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Review Article

POLLINATION REVIEW

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ABSTRACT

Pollinating insects have been undergoing significant declines for several decades in many parts of the world This is of concern because pollination represents a critical ecosystem service and declines in pollinators have been linked with declines in the plants that they interact with .However, most studies to date have focused on diurnal pollinating insects, largely ignoring nocturnal insects, many of which have also undergone significant declines. In Great Britain, two-thirds of widespread larger moth species populations declined over a 40-year period with probable detrimental cascading effects on ecosystem functioning: the nature of these is considered a priority, policy-relevant question Recent work suggests that nocturnal moths (Lepidoptera) may perform an important, although often overlooked, functional role as plant pollinators

INTRODUCTION

Pollination Review

The idea of occurrence of sex in plants was given by Theophrastus in 4th century B.C. but it was only during the end of 19th century that plant reproduction and the mechanism of pollination were discovered (Verma, 1997).

Pollinating insects have been undergoing significant declines for several decades in many parts of the world (Williams, 1982; Potts *et al.,* 2010; Carvalheiro *et al.,* 2013). This is of concern because pollination represents a critical ecosystem service (Costanza *et al.,* 1997; Ollerton *et al.,* 2011; Garibaldi *et al.,* 2013), and declines in pollinators have been linked with declines in the plants that they interact with (Biesmeijer *et al.,* 2006; Pauw, 2007; Potts *et al.,* 2010). However, most studies to date have focused on diurnal pollinating insects, largely ignoring nocturnal insects, many of which have also undergone significant declines. In Great Britain, two-thirds of widespread larger moth species populations declined over a 40-year period (Fox *et al.,* 2013), with probable detrimental cascading effects on ecosystem functioning: the nature of these is considered a priority, policy-relevant question (Sutherland *et al.,* 2006). Recent work suggests that nocturnal moths (Lepidoptera) may perform an important, although often overlooked, functional role as plant pollinators (Philipp *et al.,* 2006; Devoto *et al.,* 2011; LeCroy *et al.,* 2013).

Aristotle put forward the idea of a relationship between bees and flowers. Dobbs (1870) first described the detail of flower structure and the role of insects in pollination.

Darwin's (1887) research on pollination techniques helped greatly in understanding the theories of plant perpetration and vigour maintenance through cross pollination.

Sprengel (1793) put forward a theory stating that every peculiarity of plant anatomy and physiology is related to the peculiarity of the structure and behaviour of the insects, which visits to pollinate the flowers and it is now well known that a number of flowering plants use insects as vector for the transfer of pollens and that they actually depend on the visit of insects for the pollination. Moreover, owing to the different kinds of flowers, the various insect pollinators have shown an increasing adaptation towards morphological, physiological and ethological features.

The Coleoptera are the oldest order of insects that were able to forage on flowering plants. During later geological period in the cretaceous tertiary and quaternary periods, this was followed by Diptera, Lepidoptera and Hymenoptera. During this period, numerous species of wasps, bees, butterflies and moths appeared culminating in the social honey bees and bumble bees for today which have well developed proboscis to

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suck the nectar and have developed structures which are suitable for transporting pollens.

Work Done In India

In India, studies were conducted on insect pollinators only since 1965-70 (Atwal, 1970; Kapil and Dhaliwal, 1970; Kapil *et al.*, 1971; Deodikar *et al.*, 1976). Earlier studies were mainly on the insect pollination of crop plants particularly *Brassica*, *Helianthus annuus* and *Allium* (Kapil *et al.*, 1971; Kumar *et al.*, 1985).

Extensive studies were carried on the survey, monitoring and importance of insect pollinators on variety of crop plants including *Brassica*, *Medicago* and *Cajanus cajan* (Sihag, 1982, 1984, 1986, 1988, 1991, 1992; Sihag and Rathi, 1994; Sihag and Singh, 1999).

Work on the insect pollinator of a variety of fruit trees were carried out particularly in Himachal Pradesh (Verma and Chauhan, 1985; Verma, 1991, 1992; Verma and Partap, 1993, 1994; Verma and Rana, 1994). Kumar and Kumar (1997a,b) studied the insect pollination of apple and almond crops of higher altitudes and reported, *Apis cerana* to be the dominant pollinator for these crops.

Sihag and Chaudhary (2002) studied the pollinator diversity on onion and found that hymenopteran were most abundant followed by dipterans and *Apis dorsata* was the most efficient species. According to Kumar *et al.* (2002), the hymenopteran and dipterans were dominant pollinators on cucumber and *Melissoides* species was the best pollinator.

Very little work has been done on the insect pollinators of forest plants in India. Kumar and Kumar (1998) worked on the insect pollinators of *Ocimum* and reported that the indigenous honey bee i.e. *A. cerana* followed by bombus species were present in largest number.

Though Eucalyptus, *Acacia*, *Azadirachtha*, *Dalbergia*, *Zizyphus*, *Greewia*, *Butea soapnut* and *Rhododendron* have been reported to be important honey sources for the domesticated honey bees *Apis cerana* and *Apis mellifera*, there is very little information available with respect to pollinator complex (Partab, 1997; Singh, 2007). The pollinator complex of *Eucalyptus* was reported by Singh (2007) and *Apis dorsata* was observed to be the best pollinator.

Insect pollinator of *Zizyphus* were reported by some investigators (Dhaliwal, 1975; Singh, 1984). Mishra *et al.* (2004) studied the diversity of flower visiting insects in relation to plant density in *Zizyphus*. Tandon *et al.* (2001) and Raju and Rao (2002) studied the pollination of ecology of *Acacia*.

Work Done Abroad

Scientists of the more advanced countries of the world have long recognized the contribution of insect pollinators in conservation and maintenance of biodiversity for sustainable plant production.

The foraging behaviour of insect pollinators have long been regarded as highly useful system for study of plant insect interactions. It has been used as a model system in optimal foraging theory (Free, 1970; Levin and Kerster, 1974; Pyke, 1978; Dukas and Real, 1993) and in evaluating plant gene flow (Levin and Kerster, 1974; Schmitt, 1980; Rasmussen and Broedsgaard, 1992). Although the foraging strategies of pollinators are complex, it was proposed that pollinators, particularly honey bees follow nearest neighbour pollination rule (Levin and Kerster, 1974; Zimmerman, 1981; Rasmussen and Broedsgaard, 1992). Torchio (1990) highlighted the risks of a very high dependence on a single pollinator i.e. *Apis mellifera* for crop pollination. One of the outcomes of these considerations has been the development of research projects on breeding systems and appropriate bee management technique with bees other than *A. mellifera*. Studies have also shown that for certain crops *A. mellifera* is a poor pollinator than managed bumble bees or leaf cutter bees (Torchio, 1990; Richards, 1993; Mackenzie, 1994; Cane *et al.*, 1996).

Banaszak (1992) worked on the strategy for conservation of wild bees in an agricultural landscape. He emphasized the need to solve the many problems of contemporary farming and the necessity to carry out total analysis of ecosystem functioning, with determination of the role of communities of animals inhabiting field and evaluation of fauna impoverishment.

A recent review by Heard (1999) has confirmed that in the tropics, stingless bees (Apidae: Meliponini) are the effective pollinators of nine crop species and contribute to the pollination of some 60 other, but evidence is still lacking for many plant species. Although a large amount of research has been devoted to test the ability of a few non-*Apis* bees as pollinators of commercially important crops (Richards, 1993, 1995; Rahman and Chopra, 1994; Cane *et al.,* 1996), data are still inconclusive to effectively support the adoption of a series of non-*Apis* pollinators in many areas of agriculture.

Several recent reports strongly suggest that numbers of crop pollinators around the world are declining, consequently, diminishing yields of some crops (Nabhan and Buchmann, 1977; Banaszak, 1995; Buchmann and Nabhan, 1996; Allen-Wardell *et al*., 1998). The problem also extends to wildlands where numbers of pollinators of native flora may also be declining to levels where reproduction of an unknown number of plant species is or may be negatively effected (Janzen, 1974; Cuddihy and Stone, 1990; Frankie *et al.*, 1997; Donaldson, 2002).

Irshad & Stephen studied in Pakistan (2014) Pollination is an essential ecosystem service that depends on symbiosis between species, the pollinated and the pollinator. Animal mediated pollination contributes to the sexual production of over 90% species of modern angiosperms. Effective pollination results in increased crop production, quality improvement and more seed production. There is serious deficit of pollinators worldwide and also in Pakistan. Small percentage of Pakistani population understands the process of pollination and its importance. It is essential to up scale the capacity of various stakeholders concerned with crop production in Pakistan.

Examination of the world literature on crop pollination and pollinatior-crop relations reveal that there are major short falls in current understandings. Much of the literature even for well-known crops are now outdated because new and improved cultivated crops that have not been adequately studied, now dominate modern agriculture and horticulture. Some reports lack scientific and experimental rigour. There is an urgent need for reliable information with respect to identification, systematics and methods for monitoring and conservation of

the pollinators of these crops.

Workers abroad have taken note of declining diversity of insect pollinators under the influence of extensive monoculture, pesticide use and habitat deterioration. This brought many scientists heads together to highlight the role played by insects in sustaining, improving the quality and quantity of crop production. The recent workshop on conservation and sustainable use of pollinators in agriculture held at Brazil in October, 1998 is an indication of the impending crisis and the need to take decisive steps in this direction lest the situation goes beyond control.

As in India, the current knowledge of flower visitors and pollination in low land and tropical forest is very limited and uneven (Gordon *et al.,* 1976; Corlett, 2003). The available evidence suggest that bees constitute one of the major group visitors to a large proportion of trees species occurring in certain low land forests (Janzen, 1967; Frankie, 1975) mainly *Trigona* and *Apis* species with beetles probably the next most important group followed by other bees and flies. *Apis* bees are also important in montane and sub-tropical habitat (Corlette, 2003).

Tayyab *et al*. (2006) conducted an extensive survey of the biodiversity of Lepidopteran insects in forest area of cropped area of Pakistan. They observed that cropped area in more susceptible host for these insects and the populations were significantly less on forest area.

Bretagnolle, and Gaba, in 2015 studied Agricultural intensification has led to the decrease of the diversity of wild and domestic pollinators. For instance, honeybees declined by 59 % in years in the USA. About 35 % of major crops in the world depend on pollination services, and 3–8 % of world crop production will disappear without pollinators. Indeed, pollination provides several ecosystem services such as enabling crop and honey productions, regulating weeds and other cultural services. Agricultural intensification has also decreased weed diversity by about 50 % in 70 years because massive herbicide sprays have reduced the competition between weeds and crops. Nevertheless, weeds are at the basis of agricultural foodwebs, providing food to many living organisms. In particular, weeds provide flowers for pollinating insects including honey and wild bees. Here, we review the decline of weeds and bees. He found the effect of bees and pollination on crop production. He studied the complex interactions between bee pollinators, e.g. honey and wild bees, and landscape habitats such as crop fields and semi-natural elements. For that, he focus on spatial and temporal effects on flower resources. We show that weed abundance can reduce crop yields, thus inducing conflict with farmers. But weed abundance enhances regulating services by ensuring the survival of honeybees in the absence of oil seed crops. Weed abundance also enhances pollination services and, in turn, honey yield for the benefit of beekeepers. Weed abundance has also improved the survival of wild flora and the socio-cultural value of landscapes, a major request from the public. From those findings, we present a conceptual framework allowing to define ecological engineering options based upon ecosystem services of weeds and pollinators.

Hicks, *et al*. (2016) studied that many ‘pollinator-friendly’ seed mixes are available, the floral resources these provide to flower-visiting insects, and how these change through time, are largely unknown. Such data are necessary to compare the resources provided by alternative meadow seed mixes to each other and to other flowering habitats. He used quantitative surveys of over 2 million flowers to estimate the nectar and pollen resources offered by two exemplar commercial seed mixes Nectar sugar and pollen rewards per flower varied widely across 65 species surveyed, with native British weed species (including dandelion, *Taraxacum* agg.) contributing the top five nectar producers and two of the top ten pollen producers. Seed mix species yielding the highest rewards per flower included *Leontodon hispidus*, *Centaurea cyanus* and *C. nigra* for nectar, and *Papaver rhoeas*, *Eschscholzia californica* and *Malva moschata* for pollen.. Perennial meadows produced resources earlier in the year than annual meadows, but both seed mixes delivered very low resource levels early in the year and these were provided almost entirely by native weeds. Pollen volume per flower is well predicted statistically by floral morphology, and nectar sugar mass and pollen volume per unit area are correlated with flower counts, raising the possibility that resource levels can be estimated for species or habitats where they cannot be measured directly. In this review, we show the importance of moths as pollinators for a diverse range of plant species in ecosystems worldwide and, hence, their role in ecosystem functioning.

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