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Diversity of Freshwater Fishes in Iraq

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Abstract: Many studies have focused on identifying and classifying freshwater fishes in Iraq, concerned with describing, organizing, and drawing up a list of freshwater fishes in Iraq or the Tigris and Euphrates rivers. Within the most recent updates at the beginning of 2023, 53 native freshwater and 20 exotic (alien or introduced) fish species are recorded and described. This study reviewed the database of morphology and molecular studies of freshwater fish in Iraq and reported species while surveying the fish fauna at different water bodies of the country from 2010 to the beginning of 2023. In conclusion, 29 species (about 40.3%) of all 72 fish species in Iraq still need to be available information on their molecular data.

Key words: Alien, endemic, freshwater, morphometric features, taxonomic, Tigris.

Introduction

Fishes are an enormous group of aquatic vertebrates and have traditionally been estimated as an indicator of water quality and a source of protein for human utilization. Fishes show the most significant biodiversity of the vertebrates (animals with backbones), and they are generally distributed in two large environments: the salty marine water environment, in which the percentage of fishes is about 57%, and the freshwater environment, with 43% of the whole number of fishes around the world¹. The search for Iraqi fish wealth dates back to the time of Babylon, Sumer, and Assyria². Ancient Mesopotamians identified and named numerous marine and freshwater species recorded on clay tablets³. The real taxonomical works in Iraq started in the 19th century when Heckel⁴ described 17 freshwater fish species from the Tigris River at Mosul city, northern Iraq. Past to that date, the works of Hasselquist (1722-1752) and Russell (1742-1753) on diverse parts of the Middle East were considered the early works on fish scientific classification in this portion of the world. The authors of these works did not collect the materials from Iraqi waters despite the reality that the species they described were displayed in Iraq. Afterward, in this way, they are considered out of their research scope⁵. The present study aimed to review the fish fauna of Iraq from the taxonomical point of view, in both morphological and molecular approaches, based on published works that recorded species from Iraqi waters during the last 12 years.

Diversity of freshwater fishes in Iraq

The present study covers the studies on freshwater fish species of Iraq after 2010 due to the most fish species before this period have been reviewed and prepared lists of each fish group⁶. As well as the history of the fish fauna (Freshwater and marine) of Iraq during 19th, 20th and 21st

centuries were pointed and reviewed until⁷. Based on morphometric and meristic characteristics, the *Cobitis linea* was recorded in Huweza marsh, southern Iraq⁸. At Al-Rathwania Lake, western Baghdad, 18 species of fish were recorded belonging to six families (Cyprinidae, Bagridae, Mugilidae, Heteropneustidae, Mastacembelidae, and Siluridae)⁹. A total of 53 fish species, including 51 species belonging to bony fishes and two species to Chondrichthyes, were recorded from Shatt Al-Basrah, canal southern Iraq¹⁰. At Um Alnaaj, Al-Hawizah marsh, east of the Tigris River in southern Iraq, 13 species of fish were recorded belonging to six families (Cyprinidae, Mugilidae, Siluridae, Heteropneustidae, Mastacembelidae, and Bagridae)¹¹. A total of 27 species of fish belonging to five families (Cyprinidae, Mugilidae, Heteropneustidae, Sisoridae, and Mastacembelidae) were recorded from Dukan Lake¹². While 20 species of fish were identified belonging to six families (Cyprinidae, Bagridae, Siluridae, Mugilidae, Mastacembelidae and Cichlidae), including *Liza abu* (= *Planiliza abu*), *Carassius auratus*, and *Carasobarbus luteus* most abundant species from the Euphrates River at Al-Hindia city south of Baghdad, Iraq¹³. From Al-Chybayish marsh, 14 fish species were identified and reported; *Liza abu* (= *Planiliza abu*) was the most abundant species¹⁴. Forty species of fish were recorded belonging to 19 families (Cyprinidae, Scaenidae, Mugilidae, Clupeidae, and Gobiidae families from freshwater) in the Shatt Al-Arab River, *Carassius auratus* was the most abundant species, followed by anadromous shad *Tenulosa Elisha* and *Liza abu* (= *Planiliza abu*)¹⁵. Tooth carp fishes *Aphanius dispar* (= *A. stoliczkanus*), *A. mento* (*Paraphanius mento*), *Poecilia latipinna*, and *Gambusia holbrooki* were described using morphometric and meristic characteristics from Hammar Marsh, southern Iraq¹⁶. In Darbandikhan Lake, 17 species of fish were identified belong to four families (Cyprinidae, Bagridae, Siluridae, and Mastacembelidae)¹⁷. *Carassius*

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auratus auratus was recorded within Basrah freshwater systems based on morphometric and meristic characteristics¹⁸. The exotic *Oreochromis niloticus* was recorded for the first time in Iraq from the Shatt Al-Arab River¹⁹. Tigris catfish *Silurus triostegus* was redescribed by using 13 morphometric characters from three localities within Tigris and Shatt al-Arab Rivers²⁰. From the southern marshes of Thiqr Province, southern Iraq Day's goby *Acentrogobius dayi* was recorded for first time²¹. Brond-snout *Chondrostoma regium* was recorded for the first time from the Shatt Al-Arab River by studing 25 morphometric and 16 meristic characters to describe the species²². From East Hammar Marsh southern Iraq, identified 47 species of fishes belong to 35 genera and 20 families, including 23 marine and 24 freshwater species, *Liza abu* (= *Planiliza abu*) and *Carassius auratus* were the most abundant species²³. Two new species of *Oxynoemacheilus Banarescu* & Nalbant, 1966 (*O. gyndes* and *O. hanae*) were reported from the Sirwan River, Tigris River, northern Iraq²⁴. *Carasobarbus sublimus* was reported for the first time in Iraq from Shatt al-Arab River, south of Qurna city²⁵. Based on morphometric and meristic parameters, 27 species of fish were recorded from Greater Zab River, Aski-kalak, west of Erbil city, northern Iraq; the most fish species recorded were native species, except five species were exotic, including *C. carpio*, *C. auratus*, and *Ctenopharyngodon idella*, *Heteropneustes fossilis*, and Caspian trout *Salmo campus*. Caspian trout was recorded for the first time in Iraq²⁶. The taxonomic status of five nominal species of cyprinid fishes, *Alburnus mossulensis* was a synonym of *Alburnus sellae*²⁷. Single specimen of alligator gar, *Atractosteus spatula* belonging to Lepisosteidae was recorded for the first time in the Shatt al-Arab River, Basrah, Iraq²⁸. Depending on the morphometric and meristic parameters and electrophoretic analysis of lateral muscle proteins, *Planiliza abu* has been recorded in Qarmat Ali River, north Basrah, Iraq²⁹. The status of the fish assemblage structure of Al-Huwaizah marsh and abundance were described to compare the fish assemblage in this marsh before a decade³⁰. Twenty-four species of fishes were recorded belonging to 10 families, including 17 native species and seven alien species; the most abundant species were blue tilapia *Oreochromis aureus*, which accounted 26.84% of the overall capture in a north station in the Euphrates River in Al- Samawa city southern Iraq, the most abundant species in the south station was Prussian carp *Carassius auratus*³¹. From the Great Zab River, northern Iraq 11 species of fish *Garra rufa*, *Chondrostoma regium*, *Luciobarbus xanthopterus*, *Barbus barbulus* (= *Luciobarbus barbulus*), *Barbus belayewi* (= *Capoeta damascina*), *Barbus grypus* (= *Arabibarbus grypus*), *Cyprinion kais*, *Capoeta trutta*, *Mastacembelus mastacembelus*, *Carassius carassius*, and *Liza abu* (= *Planiliza abu*) were described³². Twelve freshwater fish species belonging to the family Cyprinidae were recorded from different water bodies of Halabja province, northeast of Iraq³³. The biodiversity of fishes belonging to eight families and 35 species were studied from the Lesser Zab, and Sirwan within Sulaimani province, Iraq, and *Cyprinion macrostomum* was the more abundant and widespread species in the area, while *Leuciscus vorax* was rare³⁴. *Capoeta trutta* from Dukan Lake and *Liza abu* (= *Planiliza abu*) from Sirwan River, northwestern and southeastern Sulaimani province, Iraq were recorded³⁵. An updated checklist of the freshwater fishes of Iraq was reviewed and represented

with 50 native and 16 exotic fish species counted³⁶. Wels catfish *Silurus glanis* was a confirmed recorded from the Chibayish marsh area, southern Iraq, and made a comparison with Tigris catfish *S. triostegus*³⁷. A single specimen, Danube sturgeon *Acipenser gueldenstaedtii*, was recorded for the first time from the Euphrates River, western Iraq³⁸. The freshwater fish diversity, abundance, ecological indices, and water quality were reported from the main outfall drain in Al- Diwaniya city, middle Iraq³⁹. The fishes of the Euphrates and Tigris Rivers basin were reviewed, and identified 52 fish species in Iraq⁴⁰. *Glyptothorax kurdistanicus*, *G. cous*, and *G. daemon* were recognized from Euphrates and Tigris drainages, one of which (*G. daemon*) was described as a new species⁴¹. *Cyprinion carpio*, *Tenualosa ilisha*, and *Clarias gariepinus* from Little Zab river, in Tikrit province, northern Iraq were recorded⁴². A single specimen of Oscar, *Astronotus ocellatus*, was described for the first time from the Euphrates River in Babylon Province in central Iraq⁴³. The morphology of pharyngeal bones and teeth in seven cyprinid species were studied in the Greater Zab River, Kurdistan province, northern Iraq⁴⁴. From the Euphrates River in Karbala province, 27 species belonging to 11 families and six orders⁴⁵ were recorded. A single Caspian trout *Salmo caspius* specimen was reported at Shatt Al-Arab, Basrah, southern Iraq⁴⁶. The Amazon sailfin catfish, *Pterygoplichthys pardalis*, belonging to Loricariidae, was recorded for the first time in the Shatt al-Arab River, Basrah, Iraq⁴⁷. Table (1) summarizes the current morphological studies between 2010 the end of 2022.

Molecular study of freshwater fishes

Fishes show a spectacular diversity of sizes, shapes, and colors; the delimitation and identification of fish species are not only crucial for scientific classification and systematics, but it is additionally a requirement in studies of fishery management, normal history, and biology, following the dispersal styles of eggs and larvae, estimations of spawning and spawn areas, and food product authentication⁴⁸. Fish identity is historically based on morphological features. However, because of excessive variety and morphological plasticity, fish and their diverse developmental stages are difficult to identify by using morphological characteristics alone⁴⁹. Deoxyribonucleic acid (DNA) based identification techniques have been advanced and proved to be analytically⁵⁰. As a standardized and familiar method, DNA barcoding identification systems have been widely advocated to identify species and broadly biological diversity in recent years⁵¹. Researchers have started to apply new technologies primarily based on the polymerase chain reaction (PCR) method, such as recombinant DNA and polymorphic DNA markers and DNA sequence information to resolve fish taxonomy, phylogeny, population, and genetic and evolutionary biology questions⁵². Geometric morphometric and molecular techniques have become major equipment for systematic ichthyologists and fish biologists to ratify taxonomic problems at species and population levels⁵³.

Molecular study of freshwater fishes in Iraq

The first molecular study of Iraqi fish started when used the DNA fingerprints to identify eight cyprinid fish species *Luciobarbus kersin*, *Barbus barbulus* (= *Luciobarbus barbulus*), *B. grypus* (= *Arabibarbus grypus*), *B. sharpeyi* (= *Mesopotamichthys sharpeyi*), *B. luteus* (= *Carasobarbus luteus*), *B. xanthopterus* (*Luciobarbus xanthopterus*), *Aspius vorax* (= *Leuciscus vorax*), and *Cyprinus carpio* in Iraqi waters

Fish species	Family	Locality	Reference
<i>Cobitis linea</i>	Cobitidae	Huweza marsh, southern Iraq	Abd and Abd ⁸
<i>Aphanius dispar</i> ?(= <i>A. stoliczkanus</i>) <i>A. mento</i> (= <i>Paraphanius mento</i>) <i>Poecilia latipinna</i> * <i>Gambusia holbrooki</i>	Cyprinodontidae	Hammar marsh, southern Iraq	Al-Faisal and Mutlak ¹⁶
<i>Carassius auratus auratus</i> *	Poeciliidae	Basrah	Habbeb ¹⁸
<i>Oreochromis niloticus</i> *	Cyprinidae	Shatt Al-Arab River	Al-Faisal and Mutlak ¹⁹
<i>Silurus triostegus</i>	Cichlidae	Tigris and Shatt al-Arab Rivers	Jawad and Al-Janabi ²⁰
<i>Acentrogobius dayi</i>	Siluridae	southern marshes Thiqar Province	Jawad et al. ²¹
<i>Chondrostoma regium</i>	Gobiidae	Shatt al-Arab River	Mohamed and Abood ²²
<i>Oxynoemacheilus</i> <i>O. gynodes</i> and <i>O. hanae</i>	Leuciscidae	Sirwan River, Tigris River, northern Iraq	Freyhof and Abdullah ²⁴
<i>Carasobarbus sublimus</i>	Nemacheilidae	Shatt al-Arab River	Mohamed et al. ²⁵
<i>Cyprinus carpio</i> * <i>Carassius auratus</i> * <i>Carasobarbus kosswigi</i> <i>Cyprinion kais</i> <i>Luciobarbus subquincunciatus</i> <i>Ctenopharyngodon idella</i> * <i>Heteropneustes fossilis</i> * <i>Salmo caspius</i> *	Cyprinidae Xenocyprididae Heteropneustidae Salmonidae	Greater Zab River, Aski-Kalak, west of Erbil city, northern Iraq	Agha ²⁶
<i>Alburnus sellal</i>	Cyprinidae	Hammar Marsh, southern Iraq	Mohammadian-Kalat et al. ²⁷
<i>Atractosteus spatula</i>	Leuciscidae	Shatt Al-Arab River	Mutlak et al. ²⁸
<i>Planiliza abu</i>	Lepisosteidae	Qarmat Ali River, north Basrah	Mohamed et al. ²⁹
<i>Silurus glanis</i>	Mugilidae	Chibayish marsh, southern Iraq	Jawad et al. ³⁷
<i>Acipenser gueldenstaedtii</i> *	Siluridae	Euphrates River, Al-Anbar Governorate, western Iraq	Jawad et al. ³⁸
<i>Glyptothorax kurdistanicus</i> <i>G. cous</i> <i>Glyptothorax daemon</i>	Acipenseridae	Euphrates and Tigris drainages	Freyhof et al. ⁴¹
<i>Astronotus ocellatus</i> *	Sisoridae	Euphrates River , Babylon Province	Jawad et al. ⁴⁴
<i>Salmo caspius</i> *	Cichlidae	Shatt al-Arab River, Iraq	Al-Faisal and Mutlak ⁴⁵

Table 1. Morphometric and meristic studies of some freshwater fish species in Iraq (* Exotic species).

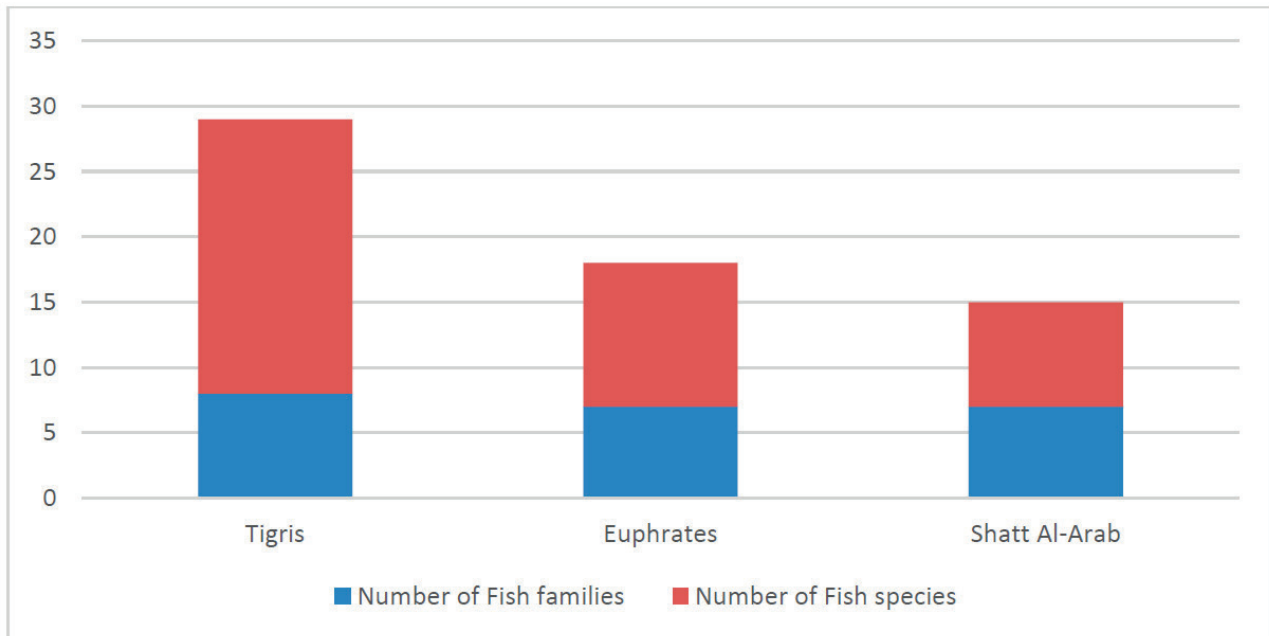


Figure 1. Number of fish families and number of fish species in taxonomical studies in each main river in Iraq.

Fish species	Order	Family
<i>Acipenser guel</i>	Acipenseriformes	Acipenseridae
<i>Atractosteus spatula</i>	Lepisosteiformes	Lepisosteidae
<i>Cyprinus carpio</i>	Cypriniformes	Cyprinidae
<i>Carassius auratus</i>	Cypriniformes	Cyprinidae
<i>Carassius gibelio</i>	Cypriniformes	Cyprinidae
<i>Hypophthalmichthys nobilis</i>	Cypriniformes	Xenocypridae
<i>Ctenopharyngodon idella</i>	Cypriniformes	Xenocypridae
<i>Hemiculter leucisculus</i>	Cypriniformes	Xenocypridae
<i>Clarias gariepinus</i>	Siluriformes	Clariidae
<i>Pterygoplichthys pardalis</i>	Siluriformes	Loricariidae
<i>Pangasianodon hypophthalmus</i>	Siluriformes	Pangasiidae
<i>Silurus glanis</i>	Siluriformes	Siluridae
<i>Heteropneustes fossilis</i>	Siluriformes	Heteropneustidae
<i>Salmo caspius</i>	Salmoniformes	Salmonidae
<i>Coptodon zillii</i>	Cichliformes	Cichlidae
<i>Oreochromis aureus</i>	Cichliformes	Cichlidae
<i>O. niloticus</i>	Cichliformes	Cichlidae
<i>Astronotus ocellatus</i>	Cichliformes	Cichlidae
<i>Gambusia holbrooki</i>	Cyprinodontiformes	Poeciliidae
<i>Poecilia latipinna</i>	Cyprinodontiformes	Poeciliidae
<i>Poecilia sphenops</i>	Cyprinodontiformes	Poeciliidae
<i>Poecilia reticulata</i>	Cyprinodontiformes	Poeciliidae

Table 2. The exotic fish species in Iraq.

using RAPD-PCR method with seven decamere primers⁵². Mitochondrial 16S rRNA gene was employed to identify cyprinid fish species *B. xanthopterus* (*L. xanthopterus*), *B. kersin*, (= *Luciobarbus kersin*), *B. barbulus* (= *L. barbulus*), *B. grypus* (= *A. grypus*), *B. sharpeyi* (= *M. sharpeyi*), *B. luteus*

(= *C. luteus*), and *C. carpio* in Shatt Al-Arab River 54. *Barbus barbulus* (= *L. barbulus*), *B. grypus* (= *A. grypus*), *B. sharpeyi* (= *M. sharpeyi*), *B. luteus* (= *C. luteus*), *B. xanthopterus* (*L. xanthopterus*), *B. kersin*, (= *L. kersin*) were identified using PCR-RAPD in Iraqi freshwater fishes⁵⁵. The molecular di-

versity for nine species of Cyprinidae was described *Barbus grypus* (= *A. grypus*), *Carasobarbus luteus*, *Carassius carassius*, *Chondrostoma regium*, *Capoeta trutta*, *C. carpio*, *Cyprinion macrostomum*, *Luciobarbus esocinus*, and *L. xanthopterus* in Dukan Lake, Kurdistan Region Based on morphological and DNA barcode⁵⁶. The genetic diversity of *L. xanthopterus* was recorded in four habitats in Iraq; Shatt Al-Arab River, Dukan reservoir, Kut city, and Kerbala'a, using the RAPD technique⁵⁷. The mitochondrial (COI) and nuclear molecular markers (Rhodopsin) were employed to redescribe *Garra elegans* from the lower Tigris River in Iraq⁵⁸. The new species *Eidiuemacheilus proudlovei* was described from subterranean waters in the Little Zab River in northern Iraq using DNA barcode⁵⁹. The RAPD-DNA markers were used to study genetic diversity between the different common carp populations from Dukan and Darbandikhan Lakes in Sulaimani province, northern Iraq⁶⁰. *Carassius auratus*, *L. kersin*, and *S. triostegus* were identified within Greater Zab River, northern Iraq by using the PCR-sequencing method²⁶. The molecular genetic status of *Aphanius stoliczkanus* was redescribed from Arabian Gulf region using mitochondrial DNA *COI* gene⁶¹. The taxonomic status of five nominal species of cyprinid fishes was studied from the Middle East by applying morphological and molecular (COI) characters. The *Alburnus mossulensis* was explained as a synonym of *Alburnus sella*⁶⁷. The mitochondrial DNA cytochrome c oxidase subunit I (mtDNA COI) locus 625 bp and 61 cytochrome b (cytb) gene 521 bp was used to identify two fishes *Capoeta trutta*, and *L. abu* (= *Planiliza abu*) in Sulaimani province, northern Iraq⁶². Based on using RAPD markers two tilapia species *Coptodon zillii*, and *Oreochromis aureus* was recognized from the Euphrates River at Governorate of Al-Muthanna⁶³. By using morphological and molecular characters studies, the family Aphaniidae reviewed and recognized eight genera, including two new genera *Esmaeilius* and *Apricaphanius*; *Aphanius mesopotamicus* and *A. sophiae* transferred to genus *Esmaeilius* and the latter species considered valid, while *A. mesopotamicus* treated as synonym of *E. sophiae*⁶⁴. Three species of tilapia, *Coptodon zillii*, *O. aureus*, and *O. niloticus* were examined using randomly amplified polymorphic DNA (RAPD) from the Shatt Al-Arab River⁶⁵. The cytochrome c oxidase subunit I (COI) gene was used to study genetic structure of *Carasobarbus kosswigi*, *C. trutta*, *C. macrostomum*, *L. barbulus*, *Garra rufa*, *Acanthobrama marmid*, *Alburnus mossulensis*, *Chondrostoma kinzלבachi*, *Leuciscus vorax*, *Squalius cephalus*, *Arabibarbus grypus*, *Carasobarbus luteus*, and *Capoeta damascina* from Greater Zab River, Iraq⁶⁶. *Glyptothorax kurdistanicus*, *G. cous*, and *G. daemon* were recognized using mitochondrial DNA COI gene from Euphrates and Tigris drainages, *G. daemon* is described as new species⁴¹. The evaluation of the genotype of *Barbus luteus* (= *C. luteus*) was studied from the governorates of Basrah and Dhi Qar, based on the ISSR-PCR Technique⁶⁷. The mtDNA *cytochrome-b* gene was used as a molecular marker for detecting genetic diversity, origin, and divergence of the Hilsa shad *Tenulosa ilisha* population within the Shatt Al-Arab River⁶⁸. The genetic structure of three *Capoeta* species (*C. trutta*, *C. damascina*, and *C. umbla*) were studied using the mitochondrial cytochrome oxidase I (COI) gene in the Greater Zab River of the Kurdistan Region- Iraq⁶⁹.

Conclusions

The current study reviewed freshwater fishes in Iraq and is an essential reference for all researchers and authors who plan to study this field more comprehensively. Our study revealed that in the 12 years, incredibly alien fish fauna was introduced and recorded, and the generic or familiar status of some native fishes has been revised. A total of 53 native freshwater species belonging to 18 families and eight orders, in addition to 20 exotic (alien and introduced) fishes belonging to 13 families and eight orders, were recorded in Iraq until the beginning of 2023. This research will be the keystone for other studies in various taxonomic, parasitological and ecological fields, and it will facilitate others to obtain these sources that were scattered in several journals and also help them to study other aspects that were not previously studied, such as selecting new genes that were not studied on Iraqi fish.

Conflicts of Interest

The authors declare no conflict of interest.

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Fish species	Family	Order
<i>Alburnoides diclensis</i>	Cyprinidae	Cypriniformes
<i>Alburnoides caeruleus</i>	Leuciscidae	Cypriniformes
<i>Alburnoides velioglui</i>	Leuciscidae	Cypriniformes
<i>Barbus lacerta</i>	Cyprinidae	Cypriniformes
<i>Barilius mesopotamicus</i>	Danionidae	Cypriniformes
<i>Caecocypris basimi</i>	Cyprinidae	Cypriniformes
<i>Carasobarbus sublimus</i>	Cyprinidae	Cypriniformes
<i>Cyprinion kais</i>	Cyprinidae	Cypriniformes
<i>Garra widdowsoni</i>	Cyprinidae	Cypriniformes
<i>G. variabilis</i>	Cyprinidae	Cypriniformes
<i>G. holbrooki</i>	Poeciliidae	Cyprinodontiformes
<i>Glyptothorax steindachneri</i>	Sisorida	Siluriformes
<i>Luciobarbus subquincunciatus</i>	Cyprinidae	Cypriniformes
<i>Mystus peluisus</i>	Bagrifidae	Siluriformes
<i>Mastacembelus mastacembelus</i>	Mastacembelidae	Synbranchiformes
<i>Oxynoemacheilus chomanicus</i>	Nemacheilidae	Cypriniformes
<i>O. euphraticus</i>	Nemacheilidae	Cypriniformes
<i>O. frenatus</i>	Nemacheilidae	Cypriniformes
<i>O. gyndes</i>	Nemacheilidae	Cypriniformes
<i>O. hanae</i>	Nemacheilidae	Cypriniformes
<i>O. kurdistanicus</i>	Nemacheilidae	Cypriniformes
<i>O. zarzianus</i>	Nemacheilidae	Cypriniformes
<i>Paracobitis movie</i>	Nemacheilidae	Cypriniformes
<i>Paracobitis zabgawraensis</i>	Nemacheilidae	Cypriniformes
<i>Paraphanius mento</i>	Aphaniidae	Cyprinodontiformes
<i>Silurus glanis</i>	Siluridae	Siluriformes
<i>Clarias gariepinus</i>	Clariidae	Siluriformes
<i>Squalius break</i>	Leuciscidae	Cypriniformes
<i>Squalius lepidus</i>	Leuciscidae	Cypriniformes
<i>Turcinoemacheilus kosswigi</i>	Nemacheilidae	Cypriniformes

Table 3. The fish species that have not been studied genetically yet in Iraq.

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Fish species	Method	Family	Reference
<i>Luciobarbus kersin</i> <i>Barbus grypus</i> (=A. grypus) <i>B. sharpeyi</i> (=M. sharpeyi) <i>B. luteus</i> (=C. luteus) <i>B. xanthopterus</i> (L. xanthopterus) <i>Cyprinus carpio</i> <i>Aspius vorax</i> (=Leuciscus vorax)	Randomly Amplified Polymorphic DNA (RAPD)	Cyprinidae Leuciscidae	Faddagh <i>et al.</i> ⁵²
<i>B. xanthopterus</i> (L. xanthopterus) <i>B. kersin</i> , (L. kersin) <i>B. barbustus</i> (L. barbustus) <i>B. grypus</i> (A. grypus) <i>B. sharpely</i> (M. shrpeyi) <i>B. luteus</i> (C. luteus) <i>C. carpio</i>	Mitochondrial 16S rRNA gene	Cyprinidae	Faddagh <i>et al.</i> ⁵⁴
<i>B. xanthopterus</i> (L. xanthopterus) <i>B. kersin</i> , (L. kersin) <i>B. barbustus</i> (L. barbustus) <i>B. grypus</i> (A. grypus) <i>B. sharpely</i> (M. shrpeyi) <i>B. luteus</i> (C. luteus)	PCR-RAPD	Cyprinidae	Faddagh ⁵⁵
<i>Barbus grypus</i> (=A. grypus) <i>Carasobarbus luteus</i> <i>Carassius carassius</i> <i>Capoeta trutta</i> <i>Cyprinus carpio</i> <i>Cyprinion macrostomum</i> <i>L. esocinus</i> <i>L. xanthopterus</i> <i>Chondrostoma regium</i>	DNA barcode	Cyprinidae Leuciscidae	Aziz ⁵⁶
<i>L. xanthopterus</i>	PCR-RAPD	Cyprinidae	Faddagh ⁵⁷
<i>Garra elegans</i>	Mitochondrial DNA <i>COI</i> gene	Cyprinidae	Freyhof ⁵⁸
<i>Eidiuemacheilus proudlovei</i>	DNA barcode	Nemacheilidae	Freyhof <i>et al.</i> ⁵⁹
<i>Cyprinus carpio</i>	RAPD-DNA markers	Cyprinidae	Abdulrahman <i>et al.</i> ⁶⁰
<i>Carassius auratus</i> <i>L. kersin</i> <i>Silurus triostegus</i>	PCR-sequencing method	Cyprinidae Siluridae	Agha ²⁶
<i>Aphanius stoliczkanus</i>	Mitochondrial DNA <i>COI</i> gene	<u>Aphaniidae</u>	Freyhof <i>et al.</i> ⁶¹
<i>Alburnus sellal</i>	Mitochondrial DNA <i>COI</i> gene	Leuciscidae	Mohammadian-Kalat <i>et al.</i> ²⁷

Table 4. Molecular studies of some freshwater fish species in Iraq.

<i>C. trutta</i> <i>Planiliza abu</i>	Mitochondrial DNA COI gene & cytochrome b (<i>cytb</i>) gene	Cyprinidae Mugilidae	Ali and Abdullah 62
<i>Coptodon zillii</i>	RAPD markers	Cichlidae	Al- Khafaji et al. 63
<i>Oreochromis aureus</i> <i>Esmaeilius sophiae</i>	Molecular studies	Aphaniidae	Freyhof and Yoğurtcuoğlu, 64
<i>C. zillii</i> <i>O. aureus</i> <i>O. niloticus</i>	RAPD markers	Cichlidae	Faddagh et al. 65
<i>Carasobarbus kosswigi</i> <i>C. trutta</i> <i>Cyprinion macrostomum</i> <i>L. barbustus</i> <i>Garra rufa</i> <i>Arabibarbus grypus</i> <i>Carasobarbus luteus</i> <i>Capoeta damascina</i> <i>Acanthobrama marmid</i> <i>Alburnus mossulensis</i> <i>Chondrostoma kinzelbachi</i> <i>Leuciscus vorax</i> <i>Squalius cephalus</i>	DNA barcode	Cyprinidae Leuciscidae	Agha 66
<i>Glyptothorax kurdistanicus</i> <i>G. cous</i> <i>Glyptothorax daemon</i>	Mitochondrial DNA COI gene	Sisoridae	Freyhof et al. 41
<i>Barbus luteus</i> (= <i>C. luteus</i>)	ISSR-PCR Technique	Cyprinidae	Alomairi et al. 67
<i>Tenualosa ilisha</i>	Cytochrome b (<i>cytb</i>) gene	Dorosomatidae	Abdullah et al. 68
<i>Capoeta trutta</i> , <i>C. damascina</i> , and <i>C. umbra</i>	Mitochondrial DNA COI gene	Cyprinidae	Agha et al. 69

Table 4. Molecular studies of some freshwater fish species in Iraq.

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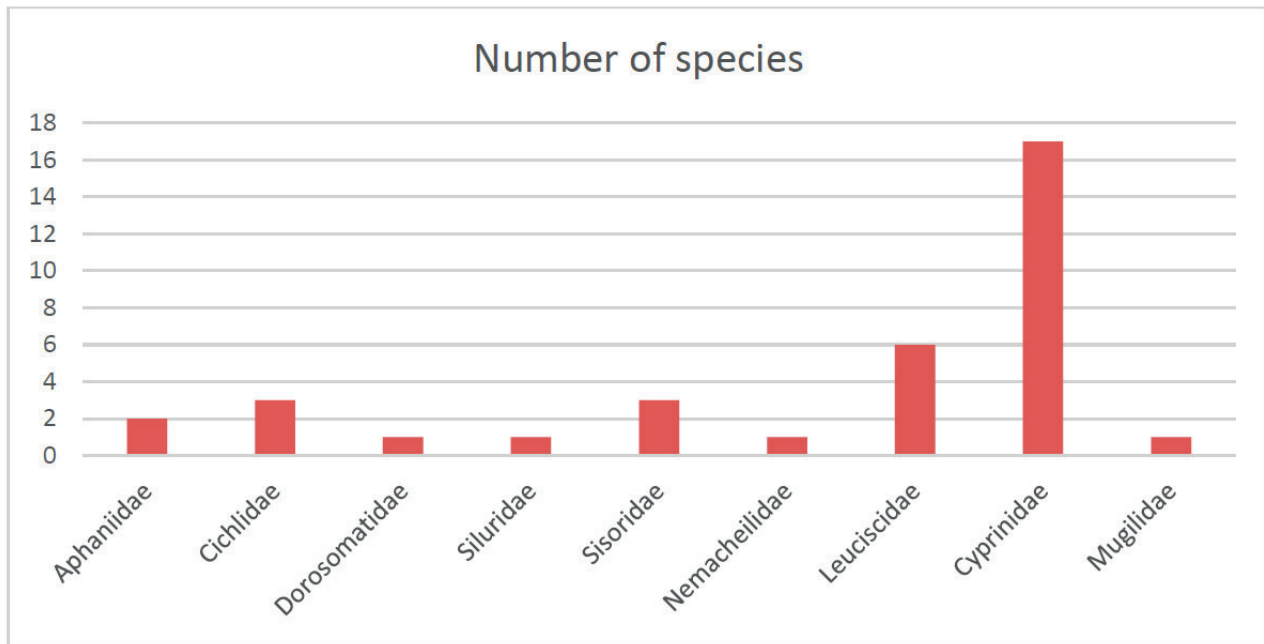


Figure 2. Number of species in each fish family in molecular taxonomical studies in Iraq.

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