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THE ROLE OF INSECTIVOROUS BIRDS IN PEST MANAGEMENT: A REVIEW

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ABSTRACT

Insectivorous and omnivorous birds play a crucial role in agricultural pest management by naturally regulating insect populations. This review explores their ecological functions, sensory ecology, and their potential for integration into Integrated Pest Management (IPM) strategies. Emphasizing recent research and its highlights in the effectiveness of these birds in reducing pest pressure, the cues they use to locate prey, and habitat enhancements that promote their presence in agroecosystems. The paper advocates for bird-friendly farming practices as sustainable, cost-effective solutions that align with ecological intensification goals in pest management.

Key words: insectivorous, birds, predatory, pest, management.

Introduction

Agricultural landscapes provide habitat to a wide range of avian species, many of which play a pivotal role in controlling insect and rodent population. With the increasing global emphasis on sustainable farming, integrating natural predators into agricultural pest management has gained traction. Predatory bird species, ranging from insectivorous songbirds to raptors, contribute to reducing pest damage and improving overall crop health (Mrazova *et al.*, 2023; Kirk *et al.*, 1996).

Larvae of moths, beetles, and flies are among the most destructive pests, causing extensive defoliation and reducing plant vigour, significantly reducing crop yields worldwide. The ability of insectivorous birds to detect and prey upon these pests makes them an essential component of natural pest management strategies. Studies indicate that insectivorous birds can suppress pest population effectively, reducing the economic losses incurred by farmers. Their predation help in maintaining the ecological balance and promotes biodiversity within farmlands (Díaz-Siefer *et al.*, 2021).

Some of the most effective predatory birds include the great tit (*Parus major*), blue tit (*Cyanistes caeruleus*), barn swallow (*Hirundo rustica*), and

various raptor species such as kestrels (*Falco tinnunculus*). Birds like myna, sparrow, baya, babbler, black drongo, cattle egret *etc.* feed on larvae of *Helicoverpa armigera* causing significant reduction in pod damage which result in remarkable increase in the yield (Parasharya *et al.*, 2002). House crow (Satyanaryana *et al.*, 2002), jungle babbler (Bharucha *et al.*, 2002) found effective in some crops (Korine *et al.*, 2022).

In middle Gujarat, twenty one insectivorous, nine omnivorous bird species occurring in mustard crop and sixteen bird species occurring in cabbage crop, are all predators of insect pests, particularly the mustard aphid, *Lipaphis erysimi*. Predatory bird species involves birds like yellow wagtail (*Motacilla flava*), common swallow (*H. rustica*), dusky crag martin (*H. concolor*), jungle babbler (*Turdoides striatus*) and rosy starling (*Sturnus roseus*) (AINP Agril. Ornitho., Anand; Jadav, 2013).

Beyond pest management, predatory birds also contribute significantly to ecosystem health. They enhance biodiversity and support nutrient cycling. Therefore, efforts to conserve and promote predatory bird population can enhance agricultural sustainability and

reduce the ecological footprint of farming (Nguyen *et al.*, 2022). This review focuses on researches on foraging behaviour, impact and on agro-ecosystem and discusses pest management strategies to encourage insectivorous birds.

Birds: Olfactory and Visual Integration

Traditionally, birds were thought to rely almost exclusively on vision for locating and capturing prey. Earlier it was suggested that avian olfaction was underdeveloped compared to mammals and that birds lacked the ability to detect prey using smell. This view rooted in early anatomical studies that underestimated the complexity of avian olfactory systems (Roth, 1976). However, this view has shifted significantly with recent scientific advancements. Numerous studies demonstrated that birds utilize olfaction for a range of behaviours, including navigation, mate selection, kin recognition, and importantly, foraging (Díaz-Sieffer *et al.*, 2021). For example, seabirds such as petrels and albatrosses can detect dimethyl sulfide to locate prey over vast oceanic areas. Passerine birds have also shown the ability to detect chemical cues related to food sources, including insect pheromones and plant volatiles (Amo *et al.*, 2013; Saavedra and Amo, 2018). Similarly, raptors, such as kestrels and barn owls, can detect prey using olfactory cues in addition to their keen eyesight. This discovery challenges the traditional notion that birds rely solely on

vision. Researchers have also identified olfactory receptors in various bird species, further supporting the hypothesis that smell plays a crucial role in avian predation (Korine *et al.*, 2022). While olfaction plays a critical role, visual cues also contribute to foraging efficiency. Changes in leaf coloration or reflectance caused by insect feeding can serve as additional signals for birds (Amo *et al.*, 2013). The integration of visual and olfactory cues likely enhances prey detection, particularly in complex environments where single cues may be insufficient.

Role of Birds in Integrated Pest Management

1) Birds as insectivorous predators:

Insectivorous birds provide significant pest management benefits in various agroecosystems. Díaz-Sieffer *et al.*, (2021) concurred that birds such as great tits and blue tits effectively suppress caterpillar population. The predominant predatory birds; common myna, black drongo, green bee eater, house crow, common babblers, Indian robin, pied-bush chat and red-wattled lapwing were also noticed.

2) Birds as carrier of microbial biocontrol agents:

The birds, Indian myna, cattle egret and house sparrow were capable of dispersing *Bacillus popilliae* var. *Holotrichia* causing milky disease in white grub, *Holotrichia consanguinea* (Vyas *et al.*, 1988a). They also indiscriminately feed on the diseased larvae of *H. armigera* and help in the dispersal of Nuclear Polyhedrosis Virus [(NPV) (Vyas *et al.*, 1988b)]. Sunitha *et al.*, (2024) studied role of predatory birds in okra against various larval pest suggested that spread of the *HaNPV* and *SINPV* might be due to the faster virus spread by the bird excreta leading to larval mortality. They found that the cumulative effect of installation of 'T' perches and application of NPV against *H. armigera* and *Spodoptera litura* effectively suppress the pest population.

3) Bird's impact on Agricultural Yield:

Increased avian predation on pests also correlate with various crop yields. The insectivorous birds that followed

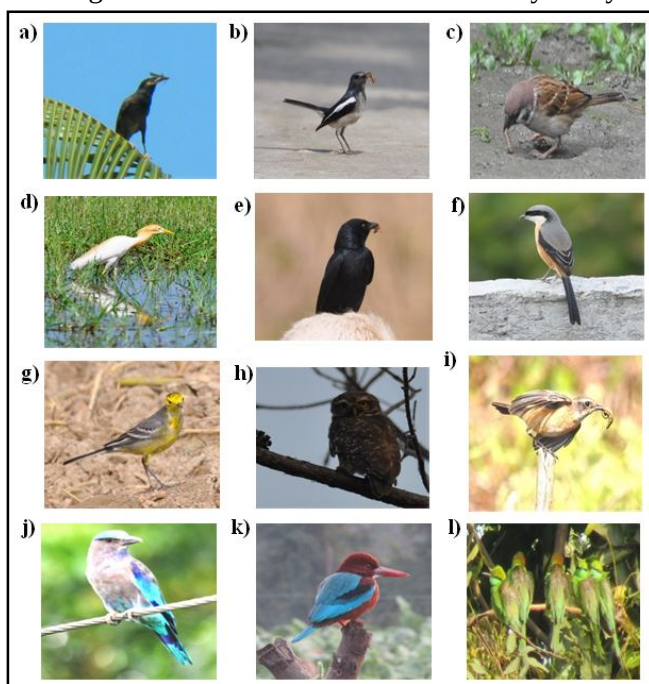


Fig. 1: Important predatory birds in agriculture [a] Bank myna; b) Oriental Magpie Robin; c) House sparrow; d) Cattle egret; e) Black drongo; f) Grey Shrike; g) Yellow Wagtail; h) Spotted owl; i) Common Babbler; j) Indian roller; k) Kingfisher; l) Green Bee eater]



Fig. 2: Cattle egret foraging in ploughed field.

the laborers cutting lucerne reduced about 91.7 per cent of *H. armigera* in Gujarat and only very small larvae escaped predation (Patel, 1991). In wheat, the rosy pastor, grey wagtail, white wagtail, black drongo and bank myna reduced about 34 per cent *H. armigera* population in Gujarat (Borad and Parasharya, 2018). According to Nguyen *et al.*, (2022), birds contribute to significant reductions in pest population, leading to increased agricultural productivity. These findings reinforce the value of preserving bird-friendly habitats within agricultural landscapes. Bat and bird exclusion increased insect herbivore abundance, despite the concurrent release of mesopredators such as ants and spiders, and negatively affected fruit development, with final crop yield decreasing by 31 per cent (Maas *et al.*, 2013).

Various Ways to Entices Avian Foraging

a) Cultural methods:

- i) **Hedges and tree boundaries:** Maintaining hedgerows and native plants and trees enhances the bird habitat in the area. Vincent Arockiaraj (2018) interviewed a farmer from Trichy district, Tamil Nadu, who stated that “Most of the backyard birds eat a combination of seeds, fruits, berries and insects. So, if we plant a variety of trees bearing those things, birds will automatically land there to eat the fruits. When they approach the trees, which are planted around agriculture lands, they instinctively start to pick their prey (pests). Birds eat grasshoppers, crickets, beetles, larvae and moths.” This proves that in order to attract the insectivorous birds fruit bearing and shelter providing trees, hedges on boundaries of farm plays a vital role in insect predation through birds.

The farmers of Central and North Gujarat, Kachchh and Saurashtra are advised to grow pilu, *Salvadora persica* plants in the hedge around their crop field for retaining insectivorous/beneficial birds. The cattle egret, *Bubulcus ibis* is the important avian predator of insect pests and it can be encouraged to breed by providing



Fig. 3: ‘T’ shaped perches installed in rice field being used by insectivorous birds.

minimum breeding requirements, *i.e.* thorny trees (Babul) on outskirts of village or on village pond (AINP Agril. Ornitho, Anand).

- ii) **Ploughing:** Three ploughing on consecutive days are recommended for the control of white-grub, *H. consanguinea* by birds, (AINP Agril. Ornitho, Anand). Ploughing during summer, is a general practice recommended for all the crops in India. Such off seasonal ploughing would expose the insect stages hiding underground to birds (Kumar *et al.*, 2020).

b) Physical and Mechanical methods:

- i) **Food:** Kapil Dave. (2011) wrote in Indian Express about how tourist use ganthiya to lure birds at Nal Sarovar. Flamingos are filter feeders, feeding on brine shrimp, small insects, crustaceans and algae. But, the flamingos were seen feeding on ganthiya in Rajkot. Dr. Bakul Trivedi further confirmed with Dhaval Vargiya that the flamingos feed on this snack in Gujarat (Anonymous, 2020). Also, puffed rice are used by many farmers to encourage the birds at home and in agricultural fields to promote predatory birds (Gopal *et al.*, 2009).
- ii) **Shelter:** Installation of bird nests to increases the bird population in the surrounding area is a common practice. Installation of ‘T’ shaped bird perches @ 100 /ha at 15 days after germination has been recommended in bio-intensive cropping of chickpea (Anonymous, 2013).

Usage of ‘T’ shaped bird perches has gained a tremendous success in management of *H. armigera* and promoting the bird habitat in the farmlands (Kaur *et al.*, 2022). The insectivorous bird community *i.e.* red vented bulbul in tomato crop field installed with ‘T’ shaped bird perches



Fig. 4: Larvae damaged by bird pecks (Source: Díaz-Siefer *et al.*, 2021).

found effective in suppression of larval population of tomato fruit borer, *H. armigera* (AINP Agril. Ornitho, Anand). According to Sunitha *et al.*, (2024) the per cent utilization of bird perches by various birds were recorded as common myna (48%), black drongo (28%), Indian robin (12%), common babbler (7%) and pied bush chat (5%).

iii) Water: Keeping water sources or installing bird water baths can encourage more birds to wander more in the field. Birds are attracted to water for drinking and bathing especially in flowing water. As per the report of Kathy LaLiberte (2024), re-circulating waterfall will draw birds from blocks away. This can positively impact the insect predation rate.

iv) Sound: Moreover, use of certain bio-acoustics devices with calling sound of predatory birds not only encourages insect predation but also check the population of crop damaging birds (Anon., 2025).

c) Use of Insect Pheromones

i) Larval Aggregation Pheromones: Díaz-Siefer *et al.*, (2021) demonstrated that insectivorous birds could detect larval aggregation pheromones produced by *Chilecomadia valdiviana*, a species of wood-boring moth. The results revealed a significantly higher predation rate on artificial larvae near pheromone dispensers, indicating that birds can exploit larval-derived chemical cues to enhance foraging efficiency. This finding suggests that olfactory cues can compensate for the visual crypticity of wood-boring larvae, which are often hidden within tree trunks and branches.

ii) Adult Insect Pheromones: Saavedra and Amo (2018) provided concrete evidence that insectivorous birds, such as great tits and blue

tits can eavesdrop on the sex pheromones of adult moths of *Operophtera brumata*. In their experiment, artificial larvae placed near pheromone dispensers experienced higher predation rates compared to controls. This indicates that birds can detect airborne pheromones emitted by adult insects, using these cues to locate potential prey even when the prey itself is not directly visible.

d) Using Methyl Jasmonate (MeJA) as chemical cue

Methyl jasmonate (MeJA), a phytohormone involved in plant defense, has been widely studied for its role in inducing herbivore-induced plant volatiles (HIPVs), which attract natural predators, including insectivorous birds. Studies have demonstrated that the exogenous application of MeJA can mimic herbivory and trigger the release of volatile organic compounds (VOCs) similar to those produced by herbivore-attacked plant. The use of MeJA to simulate herbivore damage and attract predatory birds has shown promise, although results vary depending on plant species and the emission of defensive volatiles (Mohammadi *et al.*, 2016). Research on Pyrenean oak, *Quercus pyrenaica* has shown that MeJA-treated trees exhibit increased VOCs emissions, although some differences in composition compared to herbivore-induced trees may affect avian attraction (Amo *et al.*, 2022). Similarly, experiments with birch, *Betula pubescens* sp. *czerepanovii* revealed that while insectivorous birds were most attracted to naturally herbivore-damaged trees, MeJA-treated trees did not significantly differ from controls in terms of bird predation rates (Mäntylä *et al.*, 2014). However, studies on grey willow, *Salix cinerea* and oak species have reported increased avian predation on artificial caterpillars placed on MeJA-treated plants, suggesting that specific VOCs such as α -pinene may serve as foraging cues for birds (Mrazova and Sam, 2017;



Fig. 5: Pheromone dispensers and beck mark on larvae (Source: Saavedra and Amo., 2018).

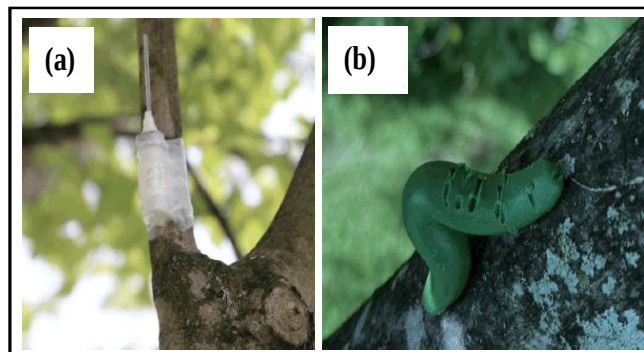


Fig. 6: (a) HIPV solutions or hexane controls were slow-released from glass vials punctured with a capillary tube. (b) Clay caterpillar with peck marks. (Source: Nguyen *et al.*, 2022).

Table 1: Comparative Analysis of Mechanisms.

Mechanism	Principle	Effectiveness	Advantages	Limitations
Cultural Methods	Providing natural food sources and shelter to attract birds	High – Birds naturally inhabit areas with abundant food	Sustainable, enhances biodiversity, long-term impact	Requires land and time for plant growth
Physical Methods	Birds associate specific locations with food availability	Moderate – Some birds may not be attracted to artificial food	Simple and cost-effective, easy implementation	May alter natural feeding behaviour, risk of over-reliance
Mechanical Methods	Creating artificial structures to support bird presence and enhance predation	High – Encourages birds to stay in agricultural areas	Long-term investment, low maintenance, improves bird population	Requires initial setup and space planning
Use of Insect Pheromones	Exploiting birds' ability to detect insect chemical cues	High – Birds locate hidden prey effectively	Can be species-specific, enhances natural foraging behaviour, immediate effect	Effectiveness varies with species and environmental conditions
Use of Methyl Jasmonate (MeJA) as a chemical cue	Mimicking herbivore-induced plant volatiles to attract predatory birds	Some studies show increased bird activity, others do not	Mimics natural plant defences, environmentally friendly	Responses vary among plant species and bird species
Herbivore-Induced Plant Volatiles (HIPVs)	Signaling birds through volatile organic compounds released by plants	High – Birds respond to VOCs as cues for insect presence	Natural and sustainable method of pest management	Requires further research on species-specific responses

Mrazova *et al.*, 2023). These studies remain controversial and further research is needed for clear understanding and specific role of VOCs as bird attractant.

e) Herbivore-Induced Plant Volatiles (HIPVs)

Herbivore-Induced Plant Volatiles (HIPVs) play a crucial role in plant defense by attracting natural enemies of herbivorous insects, thereby serving as an ecological pest management strategy. According to Mäntylä *et al.*, (2020), HIPVs emitted by systemically herbivore-damaged pine trees can be detected by insectivorous birds, which are key predators of herbivorous insects. Hiltpold and Shriver (2018) showed that the attraction of a wild bird population to the specific HIPV released upon herbivory by maize. This interaction not only reduces pest population but also contributes to plant health and growth. Similarly, Mäntylä *et al.*, (2008), also highlighted that insectivorous birds are attracted to specific plant traits, including HIPV emissions, reinforcing the role of volatile cues in shaping ecological networks. The ability of HIPVs to recruit natural predators presents a sustainable alternative to chemical pesticides, promoting biodiversity and thereby reducing agricultural reliance on synthetic inputs.

f) Plant Responses to Insect Egg Deposition

Mäntylä *et al.*, (2018) explored how insectivorous birds respond to plant volatiles induced by insect egg

deposition. Their study focused on Scots pine, *Pinus sylvestris*, which releases specific VOCs after being oviposited upon by sawflies. These HIPVs attract birds that prey on insect eggs and larvae. Birds in controlled experiments were more likely to visit egg-infested branches, indicating that they can detect and respond to subtle chemical changes in plants that signal the presence of prey.

Comparative Analysis of Mechanisms

A comparison for different mechanism mentioned above is represented in Table 1:

Ecological and Agricultural Implications

The ability of birds to detect chemical cues has significant ecological and agricultural implications. In natural ecosystems, this foraging behaviour contributes in regulating insect population, maintaining biodiversity, and supporting trophic interactions. In agricultural landscapes, insectivorous birds can serve as natural pest management agents. Understanding their reliance on chemical cues can inform Integrated Pest Management (IPM) strategies, potentially reducing the need for chemical pesticides (Whelan *et al.*, 2008). Enhancing habitat maintaining that support bird population, such as maintaining hedgerows and native vegetation, can amplify these ecosystem services.

Conclusion

The integration of insectivorous and omnivorous birds into agricultural pest management strategies offers a sustainable and ecologically sound alternative to chemical pesticides. These avian predators contribute not only effective in pest suppression but also to enhance biodiversity conservation, ecosystem balance, and increased crop productivity. Their roles extend beyond direct predation, encompassing the dispersal of microbial biocontrol agents and responsiveness to chemical cues like HIPVs and insect pheromones, which enhance their foraging efficiency. Encouraging avian predators through habitat enrichment, creating food and water facilities, and structural supports like bird perches represents a practical and low-cost approach to natural pest control. The promising outcomes from studies across various cropping systems, particularly in regions like Gujarat, underscore the value of birds as vital allies in Integrated Pest Management (IPM). In the era of natural and organic farming, promoting bird-friendly practices in farmlands not only supports sustainable ecological farming but also aligns with broader goals of environmental sustainability and climate-resilient agriculture.

Future Research Directions

- **Sensitivity Thresholds:** What are the minimum detectable concentrations of pheromones and HIPVs for different bird species?
- **Multisensory Integration:** How do birds integrate olfactory, visual, and auditory cues when foraging in diverse environments?
- **Species-Specific Responses:** Are there evolutionary adaptations in certain bird lineages that enhance olfactory sensitivity?
- **Climate Change Impact:** How would climate-induced changes in plant VOC emissions affect bird-insect interactions?
- **Utilize modern tools viz.,** GPS tracking, AI monitoring and remote sensing to study bird movement and predation patterns.
- **Interdisciplinary research:** Integrating ornithology, agroecology, and chemical ecology.

Conflict of Interest: The authors declare no conflict of interest regarding the publication of this paper.

Declaration for Generative AI

During the preparation of this work the authors used ChatGpt in order to writing effective sentences. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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