A review: The Iranian Cichlid fish (*Iranocichla hormuzensis*)

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Abstract

The Iranian cichlid (*Iranocichla hormuzensis*) is a unique endemic fish species inhabiting the freshwater and brackish ecosystems of southern Iran, specifically within the Hormozgan province river basins draining into the Persian Gulf and Oman Sea. As the sole representative of the Cichlidae family native to the region and one of the few cichlids in Asia, *I. hormuzensis* exemplifies a remarkable case of evolutionary isolation and ecological specialization. This species demonstrates distinct morphological and physiological adaptations enabling survival in extreme and fluctuating environmental conditions, including wide temperature ranges and variable salinity, arising from the region's complex geology and climate. Behavioral traits such as territoriality, nest-building, biparental care, and specialized feeding on benthic algae contribute significantly to its reproductive success and ecological role. Despite its biological significance, *I. hormuzensis* faces critical conservation challenges due to its limited and fragmented distribution, habitat degradation, pollution from industrial developments, and the effects of climate change. Genetic studies reveal structured populations with reduced gene flow, emphasizing the need for targeted conservation strategies incorporating habitat protection, pollution control, and long-term population monitoring. Phylogenetic analyses position this genus as a relict lineage within the Pseudocrenilabrinae, providing valuable insights into cichlid biogeography, speciation, and historical faunal dispersal events connected to the Tethys Sea and regional geological evolution. This review synthesizes current knowledge on the taxonomy, ecology, physiology, behavior, and conservation status of the Iranian cichlid, highlighting its importance as a model for evolutionary and ecological studies in arid and semi-arid freshwater systems. It underscores the urgency of integrated multidisciplinary research and conservation efforts to preserve this emblematic species, thereby safeguarding a critical component of Iran's freshwater biodiversity and contributing to broader global ichthyological understanding.

Keywords: Endemism, Phylogeny, Adaptation, Conservation, Biodiversity

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Introduction

Iran is a country characterized by diverse climatic zones and a rich array of aquatic ecosystems, ranging from freshwater rivers and streams to brackish estuaries and coastal marine waters. Despite being located in a generally arid and semi-arid region, Iran harbors a surprisingly high biodiversity of freshwater fish species. Among these species, the Iranian cichlid (*Iranocichla hormuzensis*) stands out as a singular and important component of the country's aquatic fauna. This fish is notable not only for its endemic presence, restricted exclusively to the southern river basins of Iran, but also for its unique biological and ecological traits that make it a subject of considerable scientific interest. The Iranian cichlid occupies a critical ecological niche within the freshwater and brackish water systems that drain into the Persian Gulf and the Oman Sea. The limited geographic distribution and specialized habitat preferences of this species underscore its vulnerability but at the same time highlight its evolutionary adaptation to the warm, often fluctuating thermal and saline conditions characteristic of southern Iranian waters. As such, *Iranocichla hormuzensis* offers a distinct window into understanding how fish species adapt to challenging environmental conditions, such as extreme temperature ranges and variable salinity levels, conditions that are increasingly relevant under the impacts of global climate change. Beyond its ecological role, the Iranian cichlid holds importance for broader biological disciplines, including systematics, evolutionary biology, and conservation science (Owfi and Rameshi, 2021). As the only endemic representative of the diverse cichlid family in Iran and one of the very few in Asia, this species serves as a valuable model for studying biogeographic history, speciation processes, and the evolutionary consequences of geographic isolation. The historical connectivity of the region through ancient marine seaways like the Tethys Sea has likely influenced its biogeography, rendering the Iranian cichlid an important species for reconstructing past faunal distributions.

Despite its scientific importance, knowledge about *Iranocichla hormuzensis* remains limited in the global literature, and its conservation status has not yet been thoroughly assessed by international bodies such as the International Union for Conservation of Nature (IUCN, 2020). With growing anthropogenic pressures including habitat degradation, water pollution, and climate-induced changes in hydrology and water quality, there is an urgent need to better understand and protect this species. This essay aims to provide a comprehensive introduction to the Iranian cichlid by exploring key aspects of its taxonomy, geographic distribution, morphology, behavior, ecology, and conservation status. Through this synthesis, the paper seeks to contribute to the awareness of Iran’s unique aquatic biodiversity and to underline the importance of targeted research and conservation actions to preserve this

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emblematic species for future generations (Esmaeili *et al*., 2016).

Taxonomy and systematics

The Iranian cichlid (*Iranocichla hormuzensis*) belongs to the family Cichlidae, which is one of the most diverse and evolutionarily significant families within the order Perciformes. The Cichlidae family encompasses over 1650 described species distributed primarily across tropical freshwater ecosystems in Africa, South and Central America, and parts of Asia. This family is renowned for its extraordinary diversity in morphology, behavior, and ecological adaptation, often serving as a key model for evolutionary and ecological studies. Within this extensive family, *Iranocichla hormuzensis* occupies a unique taxonomic position due to its geographic isolation and distinctive features. It is placed in the subfamily Pseudocrenilabrinae, which predominantly includes African cichlids, making the Iranian species phylogenetically notable for its presence in Asia. The genus *Iranocichla* was first described by Coad in 1982, marking the discovery of the only endemic cichlid genus in Iran and, indeed, one of the few cichlid genera known from the Asian continent. Since the initial description of *I. hormuzensis*, taxonomic research has advanced with the identification of additional populations showing notable morphological and genetic variations (Coad, 2019). For instance, recent studies have described a new species, *Iranocichla persa*, which shares the genus but differs in certain phenotypic traits and occupies distinct river systems within southern Iran. These findings suggest ongoing speciation processes and hint at a more complex evolutionary history within the genus than previously understood. Molecular phylogenetic analyses utilizing mitochondrial DNA sequences, such as cytochrome b and control region markers, have been instrumental in clarifying the relationships between these taxa. Such genetic studies indicate that Iranian cichlids form a well-supported clade distinct from other Old World and African cichlids, with evidence of historical isolation possibly linked to paleogeographic events such as the closure of the Tethys Sea and the geological evolution of the Zagros and Makran Mountain ranges (Esmaeili *et al*., 2010). The evolutionary origin of *Iranocichla* remains a subject of scientific interest, as its presence in southwestern Asia may represent a relictual lineage reflecting a wider historical distribution of cichlids during the Miocene or earlier. Comparative morphological and genetic data also aid in distinguishing *Iranocichla* from closely related genera, which is crucial for accurate species identification and implementation of conservation measures. Taxonomic precision is fundamental for the management of these species because misidentification can lead to ineffective or harmful conservation policies. Given the restricted range and specialized habitats of *Iranocichla* species, understanding

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their genetic diversity and population structure helps identify distinct conservation units and prioritize areas for protection. In conclusion, the taxonomy and systematics of the Iranian cichlid fish reflect a fascinating example of evolutionary divergence and adaptation in an isolated, geologically dynamic region. The genus *Iranocichla* not only enriches the biodiversity of Iran but also provides an invaluable window into the biogeography and evolutionary patterns of cichlids, a group commonly associated with African and South American faunas. Continued taxonomic and molecular research will undoubtedly deepen our understanding of this unique genus and inform critical conservation efforts in the region (Esmaeili *et al*., 2013).

Habitat and geographic range

The Iranian cichlid (*Iranocichla hormuzensis*) is endemic to a narrowly defined geographic region in southern Iran, restricted predominantly to several river basins draining into the northern reaches of the Persian Gulf and the Oman Sea. Its distribution is limited to freshwater and brackish water systems within Hormozgan Province, including important rivers such as the Mehran, Kol, Tang-e-Khor, Charak, and adjacent smaller streams. This restricted and fragmented range reflects the species' ecological specialization and provides significant conservation challenges. The environmental conditions of these habitats are characterized by considerable variability in both salinity and temperature. Many of the rivers and streams inhabited by *Iranocichla hormuzensis* experience seasonal fluctuations in water flow, salinity, and temperature, resulting from regional climatic patterns, geological factors, and anthropogenic influence. For instance, some water bodies are subject to periodic flooding during winter and early spring, while in dry seasons, water levels often decrease, leading to elevated salinity and temperature extremes due to evaporation. The cichlid's ability to thrive in both freshwater and mildly brackish habitats is a distinctive ecological trait, rare among freshwater fish in Iran. These fishes inhabit warm waters that can reach temperatures ranging widely, from as low as approximately 5°C during cooler months to upwards of 45°C in summer, showcasing remarkable physiological tolerance to thermal stress (Dadgar *et al*., 2014). Moreover, certain populations inhabit springs and streams with elevated sulfur content and unique ionic compositions, resulting from the underlying geology of the region. This environmental heterogeneity demands significant osmoregulatory adaptation and resilience from *Iranocichla hormuzensis*. Habitats occupied by the Iranian cichlid typically feature slow to moderate flowing waters with substrates composed mainly of mud, sand, and gravel. Areas with sparse aquatic vegetation, algal mats, and rocky or sandy riverbeds provide essential resources for feeding and reproduction. The species frequently prefers shallow

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river stretches and pools, where it establishes territories and nests during the breeding season. These microhabitat preferences play a critical role in its reproductive ecology and population dynamics. Because of its localized distribution, the Iranian cichlid's habitat is highly susceptible to environmental disturbances. Urban development, agricultural runoff, water diversion for irrigation, industrial pollution, especially from petrochemical industries along the Persian Gulf coast, and habitat fragmentation pose significant threats to the quality and continuity of its habitat. Climatic factors such as prolonged droughts and rising temperatures also exacerbate these threats by altering hydrological regimes and water quality (Ghasabshiran *et al*., 2013). The species' confined geographic range and specific habitat requirements make it an important indicator of ecosystem health within the southern Iranian aquatic networks. Its presence or absence can reveal changes in environmental conditions that might otherwise go undetected, thus serving as a critical focus for ecological monitoring programs. Furthermore, the distribution pattern of *Iranocichla hormuzensis* offers insights into the biogeographic history of the region. The southern Iranian watersheds are among the few natural refugia in the Arabian Peninsula and the Middle East harboring endemic freshwater fish fauna, likely due to historical hydrological connections and climatic fluctuations throughout the Quaternary period. This distribution suggests a relatively stable but isolated evolutionary history for the species, emphasizing the importance of protecting these freshwater environments from further degradation.

In summary, the Iranian cichlid inhabits a highly specialized and limited range within southern Iran's freshwater and brackish ecosystems. Its adaptation to extreme thermal and salinity conditions, its preference for specific habitat characteristics, and the vulnerability of these habitats highlight the urgent need for comprehensive habitat protection and management strategies. Conserving these habitats is not only essential for maintaining the survival of *Iranocichla hormuzensis,* but also for preserving the unique biodiversity and ecological integrity of southern Iranian aquatic systems (Esmaeili *et al*., 2016).

Morphology and physiology

The Iranian cichlid (*Iranocichla hormuzensis*) exhibits a remarkable set of morphological and physiological adaptations that allow it to thrive in the challenging environments of southern Iran's freshwater and brackish water systems. This species is characterized by a body form and internal adaptations that reflect both its evolutionary heritage within the Cichlidae family and its habitat-specific ecological niche.

Morphological Characteristics

Morphologically, *Iranocichla hormuzensis* is a moderately sized fish, with adults typically attaining a standard length ranging from 11 to 13 centimeters, although specimens of

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slightly larger size have occasionally been recorded. The body is laterally compressed and elongate, allowing efficient maneuvering in stream and river habitats characterized by moderate currents and shallow depths. The coloration of this species changes with age and sexual maturity. Juveniles generally display a silvery-green or olive coloration, which likely serves as effective camouflage against predators and foraging prey in aquatic vegetation and submerged substrate. Upon reaching sexual maturity, individuals undergo significant color transformation; adult males develop a striking dark body color, often blackish or deep brown, adorned with distinctive iridescent silvery or white spots predominantly along the dorsal fin and upper body surfaces (Keivany and Daneshvar, 2015). This sexually dimorphic coloration is thought to play a role in intra-species signaling, especially during territorial disputes and mating displays. The fins of *Iranocichla hormuzensis* are also sexually dimorphic. Males have elongated and more colorful dorsal and anal fins compared to females. These fins are used as visual cues during courtship and territorial defense, where increased fin size and vivid pigmented spots may convey fitness and dominance. The pectoral and caudal fins are well-developed, enabling precise positioning and bursts of speed while feeding or evading threats. The mouth morphology is particularly adapted to the fish's specialized feeding habits. It is moderately prognathous with slightly upturned jaws and features a pointed snout. The dentition consists of small, conical teeth suitable for scraping and grazing on periphyton, detritus, and small invertebrates found on submerged rocks and aquatic plants. This morphology reflects an omnivorous but largely algivorous diet, with a strong emphasis on benthic feeding strategies. Physiological Adaptations One of the Iranian cichlid's most notable physiological traits is its ability to cope with highly variable and harsh environmental conditions, such as fluctuating salinity and temperature, which are common in its natural habitats. These physiological capabilities are underpinned by specialized osmoregulatory and metabolic mechanisms. Living in habitats where salinity can vary from freshwater levels up to mildly brackish conditions requires efficient osmoregulation. *Iranocichla hormuzensis* achieves this through highly developed ion-exchange systems located in the gills and kidneys, which regulate the balance of sodium, chloride, and other electrolytes. The fish's gill epithelium contains chloride cells that actively pump ions to maintain internal homeostasis despite external salinity swings, preventing dehydration or ion overload. Similarly, the kidney's nephrons adapt to varying osmotic pressures by modifying filtrate concentration, ensuring water retention during high salinity and excretion when in fresher conditions. Thermal tolerance is another critical aspect of the Iranian cichlid's physiology (Marjani *et al*.,

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2013). Specimens have been observed to survive temperatures ranging widely from approximately 5°C during cold seasons to nearly 45°C during peak summer months. Such thermal resilience necessitates efficient heat shock protein expression, metabolic flexibility, and cardiovascular adaptations to maintain cellular function and oxygen transport under thermal stress. Metabolically, *Iranocichla hormuzensis* has a relatively low basal energy requirement, which is beneficial in its often resource-limited environments. The digestive tract shows adaptations to an algal and detrital diet, with a somewhat elongated and coiled intestine that facilitates the breakdown and absorption of plant-based matter and microbial biomass. Enzymatic activity within the digestive system supports the digestion of cellulose and complex carbohydrates found in algae, indicating a degree of herbivory uncommon among many other regional fish species. Reproductive Morphology and Physiology Sexual dimorphism in morphology extends beyond coloration and fin structure to reproductive organs and behaviorally linked physiology. During breeding seasons, males develop secondary sexual characteristics such as intensified pigmentation and slight hypertrophy of gonadal tissue. Hormonal regulation drives these changes, with increased levels of androgens influencing behavior and physical traits related to territory defense and courtship rituals (Esmaeili *et al*., 2010). Reproductively, the species exhibits complex parental care involving not only behavioral investment but probable physiological adaptations to enhance offspring survival under harsh environmental conditions. Mouthbrooding behavior observed in this genus necessitates physiological endurance, as adults temporarily reduce feeding during brooding periods and maintain elevated aerobic activity to guard and oxygenate eggs and fry. In summary, the morphology and physiology of *Iranocichla hormuzensis* encompass a suite of specialized features finely tuned to its ecological context. Its body shape, coloration, and feeding structures reflect evolutionary adaptation for survival in fluctuating freshwater and brackish environments, while its osmoregulatory and thermal tolerance mechanisms enable endurance in extreme conditions. These attributes underscore the species' ecological uniqueness and highlight the need for further integrative studies to elucidate how morphology and physiology interact with environmental pressures (Esmaeili *et al*., 2016).

Behavioral ecology

The behavioral ecology of the Iranian cichlid (*Iranocichla hormuzensis*) is a fascinating subject that reveals sophisticated social, reproductive, and feeding behaviors uniquely adapted to its challenging natural environment. As a species endemic to southern Iran's river systems with dynamic and fluctuating ecological conditions, *I. hormuzensis* exhibits a complex suite of behaviors that are crucial to its survival,

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reproduction, and ecological role within freshwater and brackish ecosystems. Territoriality and Social Structure During the breeding season, male Iranian cichlids distinctly exhibit territorial behavior, which forms the basis of their reproductive strategy. Males actively select and defend discrete territories along riverbanks and shallow pools. These territories are typically chosen based on habitat quality, access to resources, and substrate suitability for nest-building. Males become highly aggressive toward intruders, vigorously defending their areas against rival males to secure breeding rights. The territorial behavior is accompanied by striking morphological changes, most notably the intensification of dark body coloration and the appearance of prominent black spots on the dorsal fin. These visual signals serve as both deterrents to rival males and attractants to females, demonstrating the role of sexual selection in shaping behavior and phenotype. Aggressive interactions can include threat displays such as fin flaring, rapid swimming toward opponents, and occasional physical confrontations. Such clear territorial demarcation contributes to spaced nest distribution and reduces direct competition among males, although in some areas nest densities can be high, indicating locally favorable habitat conditions or a high population density. Nesting and Reproductive Behavior Reproduction in Iranian cichlids involves complex behaviors centered around nest construction, mate attraction, and parental care. Males engage in active nest building by cleaning and preparing smooth riverbed sites, often covered with algae mats, to create an appropriate substrate for egg deposition (Keivany and Daneshvar, 2015).

The choice of nest site is critical: nests must provide protection from water current, predation, and environmental disturbances, and meet female preferences for successful spawning. Females exhibit selective behavior in nest choice, often inspecting multiple male territories before selecting a partner. This mate choice likely depends on male territory quality, nest condition, and male display intensity. Females deposit adhesive eggs on the prepared substrate, after which fertilization occurs externally. One of the most remarkable aspects of *Iranocichla hormuzensis* reproductive ecology is the advanced parental care exhibited by both males and females. After spawning, parents guard the eggs zealously, fanning them to ensure proper oxygenation and removing unfertilized or infected eggs to prevent fungal growth. The species demonstrates biparental care, which is relatively uncommon in many fish species but characteristic of cichlids, reflecting their evolutionary investment in offspring survival. Following hatching, the fry continues to receive protective care; parents engage in mouthbrooding behavior, in which they shelter the young in their mouths when threatened, effectively safeguarding them from

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predators and environmental hazards. This extended parental care significantly increases the survival rate of offspring in the variable and sometimes harsh river environments (Esmaeili *et al*., 2013).

Feeding ecology and foraging behavior

The Iranian cichlid's feeding ecology is adapted primarily to benthic and algivorous dietary habits. Its diet consists largely of periphyton, including various species of algae such as diatoms, along with detritus and small invertebrates residing on submerged substrates. This diet reflects the availability of resources in their habitats, which often have sparse vegetation and muddy or rocky bottoms. Foraging behavior involves scraping and grazing activities, where the fish uses its specialized mouth and dentition to remove thin layers of algae and organic material from rocks and riverbed surfaces. This feeding strategy not only sustains the species but also plays an important ecological role in controlling algal growth and recycling nutrients within these freshwater systems. Feeding generally occurs throughout the day, but patterns may vary with environmental factors such as water temperature and predation risk. The species also sometimes displays opportunistic omnivory by consuming small invertebrates and detrital matter, reflecting its flexible and adaptive foraging strategy. Communication and Sensory Behaviors Like many cichlids, *Iranocichla hormuzensis* utilizes a range of sensory and communicative behaviors to mediate social interactions, mating, and territory defense. Visual cues, including body coloration changes and fin displays, play a primary role, especially in the turbid waters of their habitat where chemical signals might be less effective. Behavioral displays such as lateral presentations, head shakes, and fin spreading are common in courtship and territorial disputes (Owfi and Rameshi, 2021). Acoustic communication, which is documented in many cichlids as low-frequency sounds produced by body movements or specialized structures, has not been extensively studied in Iranian cichlids but could represent an additional communication mode worthy of investigation. Chemosensory signals may also contribute to mate recognition or territory marking under certain conditions, although empirical data remain sparse. Enhancing our understanding of these communication channels could further elucidate how these fish negotiate complex social and environmental challenges. Adaptations to Environmental Fluctuations The behavioral repertoire of *Iranocichla hormuzensis* also reflects its adaptation to the highly variable environmental conditions characteristic of southern Iran's water bodies. Fluctuations in salinity, temperature, and water levels influence daily and seasonal activity patterns, breeding cycles, and habitat use. For example, during periods of high salinity or temperature extremes, the fish may reduce activity levels, seek cooler or less saline microhabitats such as

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deeper pools or spring-fed areas, and modify foraging behavior to conserve energy. Seasonal changes also synchronize reproductive timing with optimal environmental conditions, maximizing offspring survival. Such behavioral plasticity is vital for persistence in dynamic habitats and likely contributes to the species' evolutionary success in a region marked by climatic variability. In summary, the behavioral ecology of the Iranian cichlid fish exemplifies complex and specialized adaptations to its challenging environment. Its territorial and reproductive behaviors, coupled with advanced parental care and flexible feeding strategies, underscore the species' ecological significance and vulnerability. Understanding these behaviors is essential for effective conservation management, as behavioral disruption resulting from habitat degradation could have profound impacts on population viability (Esmaeili *et al*., 2016).

Population dynamics and conservation status

The population dynamics and conservation status of the Iranian cichlid (*Iranocichla hormuzensis*) remain critical subjects of research, especially given the species' restricted range and specialized ecological niche. Although this species is not currently evaluated by the International Union for Conservation of Nature (IUCN), it is widely recognized by regional researchers as vulnerable due to the combination of its limited geographic distribution and significant environmental threats. Population Dynamics Available studies indicate that populations of *Iranocichla hormuzensis* are naturally fragmented, occurring in isolated river basins across southern Iran's Hormozgan province. These discrete populations likely have limited gene flow between them due to physical barriers such as arid zones, urban development, and alterations in hydrology. This fragmentation can lead to genetic drift, reduced genetic diversity, and increased inbreeding, which compromise population resilience in the face of environmental stressors. Field observations and surveys suggest that population densities vary widely between river systems and even within microhabitats of the same watershed, often corresponding to water quality, habitat complexity, and anthropogenic pressures. Some populations exhibit relatively high nest density during the breeding season, indicating localized reproductive success. However, longitudinal data on population trends are scarce, which hinders the ability to ascertain long-term demographic stability or decline. Reproductive rates and juvenile survival are closely tied to habitat conditions such as substrate quality, water flow, and availability of food resources. Seasonal variations, particularly the pronounced dry periods in southern Iran, can significantly reduce available habitat, causing bottlenecks in population size. Conversely, winter flooding may temporarily expand available habitat but can also disrupt

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nesting sites and displace juveniles (Esmaeili *et al*., 2010). Threats to Survival The survival of *Iranocichla hormuzensis* is threatened by multiple anthropogenic and environmental factors:

Habitat degradation and fragmentation
Water extraction for agriculture, urban development, and infrastructure construction significantly alter natural river flows and reduce available habitats. Channels may dry seasonally, disconnect populations, and limit successful reproduction.

Pollution
The proximity of many of the known Iranian cichlid habitats to the Persian Gulf's petrochemical and industrial zones exposes populations to chemical pollutants, including oil residues, heavy metals, and agricultural runoff. Pollution can disrupt reproductive physiology and reduce food availability by affecting benthic algal communities.

Climate change
Increasing temperatures, reduced precipitation, and more frequent droughts threaten to exacerbate the already extreme environmental conditions of southern Iran's rivers. Climate change may lead to prolonged habitat desiccation, increased water salinity, and altered breeding cycles, potentially reducing recruitment rates (Nasri *et al*., 2023).

Invasive species
Although currently regarded as minimal, the introduction of non-native fish species for aquaculture or sport fishing poses a potential risk. Invasive species could compete for resources or introduce pathogens to which *Iranocichla* populations have no resistance.

Limited range and endemism
The very restricted geographic range of *Iranocichla hormuzensis* inherently increases its vulnerability to stochastic events such as floods, droughts, or pollution spills, as entire populations could be wiped out due to a single catastrophic event. Conservation Status and Initiatives Despite the lack of an official IUCN assessment, conservationists agree that the Iranian cichlid qualifies for at least a vulnerable category based on its narrow distribution and threats. The species is considered a priority for regional conservation due to its endemic status and ecological importance (Owfi and Rameshi, 2021).

Conservation measures currently recommended or under consideration include:
Habitat protection
Establishing protected areas within the identified key river systems and enforcing regulations to limit industrial pollution and unsustainable water extraction.

Environmental flow management
Maintaining natural hydrological patterns to ensure seasonal flows critical

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for breeding and juvenile development, which may involve coordination with agricultural and urban water users.

Pollution control

Monitoring and mitigating sources of chemical contamination near critical habitats to preserve water quality and ecosystem integrity.

Population monitoring

Implementing long-term scientific monitoring programs to gather data on population size, structure, genetic diversity, and responses to environmental changes, which is essential for adaptive management.

Public awareness and stakeholder engagement

Educating local communities and involving them in conservation efforts, as sustainable practices and support from residents are vital for long-term success (Keivany and Daneshvar, 2015).

Research on genetics and ecology

Further studies on the genetic variability and population connectivity will aid in defining conservation units and identifying management priorities.

Ex situ conservation

Although not currently established, captive breeding programs might be considered as a safeguard against severe wild population declines, especially given the species' potential vulnerability. Future Challenges and Opportunities Addressing the conservation needs of the Iranian cichlid requires integrating multidisciplinary approaches that combine ecological, genetic, hydrological, and sociopolitical factors. Given the rapid pace of environmental change in southern Iran, it is imperative to develop proactive conservation strategies rather than reactive ones. The Iranian cichlid can also serve as an umbrella species, promoting the conservation of other lesser-known organisms within these fragile aquatic ecosystems. Furthermore, international collaboration and alignment with global biodiversity targets can facilitate resource mobilization and scientific exchange to enhance conservation outcomes. Inclusion of *Iranocichla hormuzensis* in regional Red Lists and formal protection under national legislation would further strengthen conservation prospects (Nasri *et al*., 2023).

Significance in Iranian and global ichthyology

The Iranian cichlid (*Iranocichla hormuzensis*) holds exceptional significance both within the context of Iranian freshwater biodiversity and on the global stage of ichthyological research. As the only known endemic cichlid species of Iran, and one of the very few representatives of the family Cichlidae in Asia, this species provides a unique model for understanding evolutionary, ecological, and biogeographical processes shaping freshwater fish communities in arid and semi-arid regions. Importance in Iranian

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Biodiversity and Freshwater Ecology Iran's freshwater ecosystems, despite their relatively small spatial extent within the Middle East, harbor notable biological diversity and several endemic species adapted to harsh and fluctuating environments. *Iranocichla hormuzensis* exemplifies this endemic richness, highlighting its role as a flagship species for freshwater conservation in Iran. Its presence in southern Iranian rivers serves as an indicator of ecosystem health, reflecting the state of water quality and habitat integrity in these biologically sensitive zones. The species contributes uniquely to the trophic and ecological dynamics within its habitats. As a benthic feeder specializing in algae and detritus, the Iranian cichlid participates actively in nutrient cycling and energy flow, helping to maintain the ecological balance of riparian and lotic systems. Studying its ecological interactions offers insights into the functioning of freshwater communities in environments subjected to natural stresses, such as temperature extremes and salinity fluctuations typical of the Persian Gulf basin area. Beyond ecology, *Iranocichla hormuzensis* enriches the ichthyofaunal assemblage of Iran, which comprises over 200 fish species, many with restricted distributions or endemic status (Esmaeili *et al*., 2016). Conserving this species thus contributes to preserving the broader genetic and species diversity essential for ecosystem resilience under increasing anthropogenic pressures. Evolutionary and Biogeographic Significance Globally, the cichlid family is renowned for its remarkable evolutionary diversity, with thousands of species exhibiting an extraordinary array of morphological, behavioral, and ecological adaptations, primarily in Africa and South America. The occurrence of a cichlid genus endemic to Iran is biogeographically exceptional and challenges typical cichlid distribution paradigms. The evolutionary lineage of *Iranocichla* is of great interest because it likely represents a relict stock that provides a living link to the historical biogeography of the region. Its divergence from African and other Old-World cichlids is thought to correspond with major geological and climatic events including the closure of the Tethys Sea, the uplift of the Zagros Mountains, and the long-term climatic aridification of the Middle East. By studying *Iranocichla*, ichthyologists can gain valuable information about vicariance, dispersal, and speciation mechanisms operating at this geographic crossroads linking Eurasia and Africa. Molecular phylogenetics has placed *Iranocichla* within the Pseudocrenilabrinae subfamily, commonly associated with African cichlids, indicating a fascinating evolutionary history involving ancient faunal exchanges alongside long-term isolation. Thus, this genus is a critical piece in reconstructing cichlid evolutionary history on a continental scale. A Model for Adaptive Evolution and Ecophysiology *Iranocichla hormuzensis* provides a rare opportunity

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to study adaptation to environmental extremes within the cichlid family. Its ability to survive in warm, often saline or sulfur-rich waters with broad seasonal variations in temperature and water chemistry offers a natural laboratory for investigating physiological plasticity, osmoregulation, stress responses, and ecological specialization. Research using this species can advance knowledge of how freshwater fishes adapt to environmental stressors associated with climate variability and habitat degradation, topics of increasing relevance in the context of global climate change. Understanding the genetic basis of these adaptations also has implications for evolutionary biology and conservation genetics. Moreover, as a species that exhibits complex social and reproductive behaviors, *Iranocichla hormuzensis* serves as a model for behavioral ecological studies. Its biparental care, territoriality, and bright sexual dimorphism enrich our understanding of the evolutionary drivers of social complexity in fish. Conservation and Educational Value Because of its endemic and vulnerable status, *Iranocichla hormuzensis* has become emblematic in conservation circles in Iran, often serving as a flagship species to raise public awareness about freshwater biodiversity and ecosystem threats. Promoting the species in educational materials and environmental campaigns helps garner local support for habitat protection and sustainable water management practices. The Iranian cichlid thus holds intrinsic value as a symbol of Iran's unique natural heritage and extrinsic value as part of the global ichthyological community. Supporting research, conservation, and education centered on this species contributes both to safeguarding biodiversity and advancing scientific understanding relevant to biodiversity hotspots worldwide (Hafeziyeh *et al*., 2020). Contributing to Broader Global Ichthyological Knowledge Worldwide, cichlids are among the most intensively studied fish due to their speciation patterns, adaptive radiations, and behavioral diversity. *Iranocichla* broadens this comparative framework by adding an important Asian lineage characterized by unique ecological adaptations and evolutionary history. Its study assists researchers in testing hypotheses about cichlid evolution outside their primary centers of diversity, exploring how isolation and environmental pressures shape phenotypic divergence and reproductive strategies in small, restricted populations. Understanding similarities and differences between *Iranocichla* and more extensively studied cichlid lineages can refine models of fish evolution and biodiversity generation. Additionally, insights gained from *Iranocichla* ecology and physiology may be applicable to managing other freshwater ecosystems facing stress worldwide, especially in arid to semi-arid regions. The species thus has potential as a bioindicator and a comparative subject, linking region-

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specific findings to global biodiversity conservation and evolutionary biology. In summary, *Iranocichla hormuzensis* embodies a remarkable confluence of biological, ecological, evolutionary, and conservation significance. Its uniqueness and vulnerability spotlight the rich but fragile biodiversity of Iranian waters and offer essential contributions to the broader understanding of cichlid evolution and freshwater ecology worldwide. Continued research and protection of this species will extend its value for both national heritage and global scientific advancement (Esmaeili *et al*., 2016).

Conclusion and research perspectives

The Iranian cichlid (*Iranocichla hormuzensis*) represents an extraordinary example of endemic freshwater biodiversity within the ecologically challenging yet biologically rich aquatic ecosystems of southern Iran. Throughout this essay, the species has been shown to embody a unique evolutionary lineage, exhibiting specialized adaptations to extreme environmental conditions such as fluctuating salinity, high temperature variability, and habitat fragmentation. Its restricted geographic range, coupled with remarkable morphological, physiological, and behavioral traits, underscores its important ecological role and its vulnerability to anthropogenic and climatic pressures. From a conservation standpoint, *I. hormuzensis* is a species of high priority. Despite the lack of formal assessment by international conservation bodies such as the IUCN, its limited distribution, environmental specificity, and multiple threats, ranging from industrial pollution, water resource alteration, habitat destruction, to climate change, place it at significant risk. Preservation of this species is not only pivotal for maintaining regional aquatic biodiversity but also carries symbolic and practical weight for broader ecosystem integrity in Iran's southern watersheds. In terms of scientific value, the Iranian cichlid constitutes a compelling model organism for advancing our understanding of evolutionary biology, biogeography, and ecological adaptation. As one of the few Asian representatives of the highly diverse cichlid family predominantly found in African and South American freshwater systems, *Iranocichla* provides valuable insights into historic biogeographic linkages, speciation processes, and adaptive responses to environmental extremes. The species' complex social behavior, parental care strategies, and physiological resilience further enrich the scope of ecological and behavioral research (Nasri *et al*., 2023). Looking ahead, several key research and conservation priorities emerge:

Comprehensive ecological and behavioral studies

Despite foundational knowledge, detailed long-term data on population dynamics, reproductive biology, feeding ecology, and habitat utilization are

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insufficient. Intensive field observations and experimental studies are necessary to clarify life history traits and ecological requirements.

Genetic and phylogenetic research

Expanding molecular investigations will elucidate population structure, gene flow, and potential cryptic speciation within and among Iranian cichlid populations. This genetic insight is essential for delineating conservation units and formulating effective management strategies (Owfi and Rameshi, 2021).

Assessment of anthropogenic impacts

Systematic evaluation of pollution levels, habitat modification, water extraction, and the effects of climate change on *I. hormuzensis* habitats is imperative. Such studies will inform mitigation measures and facilitate adaptive conservation planning.

Development of conservation action plans

Establishing protected aquatic reserves, enforcing environmental regulations, maintaining natural hydrological regimes, and promoting habitat restoration are critical management steps. Complementary community engagement and education programs can foster local stewardship.

Ex stu conservation and captive breeding

To safeguard genetic diversity against unforeseen environmental catastrophes, initiating captive breeding programs and developing protocols for potential restocking efforts could play a strategic role in long-term species survival.

Integration within tegional biodiversity frameworks

Incorporating the species into national and international biodiversity conservation networks will raise its profile and help secure funding, collaborative research, and policy support. In summary, *Iranocichla hormuzensis* exemplifies both the exceptional natural heritage and the conservation challenges of Iran's freshwater ecosystems. As a species uniquely adapted to variable and fragile habitats, it serves as a sentinel for environmental change and a valuable subject for advancing scientific inquiry. A multidisciplinary approach combining ecological research, genetic studies, conservation policy, and public awareness is essential to ensure the survival of this emblematic species amidst accelerating environmental change. With concerted effort, the Iranian cichlid can continue to flourish, contributing to the biological richness of Iranian waters and enriching global understanding of freshwater fish evolution and ecology (Nasri *et al*., 2023).

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