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THE FISH FAUNA OF THE INLAND WATERS OF THE LOWER KABYLIE (BEJAIA, NORTHERN ALGERIA): DIVERSITY AND SPATIAL DISTRIBUTION

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Abstract: The study of species composition of the fish fauna of inland waters in the region of the lower Kabylie (Bejaia, northern Algeria), has permitted us to make out an inventory of 19 fishes species belonging to 15 genera and 9 families. The *Mugilidae* and the *Cyprinidae* are the most represented with 5 species each. Among the fish fauna, 16 are indigenous and 3 are introduced. With its 19 species, the region of the lower Kabylie is home to nearly 40 % of the Algerian inland waters fish fauna estimated at 48 species and 15 families. The spatial distribution of fish communities in different water courses has shown that it is the Soummam River which has the highest species richness with 16 species of which 15 species are inventoried only at its mouth. This study has allowed us to locate river blenny *Salaria fluviatilis* only in the eastern part of the lower Kabylie region in the Djemaa River, Aguerioune River and its tributaries. While able of the calle *Pseudophoxinus callensis* is confined only at the Soummam River and its major tributaries namely: Boussellam, Oued Ghir and Sahel. In addition, this distribution also shows the presence in all the rivers of the European eel *Anguilla anguilla* and the barbel *Barbus callensis* with an occurrence frequency of 100 % for each species.

Key words: Inventory, fish species, river, Specific richness. Lower Kabylie.

INTRODUCTION

In recent years, the fish fauna of inland aquatic ecosystems has attracted the interest of scientists and naturalists in some African countries (Lalèyè *et al.*, 2004). Indeed, many studies have been undertaken in this direction, and the current state of knowledge on the fish of certain regions is relatively advanced (Wamuini *et al.*, 2010). This is particularly the case in West Africa (Paugy *et al.*, 2003a, 2003b), in lower Guinea (Stiassny *et al.*, 2007a, 2007b), and in South Africa (Skelton, 2004).

For the region of North Africa in general and the Maghreb in particular, the work of Pellegrin (1921) is still an important reference, and other work on the systematic and phylogeny of various groups of fishes, including *Cyprinidae* have been published since then, but a synthesis of this work is needed (Doadrio, 1994). In general, the Maghreb has a very poor freshwater fish fauna, having little affinity with tropical fauna and composed mainly of *Cyprinidae* (Roberts, 1975; Doadrio, 1994; Lévêque, 1997; Lévêque *et al.*, 2008). However, this region plays a very important role in the speciation and dispersal of freshwater fishes (Doadrio, 1994). In addition, it has received many introduced species (Kara, 2011).

In North Africa, we distinguish three biogeographical zones: The Atlantic area in the north-west, characterized by the presence of *Cyprinidae* such *Labeobarbus*, *Varicorhinus* and *Cobitidae*; the Mediterranean area characterized by the *Cyprinidae Barbus* and *Pseudophoxinus* and finally the tropical zone to the east, and including the Sahara, where *Cichlidae* and *Clariidae* are encountered (Pellegrin, 1921; Lévêque and Paugy, 2006).

Studies on the fish fauna of the inland waters of north Africa in general and Algeria in particular are not common, are often scattered and incomplete, most are old and have focused on systematic, e.g., Cuvier and Valenciennes (1842), Playfair and Letourneux (1871), Boulenger (1911) and Cauvet (1913, 1915).

Since the publication of the monograph of Pellegrin (1921) on the North African freshwater fish fauna, little work has been published such those of Kraiem (1983, 1991) in Tunisia and Azeroual et *al.* (2000) in Morocco. In Algeria, we can mention the work of Dieuzeide (1927.1932) ; Dieuzeide and Champagne (1950); Dieuzeide and Roland (1951), Bouton (1957); Almaça (1969, 1970, 1990); Dumont (1981); Arab (1989); Le Berre (1989); Bouhaddad (1993); Bouhaddad and Asselah (1998); Doadrio (1994); Doadrio *et al.* (1998) on the barbels; Zouakh *et al.* (2004) on the fishes of the Hoggar and Tassili; Chaoui *et al.* (2006) on the fishes of the lagoon of El Mellah; Bacha and Amara (2007) on the fish fauna of the Soummam River; Tandjir and Djebar (2010) on the fish fauna of Kébir River; Kara (2011), and finally Chaibi *et al.* (2012) on the exotic fish fauna of eastern Algeria.

In the region of the lower Kabylie, except Bacha and Amara (2007) who conducted an inventory of the fish fauna of the Soummam River and its tributaries, and Djoudad-Kadji *et al.* (2012) who worked on the barbel reproduction in Soummam River, no study dealing with freshwater fish of the entire region of the lower Kabylie is worth mentioning. This study updates and completes data on the fish fauna of the region. The study also establishes a fish map that will serve for possible interventions of piscicultural laying out in the region, and assess the specific richness in different streams of the region from the perspectives of conservation, laying out and bio-surveillance.

MATERIAL AND METHODS

Study area

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The present study was carried out in the region of the lower Kabylie best known as little Kabylie. It belongs to the department of Bejaia. It is a coastal region that extends over an area of some 3261 km^2 which is among the largest coastal regions of central eastern Algeria between the big massifs of Djurdjura, the Bibans and the Babor. It is located between the latitudes 36 ° 15' and 36° 55' north and the longitudes 4° 20' and 5 ° 30' east. It opens onto the Mediterranean Sea on a coastline of over 100 kms. It is bounded on the east by the department of Jijel, on the west by the departments of Tizi-Ouzou and Bouira, on the south by the departments Sétif and Bordj Bouareridj, on the north by the Mediterranean Sea (Anonyme, 1980).

The region of the lower kabylie has a dense hydrographic network consisting of several rivers and streams; the main ones are: Aguerioune; Zitouna; Djemaa; Amacine; Boussellam; Sahel; Oued Dass; Acif El Hammam and the Soummam (Fig.1). The latter is one of the largest rivers in Algeria; it is as a collector of several other small rivers. This river is the result of the junction in the valley of Akbou of two equally important rivers which are: Boussellam River from the department of Setif and Sahel River from the department of Bouira. It runs through the entire valley of the Soummam on about 90 kms, draining a watershed of some 9125 km^2 and opens in the Mediterranean Sea at the city of Bejaia (Bennabi 1985; Benhamiche, 1997). Note that the Soummam River is classified as a wetland of international importance under the Ramsar convention (Ramsar, 2012).

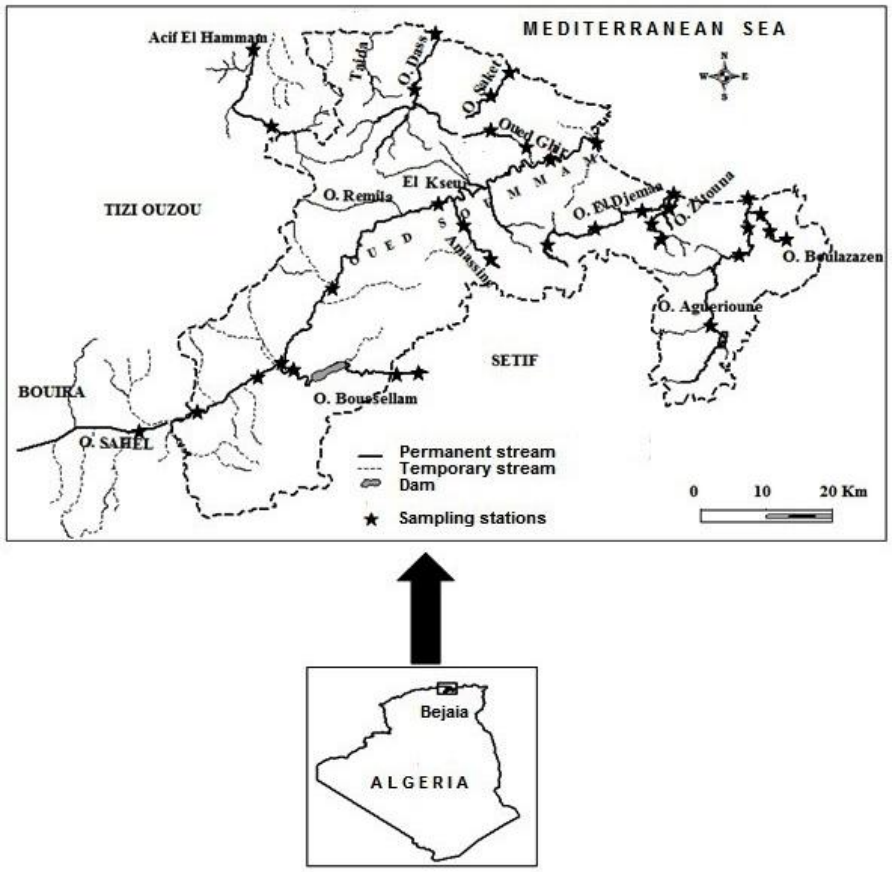

Fig. 1. Map of Location, hydrographic network and sampling stations in lower Kabylie.

Sampling protocol

During the period from April 2010 to June 2013, we surveyed almost all the watercourses including small streams in the region of the lower Kabylie. Sampling was conducted at 35 stations in 12 rivers which are: Aguerioune, Boulezzazen, Zitouna, Djemaa, Soummam, Oued Ghir, Amacin , Boussellam, Sahel, Oued Dass, Acif El Hammam (Figure1 and Table 1).

Table 1

Stations sampling of fish in different rivers and Water courses of lower Kabylie

Water courses (river)	Sampling stations
Aguerioune	Mouth of Aguerioune , Tizi el oued, Ait Annane, Gorges of Kherrata
Boulezazzen	Ighzer Zentouth , Ighzer Rha ,Tharemante
Zitouna	Tivizelt, Ighil Yesli
Djemaa	Ait Abbas, Sefah , Boukhlifa, Bakaro
Soummam	Mouth of soummam , Oumllil , Timezrit, Ighzer Amokrane , Akbou
Oued Ghir	Boubecha, Larbaa

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Amaçine	Bridge of Feraoun , Red bridge
Boussellam	Aguemoune Lemleh, Ait Mouhli, Bouhamza, Boumessaoud
Sahel	Bridge of Ahnif , Boudjellil, Tazmalt
Saket	Mouth of saket, Bridge of saket
Oued Dass	Mouth of oued dass, Ighzer Lehbal
Acif el hammam	Mouth of Sidi Khlifa, Hriz

The choice of the stations is dictated primarily by the conditions of accessibility and human disturbance; indeed, given the greater sensitivity of most fish's species, we opted for stations with relatively easy access, and are far from towns and houses, and this for minimizing the maximum disturbances that may arise from human activities. The fishes sampling took place almost throughout the year in all the stations, except mouths where fishing took place only in summer due to the difficulties encountered in winter (volume, current and turbidity). In order to get a fairly comprehensive ichthyological inventory we used different techniques and different fishing devices, depending on the water depth and habitat types. Among this panoply of devices include among others:

Fishing traps: used in relatively deep water (greater than 0.5 meters of depth). The traps are fishing devices of depth fish consisting of conical pockets endowed with a funnel-shaped entrance. The latter are placed at the bottom of rivers in areas where the waters are calm. Fish enter the trap through the funnel, attracted by pre-filed bait (a worm). The traps are laid in the evening and retrieved the next morning. Fish caught are removed through an opening provided for this purpose.

Dormant net fishing: For water streams of more than 50 cm, we used a homemade battery of gillnets of different meshes and size. Nets of 10, 20, 30 and 40 mm mesh are between 10 and 30 meters long for a drop height of 2 meters. These are monofilament nets with floats mounted on the top rope and shot at the footrope. A trammel of 50 meters in length and a drop height of 2 meters was also particularly used at river mouths. The different nets are set during the day, and raised the next morning. To access quite deep stations, including the mouths, we used a barque. For each control, the nets are thoroughly cleaned to prevent debris accumulating which may indicate the presence of a barrier to the fish, limiting the fishing power or efficiency of these devices.

Sparrow hawk net: This technique used in shallow areas water columns lower than 0.5 meters. The Sparrow hawk is a net of conical shape, roughly circular when it is spread on which weights (consisting of lead) are attached to the rear edge. A throwing rope placed at its upper edge corresponding to the center allows up to launch it then remove it from the water. A system of additional mesh allows to create a pouch around the perimeter of the net in which fish will be imprisoned. Fishing takes place during the day from the shore, in shallow areas. Sometimes the hawk is combined with dormant nets. This is a technique occasionally used in some waterways. It involves isolating a portion of the river (10 - 30 m long) by two nets and agitating the water while hitting the surface and the deep water in order to herd fish into the net. At the same time, we launched the hawk in different places of the isolated portion. This technique is practiced in times of low waters.

In addition to these different fishing devices mentioned, we have exploited and regularly utilized specimens of fish caught by artisanal fishermen and residents. Once captured by the different fishing techniques used, the fish are identified on site then released; on the contrary, the dead individuals are brought back to the laboratory for confirmation of identification then preserved and collectioned in formalin at 10%.

To analyze the structure of fish populations, a qualitative study was carried out. For this, we have chosen to study the diversity and indices of structure (specific richness and occurrence frequency). The occurrence frequency FO permit to characterize the presence of a species in a medium (Dajoz, 1985). They inform us about the species characteristic of a site, and are calculated using the following formula:

$FO = E_i / E_t$. E_i is the number of samples where the taxon i is present, E_t is the total number of samples. According to Parlier (2006), the presence of a taxon is considered as frequent when $FO \geq 75$ %, common when $75\ \% > FO \geq 50$ %, occasional when $50\ \% > FO \geq 25$ %, rare when $25\ \% > FO \geq 10$ % and accidental when $FO < 10$ %.

In addition to various indices, for more information on function, hierarchical structure and connectivity in different ecological systems fish species were grouped into ecological categories or ecological guilds which has become an important tool in providing a better understanding of the structure and operation of fish assemblages and that take into account the characteristics of their bio-ecological cycle (Elliott *et al.* 2007, Noble *et al.* 2007, Franco et al. 2008a, Mathieson *et al.* 2000).

To compare the diversity of different rivers we opted for the Kruskal – Wallis test. To measure the similarity between different streams taken two by two, we used the Sorensen similarity index that measures the similarity between two communities (Sorensen, 1948). This index is calculated from the number of common species between each two areas, according to the following formula: $S = 2c / A+B$, where: A is total number of species of area 1, B is total number of species in the area 2, C is total number of common species between the two areas.

Finally for a schematic view of the structure and assembly of the fishes, a factorial correspondence analysis (AFC) was performed using data in the

presence / absence with Microsoft Office 2010 software XLStat.

RESULTS

Specific diversity of the fish fauna of the inland waters of the lower Kabylie

The ichtyological populations inventoried at various sampling campaigns in the rivers and streams of the region of the lower Kabylie is represented by 19 species belonging to 15 genera and 9 families, with a predominance of *Mugilidae* and *Cyprinidae* with 5 species each, followed by *Clupeidae* and *Moronidae* with 2 species each .As for other families, they are represented by one species only. Among the fish fauna, 16 species are indigenous and 3 are introduced, they are: *Cyprinus carpio*, *Rutilus rutilus* and *Alburnus alburnus*

Concerning ecological guilds, Catadromous /anadromous migrants species (CA) are the most represented with 8 species, followed by Freshwater adventitious visitors' species (FW) with 6 species. As for Marines juvenile migrants' species (MJ) and Estuarine resident species (ER), there are represented only by two and one species respectively (Tab.2).

Occurrence frequency

As regards the occurrence of species in different streams studied, we note the presence of two (2) frequent species. These are *Barbus callensis* and *Anguilla anguilla*. Two (2) other species are considered as common: *Mugil cephalus* and *Atherina boyeri*. Seven (7) species are occasional, following the example of *Liza ramada* and *Pseudophoxinus callensis*., and the Eight (8) remaining are accidental species such, *Alburnus alburnus* , and *Dicentrarchus labrax* (Table 2).

Table 2

Inventory and occurrence of fish fauna in the different rivers of the lower Kabylie

				Rivers and waterways													
Family	**Species**	**Ecological guild**	**IUCN Red List Status**	**Agr**	**Bol**	**Zit**	**Djm**	**Som**	**Ghi**	**Amç**	**Bos**	**Sah**	**Sak**	**Das**	**Alh**	**Rate of occurrence**	**Status**
Cyprinidés	*Barbus callensis*	FW	LC	+	+	+	+	+	+	+	+	+	+	+	+	100 %	F
	Pseudophoxinus callensis	FW	DD	-	-	-	-	+	+	-	+	+	-	-	-	33,33 %	O
	*Cyprinus carpio**	FW	VU	+	-	-	-	+	-	-	+	+	-	-	-	33,33 %	O
	*Rutilus rutilus**	FW	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A
	*Alburnus alburnus**	FW	LC	+	-	-	-	-	-	-	-	-	-	-	-	8,33 %	A
Mugilidés	*Mugil cephalus*	CA	LC	+	-	-	+	+	+	-	-	-	+	+	+	58,33 %	C
	Chelon labrosus	CA	LC	+	-	-	-	+	-	-	-	-	-	-	+	25 ,00 %	O
	Liza saliens	MA	LC	+	-	-	-	+	-	-	-	-	-	+	+	33,33 %	O
	Liza aurata	CA	LC	+	-	-	-	+	-	-	-	-	-	+	+	33,33 %	O
	Liza ramada	CA	LC	+	-	-	+	+	-	-	-	-	-	+	+	41,66 %	O
Clupéidés	*Alosa fallax*	CA	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A
	Alosa alosa	CA	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A
Anguillidés	*Anguilla anguilla*	CA	CR	+	+	+	+	+	+	+	+	+	+	+	+	100 %	F
Atherinidés	*Atherina boyeri*	ER	LC	+	+	+	+	-	-	-	-	-	+	+	+	58,33 %	C
Carangidés	*Trachinotus ovatus*	MA	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A
Moronidés	*Dicentrarchus labrax*	MJ	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A
	Dicentrarchus punctatus	MJ	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A
Blenniidés	*Salaria fluviatilis*	FW	LC	+	+	-	+	-	-	-	-	-	-	-	-	25 ,00 %	O
Petromyzontidés	*Petromyzon marinus*	CA	LC	-	-	-	-	+	-	-	-	-	-	-	-	8,33 %	A

*: Introduced species; FW: freshwater adventitious visitors species; CA: catadromous / anadromous migrants species; ER: estuarine residents species; MA: marine Adventitious visitors species; MJ: Marines juvenile migrants species; LC: Least Concern; DD: Data Deficient; VU: Vulnerable; CR: Critically Endangered; - : Absent; +: Present; F : Frequent; C : Common; O : Occasional ; A : Accidental; Agr :Agrioune; Bol : Boulezzazen; Zit : Zitouna; Djm : Djemaa; Som : Soummam; Ghi: Oued Ghir; Amç: Amacine; Bos: Boussellam; Sah: Sahel; Sak: Saket; Das: Oued Dass; Alh: Acif El Hammam

Specific richness and spatial distribution of fish fauna in the region of the lower Kabylie

Specific richness varies from a stream to another. We see that it is the Soummam River which has the highest species richness with 16 species of which 15 species are captured only at the mouth. It should be noted that all representatives of the *Mugilidae* family are present in this stream. Aguerioune and Acif El Hammam, follow with 11 and 8 species respectively. In contrast, it is the Amacine River that is least diversified with 2 species only

The distribution of fish in the water course of the lower Kabylie shows the omnipresence of the European eel *Anguilla anguilla* and the barbell *Barbus callensis* in all the sampled stations. Furthermore, this study allows us to locate the river blenny *Salaria fluviatilis* only in the eastern part of the region of the lower Kabylie, either at Djemaa River, Aguerioune River and Boulezzazen River. Some specimens of this species are even captured outside the study area in the neighboring department of Jijel at Dar El Oued River. We also note that the able of the calle *Pseudophoxinus callensis* is confined at the Soummam River and its major tributaries namely Boussellam, Sahel and Oued Ghir only (Figure 2). The different values of species richness in different streams submitted to the Kruskal-Wallis test led to a significant difference (p = 0.05).

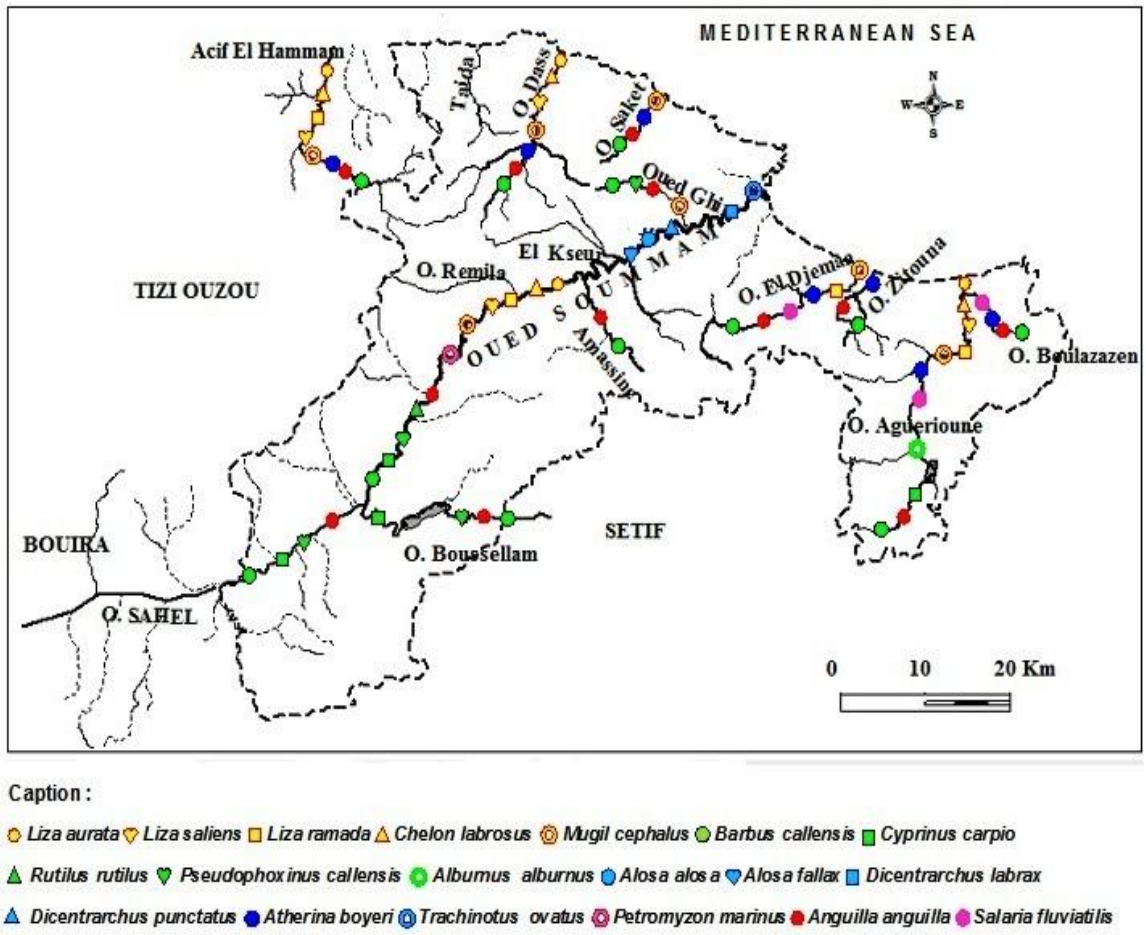

Fig. 2. Map of the spatial distribution of the fish fauna in the inland waters of lower Kabylie.

Similarity between different streams

Sorensen similarity calculated between the different streams is relatively high. They vary between 20 % and 100 %, with an average of 60 %. The strongest similarity were observed between Boussellam and Sahel (100 %) and between Oued Dass and Acif El Hammam (93.33 %). While the lowest values were recorded between Soummam and Boulezazzen (20 %), and between Soummam and Zitouna (21.05 %) (Table 3).

Table 3

Sorensen similarity index applied to different streams of the lower Kabylie

	Agr	Bol	Zit	Djm	Som	Ghir	Amç	Bos	Sah	Sak	Das
Bol	53,33										
Zit	42,85	85,71									
Djm	70,58	80,00	66,66								
Som	59,25	**20,00**	**21,05**	36,36							
Ghi	40,00	50,00	57,14	60,00	40,00						

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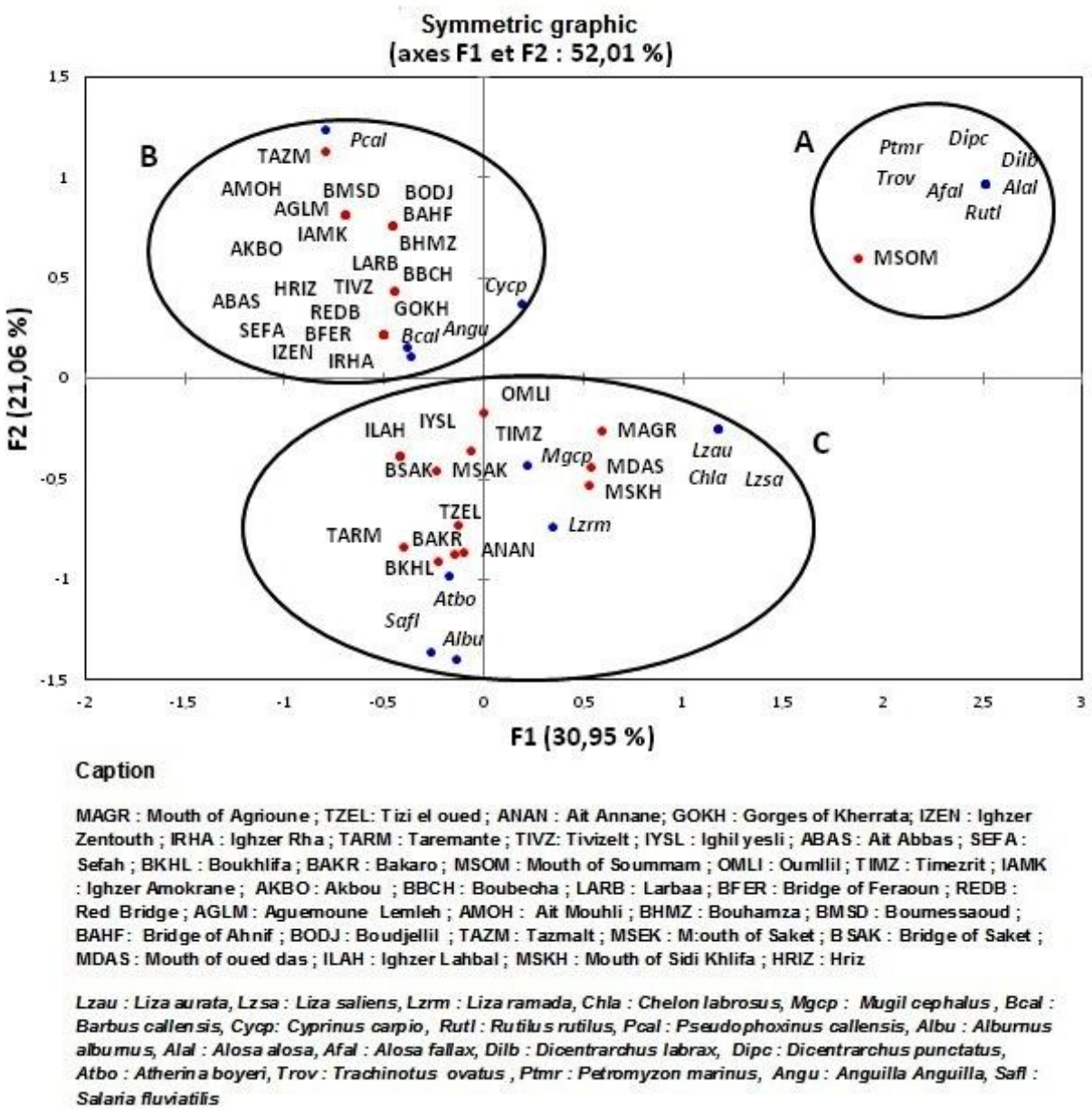
Amç	30,76	66,66	80,00	50,00	22,22	66,66					
Bos	40,00	50,00	57,14	40,00	40,00	75,00	66,66				
Sah	40,00	50,00	57,14	40,00	40,00	75,00	66,66	**100**			
Sak	53,33	75,00	85,14	80,00	30,00	75,00	66,66	50,00	50,00		
Das	77,77	54,54	60,00	76,92	63,63	54,54	44,44	36,36	36,36	72,72	
Alh	84,21	50,00	54,54	71,42	58,33	50,00	40,00	33,33	33,33	66,66	**93,33**

Agr : Aguerioune, Bol : Boulezazen, Zit : Zitouna ; Djm : Djemaa, Som : Soummam, Ghi : Oued Ghir, Amç : Amaçine , Bos: Boussellam , Sah: Sahel , Sak: Saket , Das: Oued Das, Alh: Acif el Hammam

Factorial correspondance analysis (A.F.C)

To get a comprehensive idea about the structuring and the assemblages of the fish populations, we conducted a correspondence analysis (AFC) from the data in the presence / absence. This structuring allowed us to highlight some of the mechanisms determining the spatial distribution of fishes species sampled in different stations. On the factorial map formed by the axis 1 and 2 providing 52.01% of the total inertia; three groups are individualized significantly. The first group consists essentially of the species that frequent the mouth of the Soummam River (A). The second group is composed by species that frequent the stations upstream of rivers (B). Finally the last group consists of species that frequent downstream stations and the mouths of these rivers (C) (Figure 3).

The results obtained by the AFC highlight fish's populations' characteristics of each environment. Salinity gradient is defined by the axis 1 appears to separate brackish water stands, formed by mouths of different watercourses and those of freshwater represented by the stations upstream. Furthermore, a hydrological gradient is defined by the axis 2 which separates stands characteristics of stations of mountain torrents, relatively elevated slope, high flow velocities, low flow and partial low water levels especially in summer and autumn and the stands characteristics especially of the mouths and of lowland stations so low slope and strong flows and relatively low flow velocities.



Caption

MAGR : Mouth of Agrioune ; TZEL: Tizi el oued ; ANAN : Ait Annane; GOKH : Gorges of Kherrata; IZEN : Ighzer Zentouth ; IRHA : Ighzer Rha ; TARM : Taremante ; TIVZ: Tivizelt ; IYSL : Ighil yesli ; ABAS : Ait Abbas ; SEFA : Sefah ; BKHL : Boukhlifa ; BAKR : Bakaro ; MSOM : Mouth of Soummam ; OMLI : Oumllil ; TIMZ : Timezrit ; IAMK : Ighzer Amokrane ; AKBO : Akbou ; BBCH : Boubecha ; LARB : Larbaa ; BFER : Bridge of Feraoun ; REDB : Red Bridge ; AGLM : Aguemoune Lemleh ; AMOH : Ait Mouhli ; BHMZ : Bouhamza ; BMSD : Boumessaoud ; BAHF : Bridge of Ahnif ; BODJ : Boudjellil ; TAZM : Tazmalt ; MSEK : M:outh of Saket ; B SAK : Bridge of Saket ; MDAS : Mouth of oued das ; ILAH : Ighzer Lahbal ; MSKH : Mouth of Sidi Khlifa ; HRIZ : Hriz

Lzau : Liza aurata, Lzsa : Liza saliens, Lzrm : Liza ramada, Chla : Chelon labrosus, Mgcp : Mugil cephalus , Bcal : Barbus callensis, Cycp: Cyprinus carpio, Rutl : Rutilus rutilus, Pcal : Pseudophoxinus callensis, Albu : Alburnus albumus, Alal : Alosa alosa, Afal : Alosa fallax, Dilb : Dicentrarchus labrax, Dipc : Dicentrarchus punctatus, Atbo : Atherina boyeri, Trov : Trachinotus ovatus , Ptmr : Petromyzon marinus, Angu : Anguilla Anguilla, Safl : Salaria fluviatilis

Fig. 3. Factorial map distribution of the fish fauna in the inland waters of lower Kabylie.

DISCUSSION

The different campaigns of prospecting and sampling carried out in the region of lower Kabylie allowed us to develop a qualitative inventory and a spatial distribution of fish fauna of inland waters in the various waterways and streams. This region has a sizeable potential of marine, estuarine and freshwater fish species with the predominance of *Mugilidae* and *Cyprinidae*. Among the fish fauna, two species are endemic to North Africa; these are *Barbus callensis* and *Pseudophoxinus callensis*. Three species are introduced, including two accidentally they are: *Rutilus rutilus* and *Alburnus alburnus* (Kara, 2011).

The fish communities of the lower Kabylie represent nearly 40 % of the Algerian inland waters fish fauna estimated at 48 species and 15 families. Among these species, 21 are indigenous and 27 are introduced (Kara, 2011). Furthermore, most of these families, or 60 % are represented in our study area.

Our results seem similar to those obtained by Bacha and Amara (2007) who studied the Soummam River and its tributaries, and inventoried 19 species and 11 families. However, they reported finding *Gambusia holbrooki*, *Pseudorasbora parva* and *Salaria fluviatilis* which have not been found at the river or in one of its tributaries in this study. Also, we caught fish's species that are not reported by these authors as *Alosa alosa*, *Liza ramada* and *Rutilus rutilus*.

The fish fauna of the inland waters of the Lower Kabylie is composed essentially by freshwater species, brackish water species and some marine species belonging to 4 ecological guilds. Catadromous/anadromous migrants species (CA) are the most represented, followed by Freshwater adventitious visitors' species (FW). As for Marines

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juvenile migrants' species (MJ) and Estuarine resident species (ER), there are poorly represented

The spatial distribution of freshwater fish species in the region of the lower Kabylie varies from a stream to another and from a station to another along a longitudinal gradient characterized by lower diversity of the fish from downstream to upstream. Indeed, the downstream stations especially mouthpieces are the most diverse and this diversification decreases as one moves away upstream. This is explained by the fact that the upper waterways that correspond to upstream stations are usually torrents of mountain with steep slopes, a large flow rate and cold oligotrophic water poor in prey that support a reduced habitat range. Thus at these stations there are only the most exacting species. While the lower courses that correspond to river mouths and estuaries are large, relatively deep, rich in prey and host a wide range of potential habitats, house various ecological categories, so more species. Indeed, estuaries are nursery grounds and wintering, feeding, reproduction and growth grounds, but also are essential migration routes for diadromous fish (Lobry, 2004; Pasquaud, 2006).

According to Lévêque and Paugy (2006), specific richness is a function of habitat diversity. Environments with a wide range of habitats may harbor a greater number of species. In complex environments, specific interactions are probably less intense; they allow a better sharing of resources between competing species and provide more areas of refuge for prey species. Many authors have highlighted the existence of an increase in specific richness along a longitudinal gradient in streams reflecting diversification increasingly important habitat upstream to downstream. Thus, in upstream of rivers, we found only small species adapted to flowing water, while further downstream, the river size increases, we encounter both riffles and calm water basins, and deeper habitats allowing larger species to colonize these environments (Sydenham, 1977; Paugy and Benech, 1989; Hugueny, 1990).

Based on the results of catches during the study period, we found that it is the Soummam River which has the greatest specific richness with 16 species of which 15 species are caught only at the mouthpiece except the able of the calle *Pseudophoxinus callensis* that is captured near the mouth because it is a relatively demanding species which generally prefers shallow and rapid clear waters, with sandy or rocky bottom (Bruslé and Quignard, 2001; Muus and Dahlstrom, 2007). In addition to the Soummam River, three rivers: Aguerioune, Acif El Hammam and Oued Dass also have sizeable species richness. These rivers have relatively large mouths in direct contact with the marine waters rich in diadromous fish and other ecological guilds. On the contrary, it is the Amacine River that is least diversified with 2 species only. On the other hand, this distribution also shows the presence of the European eel *Anguilla anguilla* and the barbel *Barbus callensis* in all the sampled waterways. These are two species that occupy the entire water system of the study area. Furthermore, this study allows us to locate the river blenny *Salaria fluviatilis* only in the eastern part of the region of the lower Kabylie in the Djemaa River, Aguerioune River and Boulezzazen River, until Jijel where we captured specimens in Dar El Oued River. This species seems to delight itself in this region rich in pretty deep pits with abundant rocky cliffs and whose waters are clear and relatively cold which corresponds to suitable habitat for this species (Freeman *et al.*, 1990; Bianco, 1995; Elvira, 1995; Côté *et al.*, 1999; Bruslé & Quignard, 2001; Muus & Dahlstrom, 2007). We also found that the able of the calle *Pseudophoxinus callensis* is confined only at the Soummam River and its major tributaries namely Boussellam, Sahel and Oued Ghir.

The difference in specific richness between waterways is significant (Kruskal-Wallis test ($p = 0.05$). The waterways being responsible for this difference may be the Soummam River with a maximum of 16 species and the Amaçine River with a minimum of 2 species. Sorensen similarity indices calculated between the different watercourses remain quite high. They vary between 20% and 100%, with an average of 60 %. The strongest similarities are recorded between Boussellam River and Sahel River and between Acif El Hammam and Oued Dass. While the lowest values are recorded between the Soummam River and Zitouna River and between the Soummam River and Boulezazzen River

The factorial correspondence analysis (AFC) made from data in the presence / absence, allows to contrast on axis 1 which provided 30.95% of the information appears to separate brackish water stands, formed by mouths of different watercourses and those of freshwater represented by the stations upstream. Furthermore, a hydrological gradient is defined by the axis 2 which provided 21.06 % of the information, separates stands characteristics of stations of mountain torrents, relatively elevated slope, high flow velocities, low flow and partial low water levels especially in summer and autumn and the stands characteristics especially of the mouths and of lowland stations so low slope and strong flows and relatively low flow velocities.

CONCLUSION

The present study has allowed us to make an initial qualitative inventory and to map the spatial distribution of the fish fauna of the inland waters of the region of lower Kabylie. Indeed, the fish fauna of this region is relatively rich in species, dominated by the *Mugilidae* and the *Cyprinidae*, encompassing nearly 40 % of national Specific richness which gives it a role as a reservoir of biodiversity that deserves to be protected and integrated into management, conservation and protection plans. The current situation of the fish fauna of the inland waters of lower Kabylie is very worrying because it is threatened by climatic constraints (drought) on the one hand and anthropogenic disturbances on the other.

The present work, allows us to assess the specific richness of the fish fauna of the inland waters of the

Lower Kabylie that can provide information on the environmental status of our waterways through diversity indices which are of great importance to diagnose an aquatic ecosystem for the adoption of appropriate conservation policies. However, this study needs to be extended by additional sampling quantitatively stratified by season and in space by targeting the most recent stations and using other more appropriate sampling equipment such as electro fishing for instance. It is therefore necessary to continuously monitor the status of the fish fauna for developing appropriate measures to take in order to avoid a drastic erosion of this very fragile fish diversity.

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AUTHORS CONTRIBUTIONS

Conceptualization: Djamel AMALOU (D.A.) and Riadh MOULAÏ (R.M.); Methodology: D.A.; Data collection: D.A.; Data validation: D.A. and R.M.; Data processing: D.A.; Writing — original draft preparation: D.A.; Writing — review and editing: D.A. and R.M.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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