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Putative extinction of *Cobitis kellei*: evidence from repeated field surveys and hydrological collapse

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Abstract: *Cobitis kellei*, a loach species endemic to the Göksu Stream in the upper Tigris drainage (Türkiye), has remained long-lost since its first and only collection in 1974 and was previously assessed by the International Union for Conservation of Nature (IUCN) as Critically Endangered (CR). Here, we report the results of extensive field investigations conducted between 2016 and 2021 using standardized backpack electrofishing surveys across the entire known range of the species. Our data document a complete hydrological collapse of the habitat, with no individuals of the species found. Supported by long-term anthropogenic degradation of the stream ecosystem, we hypothesize the extinction of *C. kellei*.

Keywords: Cobitidae, endemic species, habitat loss, drought, freshwater biodiversity

Conservation statement: *Cobitis kellei* has not been recorded for nearly five decades, and our repeated surveys strongly suggest that the species is now extinct following the hydrological collapse of its only known habitat. The apparent disappearance of this microendemic loach illustrates how small tributaries in the upper Tigris basin can lose narrowly distributed species before conservation measures are implemented. The upper Tigris system still supports several threatened freshwater fishes, including *Oxyneomacheilus hazarensis* (EN) and *Schistura chrysicristinae* Nalbant, 1998 (EN), both restricted to limited areas within the basin. The loss of *C. kellei* should therefore be viewed as a warning for other range-restricted taxa in the region. Protection of remaining headwater streams, prevention of further hydrological alteration, and improved management of water withdrawal are essential to avoid similar outcomes for other endemic species.

Özet: Yukarı Dicle havzasındaki Göksu Deresi'ne endemik bir taşemen balığı türü olan *Cobitis kellei*, ilk ve tek olarak 1974 yılında toplanmasının ardından uzun süre kayıt dışı kalmış; IUCN tarafından Kritik Düzeyde Nesli Tehlikede (CR) kategorisinde değerlendirilmiştir. Bu çalışmada, türün bilinen tüm yayılış alanında 2016-2021 yılları arasında elektroşok cihazıyla gerçekleştirilen kapsamlı arazi araştırmalarının sonuçları paylaşılmaktadır. Elde edilen veriler, habitatta tam bir hidrolojik çöküşe işaret etmekte olup türe ait hiçbir bireye rastlanamamıştır. Dere ekosisteminin uzun yıllar boyunca maruz kaldığı insan kaynaklı baskılar da göz önünde bulundurulduğunda, *C. kellei*'nin artık soyunun tükenmiş olabileceği düşünülmektedir.

Anahtar kelimeler: Anadolu, Endemik türler, Habitat kaybı, Kuraklık, Tatlısu biyoçeşitliliği

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Koruma bildirisi: *Cobitis kellei* yaklaşık yarım asırdır kayıt altına alınamamış olup tekrarlı arazi çalışmalarımız, türün bilinen tek habitatındaki hidrolojik çöküşün ardından artık soyunun tükenmiş olduğuna kuvvetle işaret etmektedir. Dar bir alana yayılmış bu küçük taşıyıcı balığın ortadan kaybolması, Yukarı Dicle havzasındaki küçük kolların, herhangi bir koruma önlemi alınmadan önce lokal endemik türleri yitirebileceğini açıkça ortaya koymaktadır. Yukarı Dicle sistemi, havza içindeki sınırlı alanlara hapsedilmiş *Oxybrycones hazarensis* (EN) ve *Schistura chrysicristinae* (EN) gibi çeşitli tehdit altındaki tatlısu balıklarını hâlâ barındırmaktadır. Bu nedenle *C. kellei*'nin kaybı, bölgedeki dar yayılışlı diğer taksonlar için bir uyarı niteliği taşımaktadır. Benzer sonuçların yaşanmaması adına kalan akarsu kaynak bölgelerinin korunması, hidrolojik değişikliklerin önüne geçilmesi ve su çekiminin daha etkin biçimde yönetilmesi büyük önem taşımaktadır.

INTRODUCTION

Natural history

Cobitis kellei Erk'akan, Atalay-Ekmekçi & Nalbant, 1998 is a spined loach whose natural history is unknown. The species was described based on two specimens collected in 1974, and no original or subsequent observations or ecological studies have been reported. As such, there is no available information regarding its

life history, habitat preferences, or interactions with other species. However, as in other members of the genus *Cobitis*, it was likely a benthic species inhabiting slow to moderately flowing sections of streams with sandy or fine gravel substrates, and presumably fed as a generalized bottom-dweller on small benthic invertebrates. To provide at least a visual reference, the original illustration of the holotype from the species description is shown in Fig. 1.

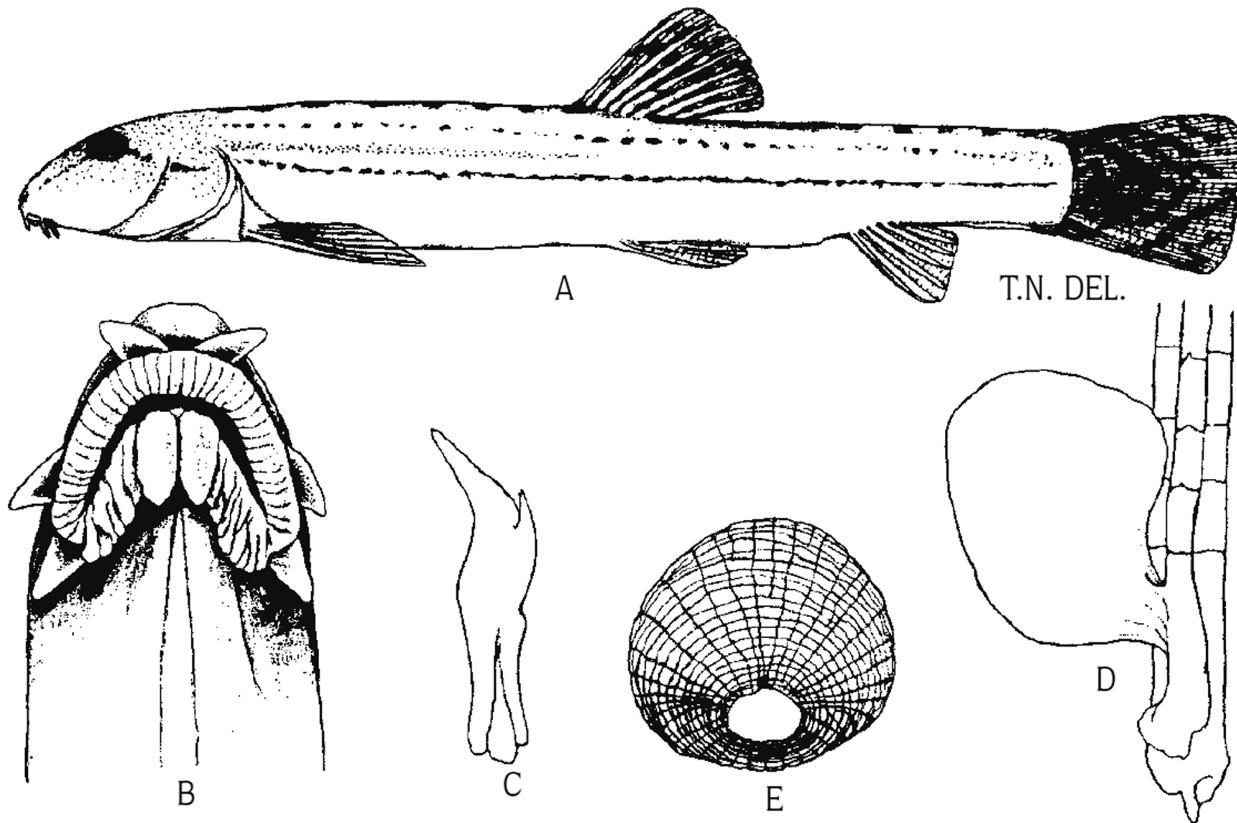


Figure 1. Drawing of holotype of *Cobitis kellei*, 46.2 mm SL (A – lateral view of the specimen, B – mouth, C – left suborbital spine, D – lamina circularis, E – subdorsal scale). Reproduced from Erk'akan et al. (1998) with permission from the author and the publisher.

Systematics

There has never been any controversy or disagreement regarding the taxonomic position of *C. kellei*, a species in the family Cobitidae (Freyhof et al. 2018; 2025). *Cobitis kellei* is distinguished from *C. avicennae* from the Iranian Tigris drainage by having one row of indistinct, minute, roundish, dark-grey dots in Z4 (vs. distinct, large, dark-brown blotches in Z4, usually horizontally elongated on the anterior body, roundish or vertically elongated on caudal peduncle) and from *C. elazigensis* from the Euphrates drainage by having one lamina circularis in the male (vs. two) (Freyhof et al. 2018). The head of *C. kellei* is moderately long; eyes are small and anteriorly positioned; mouth is arched; three pairs of very short barbels. Lips are furrowed. Mental lobes are well developed. Suborbital spine is reduced, with small latero-caudal thorn and distinct mediolateral process (Erk'akan et al. 1998).

The description of the species was based only on two specimens (holotype: 46.2 mm SL [Standard length]; paratype 58 mm SL) collected in 1974. These had been preserved in formalin and the type materials seem to be lost. They were in the private collection of T.T. Nalbant, who died in 2011. His collection was then removed from his flat by relatives and seems to have been disposed of. The systematic position of *C. kellei* is based solely on morphological characters described in the original study by Erk'akan et al. (1998). The absence of molecular evidence makes it difficult to determine the species relatives and its evolutionary links. Nonetheless, the species appears to be well-distinguished from all other species of *Cobitis* known from the region (Freyhof et al. 2018; 2025).

Geography

Within the Cobitidae family, *C. kellei* is a species with a limited range. To the best of our knowledge, there are currently no additional popu-

lations or individuals of the species. Erk'akan et al (1998) did not specify the exact location when describing *C. kellei*. The type locality in their study was stated as follows: "Göksu stream, Tigris catchment, Cinar, Diyarbakir, May 10, 1974, Demirsoy coll., donor Dr. Kelle." Therefore, the entire stream Göksu within the Çınar borders was considered a potential type locality.

STATUS

Evidence

Species of the genus *Cobitis* are benthic and relatively sedentary fishes that are typically readily detected using electrofishing, even at low population densities. Therefore, the consistent absence of *C. kellei* despite intensive electrofishing effort (see below), combined with the confirmed presence of other benthic fish species, strongly suggests true absence rather than limited detectability. *Cobitis kellei* meets the criteria for being long lost (Long and Rodriguez 2022), and we hypothesize that the species is extinct.

Three field reports prepared since 2006, all of which failed to detect *C. kellei* in its type locality, have provided important information on the habitat of the species (Ünlü 2006; 2009; 2012). Müfit Özuluğ (İstanbul) and Jörg Freyhof have also searched for the species in the lower Göksu in June 2008, 20 years after its description. In the previous studies, researchers generally conducted surveys at one or two sampling sites in the stream Göksu (Kaya et al. 2016) or emphasized that the species is under threat due to its absence for about 50 years and the desiccation of its type locality (Freyhof et al. 2018; 2021). Given the continued absence of *C. kellei* despite repeated efforts and growing anthropogenic pressures in the Göksu, this study aims to comprehensively assess the hypothesized extinction status of the species based on extensive field data collected in recent years.

Search effort

Field surveys were conducted in May 2016 and October 2021 using backpack electrofishing as the sole sampling method. A SAMUS 1000 electrofisher was used throughout all surveys. No additional gears (e.g., hand nets or seines) were employed. Sampling was conducted by a single operator moving systematically upstream against the current to maximise detectability of benthic fishes. In October 2021, ten stations (G1–G10) were surveyed along the entire course of the Göksu Stream, from its headwaters to its confluence with the Tigris River, together with four stations (T1–T4) located on the main body of the Tigris River near the mouth of the Göksu (Fig. 2, Table 1). Due to severe hydrological degradation, eight of the ten Göksu stations (G3–G10) were either

completely dry or reduced to isolated, stagnant pools unsuitable for sustaining flowing-water fish assemblages and therefore could not be effectively sampled. Only two Göksu stations (G1 and G2) retained shallow, low-flow conditions allowing electrofishing surveys. At these sites, approximately 200 m² were sampled per station, with 20 minutes of continuous electrofishing effort at each station, corresponding to approximately 160–200 electrical pulses (8–10 pulses per minute). On the main channel of the Tigris River (stations T1–T4), approximately 500 m² were sampled per station, with 40 minutes of continuous electrofishing effort per site, corresponding to approximately 320–400 electrical pulses. The substrate of the Tigris River consisted predominantly of sand, with patches of gravel, stones, and scattered rocks. Habitat conditions at G1 and G2 differed slightly. Sta-

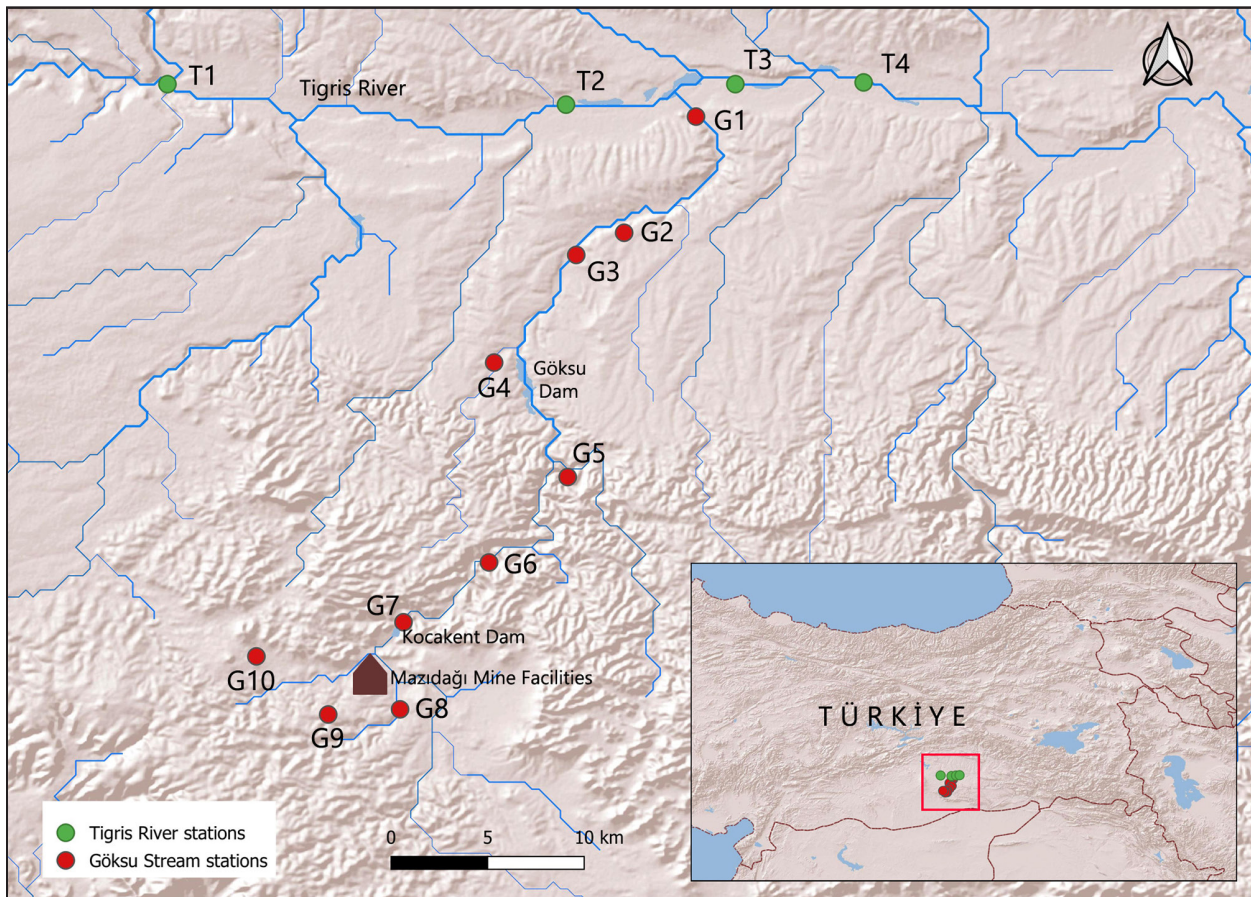


Figure 2. Map of the study area in upper Tigris River, Türkiye, with study locations shown as circles and abbreviations matching Table 1.

Table 1. Coordinates of sampling locations, see text for additional details. Site abbreviations are identical to those used in Fig. 2.

Stream Göksu		Tigris River	
Code	Coordinates	Code	Coordinates
G1	37.825N 40.548E	T1	37.844N 40.239E
G2	37.757N 40.506E	T2	37.832N 40.472E
G3	37.744N 40.478E	T3	37.844N 40.571E
G4	37.681N 40.430E	T4	37.845N 40.646E
G5	37.614N 40.473E		
G6	37.564N 40.427E		
G7	37.529N 40.377E		
G8	37.478N 40.375E		
G9	37.475N 40.333E		
G10	37.509N 40.291E		

tion G2 was characterised by flowing water with a sandy and gravelly substrate and was fed by a distinct spring source. Station G1 was located near the confluence with the Tigris River and retained a small residual flow; the substrate was predominantly sandy with occasional stones. Both sites were shallow throughout. Distribution maps were prepared using QGIS version 3.40 (Zanzibar) based on available locality records.

Earlier surveys conducted in May 2016 included sampling at station G6, where a large spring provided substantial discharge at that time. Several fish species were recorded, including *Alburnus sellal*, *Squalius verepi*, *Oxyzomacheilus marunensis*, and hybrid individuals (*Alburnus sellal* × *Squalius verepi*). This spring had completely dried up by 2021.

Despite intensive electrofishing effort across all accessible habitats and the detection of multiple other fish species, no individuals of *C. kellei* were recorded during any survey.

Threats

The most significant threats to *C. kellei* are drought and water withdrawal. Following these, we can list pollution and illegal fishing activities, which directly impact the ecosystem.

In 2016, we visited the Göksu. At the time, the site had abundant water flow and even featured a large spring discharging significant volumes of freshwater into the stream. However, during our repeated visit in 2021, we observed a drastic change in hydrological conditions. The largest spring feeding the stream, which was roughly 20 meters in diameter and 3 meters deep, was entirely dry (Fig. 3a), and no water flow was detected throughout most parts of the Göksu. Only isolated pools remained in a few lower sections (Fig. 3b). Incidentally, *C. kellei* was not found in field surveys conducted before the stream dried up and when it was still full with fish. Therefore, it is possible that *C. kellei* was extinct even while there was still sufficient water in the stream. However, the complete drying up of the source has significantly diminished the hope of re-discovering the species.

In our 2021 field expedition, it was observed that Göksu reservoir, once a major barrier within the native range of the species, had completely dried up. Even more strikingly, agricultural activities had commenced within the former reservoir area, with visible ploughed fields and tractors operating on the dry lakebed (see Fig. 4).

Historical pressures and habitat degradation

Since 1974, significant threats have started to emerge in the stream ecosystem. The Mazıdağı Mine was established on the headwater of the stream the same year *C. kellei* was collected. Fertilizers, phosphate, and sulphuric acid are still produced in this facility. Kocakent Dam was established in 1986 to 1988 just below these facilities. Before the Kocakent Dam was completed, approximately 20 km downstream from this dam, the construction of the Göksu Dam was started in 1987, and it was completed in 1991. It is thought that all these threats that cause environmental pollution and change of the river habitat drove the spined loach to be highly threatened. The absence of *C. kellei* records for five decades, despite the presence of

other fish species in the stream, suggests either a drastic decline or possible extinction.

Although *C. kellei* may have disappeared prior to the complete desiccation of Göksu Stream, the subsequent hydrological collapse is considered the primary driver that eliminated any remaining potential for persistence, confirming the irreversible loss of suitable habitat.

CONCLUSION

Our findings provide strong evidence that *C. kellei* is no longer extant in its only known habitat. The species has not been seen since its original discovery almost half a century ago,

and repeated surveys, including detailed investigations in 2021, resulted in no individuals detected. Furthermore, the complete collapse of its freshwater habitat, likely due to a combination of factors including dam construction, industrial pollution, and climate-driven aridification, eliminates the possibility of any surviving population. While we cannot entirely exclude the possibility that the species might persist in an as yet undetected refuge, this is highly unlikely given that the region has been extensively surveyed. According to guidelines from the International Union for Conservation of Nature (IUCN), extinction may be inferred when exhaustive surveys in known and expected habitats, conducted at appropriate times and using appropriate methods, fail to



Figure 3. (A, top) Empty spring pool at the type locality in 2021, previously a major water source (photo with human for scale); (B, bottom) one of the isolated pools remained on Göksu. Photo credit, Kaya

record the species (IUCN Standards and Petitions Committee 2024). Given the intensive electrofishing surveys conducted across the entire known range of *Cobitis kellei* and the complete collapse of its habitat, the available evidence meets the criteria for classification as Extinct (EX). We therefore recommend that the conservation status of *Cobitis kellei* be updated to EX in the IUCN Red List. The disappearance of *C. kellei* also represents the loss of a range-restricted benthic fish from the upper Tigris system. Species of *Cobitis* are generally small, sediment-associated loaches inhabiting low- to moderate-flow sections of streams and feeding on benthic invertebrates (Freyhof et al. 2025). Although no species-specific ecological data exist for *C. kellei*, it is reasonable to assume that it occupied a similar ecological niche. Be-

cause the species has disappeared without any documented observations of its behaviour, reproduction, or trophic interactions, its precise ecological role within the Göksu Stream ecosystem can no longer be evaluated.

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Data accessibility

This study is based solely on previously published material; no new datasets are available.

Author contributions

C.K. conceived the study (Conceptualization). C.K., E.Ü., J.F., E.B., and M.O.K. participated in the fieldwork and conducted field surveys (Investigation). C.K. and M.O.K. compiled and analysed the data (Investigation; Data curation). C.K. wrote



Figure 4. Completely dry Kocakent reservoir during the 2021 survey. Photo credit, Kaya

the first draft of the manuscript (Writing – original draft). J.F. contributed substantially to the interpretation of the results and the development of the manuscript (Conceptualization; Writing – review & editing). E.Ü., E.B., and M.O.K. contributed to reviewing and editing the manuscript. All authors read and approved the final version of the manuscript.

Ethical standards and competing interests

Field sampling conducted between 2016 and 2021 followed standard ichthyological procedures designed to minimize stress and impact on fish populations. All activities were carried out in accordance with the applicable animal welfare legislation and national regulations of the Republic of Türkiye in force during the study period. No additional institutional ethical approval was required for this type of non-experimental field research. The authors declare no competing interests.

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