Thirteenth Issue (July, 2025)

Flora SARTHI

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FloraFauna Science Foundation (FFSF)
8/23 Bahar A, Sahara States, Jankipuram, Lucknow-226 021, Uttar Pradesh, INDIA
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Cover Photo: Cover Photo: Tuberose (Rajnigandha) buds shared by Mr Shiv Kumar Maurya, a progressive farmer from village Naypur, vazirganj, district Gonda, Uttar Pradesh. The planting material of Tuberose was made available to a group of participating farmers by CSIR-NBRI for trial cultivation on the occasion of FloraFauna Innovation Summit (FFIS-2025) organised by FFSF on 14th February, 2025 in collaboration with CSIR-NBRI and CSIR-CIMAP (detailed report on page 34-37).

Title and Logo: Ms. Joyce Suman Khanuja, Schulich Business School, York University, Toronto, Canada, Technoentrepreneur, Corporate Strategy Management.

फ़्लोरा सारथी

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8/23 Bahar A, Sahara States, Jankipuram, Lucknow-226 021
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Disclaimer

Founder's Note.....✍

Sustainable nutrition goes with dietary diversity and mindful consumption for health of planet and people together

Today the world is passing through a strange dilemma of food security issues entangling hunger on one hand and nutrition or health on the other. This situation is further getting complicated by the climate change elements arising out of human indifference to lifestyles impacting the ecological balance and unknowingly ignoring planet's survival needs. Consequently, the limitless drain on natural resources for food and wishful living is adding on the question of sustainability of supplies in this unidirectional flow without giving back. While the deprived are devoid of even basic needs of food, the affluent are overwhelmed with affordability of fashion and lifestyles that produce too much waste of nutritional resources that otherwise may be the need of the deprived. Can we think scientifically to bridge the gap and bring an equilibrium through conscientious consumption of diets though sourcing of diverse food ingredients suited to both health and environment?

Human mind is the key factor in deciding what to eat and simultaneously gaining full nutrition too. In this direction, trends like plant-based diets (particularly proteins) and then furthering it to vegan lifestyle, eliminating even dairy and other non-meat animal products, creates newer deficits in sourcing, sustainability as well as whole nutrition alternatives. On the other hand, eliminating animals completely from food chain for human need is not a straight answer to environmental conflicts or nutritional food security. Rationally also, limiting the source of food shrinking to single bioresource component (plant or animal kingdom) only, may have unpredictable consequences in the food web as well as nature's equilibrium. Since the effort has to be in the direction of sustainable sourcing, intelligent ways or innovative products from nature or technology based on nature-identical or nature-like dietary ingredients can provide the holistic solutions. This approach will prevent the occurrences of situation like palm oil (plant-based) overdependence leading to oil palm plantations making forests shrink and reverse plant-animal-human conflict affecting populations of large animals like elephants, rhinos and apes not finding natural niche and hence getting threatened by plantations. Viable alternative to palm oil can be the microbial/algal lipids as scientific innovations to cultivate the fat in vast ponds in barren lands or fermentation process in bioreactors.

Understandably, we are proactively looking for ways to support our overall well-being, creating the need to search food ingredients diversity for improved nutrition. Towards alleviating the menace of human malnutrition in the economically weak populations, affordable alternative proteins with right proportion of essential amino acids have to be devised. For this purpose, blending different plant and fungal protein sources with cultivated animal-like proteins and fats can be a sustainable solution. Such a strategy can even satisfy

taste buds of meat eaters on alternative sources. Similarly ethnic foods from local communities can provide highly dependent nutritional sourcing for diverse diets that will add to agro-biodiversity ensuring supply of those essential food ingredients while simultaneously providing the livelihood and entrepreneurial opportunities at village and tribals level.

The UN's Food and Agriculture Organization (FAO) defines sustainable diets as low in environmental impacts, nutritionally adequate, safe and healthy. These need to include socio-economic dimensions and contribute to healthy life for present and future generations. Consumption of less meat and higher-amounts of plant-derived foods like beans, pulses, nuts, pseudocereals, millets, locally grown fruits and vegetables with nutritious meat alternatives like microbial (fungal or algal) protein or fermenter cultivated meat alternatives though cellular agriculture appear to be the future solution for sustainable nutrition and health of people and planet both. Let's work on this lifestyle allowing the flora and fauna on the mother earth surviving and flourishing in equilibrium with environment.

Suman Khanuja
Founder President
FloraFauna Science Foundation

संस्थापक की लेखनी से.....✍

ग्रह और लोगों के स्वास्थ्य के लिए टिकाऊ पोषण आहार विविधता और सचेत उपभोग के साथ आता है

आज दुनिया खाद्य सुरक्षा के मुद्दों की एक अजीब दुविधा से गुज़र रही है, जिसमें एक तरफ़ भूख और दूसरी तरफ़ पोषण या स्वास्थ्य उलझा हुआ है। यह स्थिति जलवायु परिवर्तन तत्वों के कारण और भी जटिल हो रही है, जो पारिस्थितिकी संतुलन को प्रभावित करने वाली जीवन शैली के प्रति मानवीय उदासीनता से उत्पन्न होते हैं और अनजाने में ग्रह की अस्तित्व की ज़रूरतों को अनदेखा करते हैं। नतीजतन, भोजन और मनचाही ज़िंदगी के लिए प्राकृतिक संसाधनों की असीमित खपत इस एकतरफा प्रवाह में आपूर्ति की स्थिरता के सवाल को और बढ़ा रही है, बिना बदले में कुछ दिए। जबकि वंचित लोग भोजन की बुनियादी ज़रूरतों से भी वंचित हैं, वहीं संपन्न लोग फैशन और जीवन शैली की सामर्थ्य से अभिभूत हैं, जो पोषण संसाधनों की बहुत अधिक बर्बादी करते हैं, जो अन्यथा वंचितों की ज़रूरत हो सकती है। क्या हम स्वास्थ्य और पर्यावरण दोनों के लिए उपयुक्त विविध खाद्य सामग्री के स्रोत के माध्यम से आहार के विवेकपूर्ण उपभोग के माध्यम से अंतर को पाटने और संतुलन लाने के लिए वैज्ञानिक रूप से सोच सकते हैं?

क्या खाना चाहिए और साथ ही साथ पूर्ण पोषण प्राप्त करने में मानव मस्तिष्क महत्वपूर्ण कारक है। इस दिशा में, पौधे-आधारित आहार (विशेष रूप से प्रोटीन) और फिर इसे शाकाहारी जीवनशैली में आगे बढ़ाते हुए, डेयरी और अन्य मांसाहारी पशु उत्पादों को भी खत्म करने जैसे रुझान, सोर्सिंग, स्थिरता और साथ ही संपूर्ण पोषण विकल्पों में नई कमी पैदा करते हैं। दूसरी ओर, मानवीय ज़रूरतों के लिए खाद्य श्रृंखला से जानवरों को पूरी तरह से खत्म करना पर्यावरणीय संघर्षों या पोषण संबंधी खाद्य सुरक्षा का सीधा जवाब नहीं है। तर्कसंगत रूप से भी, भोजन के स्रोत को केवल एक जैव संसाधन घटक (पौधे या पशु साम्राज्य) तक सीमित करने से खाद्य जाल के साथ-साथ प्रकृति के संतुलन पर अप्रत्याशित परिणाम हो सकते हैं। चूँकि प्रयास स्थायी सोर्सिंग की दिशा में होना चाहिए, इसलिए प्रकृति से बुद्धिमान तरीके या अभिनव उत्पाद या प्रकृति-समान या प्रकृति-जैसी आहार सामग्री पर आधारित तकनीक समग्र समाधान प्रदान कर सकती है। यह दृष्टिकोण पाम ऑयल (पौधे-आधारित) पर अत्यधिक निर्भरता जैसी स्थिति की घटनाओं को रोकेगा, जिससे तेल पाम बागानों के कारण जंगल सिकुड़ रहे हैं और पौधे-पशु-मानव संघर्ष उलट रहा है, जिससे हाथी, गैंडे और वानरों जैसे बड़े जानवरों की आबादी प्रभावित हो रही है, जिन्हें प्राकृतिक आवास नहीं मिल पा रहा है और इसलिए बागानों से उन्हें खतरा हो रहा है। पाम ऑयल का व्यवहार्य विकल्प सूक्ष्मजीव/शैवाल लिपिड हो सकता है, जो बंजर भूमि में विशाल तालाबों में वसा की खेती करने के लिए वैज्ञा जाहिर है, हम अपने समग्र कल्याण का समर्थन करने के तरीकों की सक्रिय रूप से तलाश कर रहे हैं, जिससे बेहतर पोषण के लिए खाद्य सामग्री विविधता की खोज करने की आवश्यकता पैदा हो रही है। आर्थिक रूप से कमजोर आबादी में मानव कुपोषण के खतरे को कम करने के लिए, आवश्यक अमीनो एसिड के सही अनुपात के साथ किफायती वैकल्पिक प्रोटीन तैयार किए जाने चाहिए। इस उद्देश्य के लिए, विभिन्न पौधों और फंगल प्रोटीन स्रोतों को खेती वाले जानवरों जैसे प्रोटीन और वसा के साथ मिलाना एक स्थायी समाधान हो सकता है। ऐसी रणनीति वैकल्पिक स्रोतों पर मांस खाने वालों की स्वाद कलियों को भी संतुष्ट कर सकती है। इसी तरह स्थानीय समुदायों के जातीय खाद्य पदार्थ विविध आहारों के लिए अत्यधिक निर्भर पोषण स्रोत प्रदान कर सकते हैं जो कृषि-जैव विविधता को बढ़ाएंगे और उन आवश्यक खाद्य सामग्री की आपूर्ति सुनिश्चित करेंगे जबकि साथ ही साथ गांव और आदिवासी स्तर पर आजीविका और उद्यमशीलता के अवसर भी प्रदान करेंगे। निक नवाचारों के रूप में या बायोरिएक्टर में किण्वन प्रक्रिया हो सकती है।

संयुक्त राष्ट्र के खाद्य एवं कृषि संगठन (एफएओ) ने संधारणीय आहार को पर्यावरण पर कम प्रभाव डालने वाला, पौष्टिक रूप से पर्याप्त, सुरक्षित और स्वस्थ आहार के रूप में परिभाषित किया है। इनमें सामाजिक-आर्थिक आयाम शामिल होने चाहिए और वर्तमान और भावी पीढ़ियों के लिए स्वस्थ जीवन में योगदान देना चाहिए। कम मांस का सेवन और पौधों से प्राप्त खाद्य पदार्थों जैसे बीन्स, दालें, मेवे, छद्म अनाज, बाजरा, स्थानीय रूप से उगाए गए फल और सब्जियों का अधिक सेवन, साथ ही पौष्टिक मांस विकल्प जैसे माइक्रोबियल (फंगल या शैवाल) प्रोटीन या किण्वित संवर्धित मांस विकल्प जैसे सेलुलर कृषि लोगों और ग्रह दोनों के संधारणीय पोषण और स्वास्थ्य के लिए भविष्य का समाधान प्रतीत होता है। आइए इस जीवनशैली पर काम करें जिससे धरती पर वनस्पतियों और जीवों को पर्यावरण के साथ संतुलन में जीवित रहने और पनपने का मौका मिले।

सुमन खनुजा
संस्थापक अध्यक्ष
फ्लोराफौना साइंस फाउंडेशन

Microbial Inoculants: Sustainable Solution for Agriculture in the 21st Century

D. J. Bagyaraj and R. Ashwin

Global agriculture has to double food production by 2050 in order to feed the world's growing population and at the same time reduce its reliance on inorganic fertilizers and pesticides which are not only deleterious to environment but also injurious to soil and human health. Thus sustainability in agricultural production has emerged as one of the most significant concerns in the 21st century (Kuila and Ghosh 2022) which can be achieved by using beneficial soil microorganisms as microbial inoculants (Laranjeiro *et al*., 2022; Soth *et al*., 2025).

Microbial inoculants are known to make a number of positive contributes in agriculture (Díaz-Rodríguez *et al*., 2025). For example, a) they supplement fertilizer supplies for meeting the nutrient needs of crops; b) they liberate growth promoting substances and vitamins which help to maintain sol fertility; c) they suppress the incidence of plant pathogens and control diseases; d) they are cheaper, pollution free and based on renewable energy sources; e) they improve soil physical and chemical properties and soil health in general.

Nitrogen, phosphorus and potassium are the 3 major plant nutrients. The irrational use of chemical fertilizers has led to several detrimental effects on soil health and environment. Under these circumstances, alternate sources for fertilizers are looked for. Further the fertilizer production in our country is less than the required amount. To fill this gap alternate sources of nutrients are necessary. Microbial inoculants are the alternate sources to meet the nutrient requirement of crops and to maintain soil health and productivity. These microbial inoculants are widely accepted as low cost supplements to chemical fertilizers having no deleterious effect on soil health or environment, making a number of positive contributes in agriculture (Díaz-(Sridhar and Bagyaraj, 2018; Rodríguez *et al*., 2025). The contribution of microbial inoculants to sustainable agriculture are discussed below.

Microbial Inoculants Supplying Nitrogen

Nitrogen present abundantly (78% by volume) in the atmosphere is fixed by several bacteria living freely in soil or in symbiotic association with plants.

Symbiotic Nitrogen Fixers: Rhizobia forming root nodules through symbiotic association with legume roots are known to fix considerable quantities of atmospheric nitrogen and are referred to as symbiotic nitrogen fixing bacteria. For example, clovers fix about 130 kg N/ ha/ season and cowpea about 62-128 kg N/ ha/ season. The practice of applying laboratory prepared cultures of rhizobia to leguminous seeds before sowing is becoming popular with the farmers. Field trials in India have shown that rhizobial inoculation can increase yield of grain legumes by 20-50%. Certain rhizobia form stem nodules in legumes like *Sesbania rostrata*. The capacity of stem nodules of *S. rostrata* to fix nitrogen is very high, exceeding 150 kg N fixed per ha in 52 days. Hence this system offers a unique potential as a green manure in rice cultivation (Tilak *et al*., 2010; Mus *et al*., 2016).

In addition to different rhizobial genera (*Sinorhizobium, Allorhizobium, Bradyrhizobium, and Mesorhizobium*) forming nodules in roots of legumes and fixing nitrogen, certain other genera like *Methylobacterium*, *Burkholderia, Ochrobactrum, Cupriavidus, Devosia* have also been reported to form nodules and fix atmospheric nitrogen, recently from other countries (Moura et al., 2020; Hnini and Aurag,

2024). But no information on this is from India, suggesting initiating research in this area in our country.

Associative and Free-Living Nitrogen Fixers: Associative nitrogen fixing bacteria are those living mostly in the epidermal cells of the host and fixing atmospheric nitrogen like *Azospirillium, Herbaspirillium, Acetobacter diazotrophicus*, etc. Considerable work has been carried out in India on these organisms (Muthukumarasamy *et al*., 1999; Shahwar *et al*., 2023). A number of free-living organisms inhabiting soil are capable of fixing atmospheric nitrogen. Bacteria belonging to the genera *Azotobacter, Beijerinkia, Derxia* and Cyanobacteria (blue-green algae) are well known among these. Besides the ability to fix atmospheric nitrogen, *Azotobacte*r is also known to synthesize biologically active substances such as IAA and gibberellins. The organism also possesses fungi-static properties against certain plant pathogens. The amount of nitrogen fixed by the cyanobacteria has been reported to vary from 35-195 kg/ ha/ season. Cyanobacteria also add a bulk of organic matter to the soil. Further they also synthesize several growth promoting substances such as auxins which improve plant growth. Field trials conducted in different parts of India and South East Asia have shown significant increases in grain yields of many rice varieties by inoculation of rice fields with cyanobacteria. The cyanobacterium *Anabaena azollae* is symbiotically associated with the water fern Azolla. Azolla not only fixes atmospheric nitrogen but adds enormous amount of green manure. It is reported from Vietnam that a 10 ton layer of Azolla increases the rice yield by 10-25% over corresponding Azolla-free rice field (Bagyaraj, 2011; Maheshwari *et al*. 2022).

Microbial Inoculants Aiding Phosphorus Nutrition

Although soil may have adequate quantities of phosphorus, it may be present in bound form unavailable to plants. Many fungi and bacteria (like *Aspergillus*, *Bacillus*) are potential solubilizers of bound phosphates. These organisms produce organic acids like citric, succinic, lactic, oxalic which are responsible for the solubilization of insoluble forms of phosphorus. Use of phosphate solubilizing microorganisms is becoming popular amongst farming community. In nature nearly 90% of vascular plants are colonized by mycorrhizal fungi in their root system. The host and the fungus live in intimate symbiotic relationship. The fungi help in phosphorus nutrition of plants through increased surface area of absorption and also protect plants against biotic and abiotic stresses (Praveen *et al*., 2023; Wang *et al*., 2023).

Potassium Mobilizing Microorganisms

Potassium is the 3rd most important macro nutrient for proper plant growth and its deficiency limits quality and yield of crop plants. Soil contains potassium in large amounts but most of it is in an unavailable from for plant uptake. Certain bacteria in soil can solubilize insoluble potassium in soil to soluble forms of K which plants can take. Bacteria such as *Acidothiobacillus ferroxidans*, *Bacillus mucilaginosus*, *B. circulans*, *Paenibacillus* spp. are the common K solubilizing bacteria. These bacteria solubilize unavailable K mainly through the production of organic and inorganic acids. These bacteria are recommended as biofertilizer to improve crop productivity in sustainable agriculture (Olaniyam *et al*. 2022; Sharma *et al*., 2024).

Organic Matter Decomposition

Various organic compounds which reach the soil by way of animal and plant residues are made up of simple sugars, starch, cellulose, pectins, proteins, fats, waxes, lignin, phenols, tannins, alkaloids, pigments and other products. The huge mass of the organic matter added to the soil is immediately acted upon by the soil biota and is transformed into various substances. Some of them useful to the

microbiota, some to the plants and some apparently not useful are less harmful to both. After the more readily available constituents are decomposed quickly the resistant residue is left as a black mass. This mass together with the dead microbial cells forms a complex water-insoluble but alkali-soluble substance known as humus. Under favourable conditions humus undergoes constant but slow decomposition by certain microbes resulting in simpler substances. Humus thus forms the store house of essential elements required by the plants (Tilak *et al*., 2010; Swaminathan *et al*., 2021).

Biocontrol of Plant Pathogens

Eco-friendly organic farming technologies for plant protection have been gaining importance in recent years. Some of the plant diseases that can be controlled by antagonistic fungi and bacteria are as follows:

Trichoderma is a common soil fungus used worldwide for the biological control of diseases such as cotton *Verticillium* wilt, crop gray mold, tomato gray mold, melon wilt, potato dry rot, tobacco root rot, and other plant diseases. *T. harzianum* significantly reduced *Phytophthora* blight in pepper and potato, lowering seedling death rates and disease indices. *T. longibrachiatum* effectively controlled pepper damping off, with a 54.8% control rate, outperforming carbendazim by 12.5%. *T. asperellum* effectively mitigated apple canker by 88.24% and corn leaf spot by 77.91% (Yao *et al*., 2023). *Pseudomonas* spp. is another widely used biocontrol agent against plant diseases. Rice seeds treated with *Pseudomonas aeruginosa* and *P. putida* reduced sheath blight infection (*Rhizoctonia solani*) in rice by 65-72% in comparison to untreated check. *P fluorescens* was found to be effective against banded leaf and sheath blight fungus (*R. solani* f. sp. *sasakii*) (Ayaz *et al*., 2023). Therefore, using these biocontrol agents behaves as an effective, safe, low-cost, eco-friendly technology for controlling plant diseases which also promotes plant growth, improves nutrient utilization efficiency, enhances plant resistance and reduce agrochemical pollution (Lahlali *et al*., 2022).

Abiotic Stress Management

Abiotic stresses such as drought, salinity, extreme temperatures, and nutrient deficiencies pose significant challenges to agricultural productivity. Soil microbiota, including arbuscular mycorrhizal (AM) fungi, plant growth-promoting rhizobacteria (PGPR), and other beneficial microorganisms, play a pivotal role in mitigating these stresses and fostering sustainable agriculture (Meena *et al*. 2017). These microorganisms enhance plant resilience by improving water and nutrient uptake, synthesizing stress-related phytohormones such as abscisic acid and auxins, and inducing systemic tolerance through antioxidant enzyme production. AM fungi form symbiotic associations with plant roots, extending their hyphal networks to access immobile nutrients like phosphorus, even in saline or nutrient-poor soils. PGPR, on the other hand, fix atmospheric nitrogen, solubilize phosphates, and produce exopolysaccharides that improve soil structure and moisture retention under drought conditions. Additionally, they modulate osmotic balance, reduce ion toxicity in saline soils, and mitigate oxidative stress by scavenging reactive oxygen species (ROS) (Hassen *et al*., 2016).

Recent Advances in Microbial Inoculants

Recent studies have brought out that yeasts, actinobacteria and cyanobacteria can also promote plant growth in many crops and have the potential to be used as microbial inoculants. Yeasts promoting plant growth through N fixation, P & K solubilization, production of plant growth hormones and controlling pathogens causing post-harvest diseases of fruits have been reported recently (Bagyaraj and Ashwin 2024). Actinobacterium *Frankia* forming nodules in actinorhizal trees like Alnus, Casuarina, etc. is well known. Recent studies have revealed that different

actinobacteria promote plant growth in other crop plants through N fixation, P & K solubilization, protecting against plant pathogens and alleviating salt tolerance (Das, 2021; Bai *et al*., 2024). Cyanobacterial inoculation promoting growth and yield of wet-land rice is known to farming community. Recent studies brought out that cyanobacteria in addition to fixing N can also supply macro and micro nutrients, produce plant growth hormones, elicit plant defense mechanisms, suppress plant pathogens, ameliorate saline soils and improve soil health through C sequestration, and in turn promoting plant growth in many crop plants other than wet-land rice (Chaudhary *et al*., 2012; Bagyaraj and Ashwin, 2024).

Conclusion

Microbial inoculants are alternatives to chemical fertilizers and pesticides reducing environmental pollution and improving soil health. They are cost effective, environment friendly helping to achieve climate-resilient practices needed for the present day sustainable agriculture. Especially in developing countries, they are a boon to farmers.

References

1. Ayaz, M., Li, C. H., Ali, Q., Zhao, W., Chi, Y. K., Shafiq, M., Ali, F., Yu, X. Y., Yu, Q., Zhao, J. T., & Yu, J. W. (2023). Bacterial and fungal biocontrol agents for plant disease protection: Journey from lab to field, current status, challenges and global perspectives. *Molecules, 28*(6735). https://doi.org/10.3390/molecules28196735
2. Bagyaraj, D. J. (2011). *Microbial biotechnology for sustainable agriculture, horticulture and forestry*. New India Publishing Agency.
3. Bai, X., Han, Y., & Han, L. (2024). Transcriptional alterations of peanut root during interaction with growth-promoting *Tsukamurella tyrosinosolvens* strain P9. *PLOS ONE, 19*(2), e0298303. https://doi.org/10.1371/journal.pone.0298303
4. Chaudhary, V., Prasanna, R., Nain, L., Dubey, S. C., Gupta, V., Singh, R., Jaggi, S., & Bhatnagar, A. K. (2012). Bioefficacy of novel cyanobacteria-amended formulations in suppressing damping-off disease in tomato seedlings. *World Journal of Microbiology and Biotechnology, 28*, 3301-3310.
5. Bagyaraj, D. J., & Ashwin, R. (2024). Soil microbiota and their role in sustainable agriculture: A review. *Journal of Soil Biology and Ecology, 44*(2), 92-100.
6. Das, P., Singh, S. K., Singh, P., Zeyad, M. T., Aamir, M., & Upadhyay, R. S. (2021). Actinomycetes as biostimulants and their application in agricultural practices. In J. White, A. Kumar, & S. Droby (Eds.), *Microbiome stimulants for crops: Mechanisms and applications* (pp. 267-282). Woodhead Publishing, Elsevier.
7. Díaz-Rodríguez, A. M., Parra Cota, F. I., Cira Chávez, L. A., García Ortega, L. F., Estrada Alvarado, M. I., Santoyo, G., & de Los Santos-Villalobos, S. (2025). Microbial inoculants in sustainable agriculture: Advancements, challenges, and future directions. *Plants, 14*(2), 191.
8. Hassen, A. I., Bopape, F. L., & Sanger, L. K. (n.d.). Microbial inoculants as agents of growth promotion and abiotic stress tolerance in plants. In D. Singh, H. Singh, & R. Prabha (Eds.), *Microbial inoculants in sustainable agricultural productivity* (pp. 23-36). Springer.
9. Hnini, M., & Aurag, J. (2024). Prevalence, diversity and applications potential of nodules endophytic bacteria: a systematic review. *Frontiers in Microbiology*, *15*, 1386742.
10. Kuila, D., & Ghosh, S. (2022). Aspects, problems and utilization of arbuscular mycorrhizal (AM) application as bio-fertilizer in sustainable agriculture. *Current Research in Microbial Sciences, 3*, 100107. https://doi.org/10.1016/j.crmicr.2022.100107
11. Lahlali, R., Ezrari, S., Radouane, N., Kenfaoui, J., Esmaeel, Q., El Hamss, H., Belabess, Z., & Barka, E. A. (2022). Biological control of plant pathogens: A global perspective. *Microorganisms, 10*(3), 596.
12. Laranjeira, S., Reis, S., Torcato, C., Raimundo, F., Ferreira, L., Carnide, V., Fernandes-Silva, A., & Marques, G. (2022). Use of plant-growth promoting rhizobacteria and mycorrhizal fungi consortium as a strategy to improve chickpea (*Cicer arietinum* L.) productivity under different irrigation regimes. *Agronomy, 12*(6), 1383.

13. Maheshwari, D. K., Dobhal, R., & Dheeman, S. (2022). *Nitrogen fixing bacteria: Sustainable growth of non-legumes*. Springer.

14. Meena, K. K., Sorty, A. M., Bitla, U. M., Choudhary, K., Gupta, P., Pareek, A., Singh, D. P., Prabha, R., Sahu, P. K., Gupta, V. K., & Singh, H. B. (2017). Abiotic stress responses and microbe-mediated mitigation in plants: The omics strategies. *Frontiers in Plant Science, 8*, 172.

15. Moura, E. G., Carvalho, C. S., Bucher, C. P., Souza, J. L., Aguiar, A. C., Ferraz Junior, A. S., Bucher, C. A., & Coelho, K. P. (2020). Diversity of rhizobia and importance of their interactions with legume trees for feasibility and sustainability of the tropical agrosystems. *Diversity, 12*(5), 206.

16. Mus, F., Crook, M. B., Garcia, K., Garcia Costas, A., Geddes, B. A., Kouri, E. D., Paramasivan, P., Ryu, M. H., Oldroyd, G. E., Poole, P. S., & Udvardi, M. K. (2016). Symbiotic nitrogen fixation and the challenges to its extension to nonlegumes. *Applied and Environmental Microbiology, 82*(13), 3698-3710.

17. Muthukumarasamy, R., Revathi, G., & Lakshminarasimhan, C. (1999). Influence of N fertilisation on the isolation of *Acetobacter diazotrophicus* and *Herbaspirillum* spp. from Indian sugarcane varieties. *Biology and Fertility of Soils, 29*, 157-164.

18. Olaniyan, F. T., Alori, E. T., Adekiya, A. O., Ayorinde, B. B., Daramola, F. Y., Osemwegie, O. O., & Babalola, O. O. (2022). The use of soil microbial potassium solubilizers in potassium nutrient availability in soil and its dynamics. *Annals of Microbiology, 72*(1), 45.

19. Praveen, R., Ashwin, R., Joanna, D., Bagyaraj, D.J. (2023). Arbuscular mycorrhizal fungi as biofertilizers for sustainable agriculture. In: Biofertilizers: Agricultural Uses, Management and Environmental Effects (Ed. Bevis, P.L.), Nova Science Publishers, NY, USA. pp. 1-31.

20. Shahwar, D., Mushtaq, Z., Mushtaq, H., Alqarawi, A. A., Park, Y., Alshahrani, T. S., & Faizan, S. (2023). Role of microbial inoculants as biofertilizers for improving crop productivity: A review. *Heliyon, 9*(6).

21. Sharma, R., Sindhu, S. S., & Glick, B. R. (2024). Potassium solubilizing microorganisms as potential biofertilizer: A sustainable climate-resilient approach to improve soil fertility and crop production in agriculture. *Journal of Plant Growth Regulation, 31*, 1-33.

22. Soth, S., Hampton, J. G., Alizadeh, H., Wakelin, S. A., & Mendoza-Mendoza, A. (2025). Microbiomes in action: multifaceted benefits and challenges across academic disciplines. *Frontiers in Microbiology*, *16*, 1550749.

23. Sridhar, K. R., & Bagyaraj, D. J. (2018). Microbial biodiversity in agroforestry systems. In *Agroforestry: Anecdotal to modern science* (pp. 645-667). Springer.

24. Swaminathan, C., Nivethadevi, P., & Pandian, K. (2021). Soil organic matter decomposition – roles, factors and mechanisms. In S. S. Porte (Ed.), *Latest trends in soil sciences* (Vol. 1, pp. 61-91). Integrated Publishers.

25. Tilak, K. V. B. R., Pal, K. K., & Dey, R. (2010). *Microbes for sustainable agriculture*. IK International Publishing House.

26. Wang, C., Pan, G., Lu, X., & Qi, W. (2023). Phosphorus solubilizing microorganisms: Potential promoters of agricultural and environmental engineering. *Frontiers in Bioengineering and Biotechnology, 11*, 1181078.

27. Yao, X., Guo, H., Zhang, K., Zhao, M., Ruan, J., & Chen, J. (2023). *Trichoderma* and its role in biological control of plant fungal and nematode disease. *Frontiers in Microbiology, 14*, 1160551.

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Indian Medicinal Plants with Documented Hepatoprotective Potential: A Comprehensive Review

Amit Kaushik and Harshika Khanna

Liver diseases remain a significant global health burden, influenced by alcohol consumption, viral hepatitis, drug-induced liver injury (DILI), and metabolic syndromes. Worldwide, liver cirrhosis is among the top 10 causes of death, with an estimated 2 million deaths annually-1 million due to complications of cirrhosis and 1 million due to viral hepatitis and hepatocellular carcinoma (HCC) [1]. According to the World Health Organization (WHO), approximately 296 million people were living with chronic hepatitis B and 58 million with chronic hepatitis C as of 2019, with a combined 1.1 million deaths annually due to hepatitis-related liver failure and cancer [2]. In India, liver disease is the tenth most common cause of death, and drug-induced liver injury is a leading cause of acute liver failure in tertiary care centers [3,4]. The rising burden of non-alcoholic fatty liver disease (NAFLD), affecting 25–30% of the Indian adult population, further contributes to hepatic morbidity [5]. Jaundice remains the most visible and common clinical presentation of liver dysfunction in both community and hospital settings.

As part of our study, we have conducted an extensive literature review of medicinal plants with hepatoprotective properties, focusing on their phytochemical constituents, mechanisms of action, and preclinical or clinical evidence of efficacy. Our review aims to consolidate current knowledge on Indian herbal medicinal plants that demonstrate protective effects against liver toxicity, particularly in the context of drug-induced and viral liver injuries. By compiling and analyzing this data, we seek to provide a foundation for future research into safe, plant-based therapeutic alternatives for managing liver disorders.

Modern Synthetic Drugs as Liver Toxicants

Drug metabolism pathways are broadly classified into Phase I reactions (e.g., oxidation, reduction, and hydrolysis) and Phase II conjugation reactions (e.g., acetylation, glucuronidation, sulfation, and methylation). These reactions typically convert lipophilic drugs into more water-soluble metabolites to facilitate excretion [6,7]. However, such metabolic processes can also generate reactive intermediates that induce hepatotoxicity.

Many hepatotoxic chemicals exert their effects by causing oxidative damage, including lipid peroxidation, mitochondrial dysfunction, and direct hepatocyte necrosis [8–10]. Of the approximately 10,000 drugs used in clinical practice, more than 1,000 have been associated with liver injury, although a definitive causal relationship has not always been established [11].

Indian Herbal Medicinal Plants with Hepatoprotective Potential

The global market for herbal medicines is expanding rapidly, as the therapeutic virtues of these remedies are increasingly recognized [23]. However, concerns persist among healthcare professionals and researchers regarding the safety profile of herbal medicines, primarily due to the lack of rigorous scientific validation and compositional analyses supporting their efficacy and stability [24]. Herbal drugs are often considered effective and safer alternatives for managing liver diseases. Various indigenous herbal remedies are used to treat liver disorders across different regions, yet many of these lack thorough scientific validation. Conducting robust studies could facilitate the development of cost-effective

Table 1: Common synthetic hepatotoxicants used in experimental models.

S. No.	Toxicant	Dose Recommended	In-vivo Study Animals	Reference
1	Carbon tetrachloride (CCl_4)	1 ml/kg BW	Wistar albino rats	[12]
2	Hexachlorocyclohexane	500 ppm/kg BW	Swiss albino rats	[13]
3	Paracetamol	2 g/kg BW	Wistar albino rats	[13]
4	Thioacetamide	100 mg/kg BW	Wistar albino rats	[14]
5	Nimesulide	10 mg/ml/kg BW	Holtzman albino rats	[15]
6	D-galactosamine	500 mg/kg BW	Wistar albino rats	[16]
7	Isoniazid	100 mg/kg/day BW	Wistar albino rats	[17]
8	Rifampicin	100 mg/kg/day BW	Wistar albino rats	[18]
9	Streptozocin	50 mg/kg BW	Wistar albino rats	[19]
10	Ethanol	4 g/kg/day BW	Wistar albino rats	[20]
11	Aflatoxin	66.6 µg/kg BW	Swiss albino rats	[21]
12	Pyrazinamide	300 mg/kg BW	Guinea pigs	[22]

BW: Body Weight

Table 2: Plants with hepatoprotective potential and their reported activities.

Botanical Name	Family	Common Name	Plant Part Used	Extract	Activity Reported	Type of Model	References
Garcinia mangostana Linn.	Guttiferae	Mangostana	Fruit	Ethanol	Hepatocellular carcinoma, antioxidants, diarrhea, skin infection, chronic wound	Paracetamol	[31]
Berberis aristata	Berberidaceae	Daruharidra	Root	Aqueous	Hepatoprotection, jaundice, antioxidant	Carbon tetrachloride	[32]
Tinospora cordifolia	Menispermaceae	Guduchi	Stem	Aqueous	Hepatoprotective, jaundice, hepatitis B & E, anti-inflammatory, antioxidant, etc.	Carbon tetrachloride	[33]
Boerhavia diffusa	Nyctaginaceae	Punarnava	Root	Aqueous	Increased GOT, GPT, ACP, ALP (but not GLDH or bilirubin)	Thioacetamide	[34]
Morinda citrifolia	Rubiaceae	Noni	Fruit	Juice	Hepatic steatosis, lipid profile (ALP, AST, ALT, TC, TG, LDL, HDL, etc.)	Carbon tetrachloride	[35]
Eclipta alba	Compositae	False daisy	Whole plant	Ethanol	Liver tonic, serum transaminases, anti-inflammatory, antipyretic, skin disorders	Carbon tetrachloride	[36]
Sargassum polycystum	Phaeophyceae	Boto-boto	Whole plant	Ethanol	Inhibits hepatic lipid peroxidation, lowers AST, ALT, ALP	D-galactosamine	[37]
Cichorium intybus	Asteraceae	Chicory	Root	Ethanol	Liver tonic, gall bladder protection	Chlorpromazine	[38]
Polygala arvensis	Polygalaceae	Mirdoi	Leaves	Chloroform	Normalizes ASAT, ALAT, ALP, TB, LDH, TC, TG, TP	D-galactosamine	[39]
Pterospermumacerifolium	Sterculiaceae	Kanak Champa	Leaves	Ethanol	Lowers AST, ALT, ALP	Carbon tetrachloride	[40]
Sida acuta Burm. f.	Malvaceae	Wireweed	Root	Methanol	Hepatoprotection, anti-inflammatory, antipyretic, blood& bile disorders	Paracetamol	[41]
Rubia cordifolia Linn.	Rubiaceae	Madder	Root	Aqueous, Ethanolic	Decreases SGOT, SGPT, SALP, γ-GT	Carbon tetrachloride	[42]

hepatoprotective agents [25].

In the absence of effective liver-protective drugs in modern medicine, traditional systems like Ayurveda recommend numerous medicinal and aromatic preparations for the treatment of hepatic ailments [26]. Herbal medicines are especially significant among rural and indigenous populations in many developing nations [27]. According to the World Health Organization (WHO), approximately 80% of the world's population relies on traditional medicine, and in India, nearly 60% of the rural population utilizes herbal remedies for primary healthcare needs [28].

India's traditional medical systems—such as Ayurveda, Siddha, Unani, and Homeopathy—continue to serve as the primary source of healthcare, particularly in rural areas. These systems are rooted in the knowledge, skills, and practices developed by folk communities based on experience, beliefs, and cultural traditions to address health concerns. Indigenous communities have developed unique medicinal systems employing diverse medicinal plants and therapies, often using wild or cultivated species for treating a wide range of ailments. As a result, a wealth of ethnobotanical knowledge on medicinal plants exists within these communities [29].

Despite significant advancements in modern pharmacotherapy, there is still no widely accepted, safe, and effective hepatoprotective agent available. Consequently, herbs have assumed a vital role in managing liver disorders. Numerous plants and herbal formulations are reported to exhibit hepatoprotective activity, and nearly 160 phytoconstituents derived from 101 plant species have been documented for their liver-protective effects [30].

Conclusion

The present compilation highlights the significant hepatoprotective potential of various medicinal plants widely used in traditional Indian medicine. Plants such as *Tinospora cordifolia*, *Berberis aristata*, *Boerhavia diffusa*, *Eclipta alba*, and *Rubia cordifolia* have demonstrated broad-spectrum liver-protective effects through multiple mechanisms, including antioxidant, anti-inflammatory, and lipid-regulating activities. The efficacy of these botanicals has been substantiated across various experimental models of hepatotoxicity, including paracetamol, carbon tetrachloride, thioacetamide, and D-galactosamine-induced liver injury.

Notably, these plants exhibit activity through modulation of serum liver enzymes (ALT, AST, ALP), reduction of oxidative stress markers, and histopathological protection of hepatic tissues. The diverse phytochemical profiles—rich in alkaloids, flavonoids, polyphenols, and terpenoids—underpin their therapeutic actions. The widespread use of aqueous, ethanolic, and methanolic extracts also reflects the pharmacological importance of different plant parts, especially roots, stems, and fruits.

While the pre-clinical evidence is promising, rigorous clinical investigations and standardization of formulations are essential to validate their efficacy and safety for therapeutic use. Collectively, these medicinal plants represent a valuable reservoir of bioactive compounds with the potential to serve as complementary or alternative strategies for managing liver disorders and mitigating hepatotoxicity.

References

1. Asrani SK, Devarbhavi H, Eaton J, Kamath PS. Burden of liver diseases in the world. *J Hepatol*. 2019; 70(1): 151–71.
2. World Health Organization. Global progress report on HIV, viral hepatitis and sexually transmitted infections, 2021. Geneva: WHO; 2021.
3. Choudhuri G, Chetri K, Majumdar K, Nayak S. Drug-induced liver injury in India: A review. *Euroasian J Hepatogastroenterol*. 2015; 5(1): 29–36.
4. Devarbhavi H. Drug-induced liver injury: Indian

perspective. *Clin Liver Dis (Hoboken)*. 2013; 2 (Suppl 1): S24–6.

5. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease: Meta-analytic assessment of prevalence, incidence, and outcomes. *Hepatology*. 2016; 64(1): 73–84.
6. Klaassen CD, Watkins JB. Mechanisms of bile formation, hepatic uptake, and biliary excretion. In: Klaassen CD, editor. *Casarett & Doull's Toxicology: The Basic Science of Poisons*. 8th ed. New York: McGraw-Hill; 2013.
7. Park BK, Kitteringham NR, Pirmohamed M. Adverse drug reactions. *Br J Clin Pharmacol*. 2001; 52(1): 1–11.
8. Kaplowitz N. Drug-induced liver injury. *Clin Infect Dis*. 2004; 38 (Suppl 2): S44–8.
9. Jaeschke H, McGill MR, Ramachandran A. Oxidant stress, mitochondria, and cell death in drug-induced liver injury. *Drug Metab Rev*. 2012; 44(1): 88–106.
10. Navarro VJ, Senior JR. Drug-related hepatotoxicity. *N Engl J Med*. 2006; 354(7): 731–9.
11. Lee WM. Drug-induced hepatotoxicity. *N Engl J Med*. 2003; 349(5): 474–85.
12. Manibusan MK, Odin M, Eastmond DA. Postulated carbon tetrachloride mode of action: a review. *Regul Toxicol Pharmacol*. 2007; 48(1): 8–23.
13. Bhattacharjee R, Sil PC. Hepatoprotective effect of Himoliv against paracetamol and hexachlorocyclohexane-induced oxidative stress. *Indian J Pharmacol*. 2006; 38(6): 417–20.
14. Pradeep K, Mohan CVR, Gobianand K, Karthikeyan S. Silymarin modulates the oxidative stress–induced hepatotoxicity of thioacetamide in rats. *Eur J Pharmacol*. 2007; 561(1–3): 123–31.
15. Akhtar AH, Ahmad M. Nimesulide-induced hepatotoxicity in rats: a dose-dependent study. *Indian J Pharmacol*. 1999; 31(5): 290–4.
16. Hirschelmann R, Bekemeier H. D-galactosamine liver injury in rats. *Arch Toxicol*. 1980; 44(1): 75–82.
17. Singh M, Dhasmana DC, Bisht M. Hepatotoxicity of isoniazid and rifampicin and effect of vitamin E in rats. *Indian J PhysiolPharmacol*. 2001; 45(2): 199–202.
18. Ramesh A, Begum S. Hepatoprotective role of *Phyllanthus amarus* against rifampicin-induced toxicity. *Indian J Pharmacol*. 1998; 30(3): 165–8.
19. Wang ZG, Zhang L, Li H, et al. Streptozotocin-induced diabetes in rats: an experimental model for studying hepatocyte apoptosis. *Exp Clin Endocrinol Diabetes*. 2005; 113(9): 538–43.
20. Lieber CS. Alcoholic fatty liver: its pathogenesis and mechanism of progression to inflammation and fibrosis. *Alcohol*. 2004; 34(1): 9–20.
21. Groopman JD, Cain LG, Kensler TW. Aflatoxin exposure in human populations: measurements and relationship to cancer. *Crit Rev Toxicol*. 1988; 19(2): 113–45.
22. Chhetri HP, Yogol NS, Sherchan J, et al. Screening of some traditionally used medicinal plants for hepatoprotective activity using pyrazinamide-induced hepatotoxicity model. *Kathmandu Univ J Sci Eng Technol*. 2008; 1(5): 49–56.
23. Ekor M. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. *Front Pharmacol*. 2014; 4: 177.
24. Izzo AA, Hoon-Kim S, Radhakrishnan R, Williamson EM. A critical approach to evaluating clinical efficacy, adverse events and drug interactions of herbal remedies. *Phytother Res*. 2016; 30(5): 691–700.
25. Subramoniam A. Plants with hepatoprotective properties: A review. *Indian J Pharmacol*. 2014; 46(5): 505–13.
26. Sharma A, Chakraborti KK, Handa SS. Anti-hepatotoxic activity of some Indian herbal formulations as compared to silymarin. *Fitoterapia*. 1991; 62(3): 229–35.
27. World Health Organization. *WHO Traditional Medicine Strategy: 2014–2023*. Geneva: WHO; 2013.
28. Patwardhan B, Warude D, Pushpangadan P, Bhatt N. Ayurveda and traditional Chinese medicine: a comparative overview. *Evid Based Complement Alternat Med*. 2005; 2(4): 465–73.
29. Kala CP, Farooquee NA, Dhar U. Traditional uses and conservation of timur (*Zanthoxylum armatum*) in the Indian Himalaya. *J Ethnobiol*

Ethnomed. 2005; 1: 3.

30. Chattopadhyay RR. Possible mechanism of hepatoprotective activity of *Azadirachta indica* leaf extract: Part II. *J Ethnopharmacol*. 2003; 89(2–3): 217–9.
31. Pedraza-Chaverri J, et al. Hepatoprotective activity of *Garcinia mangostana* fruit extract. *Food Chem Toxicol*. 2008; 46(2): 322–9.
32. Saneja A, et al. Hepatoprotective effect of *Berberis aristata* in CCl_4 -induced hepatotoxicity. *J Ethnopharmacol*. 2011; 134(2): 403–10.
33. Singh SS, et al. Hepatoprotective properties of *Tinospora cordifolia*. *Indian J Pharmacol*. 2003; 35(2): 83–91.
34. Mazumder PM, et al. Hepatoprotective activity of *Boerhaviadiffusa* root extract. *Asian J Pharm Clin Res*. 2011; 4(2): 119–23.
35. Wang MY, et al. Noni juice improves liver function in CCl_4 -induced hepatotoxic rats. *Plant Foods Hum Nutr*. 2002; 57(3–4): 375–86.
36. Arunachalam G, *et al.* Evaluation of hepatoprotective activity of *Eclipta alba* against CCl_4 toxicity. *J Ethnopharmacol*. 2009; 124(2): 294–7.
37. Darusman LK, et al. Hepatoprotective activity of *Orthosiphon stamineus* leaf extract. *J Appl Pharm Sci*. 2011; 1(9): 74–9.
38. Gilani AH, et al. Pharmacological basis for the medicinal use of *Curcuma longa* in liver disorders. *J Ethnopharmacol*. 1999; 67(2): 203–10.
39. Islam MT, et al. Hepatoprotective activity of *Phyllanthus niruri* against paracetamol-induced liver damage. *Pharmacogn Mag*. 2015; 11 (Suppl 1): S64–9.
40. Handa SS, et al. Hepatoprotective activity of *Picrorhizakurroa*. *Indian J Med Res*. 1986; 84: 634–8.
41. Dhananjayan R, et al. Hepatoprotective effect of *Tinospora cordifolia* against carbon tetrachloride-induced hepatic damage. *J Pharm Res*. 2011; 4(4): 1147–9.
42. Multiple references on *Rubia cordifolia*'s hepatoprotective effects—available upon request for detailed listing.

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Diversity, Abundance and Impact of Insect Visitors in *Litchi chinensis*

S. G. Eswara Reddy

Litchi chinensis Sonn., (Sapindaceae) is known as the "queen of fruits". It is a tropical fruit native to Southeast Asia [Nakasone and Paull,1998; Priyadarshi *et al*., 2018]. It has a sweet flavour and a white translucent aril, eaten in raw/processed form and added to ice-cream [Hui, 2006; Salunkhe and Desai, 1984]. China is the biggest producer of litchi in the world, followed by India, Vietnam, and Thailand [Kumari *et al*., 2018]. In India, litchi is cultivated in Bihar, West Bengal, Assam, Jharkhand, Uttarakhand, and Odisha in an area of 92,100 hectares with an output of 583,400 t annually. In Himachal Pradesh, litchi is grown over an

area of 5673 hectares with an annual production of 5469 t, covering Kangra, Sirmour, Bilaspur, and Una [Priyadarshi *et al.*, 2018; Lal *et al.*, 2021]. The litchi is highly self-sterile and cross-pollinated, so its flowers require sufficient pollinators for pollination and fruit set.

Litchi panicles are rich in nectar that attracts insects. Various insect orders, such as Hymenoptera, Diptera, Lepidoptera, and Coleoptera, visit litchi flowers, but honey bees, flies, and wasps play a significant role in pollination [Chaturvedi, 1965]. The low fruit set observed in self-sterile cultivars is due to the litchi's lack of sufficient pollinators, leading to low production [Free, 1993] and failure to bear fruits [UJI, 1989]. *Apis* and *Melipona* species are prominent visitors (98–99%) of litchi flowers. However, *A. mellifera* is the primary pollinator. The productivity of fruits was significantly increased by pollinators [Pandey and Yadava, 1970; McGregor, 1976; Vithanage and Ironside, 1986]. Cross-pollination enhances fruit set, yield, and quality in litchi compared to no pollination [Butcher, 1956; King *et al.*, 1989; Badiyala and Awasthi, 1991; Mahanta and Rahman, 1997; Rai and Srivastav, 2012]. Most beekeepers move honey bee colonies to litchi plantations for nectar for honey bees from March to April and harvest mono-floral honey with good color and flavour. Pollination research is more important to validate the effect of pollinators on the percentage of pollination, fruit set, productivity, and yield of litchi. In India, *Apis mellifera* and *Apis cerana* are predominant pollinators, but *A. cerana* dominates in South India, whereas *A. mellifera* in Northern India contributes more than 80% of pollination in litchi and other fruit crops. As per the literature, few scientific reports are available in India for pollination studies on litchi and their impact on yield. Therefore, the current investigation planned to study diversity, abundance and impact of insect visitors in litchi; to study the comparison of natural pollination, fruit set, and yield of litchi with that of *A. mellifera* under caged trees and excluding insect pollinators; and (c) to study the effect of weather parameters on the abundance of insect visitors in litchi.

The studies on the diversity and abundance of insect visitors and their impact on pollination, fruit set, yield, and quality characters of *L. chinensis* cv Shahi were carried out in litchi fields (0.5 ha) from April–May 2022 in three different locations such as experimental field 1 (Bhadwar) and field 2 (Kalara) and field 3 (Samma), Kangra district, Himachal Pradesh. The selected litchi trees/fields are similar in age (8–10 years), flowering without any other inter/mixed crops. The apiary (one bee colony with eight frames) was kept in the litchi field (natural pollination with *A. mellifera*). However, the treatment (T3) natural pollination alone was three kilometers away from the natural pollination with *A. mellifera* (T4) to avoid the visiting of *A. mellifera* in the natural pollination (T3) without influencing the data on quantitative parameters.

Diversity of insect visitors in *L. chinensis* ecosystem

The present study was carried out as per the previous reports [Srivastava *et al.*, 2017]. The experiment was carried out in a randomized block design (RBD) with four treatments and five replications. The treatments included: (T1) Caged tree with nylon mesh; (T2) Excluding insect pollination (bagging with nylon mesh); (T3) Natural pollination alone; (T4) Natural pollination with one *A. mellifera* colony. There were five trees/replications. The 20 trees were randomly assigned in different treatments. Five panicles of uniform size (15 cm)/tree/direction were tagged with ribbon in four directions (North, South, East, and West). Observations on insect visitors in litchi flowers were recorded by visual counting for 5–10 min/direction/tree during the morning (9–11 a.m.) and evening (3 to 6 p.m.) continuously for 10 days. The diversity of different orders was measured by using the Shannon-Wiener Diversity Index: $H = -\Sigma Pi (\ln Pi)$, where H represents the genus/species diversity index in

a given locality, and Pi is the proportion of the total sample belonging to the ith species [Shannon, 1948].

Abundance of insect visitors in natural pollination (Field 1) and natural pollination with one *Apis mellifera* Colony (Field 2)

The abundance of insect visitors in *L. chinensis* was recorded in two treatments, i.e., natural pollination (under open field conditions without using a bee colony) and natural pollination with one *A. mellifera* colony. There were five trees or replicates in each treatment. The treatment with natural pollination was three kilometers away from the natural pollination with one *A. mellifera* colony. The observed insect visitors on flowers were sampled, identified, and grouped into different orders, *viz.*, Hymenoptera, Diptera, Lepidoptera, and Coleoptera. The percentage abundance was calculated by using the following formula:

Abundance (%) = [Number of insect visitors/ Total number of all insect visitors] × 100.

The weather data were recorded with an environmental meter at different intervals during the morning/evening. The correlation analysis was performed between insect abundance and various weather parameters. The data on insect visitors were analyzed by using SPSS software version 26. The data on percentage abundance of insect visitors in field 1 (natural pollination) and field 2 (natural pollination with *A. mellifera* colony) were compared by t-test.

Diversity of insect visitors in *L. chinensis*

Many insects visited the litchi inflorescence during the flowering stage in natural pollination and natural pollination with one *A. mellifera* colony. 75 insect species visited the litchi flowers (Table 1). Of these, 14 (18.67%) insect species belong to Hymenoptera, 33 (44%) to Lepidoptera, 19 (25%) to Diptera and 9 (9%) to Coleoptera (Table 1). Based on the Shannon-Wiener diversity index (scale-low diversity (<1.5), medium diversity (>1.5) and high diversity (>2.5)). The results showed that the total diversity index value of insect pollinators is 1.15, which indicates low diversity in the present study.

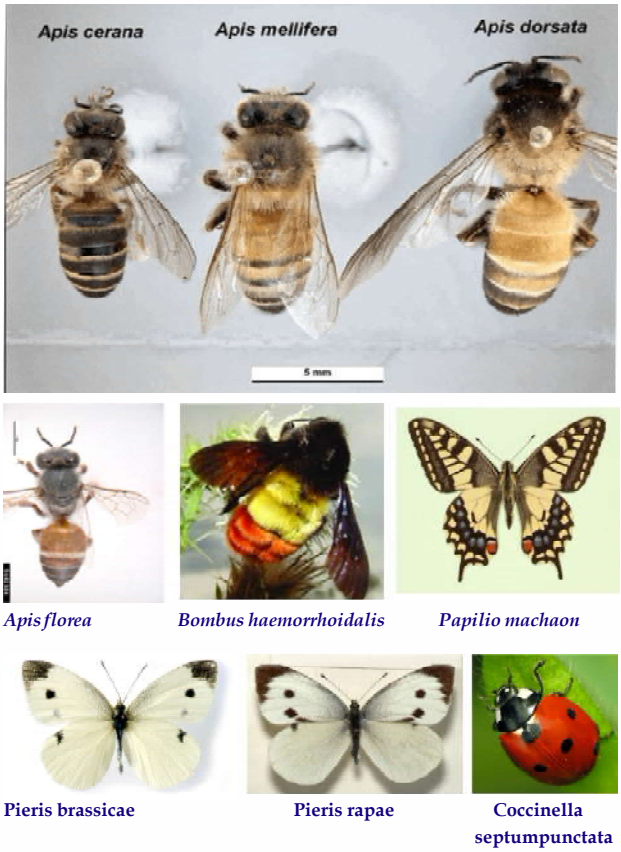

Figure 1. Selected insect pollinators/visitors in *L. chinenesis*

Relative abundance of visitors in *L. chinensis*

In natural pollination (Field 1), the percentage abundance of insect visitors of Hymenoptera was higher during the morning and evening (50.25 and 44.89%, respectively) as compared to Lepidoptera, Diptera, and Coleoptera (Figure 2a). Similarly, natural pollination with one *A. mellifera* colony (Field 2), the **Insect** percentage abundance of insect visitors of Hymenoptera was higher during the morning and evening (50 and 57 %, respectively) as compared to Lepidoptera,

Table 1. List of insect pollinators/visitors in *L. chinenesis*

Sr. No.	Scientific Name	Family	Order	Insect Species	Diversity (%)
1.	*Apis dorsata*	Apidae	Hymenoptera	14	18.67
2.	*Apis mellifera*				
3.	*Apis cerana*				
4.	*Apis florea*				
5.	*Bombus haemorrhoidalis*				
6.	*Ceratina sp.*				
7.	*Amegilla sp.*				
8.	*Anthophora sp.*				
9.	*Andrena sp.*	Andrenidae			
10.	*Componotus sp.*	Formicidae			
11.	*Vespa mandarinia*	Vespidae			
12.	*Bracon sp.*	Braconidae			
13.	*Pimpla sp.*	Ichneumonidae			
14.	*Formica sp.*	Formicidae			
15.	*Horaga onyx*	Lycaenidae	Lepidoptera	33	44.00
16.	*Tarucus nara*				
17.	*Udara dilecta*				
18.	*Pseudozizeeria maha*				
19.	*Euchrysops cnejus*				
20.	*Zizeeria karsandra*				
21.	*Junonia almana*	Nymphalidae			
22.	*Kaniska canace*				
23.	*Ypthima huebneri*				
24.	*Aglais urticae*				
25.	*Vanessa cardui*				
26.	*Symbrenthia hippoclus*				
27.	*Neptis hylas*				
28.	*Junonia iphita*				
29.	*Junonia lemonias*				
30.	*Euploea core*				
31.	*Junonia hierta*				
32.	*Cyrestis thyodamas*				
33.	*Papilio machaon*	Papilionidae			
34.	*Papilio bianor*				
35.	*Papilio polytes*				
36.	*Lithosiina sp.*	Arctiidae			
37.	*Pieris brassicae*	Pieridae			
38.	*Pieris rapae*				
39.	*Eurema sp.*				
40.	*Amata bicincta*	Erebidae			
41.	*Syntomoides imaon*				
42.	*Asota sp.*				
43.	*Lymantria marginata*				
44.	*Hesperiid sp.*	Hesperiidae			
45.	*Sarangesa dasahara*				
46.	*Asota plaginota*	Noctuidae			
47.	*Danaus chrysippus*	Danaie			
48.	*Eristalinus megacephalus*	Syrphidae	Diptera	19	25.00
49.	*Eristalinus sp.*				
50.	*Episyrphus sp.*				
51.	*Episyrphus balteatus*				
52.	*Eristalinus taeniops*				
53.	*Eristalinus sp.*				
54.	*Dasysyrphus sp.*				
55.	*Brachypalpoides sp.*				
56.	*Sphaerophoria sp.*				
57.	*Melanostoma sp.*				
58.	*Copestylum sp.*				

Sr. No.	Scientific Name	Family	Order	Insect Species	Diversity (%)
59.	*Sarcophaga spp.*	Sarcophagidae			
60.	*Stomorhina sp.*	Rhiniidae			
61.	*Rhiniid sp.*				
62.	*Exoprosopa sp.*	Bombyliidae			
63.	*Diopsis sp.*	Diopsidae			
64.	*Rhagoletis sp.*	Tephritidae			
65.	*Tachinid sp.*	Tachinidae			
66.	*Calliphora sp.*	Calliphoridae			
67.	*Batocera sp.*	Cerambycidae			
68.	*Harmonia sp.*	Coccinalidae			
69.	*Cycloneda sanguinea*				
70.	*Coccinella septumpunctata*				
71.	*Coccinella transversalis*		Coleoptera	9	12.00
72.	*Chlorophorus sp.*	Cerambycidae			
73.	*Lycus sanguineus*	Lycidae			
74.	*Epicauta sp.*	Meloidae			
75.	*Dictyoptera simplicipes*	Lycidae			

Diptera, and Coleoptera (Figure 2b). The means of two samples with equal variances from field 1 and field 2 were analyzed by t-test, which showed that there was no significant difference in the relative abundances between the fields.

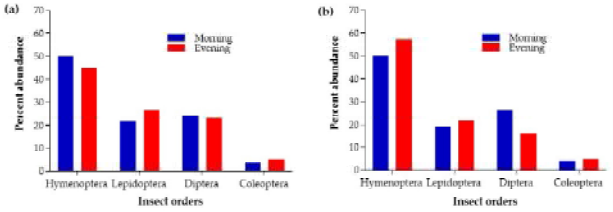

Figure 2. Relative abundance of insect pollinators: (a) Field 1 (Natural pollination); (b) Field 2 (Natural pollination with one *A. mellifera* colony).

Correlation between the abundance of insect pollinators with weather parameters

An attempt was made to establish the relationship between the mean abundance of insect visitors with weather parameters of three and seven days before observations in field 1 (Natural pollination) and field 2 (Natural pollination with one *A. mellifera* colony). In field 1, among the weekly weather variables, Diptera showed a significant positive correlation with temperature, wind speed, and UV in the morning. The Dipteran population showed a significantly negative correlation with humidity in the morning, whereas the population of Coleoptera also showed a significantly negative correlation with UV radiation in the evening. Alternatively, in field 2, all the weather parameters showed a non-significant correlation with insect orders. Similarly, the pollinator abundance recorded at three-day intervals was correlated with the previous three-day weather variables. Results showed that the Diptera population showed a significant positive correlation with wind speed and UV during the morning in field 1. On the other hand, in field 2, Diptera showed a significant negative correlation with humidity in the evening, and Coleoptera showed a significant negative correlation with temperature and wind speed during the evening.

Effect of different modes of pollination on the yield of *L. chinensis*

Among different treatments evaluated in the field, the percentage fruit set and fruit weights (g) were significantly higher in natural pollination with *A. mellifera* (23% and 1.6 g, respectively). They were at par with natural pollination (22 and 1.3 g, respectively), and the caged tree with one *A. mellifera* colony (21% and 1.4 g, respectively). The fruit set and number of fruits were seen in the treatment, excluding insect pollinators, where the panicles were covered with nylon mesh bags.

References

1. Badiyala, S.D.; Awasthi, R.P. Physico-chemical characteristics of some litchi (*Litchi chinensis* Sonn.)
2. cultivars grown in Kangra valley. *Indian Food Pack*. 1991, 45, 42–45.
3. Butcher, F.G. Bees pollinate litchi blooms. *Proc. Fla Lychee Growers Assoc*. 1956, 3, 59–60.
4. Chaturvedi, R.B. Preliminary studies in the sex distribution, pollination and fruit development in litchi (*Litchi chinensis* Sonn.). *Allahabad Farmer* 1965, 39, 49–51.
5. Free, J.B. *Insect Pollination of Crops*; Academic Press: Cambridge, MA, USA, 1993; Volume 2, p. 684.
6. Hui, Y.H. *Handbook of Fruits and Fruit Processing*; Wiley-India edition; John Wiley & Sons: Hoboken, NJ, USA, 2006.
7. King, J.; Exley, E.M.; Vithanage, V. Insect pollination for yield increases in lychee. In. D. J. Batten (ed.) *Proceedings of the Fourth Australian Conference on Tree and Nut Crops*; Exotic Fruit Growers' Association, Lismore, Australia, 1989; pp. 142–145.
8. Kumari, S.; Rani, R.; Chandola, J.C.; Mir, H.; Ahmad, M.F.; Bharti, A. Effect of pollination method on fruit set in commercial cultivars of Litchi. *Int. J. Curr. Microbiol*. 2018, 7, 603–606.
9. Lal, N.; Gupta, A.K.; Marboh, E.S.; Kumar, A.; Nath, V. Effect of mode of pollination on fruit set and fruit characteristics in litchi. *Erwerbs-Obstbau* 2021, 63, 227–232.
10. Mahanta, M.; Rahman, A. Studies on pollination of litchi (*Litchi chinensis* Sonn.) by honeybees (*Apis cerana* F.). *Indian Bee J*. 1997, 59, 74–75.
11. McGregor, S.E. Insect pollination of cultivated crop plants. The Carl Hayden Bee Research Centre, USDA, ARS, Tucson, AZ. 1976, 23, 104.
12. Nakasone, H.Y.; Paull, R.E. Tropical fruits. *CAB Int*. 1998, *16*, 445.
13. Pandey, R.S.; Yadava, R.P.S. Pollination of litchi (*Litchi chinensis*) by insects with special reference to honeybees. *J. Apic. Res*. 1970, 9, 103–105.
14. Priyadarshi, V.; Hota, D.; Karna, A.K. Effect of growth regulators and micronutrients spray on chemical parameter of litchi (*Litchi chinensis* Sonn.) cv. Calcuttia. *Int. J. Econ. Plants* 2018, 5, 99–103.
15. Rai, V.L.; Srivastav, P. Studies on the impact of bee pollination on yield and quality of litchi (*Litchi chinensis* Sonn.). *Progress. Hortic*. 2012, 44, 262–264.
16. Salunkhe, D.K.; Desai, B.B. *Postharvest Biotechnology of Fruits*; CRC Press: Boca Raton, FL, USA, 1984; pp. 1–2.
17. Shannon CE. A mathematical theory of communication. *Bell Syst. Tech. J*. 1948, 27, 379–423.
18. Srivastava, K.; Sharma, D.; Pandey, S.D.; Anal, A.K.D.; Nath, V. Dynamics of climate and pollinator species influencing litchi (Litchi chinensis) in India. *Indian J. Agric. Sci*. 2017, 87, 266–9.
19. UJI, T. Pollination in *Nephelium lappaceium* var lappaceum. *Ber. Biol*. 1989, 3, 31–34.
20. Vithanage, V.; Ironside, D.A. The insect pollinators of macadamia and their relative importance. *Aust. J. Agric. Res*. 1986, 52, 155–160.

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Breeding and Seed Production, Culture, and Prospects of Striped Murrel (*Channa striatus*) in India

Kasi Marimuthu

The striped murrel (*Channa striatus*) belongs to the family of Channidae, is a highly valued freshwater food fish species as well as a native fish species in India. It is widely distributed in different freshwater bodies such as rivers, lakes, and ponds throughout India. The distribution of murrels spans the Indian subcontinent, encompassing regions such as the Ganges-Brahmaputra basin, the Western Ghats, and the northeastern states. It fetches substantial commercial importance in India due to its excellent taste, high market demand, and medicinal values and nutritional qualities (Ong et al, 2010, Marimuthu et al, 2011). Naturally, they are carnivorous and feed on insects, plankton, and snails. They possess accessory air-breathing organs that respire atmospheric oxygen for respiration and are capable of surviving in harsh and oxygen-depleted environments (Marimuthu et al., 2001; Haniffa et al., 2004). Due to these adaptive abilities, they thrive in all kinds of shallow freshwater habitats such as marshes, paddy fields, swamps, streams, lakes, and irrigation canals. Further, the species has gained considerable attention among fish farmers for aquaculture development owing to its fast growth, hardiness, and adaptability to captive conditions. However, the dependence on the wild collection of fry and fingerlings for seed supply has long been a bottleneck for the commercial-scale aquaculture and farming of this species. Recent advances in induced breeding and hatchery seed production techniques have provided promising alternatives to overcome this limitation (Muntaziana et al 2013, Marimuthu et al 2001, Marimuthu et al 2007). The development of successful breeding protocols using natural and synthetic hormones such as pituitary extract, HCG, Ovaprim, and Ovatide and the larval rearing techniques has paved the way for expanding murrel aquaculture in India (Marimuthu et al., 2007). Despite these advances, large-scale culture of *murrels* in India is still not in a promising stage compared to other Asian countries like Thailand and Vietnam, where murrel farming is well established.

The culture practices in India are primarily limited to ponds and tanks, with varying levels of stocking densities. Issues related to cannibalism during early larval stages, feed development, and disease management continue to pose challenges in farming the fish. Any successful small-scale fish farming requires simple breeding and seed production methods and established culture practices. It is easy to breed murrel fish and grow under captive conditions and they do not require high technology and facilities. The main constraint in the expansion of murrel culture in India is the lack of an adequate and reliable supply of fry and fingerlings for fish culture. No hatcheries have been established for breeding and seed production of murrles throughout India. They are highly cannibalistic when substantial differences in size occur. Hence, it is apparent that simple protocols covering the induction of egg production, egg hatching, and particularly larval rearing techniques that enhance fry and fingerling survival need to be further simplified to ensure a sufficient supply of fingerlings. This article presents an overview of the status of striped murrel aquaculture in India, with a focus on breeding techniques, seed production, grow-out culture practices, and prospects.

Taxonomy

According to Bloch (1793), the valid scientific name of this fish is Channa striatus (Bloch, 1793). The synonymous of the species

are *Ophicephalus striatus* (Bloch 1793); *Ophiocephalus striatus.* It is also commonly known as Snakehead murrel in India, Common Snakehead, Chevron Snakehead, Asian Snakehead, and Striped Snakehead. They are commonly called different names in India as Viral meen in Tamil Nadu, Haruan in Malaysia, and Pla Chon in Thailand. The following is the taxonomical description of *Channa striatus:*

Kingdom: Animalia; **Phylum**: Chordata; **Class**: Actinopterygii; **Order**: Anabantiformes; **Family**: Channidae (snakeheads); **Genus**: *Channa;* **Species**: *Channa striata* (Bloch, 1793)

Habit and habitat

This species is found in rivers, swamps, ponds, canals, drains, reservoirs, rice fields, small streams, mining pools, roadside ditches, and lakes, across southern Asia, southern China, Indo China, and the Sunda Islands. In Malaysia, this species is reported to exist in rivers, lakes, swamps, rice paddies, mining pools, and roadside ditches. In India, it can be found in reservoirs and rice paddies. It is a benthopelagic and obligate air-breathing fish species that thrive in harsh water quality conditions, and reported that the species prefers primarily shallow waters with dense vegetation. They possess an air-breathing organ for atmospheric respiration and the breathing organ is developed in about 60 days during growth from a length of 1.0-4.5 cm The fingerlings of this species spend up to 15 percent of the time in surfacing and related activities.

Reproductive Biology

The murrles breed naturally during the southwest monsoon and northeast monsoon seasons in flooded rivers and ponds in southern parts of India but the absence of the monsoons often limits seed production. It attains sexual maturity from 8 -12 months of age and typically they matures at a size of 20 – 25 cm and a body weight of 300 – 500 g in the natural habitat. It spawns once a year in the natural environment in floodplains during the rainy seasons. The spawning is triggered by **rainfall, rising water levels,** and **temperatures** between **26°C - 30°C**. The fry collection from the wild is unreliable and limited to the rainy season. Although murrels reproductively mature in captive conditions, they rarely spawn naturally in captivity and hence to overcome these problems, induced spawning is thought to be the only alternative method for quality seed supply and production. Sexes are separate in murrels and visible and easy to identify male and female fishes. Males have slightly protruded papillae near the anus region, whereas females have a simple round opening. Morphological features like a bulging abdomen, slightly reddish and protruded genital papilla-like structures with blunt tip can help in determining the maturity of female fish. The fecundity of the species is higher than other freshwater fishes, which ranges from 5000 to 20000 eggs per female, depending on the size and age of the females. During courtship, males engage in elaborate displays, intensifying their colours and performing courtship behaviour to attract females (Marimuthu et al 2001; Haniffa et al 2004). Spawning occurs in shallow waters, with the female releasing adhesive eggs that attach to substrates (Marimuthu and Haniffa 2007). Notably, murrels exhibits unique parental care behavior, with males actively guarding and protecting the eggs and larvae until the fry and fingerling stages (Marimuthu et al 2001; Haniffa et al 2004). Factors such as water quality, temperature, and the availability of suitable spawning sites influence reproductive success.

Broodstock management

The establishment of murrel fish farming requires a consistent supply of good quality seed, necessitating captive breeding; careful broodstock management, and suitable larval rearing techniques. The broodstock can be obtained from natural water bodies, rivers, ponds, and fish farms. For best breeding performance, brood fish should be more than 1 year old at least and should be more than 500 g

body weight for both males and females. Brood fish should be collected several weeks in advance of spawning to minimize stress and transportation injury. They can be stocked in circular or rectangular cement and plastic tanks at a stocking density of 2-5 fish/square meter. A minimum water depth of 60 cm is recommended. A weekly water exchange of 50 -75% can be made to maintain the water quality parameters within the favourable ranges. The quality and quantity of feed, as well as the feeding regime, are important for spawning as well as egg quality. They are carnivores and mainly feed on small bottom-dwelling organisms in natural conditions, but animal bio-wastes, trash fish, and formulated feeds can be offered as feed. Broodstock can be fed with a commercially formulated diet with 50 - 55% protein levels twice daily at *ad libitum*. Larger, mature females produce more eggs than smaller females. Proper care and acclimation of bloodstock will improve egg quantity and quality (Figs 1& 2).

Induced spawning and seed production

Induced breeding and seed production methods have been crucial in enhancing fish production. Researchers have employed various techniques to stimulate controlled reproduction in this species, ultimately improving seed production in captivity. Hormonal induction is a commonly utilized method to synchronize and induce spawning. Successful breeding and seed production using hormonal agents, such as carp pituitary extract (CPE) or synthetic analogs of gonadotropin-releasing hormone (GnRH), was achieved in murrels (Marimuthu et al 2007). The precise timing and dosage of hormonal treatments play a pivotal role in optimizing the success of induced breeding. Additionally, environmental cues, such as temperature manipulation and photoperiod control, are often employed alongside hormonal induction to mimic natural breeding conditions.

Before hormone induction, brooders are conditioned in hapas or tanks for 2–3 weeks and fed a high-protein diet (50–40%) to enhance gonadal development. Optimal environmental conditions include a water temperature of 27-30°C and adequate aeration. Hormonal induction is generally carried out using Ovaprim at a dosage of 0.5-1.0 ml/kg body weight and human Chorionic Gonadotropin (HCG) at 500 -1000 IU/kg for females and males. The hormones are administered via intramuscular injection at the base of the caudal peduncle (Fig.3). Spawning typically occurs within 12-24 hours post-injection, depending on temperature and hormone type. Natural spawning takes place in circular tanks or earthen ponds with aquatic vegetation. The eggs are floating and adhesive, with a diameter of approximately 1.0–1.5 mm (Fig 4). Hatching takes place within 24 -36 hours at 28–30°C.

Larval rearing techniques

Murrels larvae are very delicate and require the utmost care for their growth and survival during hatchery rearing. The newly hatched larvae are about **3.0 to 4.0 mm** in total

Fig 1: Striped Murrel Channa striatus

Fig 2: Broodstock of Striped Murrel

length, transparent in appearance, and possess a prominent yolk sac, which sustains them for the first two to 48 to 72 hrs (Fig. 6). The hatched larvae are separated from unfertilized and dead eggs. They are released in rectangular glass aquariums or circular polythene pools or cement tanks for further rearing. The tanks are filled with chlorine free clean tap water with gentle aeration. During this time the larvae migrate to the corner of the rearing containers and aggregate in patches. Initially, the water level of containers needs to be maintained at 5 – 10 cm and gradually increased to 20 – 30 cm after one week. Water levels need to be adjusted at different stages of rearing to minimize the stress on larvae.

Larvae are initially nourished by their yolk sac for the first 2–3 days post-hatching. On the third day, the yolk sac is fully absorbed and the mouth is well formed and readily accepts exogenous feed, typically on live feed such as *Artemia nauplii* or *Moina*. Between days 5 to 7, the larvae exhibit more active swimming behavior and the early development of fins. From day three onwards, the larvae can be fed with small live plankton harvested from earthen ponds and /or Artemia nauplii and moina until day 15. Pigmentation begins to appear around day 15, and scales start forming (Fig 7). Boiled egg paste or artificial crumble feed can be used as a feed for larvae from the 15th day after exogenous feeding until day 25. By the 25th to 30th day, the larvae resemble juveniles in appearance and can be gradually weaned onto finely ground or formulated feeds. The supply of live plankton can be withdrawn gradually during the rearing period of 10-15 days. This mixed feeding not only enhances growth but also ensures a higher survival rate (Haniffa et al., 1999; Kumar et al 2008; Marimuthu et al 2009).

Throughout the larval development period, optimal water quality conditions such as temperatures of 28–30°C, dissolved oxygen levels above 5 mg/L, and pH around 6.8 to 7.5 are critical for high survival and growth of fish. From day 30, the fry can be fed *ad libitum* with commercial feed crumbles containing 50 % protein and 7 % lipid. The daily feed ratio should be divided into three to four meals a day. Inherent size variation and cannibalism are also some of the problems of the culture of this fish species. Frequent size grading is advisable to avoid cannibalism and increase the survival rate in the larval rearing stage. Fry can be further reared in cement for another 20 – 30 days before stocking the fingerlings into culture ponds. Healthy fry should be considered for stocking nursery tanks for higher growth and survival. Good fingerling production requires proper attention to the preparation of nursery tanks, size grading, stocking fry, and feeding of fingerlings. Higher stocking density in the larval rearing phase will affect growth and survival due to overcrowding stress

Cement tanks may be used for nursery rearing. Rearing of fry in earthen pond conditions may not give a good survival rate due to natural mortality or predation by predators. Small sized cement tanks of 10 -20 m^2 are preferred to monitor the survival rate and to avoid predation. These cement nursery tanks are provided with a 2-3 cm soil base and a water level of 10-20 cm. To promote the natural algal and plankton production, a single dose of cow dung 2-3kg are applied for this size of tanks. The tanks are then inoculated with plankton collected from earthen ponds. After 4 days of preparation, the fry can be stocked. The fry should be stocked after the development of a plankton bloom in the nursery tanks. The sizes of 50- 60 mg fry are suitable for initial stocking in nursery tanks. They are reared at a density of 100-200 fry/m^2. Increasing stocking density usually results in stress (aggressive behaviour, dominance), which leads to size variation in growth among the fingerlings and also reduces the survival rate at harvesting. During these periods, the fry should be fed with pellet feed at the rate of 5% body weight twice daily. The feed ratio needs to be increased by a weekly sampling of fish biomass. Appropriate

(Contd. on page 22)

Centre Spread

Shankapushpi [*Clitoria ternatea* L.] is a medicinal plant used in Indian Systems of Medicine and tribal medicine to treat many diseases. The plant is grown as an ornamental for its vibrant flower. The flower yields a natural colour which is used in food products, including blue tea. It is also revered as a holy flower during puja.

***Capparis brevispina* DC. is called Indian caper has unique floral characteristics. This plant produces large white flowers with blue anthers. The yellow colour in upper petals changes to red colour after successful pollination by butterflies. This traditional medicinal plant treats a number of diseases, particularly used as hepatoprotective and arteriosclerosis.**

Indian mallow [*Abutilon indicum* (L.) Sweet] is shrubby plant with bright yellow flowers with red tinges sometimes. All parts of the plants possess therapeutic properties. The Sanskrit name 'Atibala', means very powerful, indicates its effectiveness in treating diseases. The leaves are rich source of saponins.

Moon-leaf passion flower, botanically called *Passiflora leschenaultii* DC., is a native of the Western Ghats, grows in the evergreen forests with very attractive flowers. The name moon-leaf attributes to its semi-circular leaf. Traditionally, the leaf and fruits are used to treat diabetes and hypertension by the tribes of the Nilgiris in the Western Ghats.

Contributed by: Dr. R. Murugan, Assistant Professor, Ayya Nadar Janaki Ammal College (Autonomous), Sivakasi, Tamil Nadu.

(Contd. from page 19)

feeding is very important because an inadequate food supply has a direct impact on fish growth and production costs. The excess unconsumed feed and waste matter during nursery rearing pose problems for maintaining water quality. Therefore, once in two weeks, water must be exchanged for good growth and survival. Growth heterogeneity has been associated with cannibalism and, therefore, with mortality. Hence, size grading of

Fig 3: Hormone administration

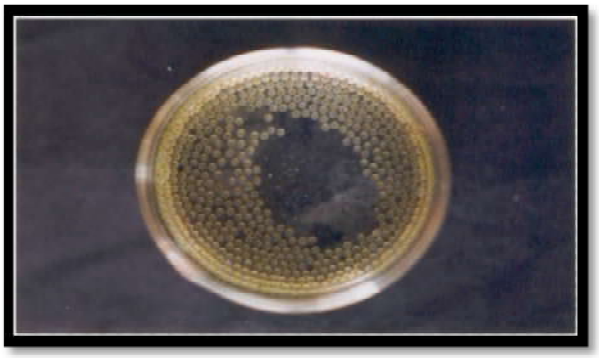

Fig 4: Fertilized eggs of Murrels

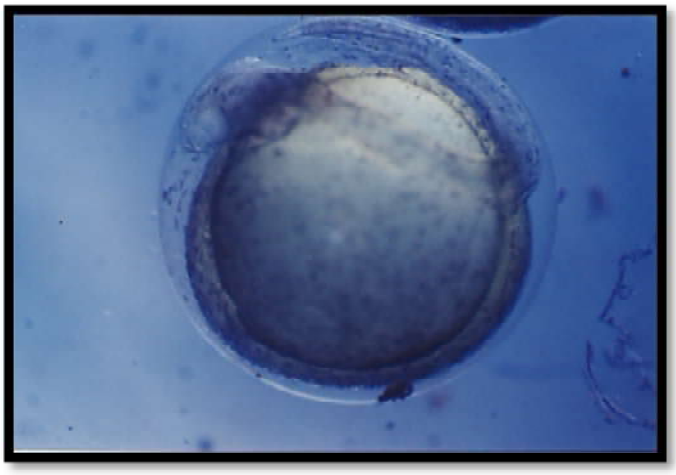

Fig 5: Fertilized egg of Murrels

Fig 6: Hatchlings of Murrels

Fig 7: Fry of Murrels

Fig 8: Fingerlings of Murrels

fingerlings has to be routinely performed to minimize growth variation and reduce cannibalism. The nursery cement tanks should be covered with nets to prevent birds and other predators. The fingerlings thus produced can be harvested depending on the demand. Usually, the fish grow up to 2 - 5 g in size within 30 days of nursery rearing, with a survival rate of 60-80%.

In seed production, specific management practices are employed to ensure the survival and growth of fry and fingerlings of murrels. The process involves the careful selection of broodstock, providing optimal conditions for spawning, and creating suitable environments for egg attachment and fry hatching. Rearing facilities equipped with controlled water quality parameters, appropriate feeding regimes, and disease prevention measures are essential in nurturing healthy fry. Several environmental factors influence the reproductive success of Channa striatus. Water temperature, photoperiod, and water quality parameters play a critical role in triggering reproductive behaviours. Adequate availability of suitable spawning substrates, such as submerged vegetation or artificial structures, enhances the likelihood of successful reproduction.

Spawning Behaviour and Parental Care

During the breeding season, murrels engage in elaborate courtship rituals. Male fish engage in courtship behavior to attract females. Spawning typically takes place in shallow waters with abundant vegetation or submerged structures. The female releases adhesive eggs and the male fertilizes them externally. The adhesive nature of the eggs allows them to attach to substrates, protecting them during the incubation period. After spawning, males actively guard and protect the fertilized eggs, demonstrating strong parental care for offspring survival (Marimuthu 2001; Haniffa et al 2004). This paternal care extends through the hatching and early stages of the fry, with the male fiercely defending the nest against potential threats, including other fish. This exceptional parental investment contributes to the overall reproductive success of murrels, ensuring the survival and well-being of their progeny in both natural habitats and controlled aquaculture settings.

Water quality management during larval rearing

Larvae of murrels are small, sensitive, and delicate, and they require a good aquatic environment for their survival. Water quality management is an important aspect during the rearing of larvae. Hence, good quality and appropriate water depth during the indoor rearing phases are maintained. Aerial respiration commences after 10-12 days, and hence aeration must be provided to the larval rearing tanks by aerators. Accumulation of metabolites and uneaten feed in the rearing tanks pollute the environment and ultimately lead to oxygen depletion, disease incidence, and mortality. Therefore, it is advisable to clean the bottom of the tank and renew 50-60% of the water daily to maintain a 60 cm depth. Care should be taken to minimize the stress on the delicate larvae while exchanging water from the tanks. The waste from fry and unconsumed feed in the rearing tanks under high-density rearing produces ammonia and hydrogen sulphide. Ammonia is toxic at low concentrations, affecting the gills and accessory respiratory organs, whereas hydrogen sulphide causes stress to the fry. Aeration and frequent water exchange are required to get rid of the above problems.

Culture of snakehead fish in ponds

Culture of murrels in earthen ponds is a common practice in India. The pond culture involves creating controlled environments that mimic the species' natural habitat. Farmers

typically select suitable pond locations with moderate vegetation and slow-flowing water to optimize conditions for growth and reproduction. Water quality management is paramount, necessitating the careful monitoring of parameters such as dissolved oxygen levels, pH, and temperature. Feeding strategies play a crucial role in pond culture, where nutritionally balanced feeds are often supplemented to ensure the fish's optimal growth and reproductive performance. Additionally, farmers may incorporate organic fertilizers or feed-based supplements to enhance the natural productivity of the pond ecosystem. Disease management practices, including routine health assessments and preventive measures, are implemented to maintain overall well-being. Murrels are typically marketed in a live condition, as they can survive for several hours in moist environments without water. This characteristic enhances their market appeal, allowing them to be sold fresh. These fish command a premium price, ranging from Rs 500 to Rs 900 per kilogram in fish markets in India, and this price is significantly higher than the other commonly cultivated carps and catfishes. There is a consistently high demand for murrels across several Indian states, including Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, Assam, Bihar, Jharkhand, Uttar Pradesh, Haryana, Punjab, and Madhya Pradesh. Consumers are drawn to murrels not only for their excellent taste but also for their recognized nutritional and medicinal properties. Their availability in live and fresh conditions at markets further boosts consumer preference and demand.

Disease management and prevention

The murrel fish can be susceptible to various diseases, including bacterial, fungal, and parasitic infections. Some common diseases include Epizootic Ulcerative Syndrome (EUS), Bacterial Hemorrhagic Septicemia (BHS), and Lymphocystis disease. These diseases can lead to stunted growth, severe mortality, and significant economic losses in fish culture. Disease management strategies for murrels involve a multifaceted approach. Proactive measures include maintaining optimal water quality, as poor water conditions can stress the fish and increase susceptibility to diseases. Quarantine protocols to be followed for newly collected individuals from wild and periodic health screenings help prevent the introduction and spread of pathogens. Proper nutrition is crucial to boost the immune system of fish, reducing vulnerability to infections. In cases of disease outbreaks, prompt diagnosis and treatment with appropriate medications are essential.

Prospects and challenges in the aquaculture and farming of Channa striatus in India

Murrel fish holds significant economic potential due to its popularity in local markets and its adaptability to diverse aquatic environments. The fish's resilience, and high consumer demand contribute to its viability as a candidate for sustainable aquaculture. Moreover, murrel fish farming can provide livelihood opportunities for local communities engaged in aquaculture. However, several challenges need careful consideration. One significant challenge is the need for effective disease management strategies, as the species is susceptible to various pathogens that can affect overall production. The potential environmental impacts of large-scale farming, such as water pollution and habitat alterations, necessitate sustainable farming practices.

Conclusion

In India, there is a huge demand for murrel fish, which also commands a high market price. Numerous farmers have started to cultivate murrels, and the demand for murrel seeds has been steadily rising. The technology for breeding

and seed production has been developed and the technique is very easy to be adopted by fish farmers. The growth and survival of larvae and fingerlings depend on the careful management of rearing tanks, feeding, and size grading. It has been felt that the production of murrels depends on the availability of high-quality seed and careful control throughout the larval rearing phase. For successful growing and lucrative murrel fish farming and aquaculture, more concerted efforts and attention must be given throughout the early larvae, fry, and fingerling stages of rearing.

References

1. Marimuthu, K., Haniffa, M. A., Arockiaraj, A. J., & Muruganandam, M. (2001). Spawning and parental behaviour in the induced bred murrels. *Indian Journal of Fisheries*, 48(4), 409–411.
2. Marimuthu, K., Haniffa, M. A., Arockiaraj, A. J., & Muruganandam, M. (2001). Low cost murrel seed production technique for fish farmers. *NAGA, WorldFish Center Quarterly*, 24(1), 21–22.
3. Haniffa, M. A., Marimuthu, K., Nagarajan, M., Arockiaraj, A. J., & Kumar, D. (2004). Breeding behavior and parental care of the induced bred spotted murrel (*Channa punctatus*) under captivity. *Current Science*, 86(10), 1375–1376.
4. Haniffa, M. A., Arockiaraj, J., & Sridhar, S. (1999). Weaning diet for striped murrel, *Channa striatus*. *Fishery Technology*, 36(2), 116–119.
5. **Haniffa, M. A.,** Arockiaraj, J., Sethuramalingam, T. A., & Sridhar, S. (2002). Digestibility of lipid in different feeds by striped murrel *Channa striatus*. *Journal of Aquaculture in the Tropics*, 17(3), 185–191.
6. **Marimuthu, K.,** Arockiaraj, J., & Haniffa, M. A. (2009). Effect of diet quality on seed production of the spotted snakehead *Channa punctatus* (Bloch). *American-Eurasian Journal of Sustainable Agriculture*, 3(3), 344–347.D
7. Muntaziana, M. P. A., Amin, S. M. N., Rahman, M. A., Rahim, A. A., & Marimuthu, K. (2013). Present culture status of the endangered snakehead, *Channa striatus* (Bloch, 1793). *Asian Journal of Animal and Veterinary Advances, 8*(2), 369–375.
8. Marimuthu, K., Kumar, D., & Haniffa, M. A. (2007). Induced spawning and seed production of striped snakehead *Channa striatus* using ovatide. *Journal of Applied Aquaculture, 19*(4), 95–103.
9. Marimuthu, K., & Haniffa, M. A. (2007). Embryonic and larval development of the striped snakehead *Channa striatus*. *Taiwania, 52*(1), 84–92.
10. Ong, Y. W., Xavier, R., & Marimuthu, K. (2010). Screening of antibacterial activity of mucus extract of Snakehead fish, *Channa striatus* (Bloch). *European Review for Medical and Pharmacological Sciences*, 14(8), 675-681.
11. Marimuthu, K., Thilaga, M., Kathiresan, S., Xavier, R., & Mas, R. H. M. H. (2011). Effect of different cooking methods on proximate and mineral composition of striped snakehead fish, (*Channa striatus*, Bloch). *Journal of Food Science and Technology*, 49, 373-377
12. Kumar, D., Marimuthu, K., Haniffa, M. A., & Sethuramalingam, T. A. (2008). Effect of different live feed on growth and survival of striped murrel *Channa striatus* larvae. *Ege Journal of Fisheries and Aquatic Sciences*, 25(2), 105–110.

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Present Scenario and Conservation Strategies of House Sparrow

Balaji Sundaramahalingam and Mahendran Selvaraj

Following the failure to fulfill the 2010 target, the Parties to the United Nations Convention on Biological Diversity (CBD) reaffirmed the international aims of reducing the rate of biodiversity loss and preventing hazardous biodiversity change in the Aichi Biodiversity Goals for 2011–2020. To provide consistent, timely data on biodiversity change, there is no worldwide standardized observation system (Pereira et al., 2013).

One essential element of a sustainable environment is biodiversity. However, preserving the natural areas that are big enough to support the complete ecosystem is challenging because of the strain that economic development and other human activities place on the environment. However, ecosystems must be handled carefully because ecosystems offer products and services that are essential to human welfare (Graham, 2004). In addition to altering building architecture, which impacts nesting locations, urbanization has led to a decrease in the population of arthropods, which are the main food source for birds during their reproductive phases. Urbanization ranks the highest among the various causes of endangerment to bird species. The IUCN reports that 189 bird species are critically endangered, 381 are endangered, 683 are vulnerable, and 1,253 are threatened with extinction worldwide (McIntyre, 2000).

As a fast-growing social species, humanity's industrial prowess enables the establishment of expansive metropolises and the colonization of virtual wilderness. Humans inhabit almost every part of the planet, and wherever they settle, they drastically alter the environment. India's urban and rural populations are growing at an alarming rate. Just 14 cities had a population of 200,000 or more in 1700. Such populations were present in 42 cities across four continents by 1900, while 171 cities across five continents had populations of over 200,000 by 2000. Just 10% of people lived in cities in 1900; by 2000, that number had risen to almost 50%, and by 2050, it is predicted that nearly 70% will. Therefore, it is predicted that by 2050, there will be 6.5 billion people living in cities, almost as many as people on Earth today (Ramachandra and Sudhira, 2011).

Species extinction is a normal and ongoing aspect of evolution. Regrettably, man has accelerated it to such a degree. Currently, over 1,000 bird species are in danger of becoming extinct, but only about 100 distinct species are known to have gone extinct in the last 600 years. Nearly half of them have tiny populations that it is doubtful they will live for many more years unless drastic measures are made to prevent extinction in the name of laws or conventions (Austen, 1988).

According to Bhattacharya et al. (2011), birds are the finest environmental change monitors. Due to the growth of urbanization and contemporary technology, no elbow room is available for birds these days. The crucial question about ecological balance, therefore, emerges. As contemporary civilization has advanced, the population is often concentrated in metropolitan regions. The stability of the ecology is uncertain. Nonetheless, local-scale factors have the potential to alter species distribution. Local birds will, therefore, serve as a gauge of the region's ecological health.

India is in distress about the declining wildlife population. Birds are at high risk of extinction. It includes Vultures, the Sarus crane, the Great Indian Bustard, the House sparrow, etc. Many hypotheses proposed reasons for the decline of house sparrows (*Passer domesticus* L.),

including habitat loss, selective hunting, disease, food availability, malnutrition during the breeding time, Invasion of exotic species, etc. (Summers-Smith, 1999; Peach *et al*., 2008). Global warming also causes the decline of house sparrows (Saetre *et al*., 2012).

Most house sparrows live within 1-2 kilometers, making them incredibly sedentary birds. Furthermore, there is proof that ringing both agricultural and urban birds has resulted in the recovery of birds with numbered rings and the observation of color-ringed birds (Smith, 2003).

In rural regions, house sparrows mostly consume seeds, with a preference for the seeds of farmed crops such as corn, maize, wheat, barley, and oats. The seeds of annual plants, including chickweed (*Stellaria* spp.), goosefoot (*Chenopodium*), docks (Polygonaceae), grasses (Poaceae), and rushes (Juncaceae), are the other main food source. Birds living in urban areas add natural vegetable matter and domestic leftovers that people intentionally discard to their diet. House sparrows often use feeders in gardens, and in London, they are by far the most prevalent feeder species utilized all year. On the other hand, nestlings consume practically only insects and other invertebrates (both larval and adult), with the types of food changing according to the season. According to Wilson et al. (1999), the most significant taxa include the grasshoppers (Orthoptera), caterpillars (Lepidoptera), weevils (Curculionidae), beetles (Coleoptera), aphids (Aphidoidea), and spiders (Arachnida).

In the past, house sparrows were quite common worldwide. In its natural environment, it is an omnivore. It consumes insects, ants, grains, and larvae. Seasonal variations exist in house sparrow eating habits (Anderson, 2006; Mahesh et al., 2021; Singh et al., 2016). Because they are drawn to colors, house sparrows nest near human habitations (Bhattacharya et al., 2010). Over their lives, house sparrows can reproduce up to four times. It attempts to deposit up to five eggs per mating season in India. Of them, 68% fly up, and 77% hatch out (Ali, 1996; Summers-Smith, 1959, 2003; Lowther, 1988; Peach et al., 2008).

Craggs (1976) observed the journey of a pair of house sparrows, which increased in number to seven pairs. He concludes that the house sparrows never leave human habitations as long as food and nest sites are available (Saetre *et al*., 2012). The ecological restoration of grassland into agricultural land and buildings made the house sparrows become human commensals.

House sparrows once dominated the Netherlands, but their population drastically decreased from 1989 to 2003. The eggs, juveniles, and adult house sparrows could not survive during this period (Klok *et al*., 2006). In Canada, the population of house sparrows declined during the 1970's (Erskine *et al*., 2006). In Spain, the house sparrow population declined during winter (Murgui *et al*., 2009). According to the Breeding Bird Survey, Britain's house sparrow population diminished (Fleischer *et al*., 1984). It specifically states that the population of house sparrows is lower in North and West Britain compared to the South and East regions. This scenario is not only restricted to the Netherlands and Britain but also to other regions. The highest decline of house sparrows was reported in Glasgow (90%), Hamberg (77%), and London (60%) (Kumar *et al*., 2015). A higher number of declines of house sparrows was found in Edinburgh (90%), followed by Hamburg (70-75%), London (60%), Warsaw (58%), Buckingham Palace Gardens, London (30%), Poland (21%), Kerala, Gujarat, and Rajasthan in India (20%). The house sparrow population also declines in Australia, Bristol, Germany, Moscow, North America, Norwich, Rotterdam, and St. Petersburg. However, the house sparrow population is stable in Berlin, Manchester and Paris and increased in Lisbon and Scotland (Hussain *et al*., 2014).

In the Sargodha district of Pakistan, an estimated 2,998 house sparrows were found in

rural regions in 2010, while 1,873 were found in urban areas. This finding indicates that because there are more food sources and nesting locations in rural regions, house sparrow populations are greater there. The house sparrow population cannot thrive in urban environments due to food shortage and nesting grounds (Mustafa et al., 2015).

Status of House Sparrow in India

There have been reports of a drop in house sparrows in many parts of India. According to reports, house sparrows vanished from Thiruvananthapuram, Kerala, in about 2000 (Dandapat et al., 2010). In 2010, Andhra Pradesh recorded a sharp 80% drop. The number of House Sparrows in West Godavari, Andhra Pradesh, has significantly declined. Bird people were last documented in Bhimavaram in 1995. However, these birds are believed to have moved to isolated parts of that town (Dandapat et al., 2010). According to Krementz et al. (1986), Bhattacharya et al. (2010), Daniels (2008), Dhanya and Azeez (2010), and Khera et al. (2010), the number of house sparrows in Gujarat and Rajasthan has decreased by around 20%.

The market and train station were chosen to study house sparrows' preferred places in Bandel, West Bengal. Food availability affected population size. 277 and 250 house sparrows were observed in the market and train station, respectively. The availability of food in market areas and the high levels of noise pollution at railway stations are why house sparrow populations are larger in the market than in the station (Ghosh et al., 2010).

The number of house sparrows in the Hyderabad-Ranga Reddy Zone has drastically decreased, according to the Bombay Natural History Society. In areas where livestock is kept, the house sparrow population is found to be at its highest. It suggests more house sparrows in low-income villages than in affluent metropolitan areas. Cities like Mumbai, Bangalore, Hyderabad, Chennai, Delhi, and Kolkata have seen a decline in house sparrow populations, according to ornithologists (Chopra et al., 2012; Hussain et al., 2014; Mahesh et al., 2021). Similar observations were made in the villages of Tamil Nadu's Erode and Namakkal districts. The growing number of house sparrows is more prevalent in communities with more agricultural land and abandoned structures. The absence of nesting grounds is the primary cause of decreased house sparrows (Deepalakshmi and Antilin Salomi, 2019).

Figure 1. House sparrow nesting sites in olden architecture building sites

Causes for the declining of House Sparrow population

In the 18th century, there was an attempt to deliberately decrease the house sparrow population as it was considered a pest because house sparrows destroyed agricultural produce. The "Sparrow Club" was initiated to reduce the population size by killing the house sparrows. The sparrow clubs encouraged their members through "Sparrow Money" by producing the killed house sparrows or their eggs (Clark, 2002).

The switch from horse-drawn to car-drawn transportation is also thought to have contributed to House Sparrow's decline. It makes it appear impossible for the house sparrow's offspring to thrive on the busiest streets. Predators, urbanization, pesticides, a shortage of nesting locations, food supplies, pollution, electromagnetic radiation, and the adoption of modern farming methods are some of the common causes of house sparrow declines (Hussain et al., 2014).

The predators of house sparrows include the domestic cats. On average, 30% of house

sparrows are killed by cats. According to a study in Bedfordshire, domestic cats predate 16% of house sparrows in one year (Churcher and Lawton, 1987; Mahesh *et al*., 2021). Pollutants for house sparrows include the deadliest toxins, such as chlorinated hydrocarbons from insecticides and polychlorinated hydrocarbons from industries. Heavy metals like zinc, lead, and cadmium are found in higher concentrations in the house sparrow's liver, which causes an increased mortality rate. It also causes reduced body weight and delayed development in the house sparrows (Romanowski *et al*., 1991). Balaji (2014) reported that the olden-styled architecture building in India had a natural site for its nest building. However, from the author's recent observation, it was evident that the house sparrow uses the opportunity to nest in sites that may threaten its juveniles and development.

Figure 2. Use of opportunity nesting sites by the house sparrow population (Balaji, 2014)

How can we conserve the house sparrows?

One of the possible causes of the fall in house sparrows may be the loss of nest locations, particularly in buildings due to current building construction and restoration styles (Pineda et al., 2013). Since house sparrows nest in cavities, using artificial nest boxes may be an effort to slow the decline in house sparrow populations in urban and suburban areas. During the breeding season, attempts have been undertaken to install artificial nest boxes at various locations in Sivakasi town for the sparrows that responded well (Figure 1). In Sivakasi town, Tamil Nadu, house sparrows respond better to artificial nest boxes positioned in undisturbed regions (Balaji, 2014). However, it is hypothesized that house sparrows are particularly associated with metropolitan regions of lower socioeconomic levels, where more nesting places are available due to structures in inferior condition. Furthermore, because they have a flexible nest site selection, house sparrows are anticipated to construct nests in other accessible locations, such as nest boxes, without those in buildings (Shaw et al., 2008). One of the key elements affecting sparrow abundance in urban areas is the availability of nest locations (Anderson, 2006).

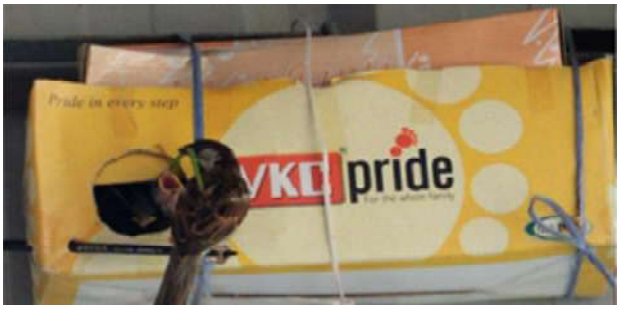

Figure 3. An Artificial nest box design for the house sparrow population (Balaji, 2014)

Similar reactions by house sparrows to artificially positioned nest boxes were seen in Kerala's Manjeri municipality in India (Balakrishnan et al., 2011). The majority of the nests were situated above the roller shutter boxes (89.3%), followed by the artificial boxes (4.8%), shelter boards in front of the shops (3.57%), and ventilators (2.4%), according to their study on house sparrow nest site features. Shaw et al. (2008) state that house sparrows prefer to nest in buildings and only choose other locations when building nests are unavailable. Artificial nest boxes are not well received near bus stops, busy streets, and marketplaces. Renovating buildings (insulation) in suburban regions contributes to the decline of house sparrow populations (Wêgrzynowicz, 2012).

In certain regions, Indian Myna (Acridotheres tristis) has been seen to compete

with and damage the artificial nest boxes in Sivakasi (Balaji, 2014). Woodpeckers and the Pied Cuckoo (Clamator jacobinus) have also been seen to cause similar types of disruptions (Bhattacharya et al., 2011). Human society will determine the house sparrow population's destiny. The house sparrow population is growing thanks to the work of volunteers and conservationists, and a global census should be conducted to confirm the present number.

Acknowledgements

The authors are grateful to the Management and Principal of Ayya Nadar Janaki Ammal College (Autonomous), Sivakasi, for providing facilities and camera facilities in the name of the Centre for House Sparrow Studies at the Postgraduate Department of Zoology.

References

Ali S., 1996. *The Book of Indian Birds*, BNHS, Oxford University Press, Mumbai.

Anderson R.T., 2006. *Biology of the Ubiquitous House Sparrow: From Genes to Populations,* Oxford University Press, p. 560.

Austen O.L., 1988. Birds of the world. Spring Books publication, London, U.K.

Balaji S. 2014. Artificial nest box for house sparrow: An apt method to save the dwindling species in an urban environment. *International Journal of Biodiversity and Conservation,* 6(3), 194-198.

Balakrishnan P., Jijeesh N., Kurikkal M.S., Maya T., Lijitha M.P., Bhaskar, R.R. and Vipeesh N. 2011. Distribution, abundance and nest site characteristics of the House Sparrow Passer domesticus in Manjeri Municipality, Kerala. Technical Report submitted to Wildlife Research and Conservation Trust. NSS College, Manjeri.

Bhattacharya R., Roy R., Ghosh S. and Dey A. 2010. Observations on house sparrow at Bandel, Hoogly, *Proceedings of National Seminar on Biodiversity*, Water resource and Climate change issues, Department of Environmental Science, Kalyani University, pp. 147-152.

Bhattacharya R., Roy R. and Goswami, C. 2011. Studies on the response of House Sparrows to artificial nest. *International Journal of Environmental Sciences,* 1(7), 1574-1581.

Chopra G., Kumar A. and Kumar P. 2012. Population of House Sparrow, Passer domesticus (Linnaeus, 1758) in Different Habitats of District Kurukshetra, Haryana (India). *Nature and Science,* 10(1), 113-122.

Churcher P.B. and Lawton J.H. 1987. Predation by domestic cats in an English village. *Journal of Zoology,* 212(3), 439-455.

Clark J.F.M. 2002. *The Irishmen of Birds*. History Today, 16–18.

Craggs J.D. 1976. An isolated colony of House Sparrows. *Bird Study*, 23(4), 281-284.

Dandapat A., Banerjee D. and Chakraborty D. 2010. The case of the disappearing House Sparrow (*Passer domesticus indicus*). *Veterinary World*, 3(2), 97-100.

Daniels R.J.R. 2008. Can we save the sparrow? *Current Science,* 95(11), 1527-1528.

Deepalakshmi S. and Antilin Salomi A. 2019. Impact of urbanization on House sparrow (*Passer domesticus*) diversity from Erode and Namakkal districts, Tamilnadu, India. *International Journal of Advanced Research in Biological Sciences*, 6(11), 22-27.

Dhanya R. and Azeez P.A. 2010. The House Sparrow *Passer domesticus* population of Arakku township, Andhra Pradesh, India. *Indian Birds,* 5(6), 180–181.

Erskine A.J. 2006. Recent Declines of House Sparrows, *Passer domesticus*, in Canada's Maritime Provinces. *Canadian Field- Naturalist,* 120(1), 43–49.

Fleischer R.C., Lowther P.E. and Johnsto R.F. 1984. Natal dispersal in House Sparrows: Possible causes and consequences. *Journal of Field Ornithology*, 55(4), 444-456.

Ghosh S., Kim K.H., and Bhattacharya R. 2010. A survey on house sparrow population decline at Bandel, West Bengal, India. *Journal of Korean Earth Science Society*, 31(5), 448"453.

Graham B., 2004. Integrating biodiversity conservation and sustainable use: Lessons learned from ecological networks. IUCN, Gland, Switzerland

and Cambridge, U.K.

Hussain A., Dasgupta S. and Bargali H.S. 2014. Case of House sparrow (*Passer domesticus*) population decline: Role of semi-nomadic pastoralist community (*Van Gujjars*) in their conservation. *International Journal of Conservation Science*, 5(4), 493-502.

Khera N., Das A., Srivasthava S. and Jain S. 2010. Habitat-wise distribution of the House Sparrow *Passer domesticus* in Delhi, India. *Urban Ecosystem,* 13(1), 147-154.

Klok C., Holtkamp R., Apeldoorn R., Visser M.E. and Hemerik L. 2006. Analysing Population Numbers of the House Sparrow in the Netherlands with a Matrix Model and Suggestions for Conservation Measures. *Acta Biotheoretica*, 54(3), 161–178.

Krementz D.G. and Ankney C.D. 1986. Bioenergetics of egg production by female house sparrows. *The Auk*, 103, 299-305.

Kumar A., Kanaujia A., Kushwaha S. and Kumar A. 2015. A house for the House Sparrow. *Science Reporter*, 52(6), 14-19.

Lowther P.E. 1988. Spotting pattern of the last laid egg of the House sparrow. *Journal of Field Ornithology*, 59(1), 51-54.

McIntyre N. 2000. Ecology of Urban Arthropods: A Review and a Call to Action. *Entomological Society of America*, 93, 825-835.

Murgui E. and Macias A. 2009. Changes in the House sparrow *passer domesticus* population in Valencia (spain) from 1998 to 2008. *Bird Study*, 57(3), 281-288.

Mustafa I., Arif N., Hussain S.M., Malik I.U., Javid A., Ullah M.I., Asif S., Khan M.R., Waqas A., Eqani S.A.M., Irum, S. and Ahmed S. 2015. Population Dynamics of House Sparrow (*Passer domesticus*) and House Crow (*Corvus splendens*) in Punjab (District Sargodha), Pakistan. *Pakistan Journal of Zoology,* 47(4): 1147-1155.

Peach W.J., Vincent K.E., Fowler J.A. and Grice P.V. 2008. Reproductive success of house sparrows along an urban gradient. *Animal Conservation*, 11(6), 493-503.

Pereira H.M., Ferrier S., Walters M., Geller G.N., Jongman R.H.G., Scholes R.J., Bruford M. W., Brummitt N., Butchart S.H.M., Cardoso A.C., Coops N.C., Dulloo E., Faith D.P., Freyhof R.D., Gregory C., Heip R., Höft G., Hurtt W., Jetz D., Karp S., McGeoch M.A., Obura D., Onoda Y., Pettorelli N., Reyers B., Sayre R., Scharlemann J.P.W., Stuart S.N., Turak E., Walpole M. and Wegmann M., 2013. Essential Biodiversity Variables. *Science*, 339:227-228.

Pineda J., Herrera A., Antonio M.T. and Aguirre J. 2013. Urban models and their effects on immune system of house sparrow Passer domesticus populations in Central Spain. EOU2013UK - 9th Conference of the European Ornithologists' Union. pp 25.

Ramachandra T.V. and Sudhira H.S. 2011. Influence of Planning and Governance on the Level of Urban Services. *IUP Journal of Governance and Public Policy*, 6(1): 24-50.

Romanowski J., Pinowski J., Sawicka-Kapusta K. and Wlostowski T. 1991. The effect of heavy metals upon development and mortality of *Passer domesticus* and *Passer montanus* nestlings. *In*: Pinowski J., Kavanagh B. and Gorski W. (eds.) Nestling mortality of granivorous birds due to microorganisms and toxic substances. *The International Symposium of the Working Group on Granivorous Birds*, 197-204.

Saetre G.-P., Riyahi S., Aliabadian M., Hermansen J.S., Hogner S., Olsson U., Gonzalez Rojas M.F., Saether S.A., Trier C.N., and Elgvin T.O. 2012. Single origin of human commensalism in the house sparrow. *Journal of Evolutionary Biology,* 25, 788-796.

Shaw L.M., Chamberlain D. and Evans M. 2008. The house sparrow, Passer domesticus in urban areas: Reviewing a possible link between post-decline distribution and human socioeconomic status. *Journal of Ornithology*, 149, 293-299.

Singh R., Kour P. and Koul S. 2016. Comparative study of food habits and seasonal variations in the food of adult house sparrow *Passer domesticus indicus* in some rural and urban areas of Jammu province. *International Journal of Advanced Research*, 4(7), 951-958.

Smith, S.D., 2003. Decline of House Sparrows in Large Towns. British Birds, 93: 256-257.

Summers-Smith, D. 1999. Current status of the House Sparrow in Britain. British Wildlife, UK, 381-386.

Summers-Smith D. 2003. Changes in the House Sparrow Population in Britain. *International Studies on Sparrows,* 30, 23-37.

Summers-Smith D. 1959. House sparrow *Passer domesticus*: population problems. *International Journal of Avian Science*, 101 (3-4), 449-455.

Mahesh V. and Suseela L. 2021. Status Survey of House Sparrow (*Passer domesticus*) at West Godavari District, Andhra Pradesh, India. *International Journal of Zoological Investigations*, 7 (2), 512-518.

Wêgrzynowicz, A. 2012. The use of nest-boxes by two species of Sparrows (*Passer domesticus* and *P. montanus*) with opposite trends of abundance – The study in Warsaw. *International Studies on Sparrows*, 36(1), 18-29.

Wilson J., Morris A., Arroyo B., Clark S. and Bradbury R. 1999. A review of the abundance and diversity of invertebrate and plant foods of granivorous birds in northern Europe in relation to agricultural change. *Agriculture, Ecosystems and Environment*, 75, 13-30.

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Natural Colours are Controlled by Astronomical, Meteorological, Geological, Genetical and Biological Phenomena in our Biosphere

Priti Mathur

Each living and non-living components in our earth is full of color and surrounded by Colors. Humans use colors for different purposes -from food to philosophy. We see color in all organisms, including bacteria, plants, animals, soil, water, landscapes, and the atmosphere. This is a big question among scientists about how and why colors are present on Earth. Colors are more than recreation, painting, and printing. All organisms on Earth are controlled by colors from sunlight-VIBGYOR, directly and indirectly. Natural colors are neither created nor destroyed; they pass from one form to another and finally go back to nature. A Genetic-metro-bio-geological evolution took place for color development in flora, fauna, living and non-living components of Earth.

With the evolution of cells on earth, colored molecules formed in proto cells and prokaryotic systems for some important physiological functions for their survival on earth. They interact with specific electromagnetic wavelengths of VIBGYOR for their specific function, though Light Harvesting Complexes,

which are found in plasma membranes. Simultaneously, genes started developing for this colored molecule in cells to establish itself with continuous and drastic changes in climatic conditions, which was part of evolution. These developed genes of chromatic pigment were mainly for physiological and biochemical purposes, which were transferred from one species to another species with continuous evolution. Genes for colors are transferred into the organism automatically, according to the need of that chromatic pigment in a single or multicellular system. Although this different chromatic pigment is mainly required for metabolism, beautiful VIBGYOR colors -violet, indigo, blue, green, yellow, orange, and red- started expressing externally or internally by linked or independent genes.

Same time, chromatic molecules and their related genes passed from the prokaryotic system to the eukaryotic plants and animal systems simultaneously. As the most accepted theory of cellular evolution is endosymbiotic, so many genes for color/chromatic pigment, passed or joined together through one or more organisms, and thus, multicolored organisms developed. During the journey of the development of colors, multicolored organisms developed in nature. In due course of time colours with special physiological functions developed in internal organs also. Colors, along with their energy, are trapped and controlled by sunrays through biological systems- Light Harvesting complexes (LHC) for specific physiological processes through pigments. Colors flow in nature and ultimately back to nature. This is a cyclic process, like all other natural components. Back to nature refers to abiotic components like air, water, and soil. The colors go back by decomposition, or directly by evaporation along with water or wind. Generally, this process cannot be seen by eye, as this is very slow and goes on a nano/ molecular level. Colors from plants like flowers, leaves, and fruits, if not taken out from plants, after a period, change first in their chemical composition and then evaporate or get mixed with the soil. Thus, colors go back to the atmosphere. Water content in soil, heat, and temperature play a major role in this phenomenon. In animals, colors do not fade or evaporate because here, colors are very strong/ complex, and stable. They last as long as the lifespan of animals. Only after their death does it decompose and often get mixed with soil or water.

Artists have long explored the relationship between art and nature, often using organic materials to create their works. One fascinating aspect of this relationship is the idea that organic colors, derived from natural sources such as plants, minerals, and insects, eventually revert to nature in a cyclical process. An artist creates a painting on paper, canvas, wall, or on fabric using organic pigments sourced from

plants. Over time, as the painting ages, these pigments gradually break down and return to the environment. This process is accelerated when colors are exposed continuously to natural elements such as sunlight, rain, and wind. As the organic colors decompose, they release their components back into the ecosystem, where they can be absorbed by plants or enter the soil and water systems. This re-integration of the pigments into nature parallels the natural cycle of life, death, and rebirth seen in the natural world. A systematic study on colors could provide answers to many complex processes and diseases. This could give scientists a new way to see the evolution of life. There is a great need to focus on this unexplored subject.

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FFSF Activities at a Glance

FFSF organized FloraFauna Innovation Summit in collaboration with CSIR-NBRI and CSIR-CIMAP

To translate the outcome of research and innovation for the benefit of society and for the creation of entrepreneurial opportunities, FloraFauna Science Foundation (FFSF) organized the sixth Innovation Summit (FFIS-2025) through real time *In Village* mode on 15th February, 2025 in technical collaboration with CSIR-NBRI and CSIR-CIMAP. The venue chosen for holding this Summit was Mahayogi Dharmshala meeting hall located in the campus of Ma Chandrika Devi Temple, near village Kathwara falling under the block Bakshi ka Talab, Lucknow, which is well connected with the city of Lucknow as well as number of adjoining villages. FFIS-2025 had an active participation of about 150 participants comprising scientists, innovators, progressive farmers, start-ups, entrepreneurs, students, researchers, beneficiaries, besides a large number of members of the FloraFauna Science Foundation.

At the outset in 'Aarambh' session, Founder Chairman of FFSF and Former Director CSIR-CIMAP, Prof Suman PS Khanuja in his initiation and theme lecture said that the current sixth summit was planned to have selected presentations on the innovations, ideas

and exhibits by participants in 'Khoj' and 'Sakshat' sessions besides the interaction with the experts panel in 'Manthan' session covering various aspects of horticulture, aroma, and nutrition demonstrating beneficial outcome of technologies and direct positive impact on bringing happiness to the society and the planet in tune with last year's theme of FFSF "विज्ञान से मुस्कानः Science to Smile". Prof Khanuja thanked CSIR-NBRI and CSIR-CIMAP in having MoU with FFSF recently to have joint activities for reaching the unreached especially among the farmers and entrepreneurs in extending new knowledge and improved technologies, which can provide them entrepreneurial opportunities and enhance their income.

Dr Prabodh K Trivedi, Director, CSIR-CIMAP, delivered the technology lecture and apprised about the major achievements of the institute in the area of development of improved technologies and plant varieties of medicinal and aromatic crops which have gone a long way in increasing the production as well as income of the farmers. Dr Prabodh K Trivedi along with Prof Suman PS Khanuja and members of FFSF also planted Rudraksh, Chandan and Tulsi saplings near the venue to mark the inauguration of the Summit.

Thereafter, in the 'Khoj'session' 14 presentations were made by the participating researchers and students. Besides above, five stalls of exhibits of different types of plant products were arranged by the farmers under the concurrent 'Sakshat' session.

All the presentations were evaluated by a special Jury of scientists and finally, the best presentations were awarded cash prizes (First-Rs 1000; Second-Rs 700; Third-Rs 500) and certificates. The awards in the 'Khoj' and 'Sakshat' session were sponsored by M/s JKG Development Foundation and SKiES India, Lucknow, respectively. The details of the winners are given as under:

A. 'Khoj' Awards under 'Science' Category: Ms Khusi Maheswari (First), Ms Tanuja (Second), Mr Ashis Singh (Third); Innovation Category: Ms Sabia Rabbani (First), Ms Ayesha Usmani (Second), Dr Priti Mathur (Third); Entrepreneurship Category: Mr Nand Ram (First), Mr Durgesh Maurya (Second), Ms Menika Pandey (Third)

B. Sakshat Awards: Mrs Kusum Maurya (First), Mr Harakh Chand Verma (Second)

Under the 'Manthan' Session a face -to-face interaction of participants with experts drawn from various walks of life was held. Director CSIR-NBRI, Dr Ajit K Shasany also addressed the participants and exhorted them to adopt various floral crops suitable for cultivation in their areas for augmenting their income. He told that CSIR-NBRI is also making available the improved planting material of various floral crops to the interested farmers under the CSIR Floriculture Mission. Dr Shasany assured all the help and guidance by the institute to the farmers willing to take up production and marketing of the flowers.

A team of CSIR-NBRI scientists, Dr KJ Singh, Dr Sharad Srivastava, Dr Manish K Bhoyar and Technical Officer Dr Daya Shankar conducted a workshop for the participating farmers and entrepreneurs of the Summit. A kit of tuberose bulbs was also presented to the participating farmers by Director CSIR-NBRI on the occasion.

A team of CSIR-CIMAP scientists, Dr Rajesh K Verma, Dr Sanjay Kumar and Dr Ramesh K Srivastava also interacted with the participants and apprised them about the economically important aromatic crops, which can be grown in degraded and poor soils. The essential oils derived from these plants have great demand in domestic as well as in the overseas market.

A team of SKiES India, Lucknow led by Prof Suman PS Khanuja and Dr Archna Suman highlighted the importance of biofertilizers in not only improving the health of the soil but also cutting down the requirement of chemical fertilizers and pesticides considerably. The kits of biofertilizers with method of its application etc were also distributed among the farmers by the team SKiES India on this occasion.

The 'Amrit' Session was chaired by Prof Suman PS Khanuja, Founder Chairman FFSF. Based on the presentations and interactions held during the Summit, following major recommendations have emerged:

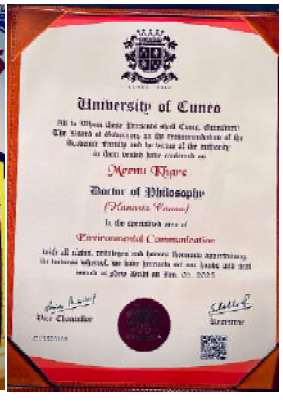
- Integration of cereal and vegetable crops with floral and aromatic and medicinal crops should be promoted
- Technology for extraction of aromatic oils from the discarded or used flowers should be developed and popularized
- Innovative efforts are needed in agriculture by developing soil, water, air-friendly technologies together with organic cultivation to a certain level
- Linkage of the farmers and entrepreneurs with research institutions must be strengthened and vice versa
- Judicious and sustainable use of bioresources be made for the development of novel products
- Agriculture waste be utilized for the development of fertilizers/ manures, etc.
- Various rural enterprises such as honey-bee keeping, biofertilizer production etc. be encouraged under the training and outreach programme
- We should protect the nature, which is essential for our survival on this planet

FFSF Founder Chairperson Prof Suman PS Khanuja thanked both the collaborating institutes (CSIR-NBRI and CSIR-CIMAP) and Ma Chandrika Devi Mela Vikas Samiti for all the help and cooperation in organizing the sixth FFIS. He also thanked all contributors and participants for making the FFIS-2025 a great success. Prof Khanuja also announced that the theme for next year's FloraFauna Innovation Summit would be '*Prakriti Se Unnati*'.

Dr Anil Kumar Singh, Chairman Organizing Team of FFIS-2025 conducted the proceedings. Other dignitaries and scientists present on the occasion included Dr Ashwani K Srivastava, Dr Rashmi Srivastava, Prof Brijesh Pandey, Dr Birendra Kumar, Dr Daya N Mani, Dr DU Bawankule, Dr Ram S Verma, Dr RP Bansal, Dr Shuchi Srivastava, Dr Ashutosh Shukla, Dr Swaha Shee Chanda, Dr Priti Mathur, Dr Uma Shankar, Mrs Anita Yadav, Dr Amita Dubey, Dr Ram Suresh, Dr Rakshapal Singh among others.

Participation/ Achievements/ Recognitions of FFSF Members

- Ms Meenu Khare awarded an Honorary Doctorate in Environmental Communication by Cuneo University, Italy, on 5th January, 2025 in recognition of the Asia's first-ever human chain built on the airwaves in support of the water conservation-a groundbreaking adio initiative that continued uninterrupted for 367 days, featuring daily interviews with water warriors from across India including Dr. SPS Khanuja who described various techniques in agriculture to reduce water consumption in crops). This pioneering campaign significantly advanced public engagement and awareness on water conservation through the power of audio storytelling and environmental broadcasting.



- Prof Suman PS Khanuja was invited to deliver a plenary address titled **"Innovations for Next-Gen Agriculture and Future Foods"** on the occasion of Nationa Conference & Workshop held at Jamia Hamdard on 19th February, 2025. He outlined cutting-edge biotechnological pathways for climate-smart farming and nutritionally enhanced crops, sparking lively discussion among hundreds of students, scholars, and faculty from leading research institutions and universities.

- Dr AK Singh, Dr RP Bansal along with Dr RK Srivastava, Sr Scientist, CSIR-CIMAP attended the inaugural function of Livelihood & Entrepreneurship Development Programme sponsored by NABARD and organised by Mrs Bandana Singh of Sundaram Seva Sanshan, Lucknow at Panchayat Bhawan, Uttardhauna village, near Tiwariganj,

Ayodhya Road, Lucknow on 2nd April, 2025. Mayor of Lucknow Mrs Sushma Kharakwal was the Chief Guest who had inaugurated the facility to be used to make various products including incense sticks, cone, and other products by the local women from the offered and discarded flowers based on CSIR-CIMAP technology.

- Dr N Manika delivered a radio talk at All India Radio (Regional Service) on the occasion of International Day for Biological Diversity held on 22nd May 2025. She explored the rich biodiversity of Kerala's ecosystems and argued for integrative conservation strategies that balance livelihoods with ecological integrity. The broadcast broadened public awareness of the state's unique flora and fauna and underscored the urgency of habitat restoration.

Forthcoming Event

"Prof Sushil Kumar Innovation Award-2025" (SKIA-2025)

(1940-2021)

About the award: This prestigious award was instituted in the year 2021 in memory and respect of the legendry scientific leader, innovative researcher and teacher of uncountable scholars and students across generations, (Late) Prof. Sushil Kumar by all of us (Prof Sushil Kumar's School – PSKS to represent his legacy perpetuation) who have been positively impacted by his mentorship and working atmosphere created by him in his lifetime. This award of unique recognition in Agriculture, Life Sciences and Applied fields including multi- and inter-disciplinary areas going beyond traditional classification of scientific research leading to inventions, discoveries and technologies will be known as the "Prof. Sushil Kumar Innovation Award (SKIA)".

Prof Sushil Kumar Innovation Award (SKIA) is founded to promote and encourage future generation leaders of science on innovation path and recognize their pathbreaking approach in R&D and will be steered by Flora Fauna Science Foundation – FFSF (*www.florafauna.in*) for all operational and financial base through contributions made by members of FFSF and PSKS together. Founder of the School (PSKS) is the Founder of FFSF to chair the deliberations and decisions.

The Award is conferred annually on 14th December, the Birth Anniversary of (Late) Prof Sushil Kumar to an individual who leads the innovative research in INDIA towards outstanding contributions in Agriculture, Life Sciences and Applied fields including multi- and inter-disciplinary areas covering emerging and Science & Technology (S&T) domains with direct impact on societal empowerment or a high end scientific breakthrough as game changer benefiting scientific community/ society, which should be obvious or documented either in peer reviewed publications or translational research support by national/ international agencies of repute.

Area of award:Agriculture, Life Sciences and Applied fields including multi- and inter-disciplinary areas going beyond traditional classification of scientific research leading to inventions, discoveries and technologies.

Purpose: This unique award (SKIA) is for young and mid-career scientists and researchers below the age of 40 years towards recognition in Agriculture, Life Sciences and Applied fields including multi- and inter-disciplinary areas going beyond traditional classification of scientific research leading to inventions, discoveries and technologies. The main purpose of this award is to bring to the forefront outstanding work and contribution of the nominee in multidisciplinary area with direct impact on societal empowerment or a high-end scientific breakthrough as game changer benefiting scientific community/society.

Nature of award: A citation and token amount of Rs. 11,000/- (Rs. Eleven Thousand only) will be presented to the recipient. As stated, the award (SKIA) is to recognize the notable and outstanding research, applied or fundamental, in the inter- disciplinary subject/ field of Sciences, Technology and Innovation and/or significant contribution with direct impact on societal empowerment. The awardee should not have received any other award previously for same work and a self-declaration will have to be appended in the nomination in this respect.

Eligibility: Any citizen of India engaged in Sciences, Technology and Innovation. Overseas citizens of India (OCI) and Persons of Indian Origin (PIO) working in India are also eligible. The upper age limit is 40 years as on 14 December of the year of award. The work of innovation and research submitted for recognition should have been performed in India only.

Search Committee: The Search Committee for each year's award would be constituted by PSKS & FFSF and facilitated by the Founder FFSF and a senior convener nominated by the founder. The Committee would consist of a maximum of five experts representing above areas of translational and interdisciplinary fields. The composition of Search Committee, the information submitted for their scrutiny, the proceedings of the meeting and the procedure for consideration of the nominations/ applications, other than as detailed herein would be kept confidential. Decision of the Search Committee will be final and binding on all.

Who can nominate: Nationally recognized scientific societies and academies, Vice-Chancellors of Universities; Deemed Universities and Institutions of national importance; Directors of recognized organizations, Prof. Sushil Kumar Innovation Awardees, Heads of 'Not-for-Profit' organizations, members of FloraFauna Science Foundation. One can also self-nominate, and in that case, the person must provide contact and designation of two references (with email and mobile number) of established scientific experts having direct knowledge of the work of the candidate being submitted for award consideration.

Nominations/applications must be submitted in the prescribed format via e-mail by sending all materials in a zip file to profskia1940@gmail.com on or before **15th September, 2025.** No hard copy to follow. The subject line of email should be written as **"Prof. Sushil Kumar Innovation Award-2025".**

Nominations/applications would be considered for a total period of three years, if otherwise eligible. However, updated version of nomination will be required to be submitted with request for consideration by the applicant for subsequent year/s. Age on first year of submission of the application should be with in the defined bar of 40 years.

Note: For further details of the award including its guidelines and prescribed proforma for nomination, please visit FFSF website *www.florafauna.in* or send e-mail to profskia1940@gmail.com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FloraFauna Science Foundation (FFSF) invites proposals from academic institutions and research and development organizations and industries for joint/collaborative/sponsored projects in the areas of health, nutrition and agriculture having impact on societal upliftment and/or leading to development of e-villages (entrepreneurial villages) in different parts of the country. The ideas/concepts or proposals may be submitted to Founder President, FFSF (spskhanuja@gmail.com).

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