

EVALUATION OF NATURAL STOCKS OF MEDICINAL LEECHES IN WETLAND ECOSYSTEMS AND SUSTAINABLE MANAGEMENT RECOMMENDATIONS

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ABSTRACT

Medicinal leeches, particularly *Hirudo verbana*, are recognized as sensitive bioindicators of freshwater ecosystems, and water quality parameters directly govern their entire life cycle. Key physicochemical variables such as temperature, dissolved oxygen concentration, pH, electrical conductivity, and organic matter load constitute the primary environmental determinants regulating metabolic activity, growth performance, and survival rates. Optimal thermal regimes and sufficient dissolved oxygen levels enhance post-feeding digestion efficiency, accelerate somatic growth, and improve overall physiological condition. Conversely, contamination by heavy metals, pesticides, and surfactants exerts both acute and chronic toxic effects, disrupting osmoregulatory balance, suppressing immune function, and elevating oxidative stress. These stressors may result in reduced hematophagous activity, impaired growth trajectories, increased mortality, and diminished reproductive fitness. Water quality also plays a decisive role in reproductive success and cocoon production. Under suitable environmental conditions, medicinal leeches exhibit higher cocoon output, increased hatchling numbers per cocoon, and improved embryonic development rates. In contrast, suboptimal water quality may lead to structural abnormalities in cocoon morphology, decreased hatching success, and prolonged incubation periods. Therefore, the conservation of natural populations and the sustainability of aquaculture-based production systems depend fundamentally on systematic monitoring of water quality parameters and the implementation of ecosystem-based management strategies. Such an integrative approach is essential not only for maintaining biodiversity integrity but also for ensuring the long-term continuity of medicinal leech resources for therapeutic applications. This study was designed as a comprehensive review aiming to evaluate the effects of water quality on the life cycle, physiological processes, reproductive success, and sustainability of medicinal leeches, particularly *Hirudo verbana*. Within the scope of the study, the critical role of water quality in both natural habitats and aquaculture systems was examined through a holistic assessment of national and international scientific literature. In particular, the effects of major water quality parameters, including temperature, dissolved oxygen, pH, organic load, and nitrogenous compounds, on growth performance, behavioral characteristics, population dynamics, and ecological tolerance of medicinal leeches were comparatively evaluated. Furthermore, the ecological significance of medicinal leeches as bioindicator organisms in freshwater ecosystems was emphasized, highlighting that preserving water quality is essential not only for the continuity of natural populations but also for the development of sustainable aquaculture practices.

Keywords: *Hirudo verbana*, water quality, freshwater ecosystems, natural populations

1. INTRODUCTION

Wetland ecosystems are among the most critical habitats on Earth due to their rich biodiversity, their role in maintaining ecological balance, and their contribution to sustainable water quality¹. However, during the last century, increasing global climate change² and anthropogenic pressures, including agricultural activities, pollution, and habitat transformation, have led to a substantial decline in both the extent and functional capacity of wetlands³⁻⁴. This situation poses a significant threat, particularly to species with high habitat dependency.

Medicinal leech species are considered important components of wetland ecosystems from both ecological and economic perspectives. The distribution of these freshwater-associated organisms is largely influenced by environmental factors such as temperature, host availability, and water quality. Through their parasitic and hematophagous feeding behavior, medicinal leeches occupy a unique trophic position within aquatic ecosystems and are also regarded as biological indicators of habitat quality⁵. Nevertheless, recent studies have demonstrated that natural populations have undergone considerable declines due to habitat loss and intensive harvesting pressure, with some species now facing significant conservation threats⁶.

The importance of medicinal leeches is not limited to their ecological functions but also derives from their high economic and biomedical value. In particular, *Hirudo verbana* is currently one of the most widely utilized medicinal leech species and has extensive applications in pharmaceutical and clinical practices⁷. However, the increasing global demand for medicinal leeches has imposed substantial pressure on natural stocks. Unregulated and intensive harvesting activities, together with the degradation of wetland habitats, threaten the sustainability of populations in many regions⁵.

In Türkiye, studies conducted in important wetland ecosystems such as Lake Eğirdir, Lake Ulubat, and Lake Manyas

have revealed that, despite the high economic value of medicinal leech populations, reductions in reproductive individuals and increasing habitat pressures place these populations at considerable risk in terms of long-term sustainability⁶.

2. ECOLOGICAL CHARACTERISTICS AND BIO-INDICATOR POTENTIAL OF *Hirudo verbana*

This Studies investigating the distribution and ecological preferences of Hirudinea species in freshwater ecosystems have demonstrated that these organisms possess relatively broad tolerance ranges to environmental variables, although habitat characteristics largely shape their distribution patterns. Early classical studies emphasized that dissolved oxygen concentration, water temperature, substrate structure, and organic matter content are among the principal environmental factors determining the distribution of leech communities⁸⁻⁹. Investigations conducted within the framework of the saprobic system further revealed that many leech species can tolerate mesosaprobic and polysaprobic conditions, allowing them to persist even in habitats characterized by elevated levels of organic pollution¹⁰.

Research concerning the use of leeches as bioindicator organisms has generally adopted a more cautious perspective. Koperski¹¹⁻¹² argued that the broad ecological tolerance of leeches limits their reliability as standalone bioindicators; however, meaningful ecological assessments can be achieved when species composition and community structure are evaluated collectively. Similarly, Rosenberg & Resh¹³ emphasized that benthic macroinvertebrates provide more reliable information for water quality assessments when analyzed at the community level rather than through individual species responses. Furthermore, several studies have shown that leeches can accumulate various contaminants through bioaccumulation processes, indicating their potential use as

indirect biological indicators in environmental monitoring programs¹⁴⁻¹⁵.

Studies focusing specifically on *H. verbana* suggest that the ecological characteristics of this species differ partially from those of other Hirudinea taxa. The species is typically associated with shallow, stagnant freshwater habitats rich in macrophytes and organic matter. In addition, habitat structure and the availability of suitable host organisms are considered critical determinants of its distribution⁵. Research has demonstrated that *H. verbana* can feed not only on mammals but also on fish and amphibians, thereby increasing its ecological flexibility. Nevertheless, the historical confusion between *H. verbana* and *Hirudo medicinalis* has generated substantial taxonomic uncertainty regarding the ecological and biogeographical interpretation of the species¹⁶.

Recent investigations have further demonstrated that *H. verbana* possesses important biological characteristics not only at the macroecological level but also at the microbial scale. Studies have shown that the digestive tract of the species harbors a relatively limited yet functionally significant microbiota that plays critical roles in nutrition, symbiotic interactions, and pathogenicity¹⁷. More recent metagenomic analyses have revealed that microbiota composition may vary according to feeding status and that environmental bacteria can also become incorporated into this microbial system¹⁸. This issue represents an important biosafety concern, particularly regarding infection risks associated with the medical use of leeches.

Physiological responses to environmental stressors also constitute an important aspect of the ecological evaluation of the species. Experimental studies on microplastic pollution have demonstrated that *H. verbana* develops oxidative stress and inflammatory responses when exposed to such contaminants¹⁹. These findings indicate that the species is sensitive not only to classical habitat variables but also to modern environmental pollutants,

highlighting its potential utility as a model organism in ecotoxicological research.

Collectively, the available literature indicates that *H. verbana* possesses broad ecological tolerance; however, its distribution is strongly influenced by habitat structure, trophic conditions, and host availability. Its ability to tolerate mesosaprobic conditions suggests that the species is neither strictly dependent on pristine freshwater environments nor exclusively associated with heavily polluted habitats. Consequently, *H. verbana* should not be considered a direct bioindicator of water quality but rather a complementary biological indicator reflecting habitat quality and ecosystem stability. Moreover, considering its microbial structure, bioaccumulation potential, and physiological responses to environmental stressors, the species should be regarded as an important biological model that requires careful management in aquaculture, environmental monitoring, and medical applications.

Scientific studies on medicinal leech species inhabiting wetland ecosystems have increased considerably over the last three decades. However, an examination of the existing literature indicates that these studies have primarily focused on species identification, distribution ranges, and basic biological characteristics. In particular, research conducted on *H. verbana* and closely related species has revealed the geographical distribution, habitat preferences, and genetic diversity of populations across Europe and Western Asia^{16,20}. These studies have demonstrated that the species generally prefers shallow freshwater habitats characterized by dense aquatic vegetation, high organic matter content, and well-oxygenated conditions⁵.

When methodological approaches used to assess natural stocks are evaluated, it becomes evident that there is no standardized sampling protocol for medicinal leech populations. Sampling methods employed in different studies, including hand collection, baited traps, and

drag-net techniques, as well as differences in sampling effort, vary considerably among investigations, thereby limiting the comparability of the obtained data²¹.

Another major deficiency within the current literature is the lack of long-term monitoring studies. Available datasets describing temporal changes in medicinal leech populations are extremely limited. This insufficiency significantly restricts the assessment of the impacts of climate change²², habitat degradation, and anthropogenic pressures on population dynamics. For instance, the effects of increasing water temperatures and decreasing water levels on the reproductive success and distribution of medicinal leeches have not yet been sufficiently clarified⁴⁻⁵.

Furthermore, studies investigating the impacts of overharvesting and international trade on natural populations remain limited. Although the trade of medicinal leeches is regulated under CITES, illegal and

uncontrolled harvesting activities are still known to persist in many regions⁵.

3. STUDIES ON MEDICINAL LEECH (*H. verbana*) POPULATIONS IN TÜRKİYE AND SUSTAINABILITY ASSESSMENTS

Türkiye is considered one of the important countries in terms of natural medicinal leech (*H. verbana*) populations due to its extensive wetland ecosystems. In particular, wetlands such as Uluabat Lake, Manyas Lake, Lake Eğirdir, and the wetlands located within the Kızılırmak Delta are among the prominent medicinal leech habitats in terms of both biodiversity and economic value. However, recent studies have revealed that natural medicinal leech stocks are gradually declining and that populations are under serious environmental pressure.



Figure 1. Medicinal leech harvesting quotas applied in Türkiye between 1996 and 2026 (kg/year)

The hunting quotas and fishing bans implemented for medicinal leeches (*H. verbana*) in Türkiye indicate that management policies aimed at conserving natural stocks have gradually evolved toward a more protective and sustainability-oriented framework²³. Examination of the period between 1996 and 2026 reveals a general declining trend in medicinal leech24 harvesting quotas. While the quota was approximately 10,000 tons/year in 1996, it stabilized around 6,000 tons/year during the 2000s, followed by a significant decline after

2010. Since 2021, the quota has remained fixed at 1,500 tons/year, reflecting both the decreasing abundance of natural populations and the adoption of a stock-based controlled harvesting approach (Figure 1).

Similar regulatory changes have also been implemented regarding fishing ban periods. Medicinal leech harvesting in Türkiye was first regulated under Circular No. 28 concerning the 1994–1995 fishing season, which introduced a two-month prohibition period between April 15 and June 15. In subsequent years, several

circulars gradually extended the duration of the fishing ban, and with Circular No. 37/1 covering the 2006–2008 fishing season, harvesting was prohibited between March 1 and June 30, thereby extending the ban period to four months. Currently, these regulations continue to be enforced under the “Communiqué No. 3/1 on Commercial

Fisheries”. However, the absence of legal restrictions on minimum body size or weight limits outside the closed season is considered a significant deficiency in protecting reproductively mature broodstock individuals and ensuring the long-term sustainability of natural populations.

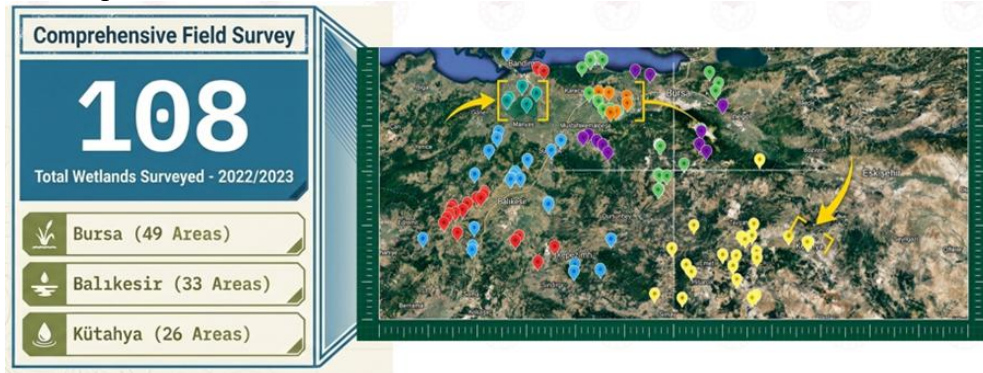


Figure 2. Areas surveyed within the basin scope during the project

One of the first comprehensive studies on natural populations in Türkiye was conducted by Kasperek et al.²⁵, who reported the presence of medicinal leeches in 42 out of 65 investigated wetlands across the country and identified Eğirdir, Uluabat, and Manyas Lakes as important stock areas. Nevertheless, subsequent studies demonstrated that population densities in these habitats have significantly declined over time. In a study conducted in Eastern Anatolia, Sağlam et al.⁶ detected medicinal leech populations in only 22 of the 87 surveyed wetlands and reported that population structures had deteriorated particularly in areas exposed to intensive harvesting pressure. The researchers emphasized that natural stocks had begun to fall below sustainability limits mainly due to excessive commercial collection activities.

Similarly, studies conducted by Ceylan²⁶; Ceylan & Çetinkaya²⁷ indicated that although economically valuable medicinal leech populations are still present in Lake Eğirdir and wetlands of the Lakes Region, these populations have been gradually declining due to habitat degradation, water level fluctuations, climate change, and overharvesting. In particular, prolonged drought periods

observed in recent years have been reported to affect shallow wetland habitats directly, thereby restricting the breeding and developmental areas of medicinal leeches.

One of the most comprehensive recent studies on the current status of natural stocks in Türkiye was carried out by Ergün et al.²⁸ within the Susurluk Basin. In this study, a total of 108 wetlands located in the provinces of Bursa, Balıkesir, and Kütahya were surveyed to evaluate the present condition of medicinal leech populations (Figure 2).

The results demonstrated that medicinal leeches could no longer be found in some habitats where populations had previously been reported, indicating serious population losses within wetland ecosystems (Figure 3). Population density was recorded as 3.77 individuals/m² in Bursa-Keles Epçeler, whereas it decreased to 0.46 individuals/m² in Balıkesir-İvrindi Çelimler and to only 0.04 individuals/m² in Dursunbey Aşağımusalar. In addition, the populations were largely composed of low-weight juvenile individuals, while the proportion of reproductively mature adult individuals remained extremely limited (Figure 4).



Figure 3. Areas where medical leeches were previously reported but were not found during the sampling

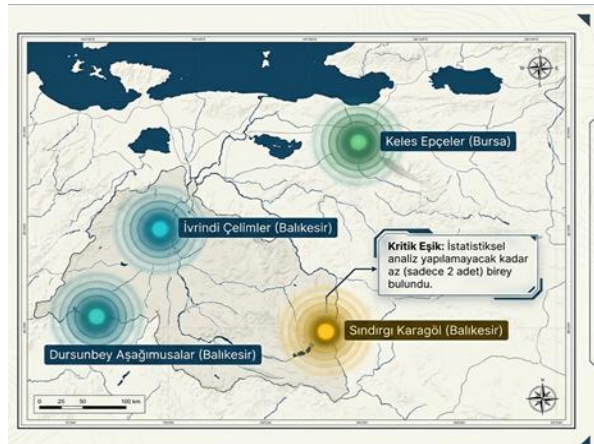


Figure 4. Areas where medical leech sampling is conducted

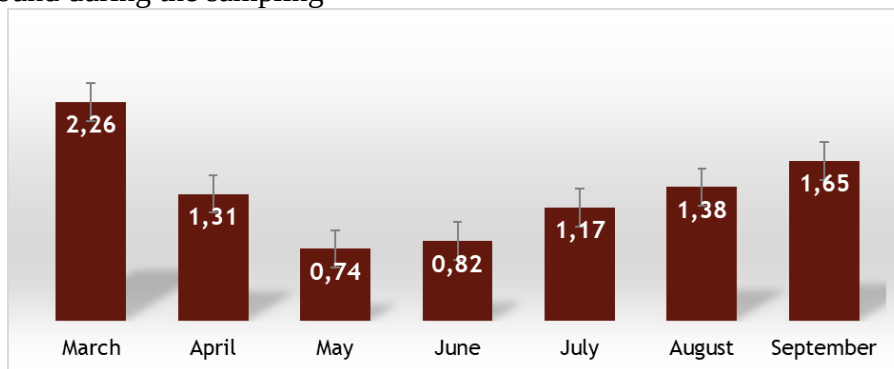


Figure 5. Weight chart for medicinal leeches in Lake Uluabat (monthly)

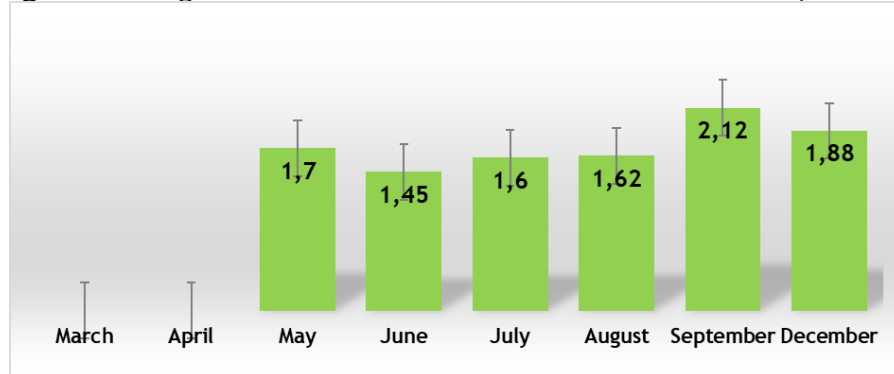


Figure 6. Weight chart for medicinal leeches in Lake Manyas (monthly)

Ergün et al.²⁸ also emphasized that uncontrolled harvesting activities continue throughout the year, particularly in Uluabat and Manyas Lakes, and exert severe pressure on natural stocks. The removal of reproductively mature large individuals from populations reduces the regeneration capacity of stocks and threatens long-term sustainability. Furthermore, environmental pressures such as water-level fluctuations, agricultural drainage practices, increasing organic loads, and habitat alterations have

been reported to affect population dynamics directly. Population densities were found to be higher in shallow habitats rich in organic matter and dense reed vegetation, whereas populations significantly declined in areas where shoreline structures had deteriorated and anthropogenic impacts had increased.

Studies focusing on the biometric characteristics of natural populations in Uluabat and Manyas Lakes also support these findings regarding changes in stock structure. Measurements indicated that

individual body weights were generally low, condition factors varied depending on habitat conditions, and populations mainly consisted of juvenile individuals. In particular, the average body weight recorded in Lake Uluabat decreased from 2.26 g in March to 0.74 g in May (Figure 5). In Manyas Lake, no specimens could be collected during certain periods due to fluctuations in water level. These findings clearly demonstrate the determining role of environmental conditions on population structure (Figure 6).

In addition, recent studies have shown that medicinal leeches are not only economically valuable organisms but also important biological indicators reflecting the ecological integrity of wetland ecosystems. Changes in water quality, particularly dissolved oxygen levels, organic pollution load, heavy metal accumulation, and toxic contaminants, have been reported to affect population physiology, leading to declines in growth performance, condition factor, reproductive success, and survival rates. Moreover, increasing temperatures and drought processes associated with climate change further threaten natural populations by reducing available wetland habitats.

4. CONCLUSION

When studies conducted on natural medicinal leech populations, particularly in Türkiye, are evaluated collectively, it becomes evident that significant declines in natural stocks have occurred over the last 20–25 years. The determination of lower stock sizes in many wetlands previously reported to support dense populations clearly

demonstrates the effects of habitat degradation and uncontrolled harvesting on natural populations. Intensive harvesting of reproductively mature large individuals causes populations to become dominated by juvenile individuals, thereby weakening long-term stock regeneration capacity.

In addition, habitat loss within wetland ecosystems, irregular water level fluctuations, organic and chemical pollution associated with agricultural activities, and the impacts of climate change are among the major environmental pressures threatening the sustainability of medicinal leech populations. In particular, the drying or fragmentation of shallow reed-dominated habitats directly restricts breeding and developmental areas of the species. Therefore, conservation efforts should not be limited solely to harvesting regulations but should also be supported by habitat restoration programs, wetland management strategies, water quality monitoring, and long-term population assessment studies.

Current findings further indicate that reliance solely on natural stocks is not sustainable in the long term. Consequently, the development of controlled and sterile aquaculture systems is considered an important alternative both for reducing harvesting pressure on natural populations and for providing reliable biological material for medicinal applications. Ultimately, conserving natural medicinal leech resources requires ecosystem-based management strategies, effective control of harvesting activities, and holistic conservation approaches for wetland ecosystems

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