STUDY ON THE TAXONOMY, BIOLOGY AND CONSERVATION STATUS OF THE HUCHEN (*HUCHO HUCHO*) IN THE MOLDOVA REGION

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Abstract

This paper presents a synthesis of the specialist literature on the huchen (Hucho hucho, Linnaeus 1758), the largest salmonid of mountain watercourses, with populations also recorded in the Moldova region, along the Bistrița, Dorna and Bistricioara rivers. The taxonomic position of the species is reviewed, together with its main biological features its piscivorous feeding behaviour and reproductive habits as well as its historical and current distribution. Particular attention is given to its current conservation status: the species is listed on the IUCN List as endangered, and populations in the Moldova region face an ongoing decline, driven mainly by dams fragmenting the habitat, by water quality deterioration and by uncontrolled fishing. The synthesis underlines the need for sustained conservation measures, grounded in rigorous biological monitoring of the regional populations.

Key words: *Hucho hucho, salmonidae, ecosystem.*

INTRODUCTION

The Danube salmon *(Hucho hucho Linnaeus, 1758)* is a freshwater fish species belonging to the family Salmonidae and the genus Hucho Günther, 1866. The species was originally described by Carl Linnaeus as *Salmo hucho* in Systema Naturae (1758) and was subsequently transferred to the genus *Hucho*. The currently accepted scientific name is Hucho hucho, with Salmo hucho Linnaeus, 1758 representing the original combination and Hucho germanorum Günther, 1866 being regarded as a taxonomic synonym [1, 2].

Internationally known as the "Danube salmon" or "huchen", *Hucho hucho* is one of the largest salmonid species native to Europe and is endemic to the Danube River basin. The species can exceed 150 cm in length and attain a body mass of 30–40 kg, with a lifespan of approximately 15–20 years. Owing to its considerable size, trophic position and specific ecological requirements, *H. hucho* is regarded as an emblematic species of the lotic ecosystems within the Danube River basin [3, 4, 5].

Several vernacular and regional names have been documented in Romanian literature, including lostriță, lostoză, lostosă, lostocă, lastiță, lostruță and lostucă, reflecting the historical importance of the species to communities living along river systems [6, 7].

Hucho hucho is a non-anadromous freshwater species primarily associated with cold, well-oxygenated rivers within the Danube River basin. Adults preferentially inhabit deeper river sections, while successful reproduction depends on the availability of suitable spawning substrates and favourable hydrological conditions. River fragmentation, alterations to hydrological regimes, habitat degradation, pollution and fishing pressure have

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contributed to the decline of natural populations [8, 9, 4, 5].

In Romania, research on the Danube salmon has a history spanning more than a century, beginning with the pioneering work of Grigore Antipa and continuing through studies investigating the species' distribution, biology, reproduction, genetics and conservation [6, 7, 10, 4]. Currently, *Hucho hucho* is classified as Vulnerable (VU) on the IUCN Red List of Threatened Species. The conservation of its populations requires habitat protection, the maintenance of river connectivity and the preservation of genetic diversity [11, 12, 5].

Against this background, the present review aims to synthesise existing scientific knowledge on the taxonomy, biology, morphology, nutrition, distribution and aquaculture of *Hucho hucho*, as well as its current conservation status, with particular emphasis on populations occurring in Romania, especially those inhabiting the Bistrița River basin and the Moldavian region.

TAXONOMY

From a systematic perspective, *H. hucho*, belongs to the phylum *Chordata,* class *Actinopterygii,* order *Salmoniformes,* family *Salmonidae,* subfamily *Salmoninae* and genus *Hucho Günther, 1866*. The taxonomic classification of the species is summarised in Figure 1.

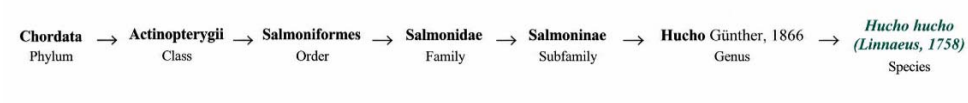


Figure 1. Taxonomic classification of Hucho hucho (Linnaeus, 1758).

The species was first described by Carl Linnaeus in 1758 under the name *Salmo hucho* in his work Systema Naturae. Subsequently, Günther (1866) proposed the name Hucho for *Salmo hucho* and other closely related forms. The initial delimitation of this taxonomic group was approached with caution owing to the limited knowledge of their distinguishing characteristics at the time. *Hucho* was therefore initially treated as a subgenus within *Salmo* and was subsequently recognised as a distinct genus [1, 13].

The recognition of Hucho as a distinct genus was subsequently reinforced, with Jordan and Snyder (1902) treating *Hucho* as a separate genus. Subsequent studies on the systematics of the family *Salmonidae* examined its relationships with other salmonid genera, particularly *Salmo*, *Salvelinus* and *Brachymystax*. The taxonomic history thus reflects a transition from the inclusion of the *Danube salmon* within the broadly defined genus *Salmo* to the recognition of a distinct taxonomic lineage represented by the *genus Hucho* [14, 15, 16].

The taxonomic separation of *Hucho* from *Salmo* is supported by genetic markers, as well as several morphological and anatomical characteristics. *Hucho hucho* is characterised by a robust body, a relatively long and dorsoventrally flattened head, approximately 180–200 scales along the lateral line and a deeply emarginate caudal fin. The number of gill rakers and distinctive colouration patterns also represent useful diagnostic characteristics. The species is characterised by the absence of red spots and conspicuous white fin margins, features that contribute to its differentiation from other European salmonids [17].

The transition from *Salmo hucho* to *Hucho hucho* does not represent the description of a new species or a change in the biological identity of the taxon, but rather a revision of its generic classification. The authority and year of the original description are retained, which explains the

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current nomenclatural form *Hucho hucho*. The parentheses enclosing the author's name and year indicate that the species was originally described under a different genus from that in which it is currently classified [2].

A distinctive feature of the species' nomenclature is the tautonymy of the combination *Hucho hucho*. Günther (1866) proposed the generic name *Hucho* without explicitly using the combination *Hucho hucho*. Under the current rules of zoological nomenclature, tautonymy is permitted, meaning that the identical spelling of the generic name and specific epithet does not constitute a nomenclatural impediment. Hucho germanorum Günther, 1866 is regarded in current taxonomic catalogues as an unavailable name (nomen nudum), mentioned only incidentally in connection with *Salmo hucho*, and is included in the synonymy of *Hucho hucho* [1, 2, 12].

In current taxonomic databases, *Salmo hucho Linnaeus*, 1758 is recorded as the original combination, whereas *Hucho hucho* represents the currently accepted combination [2].

Consequently, *Hucho hucho* is the recommended nomenclatural form in contemporary scientific literature and constitutes the currently valid scientific name for the Danube salmon [2].

BIOLOGY

Hucho hucho is one of the largest European freshwater salmonid species and is characterised by an elongated, robust and fusiform body adapted to swimming in fast-flowing waters. The species possesses a relatively long, dorsoventrally flattened head, accounting for approximately 22-24% of its standard length, a body rounded in cross-section and a deeply emarginate caudal fin. The lateral line comprises approximately 180-200 scales, while the number of gill rakers typically ranges from 13 to 19. Scale development in *H. hucho* occurs when juveniles reach a specific body length, allowing for a more accurate determination of growth stages [18].

The fins lack the characteristic white margins observed in certain other European salmonids, while the body is devoid of red spots, providing a useful diagnostic feature for species identification [19, 3, 17].

Body colouration varies according to age, habitat and physiological condition. Adult specimens generally exhibit a greenish-brown to greyish-brown dorsal colouration, with lighter flanks and numerous dark spots of varying sizes. Changes in body colouration may occur during the spawning season, a phenomenon documented in classical literature for reproductively active individuals [3].

From a functional perspective, body morphology (Figure 2) and muscular development are associated with the species' predatory lifestyle in high-flow river environments. The fusiform body reduces hydrodynamic drag, while the well-developed caudal peduncle and caudal fin enable rapid acceleration during prey capture. These morphological adaptations are particularly important for a predatory species occupying higher trophic levels within riverine ecosystems [3, 5].

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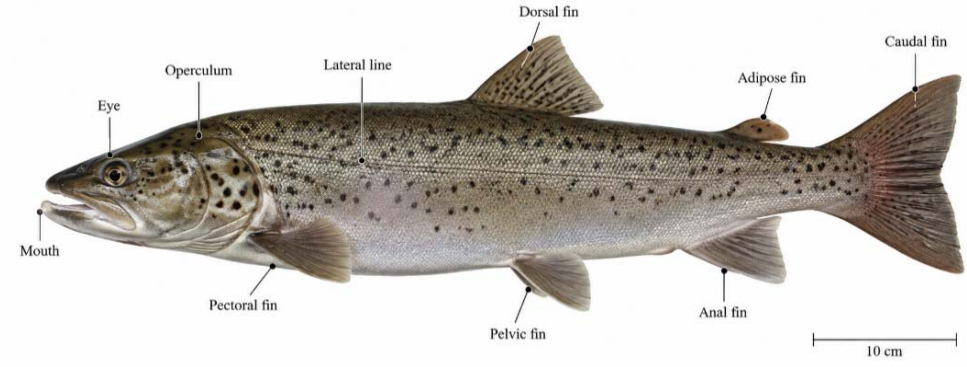


Figure 2. External morphology of huchen (Hucho hucho Linnaeus, 1758).

From an anatomical perspective, the respiratory system consists of well-developed gills adapted for gaseous exchange in cold, well-oxygenated waters. The preference for habitats with high dissolved oxygen concentrations is closely associated with the metabolic requirements of salmonids and the high energy demands of a large, active and predominantly piscivorous species. Under natural conditions, *Hucho hucho* primarily inhabits river sections characterised by cold, clean and well-oxygenated water [3, 4, 5].

Body size represents one of the distinguishing characteristics of the species. In the scientific literature, *H. hucho* is described as one of the largest freshwater salmonids, capable of exceeding 1 m in length under favourable environmental conditions. Analysis of the length–weight relationship in adult specimens from the Drina River basin indicates positive allometric growth, suggesting good nutritional condition in fish inhabiting relatively undisturbed habitats [20].

Assessment of the condition factor in rheophilic populations inhabiting the Kupa River, Slovenia, indicates good physiological condition among individuals despite moderate anthropogenic pressures [21]. However, some exceptionally high historical measurements reported in secondary literature should be interpreted with caution, as FishBase indicates that certain records exceeding 2 m in length and 100 kg in body mass are likely to be erroneous or insufficiently documented [3, 17].

The Danube salmon undergoes a significant ontogenetic dietary shift. During the early stages of development, juveniles feed predominantly on aquatic invertebrates, particularly benthic organisms and those transported by river currents. As individuals grow, their diet changes progressively, with fish constituting an increasingly large proportion of their food intake, while adults become predominantly piscivorous [3, 19, 5].

This ontogenetic dietary shift is associated with increasing body size, the development of the oral apparatus and an enhanced capacity for prey capture. Juveniles exploit smaller food resources, whereas adults are capable of capturing relatively large fish. In addition to fish, the diet of adult individuals may occasionally include amphibians, reptiles, small mammals and aquatic birds; however, fish constitute the principal component of the adult diet [3, 17].

The piscivorous feeding behaviour of adults places the species at a high trophic level within riverine ecosystems (Figure 3). Consequently, the abundance and diversity of prey fish communities directly influence the carrying capacity of habitats supporting

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H. hucho populations. Alterations in fish community structure, reduced river discharge and habitat degradation may therefore affect the species not only through the direct loss of spawning grounds but also by reducing the availability of food resources [3, 4, 5].

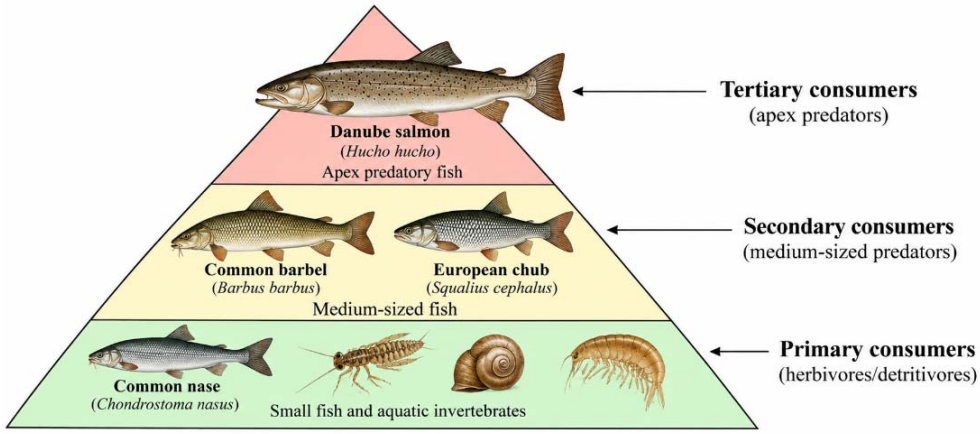


Figure 3. Trophic structure of a riverine ecosystem and the trophic position of huchen (Hucho hucho, Linnaeus, 1758).

The reproductive biology of *Hucho hucho* can be examined within the broader framework of salmonid reproductive processes, which are particularly relevant to salmoniculture and the management of fish populations [29].

Reproductive behaviour in mountain rivers involves careful selection of gravel substrates by females and intense territorial competition among males [22], while the chemical composition of the ovarian fluid plays a crucial role in stimulating sperm motility during fertilisation [23]. Egg incubation and the rate of embryonic development are closely dependent on water temperature, with a specific accumulation of degree-days required for successful hatching [24]. Furthermore, temperature fluctuations directly influence survival rates and the duration of yolk sac resorption [25]. Subsequently, early ontogenetic development involves the critical transition from the larval and yolk-sac alevin stages to the juvenile stage, characterised by the ability to initiate exogenous feeding [26].

DISTRIBUTION

The ecological preferences of *Hucho hucho* are closely associated with the hydromorphological and physicochemical characteristics of mountain rivers. The species primarily inhabits the upper reaches of Danube tributaries, characterised by low water temperatures, high dissolved oxygen concentrations and stony riverbeds. These environmental characteristics contribute to the suitability of freshwater habitats for the species. [27].

Hucho hucho is endemic to the Danube River basin, with its natural distribution closely associated with the river network of Central and South-Eastern Europe. The historical range of the species encompassed watercourses in Austria, Bosnia and Herzegovina, Croatia, the Czech Republic, Germany, Hungary, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia and Ukraine [4, 5]. From a biogeographical perspective, the distribution of the Danube salmon is distinctive owing to its almost exclusive association with the Danube drainage system. Unlike other European

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salmonids with broader geographical distributions, the natural range of *H. hucho* follows the Danube River and, in particular, its tributary systems, which provide suitable conditions for the completion of its life cycle. Consequently, the distribution of the species is more appropriately examined in relation to river basins and sub-basins rather than solely according to national administrative boundaries.

In terms of longitudinal and altitudinal distribution, the *Danube salmon* primarily inhabits mountainous and submontane sections of large rivers and their tributaries. Its occurrence is associated with rheophilic habitats characterised by flowing water, relatively low temperatures, high dissolved oxygen concentrations and predominantly stony or boulder substrates. These environmental characteristics help explain the uneven distribution of the species, even within the same river basin [3, 4, 28].

From a temporal perspective, the contemporary range differs considerably from the historical distribution. The species currently exhibits a discontinuous distribution, with populations restricted to particular rivers and river sections within its former range. Historical documentary sources indicate that the Danube salmon was once widely distributed and abundant in the northern sub-basins of the Danube River during previous centuries [28]. Therefore, the current distribution of H. hucho reflects a transition from a historically more extensive and continuous range to a fragmented contemporary distribution comprising geographically isolated population centres [5]. The principal characteristics of the distribution of *Hucho hucho*, examined from biogeographical, hydrographical, ecological and temporal perspectives, are summarised in Figure 4.

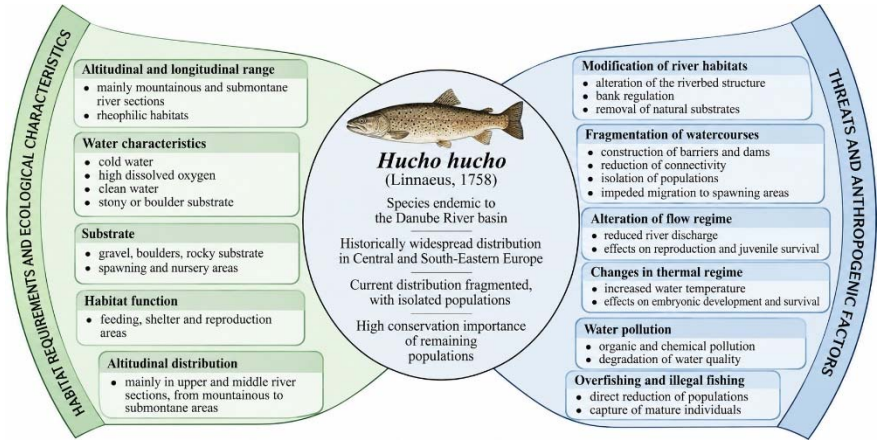


Figure 4. Schematic representation of the distribution of Danube salmon (Hucho hucho Linnaeus, 1758)in relation to its biogeographical range, hydrographical and ecological characteristics, and spatial changes in its distribution over time

In Romania, the distribution of the Danube salmon is associated with mountainous and submontane rivers within the Danube River basin. Population monitoring in the Vișeu River (Maramureș) has confirmed the presence of one of the most important viable rheophilic populations of the species in Romania [4]. Some authors consider the Vișeu River to support the last truly viable natural population of the Danube salmon in the Eastern Carpathians [31].

From a regional perspective, distribution patterns should be examined at

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the river basin level, taking into account the main watercourses, their tributaries and the river sections where the occurrence of the species has been documented. In the Romanian region of Moldavia, the Bistrița River basin and its tributary network are of particular importance, representing one of the key areas for investigating the distribution of *Hucho hucho* in Romania. Distribution analyses conducted in the Balkan region, particularly in Croatia, indicate a similar fragmentation of the contemporary range as a result of pressures associated with hydrotechnical developments [32].

CURRENT CONSERVATION STATUS

The current conservation status of Hucho hucho should be considered in relation to the most recent assessment published on the IUCN Red List of Threatened Species. The 2008 assessment classified the species as Endangered (EN), whereas the 2024 reassessment categorised it as Vulnerable (VU) under criterion A3cde. The distribution of the species, as documented in national conservation records, is schematically illustrated in Figure 5.

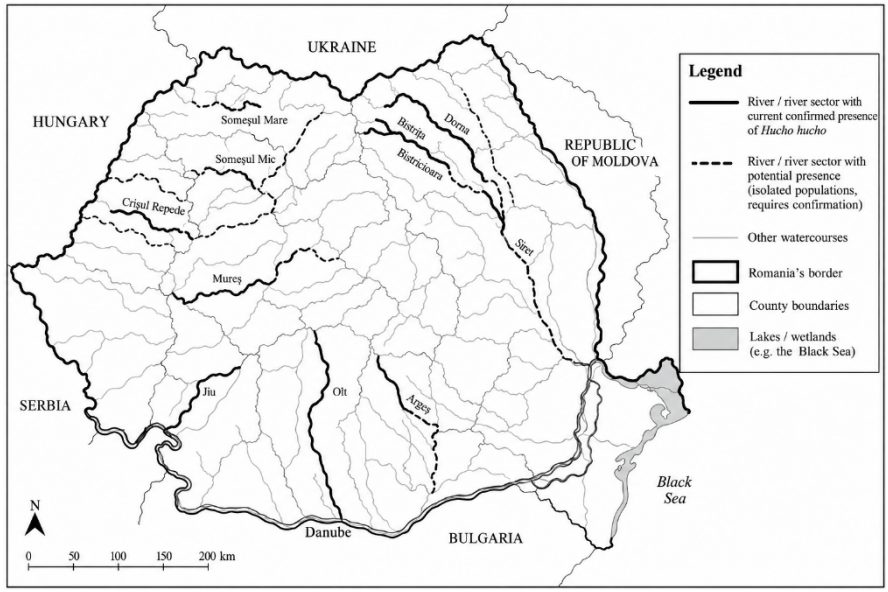


Figure 5. Distribution of the main populations and suitable habitats of huchen (Hucho hucho Linnaeus, 1758) in Romania in the context of species conservation.

From a conservation perspective, the IUCN classification indicates a high risk of population decline, highlighting the need for active protection measures. The identified threats include the alteration of watercourses through the construction of dams and hydropower plants, river channel regulation, changes in hydrological regimes, habitat degradation, pollution and fishing pressure [12].

A major challenge for the conservation of the Danube salmon is the disruption of longitudinal river connectivity. Artificial barriers may restrict spawning migrations and prevent adults from accessing suitable spawning grounds. Population fragmentation may also limit gene flow between populations and contribute to the long-term loss of genetic diversity [5].

The conservation of *H. hucho* therefore requires an integrated approach addressing

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both the species itself and the riverine ecosystems upon which it depends. Key priorities include the protection and restoration of spawning habitats, the re-establishment of longitudinal river connectivity, the maintenance of appropriate hydrological regimes, pollution reduction, population monitoring and the management of fishing pressure.

Stocking may serve as a complementary management tool, however, it should not be regarded as a substitute for the conservation of natural habitats. The long-term effectiveness of conservation measures depends on the maintenance of functional riverine ecosystems capable of supporting natural reproduction and successful recruitment of *H. hucho* populations [4, 5].

CONCLUSIONS

(Hucho hucho, Linnaeus, 1758) remains an emblematic salmonid species of the Danube River basin. The nomenclatural review confirms the validity of its classification within the genus Hucho Günther, 1866, while historical names such as *Salmo hucho* and *Hucho germanorum* represent the original combination and a taxonomic synonym of uncertain nomenclatural availability, respectively.

The species exhibits distinctive morphological and metabolic characteristics, reflecting its adaptation to cold, well-oxygenated, fast-flowing mountain rivers. The ontogenetic dietary shift from aquatic invertebrates during the juvenile stages to a predominantly piscivorous diet in adults places the *Danube salmon* at the apex of the aquatic food web. In the Romanian region of Moldavia, particularly within the Bistrița River and its tributaries (Dorna and Bistricioara), natural populations of the *Danube salmon* are experiencing a continuing decline.

Although the 2024 IUCN reassessment classifies the species as Vulnerable (VU) at the international level, regional pressures arising from habitat fragmentation caused by dams, deterioration of water quality and uncontrolled fishing threaten its long-term survival.

Conservation measures should focus on restoring river connectivity, protecting natural spawning grounds and maintaining genetic diversity. Stocking programmes may support population recovery however, they cannot replace the conservation of functional natural habitats.

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