

Geographical Distribution of Medicinal Leeches in Azerbaijan and Prospects for their Use

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ABSTRACT

This study reviews the role of leeches (Hirudinea) in aquatic ecosystems and examines their distribution patterns in collector-drainage networks in relation to biodiversity conservation and water quality assessment in agricultural landscapes. Global agricultural intensification has significantly reduced natural wetlands while promoting the development of artificial aquatic habitats, including irrigation canals, reservoirs, and drainage systems. Although these artificial environments cannot fully replace natural wetlands, they provide alternative habitats for various aquatic organisms, including leeches. The research analyzes the main environmental factors influencing leech distribution, such as hydrological conditions, water physicochemical characteristics, mineralization levels, and anthropogenic impacts. Particular attention is given to the relationship between water mineralization and the species composition, abundance, and spatial distribution of leech populations. The findings indicate that increasing salinity levels significantly affect the occurrence and reproductive capacity of freshwater leech species. The study evaluates the ecological and economic impacts of leeches on livestock production and land reclamation systems in the Mughan Plain. The results show that uncontrolled leech populations may harm animal health and reduce the efficiency of drainage infrastructure. The study demonstrates that integrated management strategies combining hydraulic engineering solutions, preventive measures, and continuous ecological monitoring are more effective than individual control methods for sustainable leech management.

Keywords: Medicinal Leech, Biogeography, Environmental Safety, Hirudotherapy, Biofactory.

1. INTRODUCTION

In contemporary society, the conservation and sustainable management of biological resources are increasingly recognized as essential pillars, serving both as a requirement for environmental security and as a critical driver of long-term socio-economic progress. In this context, medicinal leeches are particularly important. Their healing properties have been used in folk medicine for thousands of years, and modern medicine has confirmed them through scientific research (Whitaker et al., 2004; Hyson, 2005). Traditionally, leech therapy was widely used in Egyptian, Indian, Greek, and Arabic medicine, and although initially it was mainly aimed at bloodletting, over time it began to be recommended for the treatment of inflammatory diseases, skin pathologies, rheumatic pain, and disorders of the reproductive system (Parlakpınar & Polat, 2021; Sig et al., 2017). The relatively low pain of this method in the Middle Ages led to its widespread

use. Although interest in leech therapy declined somewhat with the development of modern medicine, the discovery of hirudin at the end of the 19th century reoriented scientific attention to this area. Since the second half of the 20th century, medicinal leeches have been used in clinical practice to eliminate venous congestion in reconstructive surgery, protect microsurgical grafts, and reduce inflammatory processes (Abdualkader et al., 2013; Hosseini et al., 2024).

The bioecological characteristics, distribution ranges, and economic potential of medicinal leeches are important for both public health and regional development. Although there are over 600 species of leeches worldwide, the species *Hirudo verbana*, *H. medicinalis*, and *H. orientalis* stand out. They have potential for medical applications and practical use (Sig et al., 2017; Aminov et al., 2022).

Global experience shows that in developed countries, medicinal leeches are marketed only as organic products grown under

sterile conditions. This approach ensures patient safety and protects natural populations (Lemke & Vilcinskis, 2020). Despite rich aquatic ecosystems, leech farming in Azerbaijan relies primarily on wild hunting and informal trade, leading to ecological imbalances, health risks, and economic losses.

Medicinal leeches are not limited to biological resources. They are also a strategic resource from economic and geographical perspectives. Their use opens up new economic opportunities in the pharmaceutical industry, medical tourism, export-oriented biopharmaceutical activities, and regional development. Therefore, studying the geographic distribution of medicinal leeches, assessing their natural resources, and ensuring their sustainable use are urgent and strategically important tasks for modern biology, geography, and health sciences.

Artificial breeding of leeches under sterile conditions in specially protected natural areas and suitable freshwater bodies can maintain ecological balance while providing the population with safe medicinal products. This approach is rational from both an ecological and economic perspective.

Beyond their biological value, medicinal leeches must be assessed as a strategic medical and economic resource. Determining their distribution, assessing their natural resources, and developing principles for sustainable use are crucial for environmental safety, public health, and regional development. In this context, a comprehensive study of the geographic distribution of medicinal leeches in Azerbaijan, the leading producer of medicinal leeches in the South Caucasus, a scientific assessment of existing resources, and the development of effective protection mechanisms can be characterized as a relevant and strategic area at the intersection of modern biology, geography, and health sciences (Farzali & Saglam, 2022).

The study focuses on medicinal leeches common in freshwater ecosystems of the Republic of Azerbaijan and the natural populations they form. The study examines the biological and ecological characteristics of medicinal leeches, their geographic distribution, population density, adaptation mechanisms to biotopes, the current state of their natural resources, and the impact of anthropogenic factors on these populations.

The main objective of the study is to scientifically examine the geographical

distribution of medicinal leeches in the Republic of Azerbaijan, their adaptation mechanisms to ecological biotopes, the current state of their natural resources, and to develop practical recommendations for their protection and sustainable use.

In line with the study's goals and objectives, we scientifically identified spatial patterns of medicinal leech distribution in the Republic of Azerbaijan from a geographical perspective. We identified the species' main distribution areas across natural and geographical zones and systematically elucidated their relationship with hydroclimatic (Mammadova, 2012) conditions, topographic features, and freshwater ecosystem types. We compared the ecological status of biotopes across regions, identified the main environmental factors determining leech population density, and assessed the spatial differentiation of anthropogenic impact. The study characterized the current state of natural populations and regionally and geographically substantiated trends in resource decline or stabilization.

2. RESEARCH METHOD

The study utilized various scientific sources and information resources. Zoological research materials were extensively used. Local and international scientific sources, including monographs and articles, formed the study's theoretical basis. Statistical data and official reports were key sources for assessing the status and dynamics of leech populations. The study used research results and archival documents from previous years to trace the topic's historical development and compare it with current data. The study also incorporated medical and geographical data to examine regional patterns of disease distribution.

The study used a comprehensive approach and incorporated a range of scientific methods. Morphological and taxonomic methods were used to identify medicinal leech species and subspecies accurately. The study conducted an ecological comparative analysis to examine population differences across regions. We assessed leech population dynamics using statistical methods. We used a medical-geographical analysis method to examine regional differences in disease distribution. The study also analyzed literary and archival materials to compare historical and

contemporary data.

Within an interdisciplinary, comprehensive approach, the biogeographical component examines Azerbaijan's territorial characteristics, its connection to the hydrographic network, and distribution patterns shaped by climatic and landscape factors. The economic-geographical and tourism component includes studying the role of this biological resource in economic turnover, the location of hirudotherapy farms, and assessing its potential impact on the development of regional medical tourism.

3. RESULT AND DISCUSSION

The Our research and analysis show that, although medicinal leeches have been used in folk medicine worldwide for thousands of years, their scientific therapeutic value was proven only in the late 19th century. During this period, researchers began extensive studies of the biology, physiology, and, especially, the biochemical and pharmacological properties of substances secreted in leech saliva. Scientific research has shown that leech saliva contains dozens of substances beneficial to the human body. Contains biologically active substances.

The body of medicinal leeches is flattened along the lumbo-abdominal axis, soft and elastic due to its biological characteristics and morphological structure. Five pairs of eyes are located in the anterior region, and the body consists of 33 immobile segments. It feeds with an anterior sucker, while the posterior sucker propels it and anchors the body to the substrate. Leeches breathe through the skin, and when sucking blood, a three-pronged wound forms at the bite site. This wound heals within a few days. These substances are used to produce heparin-containing drugs, creams for treating vascular and joint diseases, and other medications.

Hirudotherapy is considered an alternative medical technology based on the use of biological resources and is closely related to the production, distribution, and consumption of medicinal leeches belonging to the class *Hirudinea*. Leeches, representatives of annelids (*Annelida*), are mainly distributed in freshwater basins because of their morphofunctional characteristics and high adaptability, and their historical distribution was in Europe, the Caucasus, Central Asia, and the Middle East. In the 19th century, the widespread use of hirudotherapy in Western Europe, especially in

France, led to the intensive exploitation of this bioresource and a decrease in the local population, which made the problems of depletion of natural resources and their management relevant (Kirk et al., 2024; Copena & Gómez-Martín, 2024).

Currently, cultivating medicinal leeches in biofactories is a rational model from economic and geographical perspectives, reducing the burden on wild populations while meeting the needs of the healthcare sector. Other annelids, especially earthworms, provide important ecosystem services, improving soil fertility and increasing agricultural productivity. Thus, hirudotherapy and the use of annelids in general have complex economic and geographical significance in the context of the spatial distribution of biological resources, their participation in economic circulation, and sustainable management (Zharov, 2003; Hyson, 2005). The use of medicinal leeches has evolved under various historical and contemporary approaches worldwide. Experience in this field shows that each country's approach to medical resources is closely linked to its healthcare system, environmental policy, and economic and geographic conditions. A comparative analysis allows us to assess Azerbaijan's current situation against the backdrop of international experience.

Clinical studies in recent decades have shown that leech therapy may offer therapeutic benefits for conditions such as migraine, knee osteoarthritis, cardiovascular disease, diabetic foot ulcers, and certain skin wounds. Randomized and meta-analytic studies on knee osteoarthritis show that leech therapy has comparable, and in some cases superior, long-term effects to traditional treatments in pain reduction and improved functional mobility. However, the mechanisms underlying these clinical effects remain poorly understood.

Medicinal leeches are freshwater invertebrates belonging to the class *Hirudinea* of the phylum *Annelida*. Researchers divide the class into two subclasses: ancient leeches (*Archihirudinea*) and true leeches (*Euhirudinea*). Medicinal leeches, which have therapeutic value for human health, belong to the group of jawed leeches.

Three subspecies of medicinal leeches beneficial to humans have been identified: the common medicinal leech (*H. medicinalis*), the medicinal leech (*H. verbana*), and the oriental medicinal leech (*H. orientalis*). These

subspecies are closely related morphologically and biologically and can interbreed, producing fertile offspring. Medicinal leeches found in bodies of water were long referred to under the general name *H. medicinalis*.

Although leech therapy is used in clinical practice to a limited extent, using living organisms is associated with several risks. Therefore, modern research mainly focuses on studying biologically active leech-derived components and scientifically justifying their use as safe medicinal agents (Lemke & Vilcinskis, 2020). In Asia, particularly in countries like India and China, leech therapy has long been part of traditional medicine; for example, modern clinics in India practice systemic medical hirudotherapy as an adjunct treatment for certain diseases.

The Republic of Azerbaijan is one of the countries with abundant natural resources and high biodiversity for leech breeding. However, the country's natural habitat for the oriental leech is listed in the Red Book as a habitat for this medicinal leech species (Aliyev, 2018). Among these resources, the medicinal leech occupies a special place, playing an important role in protecting human health and in medical practice. A valuable biological resource from both a therapeutic and economic perspective, the medicinal leech is widely used in human and alternative medicine. In this regard, the medicinal leech is considered a valuable raw material for the pharmaceutical industry. Its products are widely used to treat and prevent various diseases, as well as in modern plastic surgery and cosmetology.

In countries such as Turkey and Russia, medicinal leech farming has rapidly become commercialized and developed into an export-oriented biopharmaceutical activity. Turkey is a major producer of medicinal leeches, cultivating and exporting the species *Hirudo medicinalis* and *Hirudo verbana* (Uğural, 2018). Russia, by contrast, meets domestic demand and provides access to international markets through state-owned leech farms (Zharov, 2003; Turlaev et al., 2022). These countries' experiences show that the economic and geographic significance of medicinal leeches extends beyond healthcare and is closely linked to export potential and regional development.

Hirudotherapy in clinics and medical centers - below is a brief description of the practice in this area in various countries or organizations involved in this activity:

Leech Clinic West Midlands and HirudoTherapy London, both operating in the UK, are specialized, economically significant hirudotherapy centers within the alternative and complementary medicine sector. These facilities provide therapeutic services, including individual consultations, diagnostic assessments, and hirudotherapy treatments for patients with a variety of health conditions. USA- Leech therapy is practiced in many medical institutions in microsurgery and plastic surgery departments (using FDA-approved methods).

In India, specialized institutions use leech therapy as part of their medical services (Kumar et al., 2012). Thus, leech therapy is practiced in various regions of the world—both in traditional medical centers (India, China, etc.) and in modern clinical practice (USA, England, Germany, France, etc.). In Western countries, leech therapy is more often used for microsurgery, vascular problems, and reconstructive surgery, while in Asian countries, it is used both within traditional medical systems and as functional therapy in modern health centers. In modern medicine, only qualified medical personnel perform leech therapy using sterile, certified medical-grade leeches. This is a standardized approach, particularly in the United States and Europe, as each leech is used only once and strict sanitary and hygienic procedures are followed.

A comparative analysis shows that in developed countries, medicinal leeches are considered an integral part of modern medicine, and scientific and medical standards, sanitary and hygienic norms, and legal frameworks regulate their use. The analysis highlights the following aspects of leeches' importance: population and resource sustainability: The dynamics of natural and biophysical resources determine the sustainability of their use; areas of application: Used to treat diseases of the blood vessels, joints, nervous system, and skin; and environmental compatibility: Can be used as a medical product in various climatic zones.

This approach ensures patient safety and protects natural populations. However, poaching and informal trade remain widespread in Azerbaijan, creating environmental risks and hindering the realization of economic potential. Based on the above, we can divide the benefits of using medicinal leeches into 3 main groups: medical, economic-social, and environmental (Table 1).

Table 1. Brief description of the benefits of using medicinal leeches

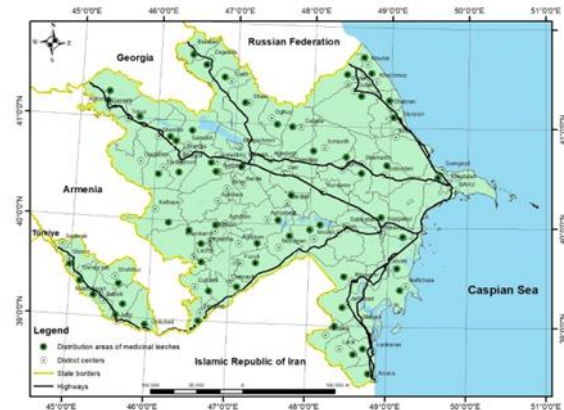
Group	General benefits
Medical	Supports circulation and overall healing.
Economic and social	It is a low-cost alternative treatment method that provides income and employment.
Ecological	This indicates the state of the aquatic ecosystem and contributes to biodiversity conservation.

Thus, global experience shows that establishing scientifically sound regional priorities for the sustainable use of medicinal leeches, establishing leech farms and biofactories in specially protected water bodies, and an integrated development model with medical tourism and the pharmaceutical industry are highly promising. Azerbaijan's rich hydroecosystems create favorable conditions for implementing this model.

The distribution of medicinal leeches in Azerbaijan is closely linked to the country's various hydroecosystems. Leeches are primarily found in freshwater bodies lakes, ponds, swamps, and slow-moving rivers where they form established populations. The hydromorphological features of these areas, the presence of moist biotopes, and biodiversity create a favorable environment for medicinal leeches to colonize. In the Goygol (Mammadova et al., 2025) region, a lake called Zeligol, whose name derives from the Azerbaijani word for leech, exists. Until 2005, the medicinal leech, widespread in Azerbaijan's fauna, was registered as *Hirudo medicinalis*, but subsequent studies established that it belongs to the species *H. orientalis* (Dadashova, 2021).

The distribution of medicinal leech populations in Azerbaijan, as identified through field research, is illustrated in the map scheme in Figure 1, which delineates the specific water bodies where these specimens were documented. The Figure 1 shows the distribution areas of medicinal leeches and their spatial organization within the Republic of Azerbaijan. Their distribution is primarily observed in the northwestern, central, and southeastern zones of the country, consistent with hydromorphological conditions, humid

biotopes, and water bodies in these regions (Imanov & Alakberov, 2017). Displaying the transport network allows for an assessment of spatial relationships in terms of resource availability and potential economic use. Overall, the map provides an analytical basis for regional natural resource planning by systematizing biogeographic distribution within administrative-geographical frameworks.

**Figure 1. Distribution areas of medicinal leeches in Azerbaijan**

Regional distribution patterns of leeches in Azerbaijan vary significantly: Lankaran-Astara boasts an extremely humid subtropical climate, rich water resources, and biodiversity. The abundance of rivers, ponds, and marshes creates favorable conditions for the development of medicinal leech populations. This region is one of the most promising for establishing leech farms.

Water bodies in the foothills and plains of the Sheki-Zagatala region provide a favorable environment for the spread of medicinal leeches. High biodiversity and favorable environmental conditions contribute to increased leech population density. The Aran region offers opportunities for controlled leech breeding using artificial lakes and ponds. The region's climate and irrigation systems create the potential for the artificial breeding of medicinal leeches. Despite the extreme climatic conditions of the Nakhchivan Autonomous Republic, medicinal leeches have been observed in some bodies of water there. Through scientific monitoring and selection, it is possible to establish leech farms in this region as well.

Lake Goygol and other natural lakes distinguish the mountainous and foothill areas of the Ganja-Dashkan economic region. Goygol National Park offers ample opportunities for ecotourism and wellness tourism. The

hydrological conditions are favorable for the spread of medicinal leeches. Goygol, Maralgol, and other mountain lakes, along with the mountainous landscape, are highly attractive to tourists. Artificial breeding of medicinal leeches in these lakes can be included in ecotourism packages. Introducing hirudotherapy services at resorts will enhance the region's tourism value.

The Gazakh-Tovuz economic region is distinguished by its historical monuments, viticulture, and rural tourism. Its proximity to the Georgian border facilitates increased tourism. River basins and irrigation systems are suitable for cultivating medicinal leeches. Hirudotherapy services can be integrated into rural tourism and offered to both local and international tourists. Leech farms integrated with agriculture could be established here. Leech farming could meet local medical needs and create export potential, enabling exports to Georgia and other neighboring markets.

The Guba-Khachmaz economic region has a humid climate and well-developed river and lake systems. It is renowned for its coastal and mountain tourism, as well as horticulture. Guba and Khachmaz are home to sanatoriums and recreation centers. Cultivating medicinal leeches in rivers and ponds will allow for the development of hirudotherapy in health centers. Establishing leech farms in this region could be integrated with medical tourism, creating new value in the region's economic and geographical structure.

Mountainous Shirvan's resort and tourism potential is rich in mountain tourism, ecotourism, and historical monuments in the Ismayilli and Shamakhi regions. Ethnographic centers such as Lahij and Basgal attract tourists. Furthermore, numerous springs and ponds here are suitable for cultivating medicinal leeches. Creating a new economy focused on health tourism and small biofactories, and incorporating hirudotherapy services into ethnographic tourism packages, will increase local employment and ensure the safety of medical products.

The Karabakh economic region boasts rich natural resources, mountain lakes, and mineral springs. The tourism infrastructure, restored after the war, creates ample opportunities to develop health tourism. Establishing leech farms here will support both biodiversity restoration and the expansion of medical services at resorts. This will give Karabakh a strategic advantage in terms of its

tourism brand.

The Eastern Zangezur economic region is distinguished by its mountainous landscape, abundant springs, and ecologically clean environment. Tourism infrastructure is being restored. Here, the artificial breeding of medicinal leeches could be combined with ecotourism and wellness tourism, contributing to the region's economic and geographical development. Hirudotherapy services could be introduced as a special brand in the region's resorts.

Despite the relatively arid climate (Mammadova, 2012) of the Absheron-Khizi region, leech farms can be established using artificial lakes and irrigation systems. Proximity to Baku facilitates access to the medical market. Establishing biofactories in this region is strategically important from a medical security perspective.

Thus, combining leech farming with the resort and tourism potential in most of Azerbaijan's economic regions opens new opportunities for the country's socio-economic development and requires making this area a state-level priority. Medical and geographical analyses show that disease distribution across the region plays a crucial role in planning healthcare infrastructure. A localization study conducted throughout Azerbaijan reveals that cardiovascular diseases are the most common. This includes the cities of Baku, Sumgait, and Ganja, as well as administrative-territorial units such as Tovuz, Sabirabad, Yevlakh, Sheki, Agdash, Goranboy, and Gobustan districts. In this context, creating and using biopharmaceutical production infrastructure, especially biofactories, in regions with high morbidity is strategically important (Healthcare, social protection and housing conditions in Azerbaijan, 2025).

Economic and geographical evidence, along with a comparative analysis of their biological and pharmacological properties, shows that medicinal leeches are not only a biological resource but also a strategically important pharmacological raw material. Their biologically active substances are used to produce drugs, opening up new opportunities for the pharmaceutical industry (Abdulkader et al., 2013). The development of hirudotherapy services in the resort and tourism sector is based on the pharmacological properties of medicinal leeches, and creating regional biofactories combines their biological reproduction

mechanisms with their pharmacological potential, creating sustainable economic value

4. CONCLUSION

A comprehensive analysis reveals that the geographic distribution, biological and pharmacological properties, and economic and geographical significance of medicinal leeches in Azerbaijan possess multifaceted scientific and applied value. This biological resource is not limited to environmental and medical aspects; it also serves as a strategic factor in shaping regional socio-economic development. Currently, the use of medicinal leeches is closely integrated into global practices, including biofactories, the pharmaceutical industry, and medical tourism, and is regulated by legal and regulatory mechanisms. Despite Azerbaijan's rich hydroecosystems, unsolicited hunting and informal trade continue to shape this territory, creating environmental risks and hindering the realization of its economic potential.

Research results demonstrate that the biological mechanisms of medicinal leeches' adaptation reproductive properties, ecological adaptability, and population dynamics form the scientific basis for their sustainable use. Their pharmacological properties, particularly the therapeutic effects of hirudin and other biologically active components, make these

organisms a unique source of natural raw materials in modern medicine. Using these substances to treat vascular, joint, nervous, and dermatological diseases expands the pharmaceutical industry's raw material base and supports the development of innovative drugs. Their pharmacological properties, in turn, make medicinal leeches a unique resource in modern medicine. Hirudin and other biologically active substances are widely used to treat vascular, joint, nervous, and dermatological diseases. These properties strengthen the pharmaceutical industry's raw material base from economic and geographical perspectives, create opportunities for medical tourism development, and provide a strategic advantage for export-oriented activities. Developing science-based regional priorities for the sustainable use of medicinal leeches, establishing leech farms and biofactories in specially protected water bodies, and creating an integrated development model linking medical tourism and the pharmaceutical industry are highly promising. This approach will ensure environmental security and open new strategic opportunities for Azerbaijan's economic and geographical development.

Designating medicinal leeches as a state-level priority will make a long-term contribution to the country's biodiversity policy, healthcare system, and regional economy.

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