Applied Science and Biotechnology Journal for Advanced Research e-ISSN: 2583-553X
Peer Reviewed Journal
Volume-2, Issue-3 (May 2023), Page: 20-25 https://doi.org/10.31033/abjar.2.3.6

Study of Birds' Ecological Function and Bio Indicators

Dr. Gargi
Associate Professor, Department of Zoology, MMH College, Ghaziabad, Uttar Pradesh, India

Corresponding Author: gargirana26@gmail.com

Received: 12-04-2023 Revised: 29-04-2023 Accepted: 26-05-2023

ABSTRACT
Birds serve a variety of functions, such as nutrient cycling, ecosystem engineering, pest control, pollination, scavenging, seed dispersal, predator control, and pest control. However, the environmental services that birds provide are also reducing as a result of the global fall in bird populations. Due to a lack of knowledge, the ecological and economic value of the services provided by birds is not fully understood. In order to support bird conservation, this review paper tries to clarify the function of birds in the agro ecosystem and their advantages for humans. The protection of numerous ecological services that ultimately enhance human well-being would be made possible by healthy bird populations and their habitats.

Keywords: ecological, bio indicators, birds pollination, pest control, seed dispersal

I. INTRODUCTION

Birds are crucial to ecosystem health. According to Whelan et al. (2008), birds support all four categories of ecological services: providing, regulating, cultural, and supporting. Through a variety of resources and processes, ecosystem services serve humans directly and indirectly. By acting as bio-indicators, pollinators, seed dispersers, predators, scavengers, and ecosystem engineers through their behaviour and the services offered by bird products, bird populations are indirectly and directly beneficial to human health. In various habitats and ecosystems around the world, they represent a significant group of vertebrates and play crucial roles in the food chain. Birds are an integral component of the food web and the cycle of nutrients. They also have significant cultural, social, scientific, and nutritional significance in human life (Siva and Neelanarayanan, 2021). One of the most crucial species groupings for the preservation of biodiversity is that of birds. They pollinate the plants, assist in improved plant survival by seed distribution, defend the plant community by suppressing pests and other animals, keep the environment clean by functioning as scavengers, and supply nutrients to the environment (Durairaj et al., 2017). An essential technique for biodiversity conservation and for identifying conservation measures in regions with significant animal and human pressure, particularly for aquatic resources, is the bird community assessment. Biological markers of nature are correctly referred to as birds (Priyanka et al., 2021). In India's highly farmed regions, there are numerous fish, dairy, honeybee, and poultry farms scattered throughout the agricultural landscape. Fish, animal feed, bees, nectar, and fruit trees are some of the additional food options these farms offer to birds. Consequently, granivorous, frugivorous, nectarivorous, insectivorous, carnivorous, and omnivorous species of birds are included in agricultural birds (Mathialagan et al., 2022; Keerthika et al., 2022). Few frugivorous, omnivorous, and granivorous species can reproduce effectively in agroecosystems, which can lead to the growth of huge populations and occasionally cause a financial loss in agricultural production by harming various crops and orchards. In contrast, carnivorous and insectivorous species are rarer but have been discovered to be valuable because they effectively control nuisance insects and rodents that damage agricultural crops. With the aforementioned context in mind, this paper reviews how important birds are to ecology, particularly in agricultural areas, and offers ideas for further research on bird conservation measures.

1.1 Utilising Birds as Bio indicators

In any ecosystem, birds have the ability to serve as bioindicators (Balasubramanyan and Imrankhan, 2016). Birds are crucial for evaluating environmental effects both upstream and downstream. Birds are employed to rate the health of the ecosystem. Bird population monitoring over an extended period of time reveals changes in both natural and artificial environments. It contributes to the preservation of local biodiversity and serves as a marker for slight changes in biodiversity (Jhenkhar et al., 2016). The diversity of birds is a crucial ecological indicator for the qualitative and quantitative evaluation of various environments. Birds are used as bio-indicators because they react to any change in their environmental conditions (Padoa-Schioppa et al., 2006). Birds serve as early warning systems because they are sensitive to environmental changes. Waterfowl are typically used as bio-indicators of wetland conditions on both a local and regional level (Zhang and Ma, 2011). A key predictor of an ecosystem's general health is the diversity of its bird populations (Dendup et al., 2021). Birds are regarded as reliable environmental quality indicators and are frequently employed as bioindicators for populated regions as well as to monitor environmental and ecosystem health (Canterbury et al., 2000).

Birds respond to changes in habitat structure and are therefore valuable indicators for conservation management at regional and landscape scales (Moning and Muller, 2008; Canterbury et al., 2000). Birds are indicator species for the quality of forest habitat. Birds make excellent sentinel species because they can be observed, are toxicant-sensitive, and may occupy a range of trophic levels (Ferreira, 2011). In this scenario, birds could be used as bioindicators in various cases of environmental pollution, such as raptor population decline caused by DDT (Henny et al., 2010), pollution caused by mining activities (Wayland et al., 2006), and radioactive events such as the Chernobyl disaster (Moller et al., 2011). Unsustainable agricultural practises were the cause of direct and indirect pollution in many developing nations (Dinesh et al.). Numerous bird species are vulnerable to pollution and serve as indicators of the threats that pollution poses to human health (Zhang and Ma, 2011). Climate change, habitat loss, and fragmentation are all contributing to the decline of bird populations (Ceballosa et al., 2017). Bird populations are at risk from some human activities, the discharge of chemicals and pesticides into the environment, and other factors (Garcia and Fernandaz, 2014). The usage of plastics, radioactive materials, oil, noise, and other factors also have a significant impact on the sustainability of birds, in addition to climate change (Richard et al., 2009). Bird population patterns can tell us how well an ecosystem is operating if birds are dependent on a habitat that performs in a specific way.

1.2 Birds' Role in Pollination

In natural and agricultural ecosystems, bird-plant interactions are significant and have effects on pollination and seed dispersal. Due to their pollination habits, many wild birds have a significant impact on food production. Numerous Nectarivorus species (family Nectariniidae), which mostly consume nectar, pollinate a variety of plant and tree species. Different fruit development processes occur in various wild and domesticated plants, depending on the exclusive pollinators involved. Bees, flies, and buzzing birds are the most significant pollinators in the ecosystem, although lepidopteran pollinators are present but less numerous. In tropical and subtropical areas where flowers and nectar are always present to support nectarivorous birds' pollination, bird pollination is most common. Around the world, 920 different bird species pollinate plants. Hummingbirds, sunbirds, false sunbirds, flower peepers, white-eyed honeyeaters, lories, and honeycreepers are a few examples of pollinator birds (Mahendiran and Azeez, 2018). The two most significant insect groups among pollinator birds in Africa and Asia are sunbirds and spider hunters. Pollinators like honeyeaters are crucial. These pollinating birds help pollinate about 5% of the food and medicinal plants.

Figure 1: Bird pollination can be advantageous for plants

Source: https://www.earth.com/news/bird-pollination-can-be-advantageous-for-plants/

Numerous studies have demonstrated that a variety of birds, including the black drongo, myna, crow, thrushe, rose-ringed parakeet, golden-backed woodpecker, bulbul, flowerpecker, titmice, and lorikeet, visit and pollinate flowers in India. Sunbirds, mynas, starlings, and oriental white-eyes, which are frequent visitors and likely the most significant pollinators among the avifauna, are only a few of the more than 290 bird species that are involved in pollination and seed dispersal (Balasubramanian, 2012). Few attempts have been made to quantify the economic value of bird pollination compared to insect and plant pollination. By sustaining biodiversity through pollination behaviours that sustain plant species that have direct and indirect benefits for humans and other organisms, birds play a vital role in the ecosystem and agroecosystem.

1.3 Birds as Seed Dispersers

Seed dispersal and bird foraging are significant components of the ecosystem. The ecosystem depends on seed dispersal to preserve its biodiversity, species diversity, population dynamics, and ecological equilibrium. Many tree and plant species that are immediately useful to people, whether for food, medicine, wood, or other purposes, are dispersed by

birds using their seeds. The majority of frugivorous bird species—nearly 48 families, or one-third of all living bird species—show evidence of these functions (Mahendiran and Azeez, 2018). Compared to other dispersal methods like wind, birds can disperse seeds across a significantly wider area. Birds have a significant role in natural ecosystems as seed dispersers, fostering and preserving biodiversity and community structure.

Figure 2: Bird species central to seed-dispersal

Source: https://phys.org/news/2021-05-bird-species-central-seed-dispersal-networks.html

Approximately 80,000 species of angiosperms, of which roughly 25,000 are trees, shrubs, and herbaceous plants, rely on birds as one of their primary seed dispersers. Additionally, birds aid in the dispersal and germination of seeds, which lowers the cost of restoration in deforested areas. Birds support the growth of forests, a crucial ecosystem function that will eventually aid in the mitigation of climate change, as well as a number of other services that largely benefit humans.

Seed dispersal is a mechanism that regulates long-term plant community dynamics and vegetation regeneration in human-disturbed ecosystems, and birds play an important role in the propagation of plant species by functioning as seed dispersers (Balasubramanyan and Imran Khan, 2016). As seed dispersers, birds are crucial to the preservation and restoration of plant communities. Seed dispersal and pollination are crucial tasks performed by frugivorous birds. According to Karubian et al. (2012), bird seed dispersal has a substantial impact on the ecological and genetic diversity patterns of many plant species. Through the mechanisms on the seed, seeds can cling to the feathers of birds. After eating, birds keep seeds on their beaks, including those of the mistletoe owl (Herse and Alice, 2021).

Ornithochory, which refers to seed dissemination by birds, is a subset of zoochory, which refers to seed dispersal by animals (Lambers, 2021). The majority of ornithochores, or plants whose seeds are dispersed by birds, feature noticeable diaspores that attract fruit-eating birds like thrushes, pigeons, barbets (Capitonidae), toucans, and hornbills (Bucerotidae), as well as other avian species. All of them either regurgitate the broken ones or defecate the hard pieces carrying the embryo. The seeds are dispersed by birds in a number of ways, including when they feed, when they transfer (they fly with the seed fruit from the second floor and may drop it on their mouthparts), when they drop (the seeds are scattered along with the droppings), and when they stick the seeds to their bodies or feet with tiny hooks or spikes made from the seed structure. By consuming a variety of berries and dispersing their waste with the berry seeds, birds contribute significantly to the spread of plants. With their droppings, the birds effectively fertilise the soil and create favourable circumstances for seed growth.

II. BIRDS PREDATORS AND PEST CONTROL AGENTS

Predators, a major selection force in the development of shape and function, are one of the most significant extrinsic variables affecting animal populations. Birds can attack prey that is unaware, making them dangerous predators. They prey on worms, turtles, reptiles, insects, and other creatures (Emmanuel Kingsley, 2022). Some raptors include buzzards, owls, kites, and eagles. They are categorised as "birds of prey." The largest and heaviest bird of prey in the world is the American vulture (Andean condor), Vultur gryphus. The goal of integrated pest management is to prevent the spread of pests before they cause financial harm and to benefit farmers financially. One of these methods is biological control, which is a significant issue for farmers and a crucial ecosystem function offered by a range of organisms. This method is anticipated to be a long-term solution for the agroecosystem. Although they are rarely used in Integrated Pest Management (IPM) practises, birds help farmers by decreasing invertebrate crop pests (Dinesh et al., 2018; 2017). Agro ecosystems that use bird species to manage pests and insects also suffer damage to other important plants with higher economic worth. According to recent research, several agro ecologies greatly benefit from the presence of insectivorous birds, which prey mostly on insect populations Maas et al., 2015).

As shown in Table 1, insectivorous birds are common in agricultural ecosystems and help many agricultural and horticultural crops, including apples, broccoli, cacao, coffee, maize, kale, grapes, and oil palms, avoid pest infestations. For instance, birds enhance output in Dutch apple orchards by 66 percent and decrease pest infestations, according to Mols and Visser's 2007 analysis. Similar to this, Borneo researchers claimed that bird pest treatment stopped 9 to 26% of fruit losses in oil palm fields. With 50% of birds feeding primarily on insects and 75% occasionally dining on invertebrates, birds are among the most significant and effective arthropod predators in agro ecosystems (Whelan et al., 2015). According to studies on bird predation on insect pests in natural and agricultural regions, avian reductions of invertebrates range from 20 to 70% (Jedlicka et al., 2014). In addition to lowering the number and occurrence of herbivores, bird predation also considerably lowers foliar damage and plant death, which can boost crop yield or fruit production by up to 60% (Whelan et al., 2015).

In Guatemalan coffee plantations, a study found that the existence of large populations of insect herbivores decreased the number of insect pests, resulting in less herbivore damage. The presence of insect herbivores and lessened coffee berry borer damage enhanced coffee productivity and farmer income in Jamaica. Additionally, great tit nests in apple orchards attract more birds to the region, which feed on caterpillars that might harm crops, greatly increasing crop yields. By minimising the usage of potentially dangerous chemicals and removing the need to buy toxic pesticides, the use of birds in pest control can reduce the demand for pesticides, eliminate their use altogether, and save farmers money. Both vertebrate and invertebrate pests, such as rats, are controlled by birds. A taught barn owl terrifies small mice and greatly lowers rodent seed intake, according to field tests carried out in Israel (Ori et al., 2018). Additionally, owls have been demonstrated to reduce rat populations in a variety of field crops, including wheat, rice, and maize. Because rodents become resistant to rodenticides like warfarin and bromadiolone, oil palm planters in Malaysia use barn owl nests to control mice in the field. In the past, it has been recognised that a mutually beneficial interaction between birds and animals is also advantageous to people. Birds are predators, so many of them choose to nest on livestock like cattle and eat the parasitic veterinary pests that dwell on the animals. Cattle egrets, which are known to survive in this way, exhibit this behaviour the most frequently. The birds gain from a ready source of food, and the animals profit from the birds' removal of dangerous parasites. People rely on cows in various regions of the world for milk and meat (food). When cows are plagued with ticks and other parasites, their milk output decreases, and they become very weak. This is supported by a study carried out in Pakistan, where birds, which are important predators, manage these parasites, leading to healthier and more productive cows. Bird management of livestock parasites is frequently much more effective than pesticides.

III. PEST BIRDS

Both as pests and biological control agents, birds have a dual role in agro ecosystems. Some birds negatively impact agricultural goods by grazing on crops while foraging. They significantly harm young seedlings as well as ripening cereals, fruits, and vegetables. Birds severely impair crops at different stages and lower production (Table 1) (Suresh and Kambrekar, 2021). The majority of bird species are insectivores, which contribute significantly to the biological management of pest populations. As a result, they are useful to farmers in agriculture and serve a variety of purposes, including supplying nutrients that primarily boost soil fertility and acting as rodent predators. In some agro ecosystems, insectivorous birds have been demonstrated to be effective biological control agents. According to estimates, non-insect pests affect a variety of crops grown in India on a regular basis, accounting for around 30% of crop output losses brought on by both insects and non-insect pests. Non-insect pests can seriously harm crops in the field and store grains in warehouses, which can cause substantial harm to our agriculture. Mites, rats, birds, wild boars, elephants, and others are some of the most prevalent non-insect pests (Vishwavidyalaya, 2021).

Table 1: Amount of bird damage to crops in agriculture

SN	Crop	Stage of damage	Birds	(%)
1	Groundnut	Ripening	Crows	24
2	Maize	Sprouting	Babblers, Crows, Doves	20
3	Mustard	Ripening	Crows, Parakeets	63
4	Pearl millet	Ripening	Parakeets, Sparrows, Weaverbirds	10-100
5	Peas	Ripening	Pigeon	54
6	Pulses	Sprouting	Doves, Pigeons, Parakeets, Sparrows	66
7	Rice	Sprouting Ripening	Cranes, Parakeets, Saras, Sparrows, Weaverbirds, Sparrows, Weaverbirds	41 26
8	Sorghum	Ripening	Doves, Pigeons	12-85
9	Sunflower	Sprouting Ripening	Crows Crows, Parakeets,	65 22
10	Wheat	Sprouting	Crows	17-20

IV. BIRDS AS SCAVENGERS AND SANITATION TOOLS

In many locations, the ability of birds to scavenge garbage plays a significant role in waste disposal, assisting in the prevention of disease epidemics that may happen when animal corpses pile up (Markandya et al., 2008). In agro ecosystems, scavenging birds are common and have a significant impact on trash disposal, nutrient cycling, and foraging (Whelan et al., 2008). Carcasses are broken down by vultures. Scavengers include raptors that are active during the day, such as eagles, hawks, and kites, as well as corvids like ravens and crows (Read and Wilson, 2004). Obligate scavengers, such as burying beetles, yellow bugs, and blowflies, are uncommon in vertebrates but common in invertebrates. Fly larvae are frequently found at the bottom of freshwater lakes, scavenging for organic matter. For instance, the midge flies, Tokunagayusurika akamusi, a scavenger at the bottom of lakes, barely lives a few weeks and consumes almost no food. Both direct and indirect disease transmission methods might occur during scavenging. Infected carcass scavengers may develop into hosts for specific infections and become disease vectors themselves.

Scavengers play a crucial role in the environment. While the majority of bird species eat only dead animals when they are around, the vulture is unquestionably a well-known and obligatory feeder of this species. Through their scavenging, vultures and other carnivorous vertebrates contribute to waste clearance, disease management, and nutrient cycling. Despite being understudied and unappreciated in the avifauna, vultures provide one of the most significant ecosystem services. By quickly and effectively removing carcasses from the ecosystem, vulture birds keep the environment clean and save people, cattle, and wildlife from infections and other dangerous diseases. Additionally, vultures possess the capacity to withstand and cleanse bacterial poisons found in decomposing meat. By eating carcasses, vultures' stomachs eliminate all dangerous germs by secreting unusually high quantities of acids, which lowers illness levels in the ecosystem. Vultures do an outstanding job in the Serengeti, eating hundreds of pounds of carcasses per kilometre each year. According to Gono et al. (2013), vultures in Yemen consume up to 25% of the organic garbage generated by people in metropolitan areas.

Due to poisoned carcasses and decreased competition from wild canines and rats for carrion, vulture numbers are on the decline in India today. This has led to an increase in their population. The rise in these possible disease carriers (wild dogs and rats) contributed to rabies outbreaks, dog attacks on people, and the bubonic plague outbreak in western India, which claimed 54 lives in 1994. According to Markandya et al. (2008), the fall in vulture populations resulted in an increase in rabies cases and the deaths of around 48,000 people. This amplifies the direct significance of a healthy avifauna for human and ecosystem benefits and demonstrates the obvious high value that people place on birds.

4.1 Birds' Role the Cycle of Nutrients

Agriculture can benefit significantly from bird droppings. Bird droppings are used as fertiliser in agriculture because they are rich in nutrients like phosphate, nitrogen, and potassium. This can quickly turn into ammonia, which can then increase the soil's nitrogen level and act as a good fertiliser for plants. There is relatively little that birds can do to improve soil fertility on farms. According to a recent study, birds contribute 38.0% of the world's agricultural output. In order for primary producers to start their work and cause the distress of primary consumers, the colonisation of the area by top predators, and the maintenance of biodiversity, two important services provided by birds are the transfer of nutrients and the formation of soils (MEA, 2005). To date, numerous ecosystems have shown that birds play an important role in the cycling of nutrients. Birds can transport nutrients from one place to another due to their capacity to fly and migrate through many environments. This is crucial in areas where the availability of nutrients restricts plant growth. All habitats benefit from the contribution of birds to nitrogen cycling, although aquatic habitats benefit most. According to Ellis (2005), seabirds are more frequently observed in coastal regions since this is where they can process huge amounts of food quickly. Seabirds do this by moving nutrients from the aquatic to the terrestrial zones. In comparison to fields without birds, areas with significant levels of guano deposits—which are rich in phosphates, nitrates, and potassium—and fast-growing flora can impact plant development and increase productivity. Plant growth and plant communities are impacted when nesting seabirds are removed. Waterfowl and other coastal birds, which move nutrients between aquatic and terrestrial environments, are the main providers of this ecosystem function.

4.2 Techniques for Bird Conservation

Little has been done to safeguard the threatened or endangered avifauna in highly cultivated fields, mostly agricultural areas, despite widespread awareness of the conservation of birds and their ecological importance. Gaston predicted that some indigenous bird species may go extinct in locations where habitats are being heavily destroyed when observing the diversity and distribution of several endemic bird species in specific parts of India. Spraying indiscriminately and heavily with pesticides and herbicides in India, especially in agricultural areas, causes a high rate of mortality in frugivorous and predatory bird species. Due to food chain contamination and habitat damage, there are drastically fewer raptors on the avian landscape. In agricultural settings, wooded environments are frequently found to support both the highest abundance and species richness of birds. Information on residue analysis in birds located in agricultural environments is hardly lacking. By encouraging birds with a specific advantageous, behavioural, or functional trait, it may be feasible to increase the benefits and costs of birds efficiently (Dinesh et al., 2017). The agricultural ecosystem would seek to improve birds by giving them specific advantageous or useful characteristics. Intercropping sunflower in organic

vegetable crops was found to increase the number and foraging activity of insectivorous bird species that consume pest species without causing any damage to crops and also benefit from sustainable agricultural productivity, demonstrating the advantages of promoting desirable bird species. Instead of using haphazard control methods that could have an impact on the entire bird community, such as scaring devices, reducing agricultural intensification, providing resources to advantageous bird species, and encouraging diversity, other strategies could include targeted control of damage-causing or pest species through habitat modification. While agricultural uniformity and intensification may indirectly increase harm by limiting avian species that may control agricultural pests, a rise in the species diversity of agricultural birds may boost the species responsible for pollination. The costs and benefits of bird activities in the agroecosystem are difficult to estimate, but it is probable to lower their potential for harm and raise the likelihood that these amazing animals will deliver ecosystem services.

V. CONCLUSION

Birds play a variety of significant roles in agro ecosystems. Through the spread of numerous plant species within an ecosystem, bird seed dispersal behaviour contributes to the preservation of biodiversity and species richness. Additionally, by clearing local habitats of carcasses that can contain dangerous bacteria, their scavenging actions in nature help to avoid a number of infectious diseases. The major role of bird predators in biological control programmes is to suppress a range of herbivorous pests, including invertebrate and vertebrate pests, and to increase crop yield. Additionally, avian predation indirectly lowers farmer costs by preventing the need for toxic chemicals. Other services, such as pollination behaviour, are equally crucial to maintaining the environment and ensuring human welfare. The majority of the services that birds offer have both financial and ecological value. Future studies must prioritise strategies aimed at avifauna conservation, habitat management, and restoration. The welfare of many living species as well as human welfare would be enhanced by preserving and sustaining healthy bird populations and their habitats.

.

REFERENCES

1. Markandya A, Taylor T, Longo A, Murty M., & Murty S. (2008). Counting the cost of vulture decline-an appraisal of the human health and other benefits of vultures in India. *Ecological economics 67*(2), 194-204.
2. Garcia-Fernandez, A.J. 2014. Ecotoxicology, Avian. In book*: Encyclopedia of Toxicology* (3rd edition), 289-294 pp.
3. Whelan CJ, Sekercioglu CH., & Wenny DG. (2015) Why birds matter: from economic ornithology to ecosystem services. *J Ornith 156*, 227-238.
4. Balasubramanyam VV, Imran Khan YD. (2016). Avian fauna of the proposed wind power project area at Chillavaripalli and Ellutla reserve forests. *Journal of Entomology and Zoology Studies, 4*(6), 722-728.
5. Dinesh, G.K. (2017). Ecology of Birds and insects in organic and inorganic rice ecosystem. Tamil Nadu Agricultural University, Coimbatore.
6. https://www.earth.com/news/bird-pollination-can-be-advantageous-for-plants/.
7. Dinesh, G.K., Ramesh, P.T., Chitra, N., & Sugumaran, M.P. (2018). Ecology of birds and insects in organic and conventional (in-organic) rice ecosystem. *Int. J. Curr. Microbiol. Appl. Sci. 7*, 1769–1779.
8. Jhenkar M, Jadeyegowda M, Kushalappa CG, Ramesh MN., & Sathish BN. (2016). Bird diversity across different vegetation types in kodagu, central western ghats, India. *International Journalof Zoology, 6*(3), 25-36.
9. Priyanka S. Patode, B. S. Salve, & R.T. Pawar. (2021). Avifaunal diversity status and abundance of Siddheshwar Reservoir, district Hingoli, Maharashtra, India. *Int. J. Adv. Res. Biol. Sci, 8*(12), 47-55.
10. https://phys.org/news/2021-05-bird-species-central-seed-dispersal-networks.html.
11. Siva, T., & Neelanarayanan, P. (2021). Diversity of Avifauna observed and recorded in Thinnanur Lake in Tiruchirappalli District, Tamil Nadu, India. *Asian Journal of Conservation Biology*, *10*(2), 308-316.
12. Keerthika Murugan, Logadharsini Vijayendran, Lusiya Mary Thangaraj, Mathialagan Mariyappan, Archana Arunachalam, Meena Rajendran, & Kumaravel Solaimuthu. (2022). Studies on diversity and distribution of avifauna in Sethu Bhaskara agricultural college and research foundation, Karaikudi, Tamil Nadu. *The Pharma Innovation Journal, 11*(12), 1599-1613.