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Millet, Mycotoxins, and Megafauna: The Bandhavgarh Elephant Tragedy

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Abstract

The Asian elephant (*Elephas maximus*) has experienced severe population decline across its range due to poaching, habitat loss, fragmentation, and escalating human–elephant conflict (HEC). In Central India, HEC has intensified over the past two decades as elephants expand westward into increasingly fragmented landscapes dominated by smallholder agriculture. In this context, the tragic death of ten elephants near Bandhavgarh Tiger Reserve in October 2024 highlights an emerging and underappreciated conservation risk linked to agricultural mycotoxins. Clinical investigations established kodo millet (*Paspalum scrobiculatum*) poisoning, implicating cyclopiazonic acid (CPA), a fungal mycotoxin produced by *Aspergillus* species, as the cause of mortality. This study examines the Bandhavgarh incident to understand its ecological, agronomic, and conservation implications. We situate kodo millet within its historical and contemporary agronomic context, emphasizing its prevalence in marginal, rain-fed landscapes adjoining elephant habitats, where crop-raiding is frequent. We review the long-standing documentation of kodo millet toxicity in humans, its association with fungal contamination during wet-harvest conditions, and its relevance to wildlife health. We argue that small, fragmented elephant populations in Central India are particularly vulnerable to such episodic risks. We further discuss, how increasingly erratic monsoons and heavy rainfall events, may elevate fungal proliferation and mycotoxin exposure in staple crops. To mitigate these risks, we outline integrated management strategies encompassing biological control agents, weather-based disease forecasting, field surveillance, and improved post-harvest drying and storage. We also acknowledge scientific and operational constraints in deploying biological controls, including environmental variability, strain persistence, and formulation stability. We emphasize that safeguarding elephants in Central India requires an integrated approach linking agricultural safety, landscape connectivity, and HEC management. Strengthening corridors, improving crop management, and embedding wildlife health into land-use planning are essential to prevent similar tragedies and promote long-term coexistence between people and elephants in a rapidly changing landscape.

Keywords: Central India, cyclopiazonic acid, elephant, kodo, millet.

The decline of the Asian elephant (*Elephas maximus*) is primarily driven by poaching, habitat loss, fragmentation, and other anthropogenic activities (Leimgruber *et al*., 2003; Chen *et al*., 2022; Pandey *et al*., 2024a). These factors have significantly reduced their population and habitat across Asia (Shaffer *et al*., 2019; de Silva *et al*., 2020). The species has garnered global concern due to a nearly 50% decline in their population over the past three generations (Williams *et al*., 2020). Over 60% of suitable elephant habitat has been lost since the 1700s, with significant fragmentation reducing the average patch size by over 80% (de Silva *et al*., 2020). Human population growth has historically contributed to the range contraction of Asian elephants and limited their habitat (Liu *et al*., 2017). This loss is largely due to agricultural expansion, urbanization, and infrastructure development, which have isolated elephant populations and reduced their genetic diversity (Chen *et al*., 2022; Neupane *et al*., 2020; Leimgruber *et al*., 2003). These factors also lead to habitat deterioration, increased human-elephant conflict, and direct threats like poaching (Joshi *et al*. 2009; He *et al*. 2020). Small, isolated populations exhibit low genetic diversity and high inbreeding, which threaten their long-term viability (He *et al*., 2020; Chen *et al*., 2022). Particularly in areas outside Protected Areas (PAs), especially along their borders, habitat degradation exacerbated by human-elephant conflicts (HEC) poses a major threat to the species' survival (Gubbi, 2012; Tilman *et al*., 2017). Over the past decade, Human–Elephant Conflict (HEC) has intensified across many Asian countries, resulting in significant economic losses and fatalities of both people and elephants (Gubbi, 2012; Shaffer *et al*., 2019). As human activities continue to expand into elephant habitats, mitigating HEC has become essential for ensuring the long-term survival of elephant populations in their natural ranges (Shaffer *et al*., 2019).

In the last two decades, HEC in the Central Indian landscape has spiked (Tripathy *et al*., 2021; Natarajan *et al*., 2024; Habib *et al*. 2025). The central Indian elephant range extends over 21,000 sq.km in the states of Odisha, Jharkhand, Chattishgarh, southern West Bengal, and the eastern part of Madhya Pradesh (Singrauli and Anuppur District). Chhattisgarh has a small elephant population that had migrated from Jharkhand and Odisha during the 1980-90s. Historically, elephants were found in parts of northern Chhattisgarh and Madhya Pradesh, but by the early 20th century, they were considered locally extinct in Madhya Pradesh (Natarajan *et al*., 2023). Due to various anthropogenic pressures, elephants are forced to move towards further west (Areeparampil, 1996; Kumar *et al*., 2023). In 2018, a herd of 40 elephants from Chhattisgarh moved to Madhya Pradesh (Uikey *et al*., 2024; Natarajan *et al*., 2023). The herd initially entered through the Panpatha buffer range, exploring various parts of Bandhavgarh Tiger Reserve before settling down. Forest department closely monitored this process, forming tracking teams to observe and manage the elephants' movements and behaviour (Uikey *et al*., 2024). Since then, the elephant population in Bandhavgarh had increased to 60 by 2023, including five solitary bulls. These elephants showed seasonal movement patterns, with the Panpatha buffer range and Bandhavgarh Tiger Reserve serving as key habitats at different times of the year. On October 29, 2024, ten elephants were found dead within the territorial limits of Salkhaniya Revenue Village, located 1 km from the boundary of Bandhavgarh Tiger Reserve (Ambade *et al*., 2025). Kodo millet (*Paspalum scrobiculatum*) poisoning in this case is clinically established (Ambade *et al*., 2025). In this article, we discuss the incident with a focus on strengthening local HEC management, promoting safer crop cultivation practices, and highlighting its broader implications for elephant conservation in the Central Indian landscape. Given that the Bandhavgarh incident involved a cultivated crop rather than natural forage, it is important to understand the ecological, agronomical, and historical context of kodo millet in India. Kodo is widely grown in marginal, rain-fed landscapes adjoining forested areas, where elephants frequently forage, making it a key interface crop in human–elephant interactions.

Kodo Millet: Resilient Ancient Grain with Nutritional and Agronomic Value

Kodo millet is native to India and belongs to the genus *Paspalum* (subfamily *Panicoideae*), which includes over 400 species distributed across the hot tropical and subtropical regions of the Old World (de Wet *et al*., 1983). It is one of the most resilient small millets, capable of growing in marginal, low-fertility soils and areas with chronic moisture deficits. The crop requires 110–130 days to mature, which is longer than most other small millets. It is cultivated in parts of West Africa, Southeast Asia, Pakistan, and India (Galinato *et al*., 1999). Globally, kodo millet is known by several names, including kodohirse, creeping paspalum, ditch millet, and Indian *Paspalum* (Knees & Gupta, 2013; Hariprasanna, 2017). Within India, it is locally called *arika* (Telugu), *varagu* (Tamil and Malayalam), *harka* (Kannada), *kodra* (Gujarati, Marathi, Punjabi), *kodua* (Odia), and *kodo* (Hindi and Bengali) (Deepika *et al*., 2022).

Archaeological evidence suggests that kodo millet has been cultivated in India since Neolithic times, with remains recovered from sites such as Nevasa, Hallur, and Nagra (Kajale, 1974). Its cultivation as an annual crop has been documented for over 3,000 years in southern Rajasthan and parts of Maharashtra (de Wet *et al*., 1983). India remains the world's largest producer of kodo millet, contributing approximately 0.08 million tonnes from about 0.2 million hectares (Bhat *et al*., 2018). The crop is predominantly grown on marginal lands, often in sloping or undulating terrains within tribal regions (Yadava & Jain, 2006). Nutritionally, kodo millet is rich in carbohydrates and proteins comparable to wheat and rice (Deepika *et al*., 2022). It also contains essential minerals such as sodium, calcium, iron, potassium, magnesium, and zinc (Longvah *et al*., 2017), along with B vitamins and high phenolic content (Hegde *et al*., 1989).

Kodo Millet Poisoning: Mycotoxin Risks and Historical Perspectives

Despite the nutritional advantages of kodo millet, for which the government of India is promoting its adoption across Central India's arid regions, 'kodo poisoning' cases have been documented in Madhya Pradesh and Uttar Pradesh (Deepika *et al*., 2022). The scientific documentation of kodo millet poisoning dates back to the late 18th century. Chevers (1870) documented that consuming kodo millet grains can result in adverse health effects, particularly when the grains mature and are harvested during rainy days. Similarly, the *Indian Medical Gazette* (1922) detailed an incident of acute "kodon" poisoning reported by an assistant surgeon in Shahjahanpur district, Uttar Pradesh (Deepika *et al*., 2022). The report described four individuals who consumed bread made from kodo millet flour and subsequently experienced symptoms such as vomiting, dizziness, and unconsciousness shortly after their meal (Swarup, 1922). However, there was also a historical report of kodo poisoning cited in Bhat (1983): "The problem of mycotoxins in kodo millet was well recognized in the ancient Indian as well. A text entitled "*Arthashastra*" (economics) written in the year 300 B.C. by Chanakya refers to the killing of tigers by baiting them with the Kodo millet."

Bhide (1962) and Bhide & Aimen (1959) noted that the husk and foliage of kodo millet frequently acquire toxic properties, a phenomenon that is frequently associated with heavy rainfall. In the states of Madhya Pradesh and Chhattisgarh, this form of poisoning is locally known as "Matawna Kodoo" or "Matona Kodo" (Pall *et al*., 1980; Ansari & Shrivastava, 1991). This seasonal association has fostered a belief among farmers in certain regions that kodo millet becomes toxic following rainfall. Rao & Husain (1985) were the first to establish the connection between the mycotoxin cyclopiazonic acid (CPA) and kodo millet seeds, which causes "kodua poisoning." They determined that the seeds were infected with *Aspergillus flavus* and *Aspergillus tamarii*, both of which produce cyclopiazonic acid. This was the initial documented association between kodua poisoning and a mycotoxin (Rao & Husain, 1985). Cyclopiazonic acid (CPA) is a potent mycotoxin that can cause a range of health problems, including gastrointestinal distress, liver damage, and neurological disorders (Ostry *et al*., 2018). In severe cases, it can lead to death. Biologically, CPA is a specific inhibitor of sarco (endo) plasmic reticulum $Ca2+$-ATPase (Ostry *et al*. 2018). While humans have been aware of the risks associated with consuming contaminated kodo millet for centuries, the impact of this toxic grain on wildlife was sporadic in the 19th and 20th centuries.

Kodo Millet Toxicity, Central India's Elephant Population

As depicted in ancient literature from the Kurinji landscape, Asian Elephants have been raiding crops since historic times (for details see Oommen, 2019). There are texts which describe elephants roaming in millet-rich hills, and often mountain dweller guarding their fields using a platform. There is information in the poetry about bull elephants often raiding millet fields (Oommen, 2019). These historical depictions highlight the persistent conflict between elephants and humans over millet. A similar incident was also reported in December 1933, 14 elephants were suspected to have ingested kodo millet and subsequently found dead near the Vannathiparai Reserve Forest in Tamil Nadu, close to the Kerala border (Morris, 1934).

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Historical records and writings from the Mughal emperors of the 16th and 17th centuries (Sukumar, 2003) provide evidence that elephants were once broadly distributed across central India, from southern Uttar Pradesh through Madhya Pradesh to Chhattisgarh. Although they eventually disappeared from these areas, they have now first recolonized Chhattisgarh, and then Madhya Pradesh. In central India, the elephant population is small, isolated groups within a highly fragmented landscape, and is still venturing into new areas. As a result, the likelihood of elephants raiding kodo millet in this area is significantly higher. The relatively low number of elephants in this landscape can be attributed to factors such as historic mass capture, poaching, habitat fragmentation and loss, and human-elephant conflict. However, the impact of elephant deaths caused by kodo poisoning on the region's small and fragmented elephant populations cannot be entirely overlooked, and several such incidents may have gone unnoticed.

Furthermore, Central India has experienced significant shifts in its precipitation patterns (Mukharjee *et al*., 2018), characterized by an increase in the frequency of heavy rainfall events and a more erratic monsoon season. Studies have shown a rise in localized heavy rainfall occurrences, while the timing and intensity of the monsoon have become less predictable, leading to both droughts and floods in different parts of the region (Kishore *et al*., 2016; Sørland & Sorteberg, 2016). Climate change is expected to impact food security through both direct effects on crop yields and indirect effects on food safety, as acknowledged by the FAO (2008). However, the majority of research on climate change and food security is primarily concentrated on yields, with limited attention given to food safety. There is a pressing need for quantitative assessments of the projected impacts of climate change on food safety, particularly concerning mycotoxin contamination in cereals and other crops.

Mitigation Measures-Mycotoxin Contamination

The primary states producing kodo millet in India: Madhya Pradesh, Uttar Pradesh, Maharashtra, Chhattisgarh, Tamil Nadu, and Karnataka, are all home to the Asian elephant (consisting of ~34% of the elephant population). Crop raiding is one of the major causes of human elephant conflict in the central Indian landscape (Natarajan *et al*., 2024). Hence, we have discussed the strategies for mitigating mycotoxin contamination in details here.

Biological control agents (BCAs) such as *Trichoderma spp.* and *Bacillus subtilis* are effective in inhibiting the growth of toxigenic fungi by colonizing plant surfaces and producing antifungal metabolites. This approach reduces the need for chemical fungicides and offers a more sustainable pathway for managing fungal contamination. Several BCAs have demonstrated potential in suppressing toxigenic fungi and reducing mycotoxin production. Yeasts such as *Saccharomyces cerevisiae* can inhibit *Aspergillus flavus* through the production of volatile organic compounds (VOCs) and binding mechanisms that remove mycotoxins from contaminated environments (Hassan *et al*., 2021; Oufensou *et al*., 2023; Alasmar *et al*., 2020). Similarly, *Bacillus megaterium* and *Bacillus subtilis* can suppress fungal growth and mycotoxin synthesis, including aflatoxins and ochratoxins, through the release of inhibitory VOCs (Saleh *et al*., 2021; Zohri *et al*., 2018). Other bacterial strains, such as *Lactococcus lactis* and *Pseudomonas fluorescens* have also shown strong antifungal activity in laboratory studies (Zohri *et al*., 2018). Additionally, non-toxigenic strains of *Aspergillus niger* and *A. tubingensis* have been used to competitively exclude toxigenic fungi, resulting in reduced mycotoxin levels (Aukkasarakul *et al*., 2014).

Overall, BCAs provide an environmentally friendly alternative to synthetic fungicides by minimizing chemical inputs, lowering the risk of fungicide resistance, and promoting natural antagonistic interactions in agroecosystems (Hassan *et al*., 2021; Oufensou *et al*., 2023; Ren *et al*., 2020; de la Huerta-Bengoechea *et al*., 2022). Their adoption could be facilitated through agricultural cooperatives, farmer training programs, and field demonstrations to validate performance under real-world conditions.

However, the effectiveness of BCAs can vary across environmental gradients, particularly with changes in temperature, humidity, rainfall patterns, and soil microbial communities, which may influence their establishment and persistence in the field. The durability of introduced strains over an entire cropping season also remains uncertain in rain-fed, low-input systems where conditions are highly variable. Furthermore, the economic feasibility of repeated BCA applications and formulation stability under tropical field conditions requires further evaluation. Addressing these challenges will require region-specific field validation trials, development of locally adapted strains, and integration of BCAs within broader crop and post-harvest management strategies rather than relying on them as a stand-alone solution.

Furthermore, timely taken action, guided by predictive weather models, can effectively prevent fungal diseases and reduce mycotoxin contamination. Real-time weather-based alerts *via* communication tools or mobile apps can help farmers target critical infection periods, minimizing costs and environmental impact. Ensuring access to safe fungicides through cooperatives and extension services is essential for widespread adoption. Continuous monitoring of fields during crop growth is essential for the early detection of fungal infections. Early intervention can prevent the spread of infection and reduce mycotoxin production. The government can establish a network of trained field scouts equipped with diagnostic kits and mobile devices to carry out regular field inspections. By providing real-time updates and advice to farmers, these scouts can play a vital role in early detection and timely management of fungal diseases.

Post-harvest handling and storage are crucial to reducing mycotoxin contamination, which thrives in moist and poorly managed conditions. Rapid drying of crops using subsidized solar or biomass dryers, centralized drying facilities, and proper training can prevent fungal growth. Safe storage practices, such as using hermetically sealed bags, metallic silos, or climate-controlled community warehouses, are essential to protect dried crops. Financial incentives can support farmers in adopting modern storage solutions. Regular monitoring for mycotoxins through mobile testing labs and certification programs ensures food safety and better market prices for toxin-free produce. Additionally, promoting good handling and sorting practices, such as using improved threshing tools and manually removing damaged grains, helps minimize fungal entry. Awareness campaigns and training can further enhance the adoption of these practices, ensuring safer and higher-quality crops. Simultaneously, studying elephant movement in the central Indian landscape is vital, given the region's highly fragmented habitats and the frequent crop-raiding behaviour.

Conclusion

The tragic mortality of ten elephants in Bandhavgarh Tiger Reserve underscores the emerging risks associated with mycotoxins, specifically cyclopiazonic acid (CPA). The incident in Bandhavgarh stresses the urgent need for a multi-sectoral approach to mycotoxin management, especially in areas where wildlife and agriculture intersect. This incident serves as a wake-up call to the interconnectedness of agriculture, wildlife health, and environmental change, highlighting the need for more comprehensive monitoring and mitigation strategies. In the coming years, climate change may increase the prevalence of fungal infestations in crops like kodo millet, creating new threats for both wildlife and humans. In light of this, it is imperative to improve crop storage methods, enhance early detection of mycotoxins in food supplies, and raise awareness among local farming communities regarding safe agricultural practices.

Additionally, capacity-building initiatives should be conducted for local farmers, agricultural departments, forest officials, and other relevant agencies to address fungal infestations in agricultural crops and implement effective mitigation measures. Moreover, efforts to reduce HEC, such as strengthening elephant corridor connectivity and ensuring sustainable forage availability within protected areas (Pandey *et al*., 2024 a, b), are critical for safeguarding elephant populations in Central India. The integration of environmental, land-use planning, agricultural, and wildlife health measures will be the key in preventing similar incidents, fostering coexistence, and ensuring the long-term survival of elephant populations in the central Indian landscape. This incident highlights the need for a holistic approach to conservation that takes into account the complexities of ecosystem health, human-wildlife interaction, and agricultural sustainability.

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CONFLICT OF INTEREST

Parag Nigam & Bilal Habib hold academic editor positions at the Journal of Wildlife Science. However, they did not participate in the peer review process of this article except as an author. The authors declare no other conflict of interest.

DATA AVAILABILITY

Data is available from the corresponding author on request.

AUTHOR CONTRIBUTIONS

A.N. wrote the first draft of the manuscript. R.K.P., P.N. & B.H. provided critical intellectual inputs, revised the manuscript for important content, and approved the final submission.

References

Alasmar, R., Ul-Hassan, Z., Zeidan, R., Al-Thani, R., Al-Shamary, N., Alnaimi, H., Migheli, Q. & Jaoua, S. (2020). Isolation of a Novel *Kluyveromyces marxianus* Strain QKM-4 and Evidence of Its Volatilome Production and Binding Potentialities in the Biocontrol of Toxigenic Fungi and Their Mycotoxins. *ACS omega*, 5(28), 17637-17645. https://doi.org/10.1021/acsomega.0c02124

Ambade, V. K. N., Sen, S., Krishnamoorthy, L., Pandey, R. K., Dubey, A. K., Sahay, A., Varma, P. K., Sarothiya, R., Jawre, S., Rajput, N., Majumdar, A., Karmarkar, T., Sudini, H., Mathesh, K., Shrivastav, S., Gupta, N. & Nigam, P. (2025). Mortality investigations in wild Asiatic elephants (*Elephas maximus*) due to infected Kodo millet consumption in Bandhavgarh Tiger Reserve, Madhya Pradesh- A case study. *Journal of Wildlife Science*, Online Early Publication, 01-08. https://doi.org/10.63033/JWLS.CRPW6521

Ansari, A. A. & Shrivastava, A. K. (1991). Susceptibility of minor millets to *Aspergillus flavus* for aflatoxin production. 44(4), 533-534.

Areeparampil, M. (1996). Displacement due to mining in Jharkhand. *Economic and Political Weekly*, 31(24), 1524-1528.

Aukkasarakul, S., Chamswarng, C., Piasai, O., Chinaphuti, A. & Manoch, L. (2014). Efficacy of non-toxigenic isolates of *Aspergillus* niger and *A. tubingensis* as biological control agents against toxigenic *A. niger* and plant pathogenic fungi. *Thai Journal of Agricultural Science*, 47(3), 147-155.

Bhat, B. V., Rao, D. B. & Tonapi, V. A. (2018). *The story of millets*. Karnataka state department of Agriculture in association with ICAR. Indian Institute of Millet Research, Hyderabad, India, pp.57-59.

Bhat, R. V. (1983). Mycotoxin health hazards in India. *JSM Mycotoxins*, 1983(17), 7-12. https://doi.org/10.2520/myco1975.1983.7

Bhide, N. K. & Aimen, R. A. (1959). Pharmacology of a tranquillizing principle in *Paspalum scrobiculatum* grain. *Nature*, 183, 1735-1736. https://doi.org/10.1038/1831735b0

Bhide, N. K. (1962). Pharmacological study and fractionation of *Paspalum scrobiculatum* extract. *British Journal of Pharmacology and Chemotherapy*, 18(1), 7-18. https://doi.org/10.1111/j.1476-5381.1962.tb01145.x

Chen, Y., Sun, Y., Atzeni, L., Gibson, L., Hua, M., Li, K., Shi, K. & Dudgeon, D. (2022). Anthropogenic pressures increase extinction risk of an isolated Asian elephant (*Elephas maximus*) population in southwestern China, as revealed by a combination of molecular-and landscape-scale approaches. *Integrative Zoology*, 17(6), pp.1078-1094. https://doi.org/10.1111/1749-4877.12534

Chevers, N. (1870). A manual of medical jurisprudence for India, including the outline of a history of crime against the person in India. Thacker, Spink.

de la Huerta-Bengoechea, P., Gil-Serna, J., Melguizo, C., Ramos, A.J., Prim, M., Vázquez, C. & Patiño, B. (2022). Biocontrol of mycotoxigenic fungi using bacteria isolated from ecological vineyard soils. *Journal of Fungi*, 8(11), 1136. https://doi.org/10.3390/jof8111136

de Silva, S., Wu, T., Thieme, A., Johnson, J., Nyhus, P., Wadey, J., Vu, T., Mossbrucker, A., Neang, T., Chen, B. S. et. al. (2020). The past, present and future of elephant landscapes in Asia. *bioRxiv*, 2020-04. https://doi.org/10.1101/2020.04.28.066548

de Wet, J.M., Brink, D. E., Rao, K. P. & Mengesha, M. H. (1983). Diversity in kodo millet, *Paspalum scrobiculatum*. *Economic Botany*, 37(2), 159-163. https://doi.org/10.1007/BF02858779

Deepika, C., Hariprasanna, K., Das, I. K., Jacob, J., Ronanki, S., Ratnavathi, C. V., Bellundagi, A., Sooganna, D. & Tonapi, V. A. (2022). 'Kodo poisoning': cause, science and management. *Journal of food science and technology*, 59, 2517-2526. https://doi.org/10.1007/s13197-021-05141-1

Food and Agriculture Organization [FAO] (2008). *Climate change and food security: a framework document* . Food and Agriculture Organization of the United Nations, Rome, Italy. https://www.fao.org/4/k2595e/k2595e00.htm [Accessed on 02 January, 2026]

Galinato, M. I. (1999). *Upland rice weeds of South and Southeast Asia*. International Rice Research Institute.

Gubbi, S. (2012). Patterns and correlates of human–elephant conflict around a south Indian reserve. *Biological Conservation*, 148(1), 88-95. https://doi.org/10.1016/j.biocon.2012.01.046

Habib, B., Pandey, R., Nath, A., Nigam, P., Ganesan, A., Roy, K. & Dutta, A. (2025a). Elephant-human conflict in the state of Jharkhand (2000-2023): Trends, Challenges and Insights. Wildlife Institute of India & Project Elephant Division, Ministry of Environment, Forest and Climate Change, Government of India. p.64. TR No./2025/05.

Hariprasanna, K. (2017). *Kodo Millet, Paspalum scrobiculatum L. Millets and sorghum: biology and genetic improvemen*t, 8, pp.199-225. https://doi.org/10.1002/9781119130765.ch8

Hassan, Z. U., Al Thani, R., Atia, F. A., Alsafran, M., Migheli, Q. & Jaoua, S. (2021). Application of yeasts and yeast derivatives for the biological control of toxigenic fungi and their toxic metabolites. *Environmental Technology & Innovation*, 22, 101447. https://doi.org/10.1016/J.ETI.2021.101447

He, C., Du, J., Zhu, D. & Zhang, L. (2020). Population viability analysis of small population: A case study for Asian elephant in China. *Integrative Zoology*, 15(5), 350-362. https://doi.org/10.1111/1749-4877.12432

Hegde, B. R. & Gowda, L. (1989). Cropping systems and production technology for small millets in India. In Proceedings of the first international small millets workshop, Bangalore, India. 29, pp.209-236.

Joshi, R., Singh, R., Joshi, B. D. & Gangwar, R. S. (2009). The Decline of the Asian elephants (*Elephas maximus*) from Hardwar forest range of the Rajaji National Park, India: The First Documented case of free-ranging wildlife species. *New York Science Journal*, 2, 1-12.

Kajale, M. D. (1974). Ancient grains from India. *Bulletin of the Deccan College Post-Graduate and Research Institute*, 34(1/4), pp.55-74.

Kishore, P., Jyothi, S., Basha, G., Rao, S. V. B., Rajeevan, M., Velicogna, I. & Sutterley, T. C. (2016). Precipitation climatology over India: validation with observations and reanalysis datasets and spatial trends. *Climate dynamics*, 46, 541-556. https://doi.org/10.1007/s00382-015-2597-y

Knees, S. G. & Gupta, A. K. (2013). *Paspalum scrobiculatum*. The IUCN Red List of Threatened Species 2020: e.T168983A1260955. https://doi.org/10.2305/IUCN.UK.2013-1.RLTS.T13584252A13597076.en

Kumar, A., Dhuria, S. S., Bhattacharya, A. & Sarkar, P. (2023). Integrating Multiple Aspects of Human-Elephant Conflict Management in Dharamjaigarh Forest Division of Chhattisgarh, India. *Uttar Pradesh Journal of Zoology*, 44(4), 60-67. https://doi.org/10.56557/upjoz/2023/v44i43433

Leimgruber, P., Gagnon, J. B., Wemmer, C., Kelly, D. S., Songer, M. A. & Selig, E. R. (2003). Fragmentation of Asia's remaining wildlands: implications for Asian elephant conservation. *Animal conservation*, 6(4), 347-359. https://doi.org/10.1017/S1367943003003421

Liu, P., Wen, H., Harich, F. K., He, C., Wang, L., Guo, X., Zhao, J., Luo, A., Yang, H., Sun, X. & Yu, Y. (2017). Conflict between conservation and development: cash forest encroachment in Asian elephant distributions. *Scientific Reports*, 7, 6404. https://doi.org/10.1038/s41598-017-06751-6

Longvah, T., Ananthan, R., Bhaskarachary, K. & Venkaiah, K. (eds.) (2017). *Indian Food Composition Tables*. 1st ed. National Institute of Nutrition, Hyderabad.

Morris. R. C. (1934). Millet Poisoning in Elephants. *Journal of Bombay Natural History Society*, 37, 723.

Mukherjee, S., Aadhar, S., Stone, D. & Mishra, V. (2018). Increase in extreme precipitation events under anthropogenic warming in India. *Weather and Climate Extremes*, 20, 45-53. https://doi.org/10.1016/J.WACE.2018.03.005

Natarajan, L., Kumar, A., Nigam, P. & Pandav, B. (2023). An Overview of Elephant Demography in Chhattisgarh (India): Implications for Management. *Journal of the Bombay Natural History Society*, 120. https://doi.org/10.17087/jbnhs/2023/v120/167989

Natarajan, L., Nigam, P. & Pandav, B. (2024). Human–elephant conflict in expanding Asian elephant range in east-central India: implications for conservation and management. *Oryx*, 59(2):256-264. https://doi.org/10.1017/S0030605324000930

Neupane, D., Kwon, Y., Risch, T. S. & Johnson, R. L. (2020). Changes in habitat suitability over a two decade period before and after Asian elephant recolonization. *Global Ecology and Conservation*, 22, e01023. https://doi.org/10.1016/j.gecco.2020.e01023

Oommen, M. A. (2019). The elephant in the room: histories of place, memory and conflict with wildlife along a southern Indian forest fringe. *Environment and History*, 25(2), 269-300. https://doi.org/10.3197/096734018X15217309861559

Ostry, V., Toman, J., Grosse, Y. & Malir, F. (2018). Cyclopiazonic acid: 50th anniversary of its discovery. *World Mycotoxin Journal*, 11(1), 135-148. https://doi.org/10.3920/WMJ2017.2243

Oufensou, S., Ul Hassan, Z., Balmas, V., Jaoua, S. & Migheli, Q. (2023). Perfume guns: Potential of yeast volatile organic compounds in the biological control of mycotoxin-producing fungi. *Toxins*, 15(1), 45. https://doi.org/10.3390/toxins15010045

Pall, B. S., Jain, A. C. & Singh, S. P. (1980). *Diseases of lesser millets*. Jawarharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India. p. 76.

Pandey, R. K., Natarajan, L., Mittal, D., Udhayaraj, A. D., Selvin, M. K., Gupta, D. K., Kumar, R., Tiwari, V. R., Yadav, S., Habib, B. & Nigam, P. (2024a). On the PAN-India Assessment of Elephant Corridors: Challenges, Opportunities, and Future Directions. *Indian Forester*, 150(10), 909-915. https://doi.org/10.36808/if/2024/v150i10/170626

Pandey, R. K., Yadav, S. P., Selvan, K. M., Natarajan, L. & Nigam, P. (2024b). Elephant conservation in India: Striking a balance between coexistence and conflicts. *Integrative Conservation*, 3(1), 1-11. https://doi.org/10.1002/inc3.38

Rao, B. L. & Husain, A. (1985). Presence of cyclopiazonic acid in kodo millet (*Paspalum scrobiculatum*) causing 'kodua poisoning'in man and its production by associated fungi. *Mycopathologia*, 89(3), 177-180. https://doi.org/10.1007/BF00447028

Ren, X., Zhang, Q., Zhang, W., Mao, J. & Li, P. (2020). Control of aflatoxigenic molds by antagonistic microorganisms: Inhibitory behaviors, bioactive compounds, related mechanisms, and influencing factors. *Toxins*, 12(1), 24. https://doi.org/10.3390/toxins12010024

Saleh, A.E., Ul-Hassan, Z., Zeidan, R., Al-Shamary, N., Al-Yafei, T., Alnaimi, H., Higazy, N.S., Migheli, Q. & Jaoua, S. (2021). Biocontrol activity of *Bacillus megaterium* BM344-1 against toxigenic fungi. *ACS omega*, 6(16), 10984-10990. https://doi.org/10.1021/acsomega.1c00816

Shaffer, L. J., Khadka, K. K., Van Den Hoek, J. & Naithani, K. J. (2019). Human-elephant conflict: A review of current management strategies and future directions. *Frontiers in Ecology and Evolution*, 6, 235. https://doi.org/10.3389/fevo.2018.00235

Sørland, S. L. & Sorteberg, A. (2016). Low-pressure systems and extreme precipitation in central India: sensitivity to temperature changes. *Climate Dynamics*, 47, 465-480. https://doi.org/10.1007/s00382-015-2850-4

Sukumar, R. (2003). *The Living Elephants: Evolutionary Ecology, Behavior, and Conservation.* Oxford University Press, New York, p.478. https://doi.org/10.1093/oso/9780195107784.001.0001

Swarup, A. (1922). Acute" Kodon" Poisoning. *The Indian Medical Gazette*, 57(7), p.257.

Tilman, D., Clark, M., Williams, D. R., Kimmel, K., Polasky, S. & Packer, C. (2017). Future threats to biodiversity and pathways to their prevention. *Nature*, 546(7656), 73-81. https://doi.org/10.1038/nature22900

Tripathy, B. R., Liu, X., Songer, M., Zahoor, B., Wickramasinghe, W. M. S. & Mahanta, K. K. (2021). Analysis of landscape connectivity among the habitats of Asian elephants in Keonjhar Forest Division, India. *Remote Sensing*, 13(22), 4661. https://doi.org/10.3390/rs13224661

Uikey, L. L., Verma, P. K. & Karmarkar, T. (2024). Colonization of Elephants in Bandhavgarh Tiger Reserve. *Trumpet* , IV(2), pp.22–27.

Williams, C., Tiwari, S. K., Goswami, V. R., De Silva, S., Kumar, A., Baskaran, N., Yoganand, K. & Menon, V. (2020). *Elephas maximus*. *The IUCN red list of threatened species* 2020: e.T7140A45818198. *Retrieved*, 12, p.2021.

Yadava, H. S. & Jain, A. K. (2006). *Advances in kodo millet research*. Directorate of Information and Publications of Agriculture, Indian Council of Agricultural Research. p. 95.

Zohri, A. A., Sabah, S. M. & Youssef, M. (2018). Inhibition of fungal growth and mycotoxins formation of selected toxigenic fungi by different bacterial strains. *GPH-International Journal of Applied Science*, 1(1), 09-19.