host plants for feeding and multiplication. Identification of host plants preferred by butterflies for oviposition is crucial to integrate such host plants in the gardens for their proliferation.

Conclusion

Growers can adopt some relatively simple practices in and around their fields to enhance farm suitability for these important beneficial insects. Enhancing the suitability of farm landscapes for native pollinators will also provide a diversified strategy for achieving good crop yields in pollination-dependent crops year after year.

References

Kamdem C, B Tene Fossog, F Simard, J Etouna, C Ndo, P Kengne, P Boussès, FX Etoa, P Awono-Ambene, D Fontenille, *et al*. (2012) Anthropogenic habitat disturbance and ecological divergence between incipient species of the malaria mosquito *Anopheles gambiae*. *PLoS One*, **7**: Article e39453.

Chen B (1995) Food preference and effects of food type on the life history of some soil Collembola. *Pedobiologia* **39**: 496–505.

Chilima C, VM Bulambo and S Chiotha (2016) The impact of deforestation and forest conversion on abundance and diversity of insects and plants in a miombo forest *Afr. J. Ecol.* https://doi.org/10.1111/aje.12291

Dhillon MK and F Hasan (2017) Temperature-dependent development of diapausing larvae of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae). *J. Therm. Biol.* **69**: 213–220. doi:10.1016/j.jtherbio.2017.07.016

Diamond, SE, H Cayton, T Wepprich, CN Jenkins, RR Dunn, NM Haddad and L Ries (2014) Unexpected phenological responses of butterflies to the interaction of urbanization and geographic temperature. *Ecology* https://doi.org/10.1890/13-1848.1

Frost CJ and MD Hunter (2004) Insect canopy herbivory and frass deposition affect soil nutrient dynamics and export in oak mesocosms. *Ecology* **85**(12): 3335-3347. DOI:10.1890/04-0003

Hanski Koivulehto H, A Cameron, P Pierre Rahagalala (2007) Deforestation and apparent extinctions of endemic forest beetles in Madagascar. *Pop. Ecol.* https://doi.org/10.1098/rsbl.2007.0043.

Heath ACG (2012) Beneficial aspects of blowflies (Diptera: Calliphoridae). *New Zealand Entomol.* **7**(3): doi.org/10.1080/00779962.1982.9722422

Inoda T, Y Indoa and JKH Rulan (2014) Larvae of the water scavenger beetle, *Hydrophilus acuminatus* (Coleoptera: Hydrophilidae) are specialist predators of snails. *European J. Entomol.* **112**(1): DOI: 10.14411/eje.2015.016.

Kruess A. and T Tscharntke (2000) Effects of Habitat Fragmentation on Plant-Insect Communities. In: Ekbom B, Irwin ME, Robert Y (eds) Interchanges of Insects between Agricultural and Surrounding Landscapes. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-1913-1_4

Lagerlo¨f, J., JD Stark, and B Svensson (1992) Margins of agricultural fields as habitats for pollinating insects. *Agric. Ecosyst. Environ.* **40**: 117–224

Liebman M and ER Gallandt (1997) Many little hammers: Ecological approaches for management of crop-weed interactions. In Ecology in Agriculture, LE Jackson (ed) San Diego: Academic Press.

Mccain CD (2005) Deforestation affects the web of plant-insect interactions affecting reproductive success in the Amazonian herb, *Rapatea ulei*. Dissertation pp 231.

Meek B., D Loxton, T Sparks, R Pywell, H Pickett and M Nowakowski (2002) The effect of arable field margin composition on invertebrate biodiversity. *Biol. Conserv.* **106**: 259–271.

Pollard E (1991) Monitoring butterfly numbers, pp. 87–111. In: Goldsmith, FB (ed.). *Monitoring for Conservation and Ecology*. Chapman and Hall, London, 275pp.

Porter JH, ML Parry and TR Carter (1991) The potential effects of climatic change on agricultural insect pests. *Agric. For. Meteorol.* **57**: 221–240. doi:10.1016/0168-1923(91)90088-8

Slade EM, T Roslin, M Santalahti and T Bell (2016) Disentangling the 'brown world' faecal-detritus interaction web: dung beetle effects on soil microbial properties *Oikos* **125**: 629-635.

Thomas JA, DJ Simcox, JC Wardlaw, WG Elmes, ME Hochberg and RT Clark (1998) Effects of latitude, altitude and climate on the habitat and conservation of the endangered butterfly *Maculinea arion* and its Myrmica ant host. *J. Insect Conserv*. **2**: 39-46.

Thomas CFG, F Green and EJP Marshall (1997) Distribution, dispersal and population size of the ground beetles, *Pterostichus melanarius* (Illiger) and *Harpalus rufipes* (Degeer) (Coleoptera, Carabidae), in field margin habitats. *Biol. Agric. Hortic*. **15**: 337–352.

Varchola JM and JP Dunn (1999) Changes in ground beetle (Coleoptera: Carabidae) assemblages in farming systems bordered by complex or simple roadside vegetation. *Agric. Ecosyst. Environ.* **73**(1): 41-49.

Woodcock BA, DB Westbury, SG Potts, SJ Harris and VK Brown (2005) Establishing field margins to promote beetle conservation in arable farms. *Agric. Ecosys. Environ.* **107**: 255–266.