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SHORT COMMUNICATION

Revolutionizing biodiversity monitoring in rural areas with eDNA techniques

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Biodiversity monitoring is a critical tool for assessing ecosystem health, species diversity, and the impact of human activities on the environment. Traditionally, biodiversity assessments in rural areas rely on labor-intensive field surveys, direct observations, and sampling methods that can be expensive and time-consuming. In recent years, environmental DNA (eDNA) techniques have emerged as a revolutionary tool to transform biodiversity monitoring practices. eDNA offers a non-invasive, cost-effective, and efficient method for detecting and monitoring a wide range of species, including those that are elusive, rare, or difficult to detect using traditional techniques. This paper explores how eDNA techniques can be employed to revolutionize biodiversity monitoring in rural areas. By analyzing water, soil, or air samples for traces of genetic material shed by organisms, eDNA allows for a more comprehensive understanding of biodiversity in rural ecosystems. The article delves into the benefits of eDNA in biodiversity monitoring, its application in rural areas, its challenges, and the potential for scaling up its use to support conservation and environmental management efforts.

Keywords: Biodiversity monitoring, Environmental DNA, eDNA, Rural areas, Conservation, Ecosystem health, Species detection, Non-invasive sampling, Genetic material, Environmental management.

Introduction

Biodiversity monitoring is a fundamental activity in ecological research and conservation management. It involves the systematic collection and analysis of data on species and ecosystems to assess their health, distribution, and trends over time. Traditional biodiversity monitoring methods primarily involve field surveys, which may include direct observations, camera trapping, acoustic monitoring, and trapping or netting of organisms. These methods often require substantial resources, including trained personnel, transportation, equipment, and time. For example, to assess fish populations in a river, researchers may need to use electrofishing, which can be disruptive to aquatic ecosystems and can miss certain species that are difficult to capture. Similarly, detecting rare or elusive species through visual surveys is often challenging, particularly in dense vegetation or in environments where species are cryptic or nocturnal. While these methods remain important tools for biodiversity monitoring, they have limitations in terms of efficiency, accessibility, and species coverage. Some species, particularly those with low population densities or secretive habits, may go undetected, leading to underestimates of biodiversity. Furthermore, traditional techniques may also be invasive, potentially disrupting ecosystems or causing stress to the species being monitored. The rise of eDNA represents a transformative shift in how biodiversity is monitored. eDNA offers a novel and non-invasive approach that enables the detection of a wide range of species in their natural habitats, including those that are difficult to detect using traditional methods. By collecting genetic material from environmental samples, researchers can gather information about species presence, composition, and abundance without having to physically capture or observe the organisms (Narayan S, et al. 2017).

Description

Environmental DNA is genetic material that organisms shed into their environment as a byproduct of their daily activities. This can include cells, tissue, feces, urine, saliva, mucous, and other biological material. eDNA is present in various environmental matrices such as water, soil, sediment, and air. For example, fish release eDNA into water through skin cells, scales, and waste products, while terrestrial animals might shed DNA into the soil or air through feces and hair. The application of eDNA techniques involves collecting environmental samples and then analyzing them to identify the presence of genetic material from target species. DNA sequencing methods, such as PCR (Polymerase Chain Reaction), are used to amplify and detect specific genetic markers associated with particular species. By comparing the amplified DNA with known reference databases, researchers can identify species in the samples without ever having to observe or capture them. One of the key advantages of eDNA over traditional methods is that it allows for the detection of a broader range of species, including those that are elusive, endangered, or hard to observe directly. For example, eDNA can be used to detect the presence of rare or cryptic species that might not be captured using visual surveys, trapping, or acoustic monitoring (Fargione JE, et al. 2018). Unlike traditional methods, which can involve capturing or handling animals, eDNA is a non-invasive technique that minimizes the impact on ecosystems. This is especially important in sensitive or protected environments where human intervention may disrupt the natural habitat.

Collecting eDNA samples can be less expensive than traditional survey methods, particularly in remote or hard-to-reach areas. For example, water sampling for eDNA analysis is often less labor-intensive and costly than setting up nets or traps for aquatic species. Efficiency and scalability: eDNA sampling can cover large geographic areas more quickly than traditional methods, making it particularly useful in rural areas where species monitoring may require significant time and resources. Additionally, eDNA can be used to monitor multiple species simultaneously, providing a more comprehensive snapshot of biodiversity. Detection of rare or cryptic species: eDNA is highly sensitive and can detect species that may be difficult to observe directly due to low abundance, secretive behavior, or nocturnal habits (Tedersoo L, et al. 2014). This is particularly important in rural areas where species may be rare or elusive. Traditional biodiversity monitoring often requires highly trained personnel with specialized knowledge of the local fauna. In contrast, eDNA analysis requires only basic training in sample collection and the use of DNA analysis techniques, making it easier for local communities or non-experts to engage in biodiversity monitoring. eDNA is increasingly being used to monitor aquatic ecosystems, such as rivers, lakes, and wetlands, for a variety of species, including fish, amphibians, and invertebrates. For example, water samples can be tested for the presence of invasive species like zebra mussels or for the presence of rare or endangered species (Battipaglia G, et al. 2013).

eDNA is particularly valuable in monitoring rare or endangered species that may be difficult to detect using traditional methods. For example, eDNA could be used to monitor the presence of elusive species like the Amur leopard or the Javan rhino in rural protected areas. Rural areas are often the first point of contact for invasive species, which can disrupt local ecosystems. eDNA techniques are an excellent tool for early detection and monitoring of invasive species, helping to prevent their spread before they become established. Despite its many advantages, there are several challenges associated with the use of eDNA for biodiversity monitoring. eDNA samples are highly susceptible to contamination from external sources, such as handling, transportation, or cross-contamination between sites. Careful sample collection, storage, and analysis procedures are essential to minimize the risk of contamination (Kjøller R. 2006). Analyzing eDNA samples requires specialized equipment and expertise in molecular biology. While PCR-based techniques have become more accessible, the complexity of data analysis and interpretation can still present challenges, especially in rural settings where access to laboratory facilities may be limited. Species-specific challenges: eDNA analysis relies on the ability to detect specific genetic markers associated with target species. This requires the development of comprehensive reference databases and primers for each species of interest. In some cases, particularly for less-studied or cryptic species, this may not be feasible.

Conclusion

Environmental DNA (eDNA) represents a transformative approach to biodiversity monitoring, particularly in rural areas where traditional methods may be difficult or impractical. By leveraging the power of genetic material shed by organisms into the environment, eDNA enables the non-invasive detection of a wide range of species, including those that are elusive, rare, or difficult to observe directly. Its advantages, including cost-effectiveness, efficiency, and the ability to detect a broad range of species, make it a valuable tool for biodiversity monitoring in rural and remote environments. Despite challenges such as potential contamination and the need for specialized DNA analysis, the application of eDNA has the potential to revolutionize biodiversity monitoring, supporting conservation efforts, enhancing environmental management, and providing critical data to inform policy decisions. As the technology continues to improve and becomes more widely accessible, it is likely that eDNA will play an increasingly prominent role in shaping the future of biodiversity monitoring and conservation in rural areas.

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Conflict of Interest

The authors declare no conflict of interest.

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