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TWO NEW SPECIES OF ATLANTIC TROUT (ACTINOPTERYGII, SALMONIDAE) FROM MOROCCO

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ABSTRACT

Four trout species of the genus *Salmo* Linnaeus, 1758 have been traditionally recognized in Morocco: *S. macrostigma* Duméril, 1858; *S. pallaryi* Pellegrin, 1924; *S. pellegrini* Werner, 1931 and *S. akairos* Delling & Doadrio, 2005. Two of these species are mainly distributed in Mediterranean (*S. macrostigma*) and Atlantic (*S. pellegrini*) river basins while the other two species are restricted to isolated lakes in the Atlas Mountains, one of them to Ifni Lake (*S. akairos*) and the other, probably extinct, to Sidi Ali Lake (*S. pallaryi*). Preliminary phylogenetic and regional studies based on molecular data have found high structuration of the populations of this genus in Morocco. These studies focused on allozymes, microsatellites and mitochondrial markers found genetic differences in populations from Isli Lake (Atlas Mountains) and the Draa Basin in southern Morocco. In this work we provide different morphological and genetic traits to distinguish these populations from Isli Lake and Draa Basin as two different species.

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Key words: Draa Basin; Isli Lake; Morocco; Salmonidae; New species; Taxonomy.

RESUMEN

Dos nuevas especies de truchas atlánticas (Actinopterygii, Salmonidae) de Marruecos

Cuatro especies del género *Salmo* Linnaeus, 1758 se han reconocido tradicionalmente en Marruecos: *S. macrostigma* Duméril, 1858; *S. pallaryi* Pellegrin, 1924; *S. pellegrini* Werner, 1931 y *S. akairos* Delling y Doadrio, 2005. Dos de estas especies se distribuyen por las cuencas mediterráneas (*S. macrostigma*) y atlánticas (*S. pellegrini*), mientras que las otras dos están restringidas a lagos aislados en las montañas del Atlas, una de ellas al Lago Ifni (*S. akairos*) y la otra, probablemente extinta, al Lago de Sidi Alí (*S. pallaryi*). Estudios filogenéticos preliminares y estudios regionales basados en alozimas, microsatélites y marcadores mitocondriales hallaron una alta estructuración de las poblaciones de este género en Marruecos, con diferencias genéticas significativas en las poblaciones del lago de Isli (Montañas del Atlas) y de la cuenca del Draa en el sur de Marruecos. En el presente trabajo nosotros proveemos evidencia morfológica y genética para distinguir estas poblaciones del lago de Isli y de la cuenca del Draa como dos especies diferentes.

Palabras clave: Cuenca del Draa; Lago de Isli; Marruecos; Salmonidae; nuevas especies; Taxonomía.

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Introduction

Salmonid fishes constitute a monophyletic clade that is composed of three main lineages, namely coregonins, thymallins and salmonins. These three lineages are widely spread in cold waters of the northern hemisphere (Shedko *et al*., 2013). Within salmonids, the taxonomy of trouts (*Salmo* spp.) is controversial because of their high phenotypic variation in contrast to the scarce genotypic differentiation between populations, occurring in an extensive original distribution in the mountains of Eurasia and North Africa. This disagreement between morphological and genetic studies has led to different taxonomic approaches. Molecular studies usually prefer the use of lineages within *Salmo trutta* Linnaeus, 1758 to refer to different geographical populations (Machordom *et al*., 2000; Bernatchez, 2001; Suárez *et al*., 2001; Cortey *et al*., 2004). In contrast, in recent years, morphological studies prefer to fragment *S. trutta* into different species, using the traditional morphological species concept with a phylogenetic argument based on the data provided by molecular studies (Delling, 2003; Kottelat & Freyhof, 2007).

For this reason, several species have been recently described from the periphery of distribution of genus *Salmo* around the Mediterranean region (Delling, 2010; Turan *et al*., 2010, 2011, 2012, 2014a, 2014b) and also in northern Africa, where a new dwarf species was described from Ifni Lake (*Salmo akairos* Delling & Doadrio, 2005). This latter species inhabits an isolated lake in the Atlas Mountains, presenting differences in morphological traits but scarce genetic differentiation with respect to other Atlantic lineages of *S. trutta* (Suárez *et al*., 2001; Delling & Doadrio, 2005; Snoj *et al*., 2011). Therefore, in northern Africa five species of genus *Salmo* have been described so far (*S. macrostigma* Duméril, 1858; *S. lapasseti* Zill, 1858; *S. pallaryi* Pellegrin, 1924; *S. pellegrini* Werner, 1931 and *S. akairos*). The species *S. lapasseti* from Algeria is considered to be a synonym of *S. macrostigma* (Delling & Doadrio, 2005). Therefore, four species are currently recognized in North Africa.

In contrast to other North African countries, Morocco preserves natural populations of trout and three of the four currently recognized species in North Africa are present in the country: *S. macrostigma*, *S. pellegrini* and *S. akairos*. The species *S. pallaryi* was described from Sidi Ali Lake, in the Middle Atlas Mountains (Morocco), but the autochthonous population of the lake seem to have disappeared due to the introduction of exotic species. Nevertheless, some authors consider that the population from Isli Lake could belong to *S. pallaryi* (Schöffmann, 1993; Delling, 2003).

The current taxonomy of Moroccan trout recognizes one species distributed in the Atlantic basins (*S. pellegrini*); one species from the Mediterranean basins (*S. macrostigma*); another species confined to Ifni Lake in the Souss basin (*S. akairos*) and the uncertain taxonomic position of the Isli Lake population. The main aims of this study are to clarify the taxonomic position of the Isli trout population and to characterize morphologically, for the first time, the populations from the Draa basin (located in southern Moroccan Atlas). Consequently we describe two new species of genus *Salmo* Linnaeus, 1758.

Material and Methods

The description of two new species of genus *Salmo* in Morocco was based on 35 individuals from the Dades River, Draa basin, Aït Aatou O'Moussa (31.871776, -5.738205), Morocco (Voucher numbers: MNCN 290751-290785) and 20 individuals from Isli Lake, Imilchil (32.217526, -5.548031), Morocco (Voucher numbers: MNCN 280413-280414; 281050-281067). For comparative purposes, we analysed also the different trout populations from North Africa detailed in Delling & Doadrio (2005). In addition to this material we included 18 adult individuals from the Ziz River, Ziz basin, Zaouia Sidi Hamza, (32.433030, -4.715145), Morocco (Voucher numbers: MNCN 290732-290749), 14 individuals from the Miaami Lagoon, Oum er Rbia Basin, Douar Khamlich (32.8985, -5.375966), Morocco (Voucher numbers: MNCN 280035-280045, MNCN 279000-279002), 13 individuals from Assif Melloul, Oum er Rbia Basin, Agoudal, (32.033595, -5.4694132), Morocco (Voucher numbers: MNCN 281068-281080), 8 individuals from Assif Melloul, Oum er Rbia Basin, Imilchil (32.151130, -5.619814), Morocco, (Voucher numbers: MNCN 115047-053, MNCN 115055), 16 individuals from Lakhdar River, Oum er Rbia Basin Aït Bou Oulli (31.604651, -6.597173) Morocco (Voucher numbers: MNCN 290623-290638), 10 individuals from Lakhdar River, Oum er Rbia Basin, Agouti (31.637684, -6.480359), Morocco (Voucher numbers: MNCN 290785-290794), 7 individuals from Ifni Lake, Aït Igran (31.030532, -7.884218), Morocco, (Voucher numbers: MNCN 281081-281087), 12 individuals from Ikiss River, Moulouya Basin, Tattiouine (32.58228, -4.76718), Morocco (Voucher numbers: MNCN 290797-290808) and 11 individuals from Imlil River, Tensift Basin, Douar Armed (31.125006, -7.919222), Morocco, (Voucher numbers: MNCN 290817-290827). These populations are geographically represented in Fig. 1.

Twenty-six morphometric measurements and ten meristic variables were recorded for all specimens. All morphometric measurements were in millimetres. Measurements and counts were taken following Delling (2002). The following abbreviations were used for morphometric and meristic characters: AFH, anal fin height; AFL, anal fin length; AP, anal fin pterygiophores; APL, anal peduncle length; AR, anal fin rays; BA, body depth, at level of origin of anal fin; BD, body depth, at level of origin of dorsal fin; BLD, body least depth; Bq, left side branquiostegals; C, central caudal

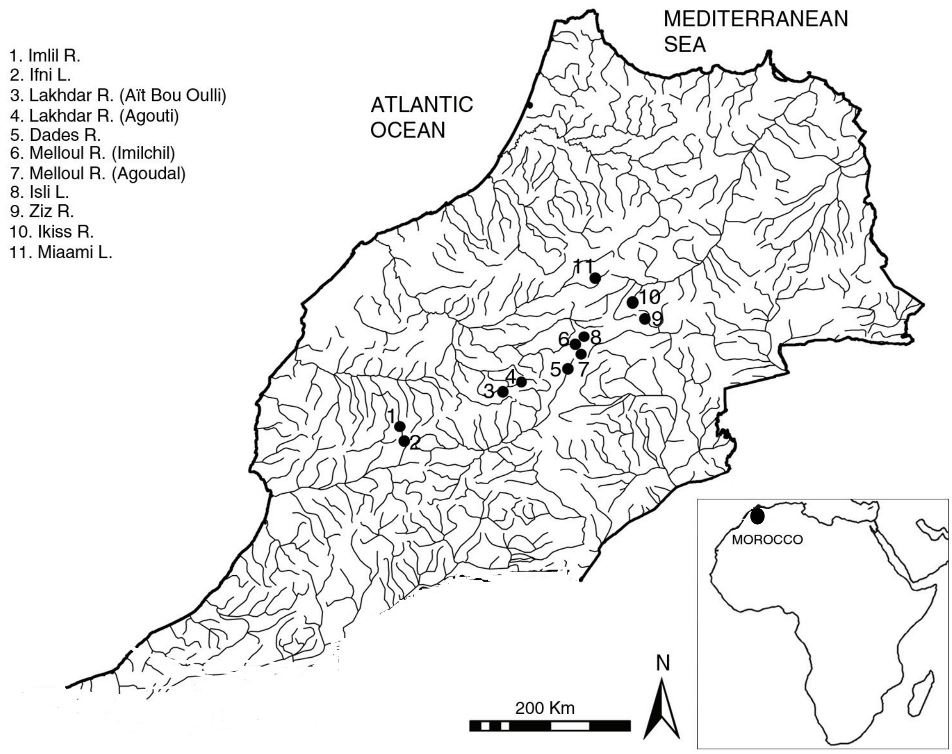

Fig. 1.— Sampling localities of Atlantic *Salmo* populations in Morocco.

Fig. 1.— Localidades de muestreo de las poblaciones atlánticas de *Salmo* en Marruecos.

fin rays; CFL, length of lower caudal fin lobe; CPA, caudal peduncle length at level of end of adipose fin; CPL, caudal peduncle length at level of end of dorsal fin; Cpr, number of procurrent rays upper caudal lobe. DFL, dorsal fin length; DFH, dorsal fin height; DP, dorsal fin pterygiophores; DR, dorsal fin rays; EDH, horizontal eye diameter; EDV, vertical eye diameter; HL, head length; LL, lateral line scales; ML, length of maxilla, from premaxilla end to posterior end of maxilla; PFL, pectoral fin length; PrAD, preanal distance; PrDD, predorsal distance; PrOL, preorbital length; PrPD, prepectoral distance, PrVD, preventral distance; PsOL, postorbital length, RSA, scales from base of adipose fin to lateral line; SL, standard length; UJD, upper jaw depth; UJL, upper jaw length, from symphysis of premaxilla to posterior end of maxilla; VFL, ventral fin length; Ve, total number of vertebrae. Number of vertebrae was obtained by direct counting on X-rays images of individuals from all studied populations.

After constructing the measurement matrix, Burnaby's method was used to correct size effect (Burnaby, 1966; Rohlf & Bookstein, 1987). All analyses were conducted with the corrected matrix. Morphometric and meristic characters were analysed independently. A two-way analysis of variance (ANOVA) comparing morphometric characters was conducted to test for sexual dimorphism and variation among populations. To identify the variables that contributed most to the variation among populations, a principal components analysis (PCA) was performed using the covariance matrix for morphometric characters. Statistical analyses were carried out using PAST software (Hammer *et al.*, 2001).

For the molecular approach, we analysed trout samples from Atlantic basins in Morocco corresponding to individuals of the genus *Salmo* from Ifni Lake (*Salmo akairos*), Isli Lake (*Salmo sp.*), Melloul R. (*Salmo pellegrini*), Miaami Lagoon (*Salmo pellegrini*), Dades R. (*Salmo sp.*), Lakhdar R. (*Salmo pellegrini*), Imlil R. (*Salmo pellegrini*) and Ziz R. (*Salmo pellegrini*) (Table 1). Likewise, we included one population from the Ikiss R. (Moulouya Basin) from the Mediterranean slope that has been associated to Atlantic trout populations (Tensift Basin) in previous molecular studies (Snoj *et al.*, 2011). The species *Salmo salar* and *Salmo orhidanus* were selected as outgroups on the basis of previous phylogenetic analyses (Snoj *et al.*, 2011). Analyses included mitochondrial cytochrome *b* gene (*MT-CYTB*) and control region (*CR*) for all data sets. Total genomic DNA was extracted from fin-clip tissue using the commercial kit Biosprint15 for tissue and blood (Qiagen). For each specimen, the complete region (1140bp) of *MT-CYTB* and a fragment (947bp including gaps) of *CR* were amplified. Primers and protocols used for PCR followed Machordom & Doadrio (2001) for *MT-CYTB* and Bernatchez (2001) for *CR*. After checking PCR products on 1% agarose gels, they were purified by ExoSAP-IT™ (USB) and directly sequenced on

Table 1.— Sampling localities for *Salmo spp* from Moroccan Atlantic basins and GenBank Accession numbers.

Tabla 1.— Localidades de muestreo de las especies de *Salmo spp* de las cuencas atlánticas de Marruecos y números de acceso de GenBank.

Population (Individuals)	Locality	GenBank Accession Numbers	Number in map
Tensift (11)	Imlil River, Tensift Basin, Morocco	*MT-CYTB*: KT279196-KT279198; *CR*: KT279164-KT279166	**1**
Ifni (30)	Ifni Lake, Aït Igran, Morocco	*MT-CYTB*: KT279176-KT279177; *CR*: KT279144-KT279145	**2**
Lakhdar 1 (16)	Lakhdar River, Oum er Rbia Basin Aït Bou Oulli, Morocco	*MT-CYTB*: KT279189-KT279191; *CR*: KT279157-KT279159	**3**
Lakhdar 2 (10)	Lakhdar River, Oum er Rbia Basin, Agouti, Morocco	-	**4**
Dades (31)	Dades River, Draa basin, Aït Aatou O'Moussa, Morocco	*MT-CYTB*: KT279185-KT279188; *CR*: KT279153-KT279156	**5**
Melloul 1 (13)	Assif Melloul, Oum er Rbia Basin, Agoudal, Morocco	*MT-CYTB*: KT279172-KT279175; *CR*: KT279140-KT279143	**6**
Melloul 2 (8)	Assif Melloul, Oum er Rbia Basin. Imilchil, Morocco	-	**7**
Isli (20)	Isli Lake, Imilchil. Morocco	*MT-CYTB*: KT279180-KT279184; *CR*: KT279148-KT279152	**8**
Ziz (18)	Ziz River, Ziz basin, Zaouia Sidi Hamza, Morocco	*MT-CYTB*: KT279184-KT279186; *CR*: KT279164-KT279166	**9**
Moulouya (12)	Ikiss River, Moulouya Basin, Tattiouine, Morocco	*MT-CYTB*: KT279192-KT279195; *CR*: KT279160-KT279163	**10**
Miaami (14)	Miaami Lagoon, Oum er Rbia Basin, Douar Khamlich, Morocco	*MT-CYTB*: KT279178-KT279179; *CR*: KT279146-KT279147	**11**

MACROGEN service using a 3730XL DNA sequencer. All generated new sequences were deposited in the GenBank database (Accession Numbers: *MT-CYTB*: KT279167-279198, *CR*: KT279135-KT279166).

Phylogenetic analyses were performed using Bayesian inference (BI) implemented in MrBayes v. 3.2 (Ronquist *et al*., 2012). The best-fitting models of sequence evolution for *MT-CYTB* and the *CR* under the AIC criterion (Akaike, 1973) were selected using PartitionFinder v1.1.1. (Lanfear *et al*., 2012). The best model scheme for running phylogenetic analysis was constituted by four partitions: *CR* (HKY+I), *MT-CYTB* 1st aminoacidic position (K80), *MT-CYTB* 2nd aminoacidic position (F81) and *MT-CYTB* 3rd aminoacidic position (TrN). This partitioning scheme was used in phylogenetic performance unlinking evolutionary models among partitions. Bayesian analysis was performed using two independent runs of four Markov Montecarlo coupled chains (MCMC) of 10^6 generations each, to estimate the posterior probability distribution. Topologies were sampled every 100 generations, and majority-rule consensus tree was estimated after discarding the first 10% of generations. Robustness of clades was assessed using Bayesian posterior probabilities. The average genetic distances between *Salmo* populations were calculated for each gene using MEGA package v.6.0 (Tamura *et al*., 2013) according to the uncorrected-*p* distances.

Results and Discussion

MORPHOLOGICAL COMPARISON BETWEEN POPULATIONS

Analysis of variance (ANOVA) for sexual dimorphism showed significant differences between sexes ($p<0.05$) for variables associated with preorbital length, anal fin and body depth (Table 2). Orbital size was also different in males in relation to females but probably as a consequence of the large difference in eye size in the Ifni lake population (in comparison to the other populations). When we removed the Ifni Lake population from the analysis no significant differences were found between males and females. In general, all variables showing significant dimorphism were greater in females than in males (Table 3). Due to the presence of sexual dimorphism and because we collected few female samples (n=38), we removed females for subsequent morphological analyses.

On the other hand, most of the morphometric variables showed significant differences between populations in the two-way ANOVA analysis (Table 2). An analysis of body proportions based on non-parametric Kruskal-Wallis and Mann-Whitney *post hoc* comparisons were used, to find differences in body shape between populations that can remain masked if only linear untransformed measurements are considered.

Table 2.— Two-way analysis of variance (ANOVA) for sexual dimorphism, population variation, and their interaction. Significant differences p<0.01 (*). N=38 females and N=119 males. Abbreviations are described in the Material and Methods epigraph.

Tabla 2.— Análisis de la varianza (ANOVA) de dos vías para dimorfismo sexual, variación poblacional y su interacción. Diferencias significativas p<0.01 (*). N=38 hembras y N=119 machos. Las abreviaturas se describen en el epígrafe de Material y Métodos.

Variables	Sexual dimorphism (f/p-value)	Population Variation (f/p-value)	Sex/pop Variation (f/p-value)
SL	1.8/	87.95/*	5.8/*
HL	6.38/	6.43/*	0.33/
PrOL	25.88/*	12.76/*	2.56/
EDH	10.71/*	26.91/*	2.21/
EDV	38.23/*	82.9/*	0.88/
PsOL	3.35/	9.81/	7.58/*
UJL	1.65/	286.1/*	3.43/
ML	1.3/	17.82/*	0.71/
UJD	2.44/	6.19/*	5.48/*
PrDD	0.02/	16.9/*	3.62/
PrPD	1.06/	6.3/*	1.5/
PrVD	0.96/	22.94/*	2.43/
PrAD	5.89/	47.82/*	4.24/*
CPL	0.003/	67.6/*	1.96/
CPA	1.29/	5.93/*	1.53/
APL	24.46/	0.02/*	0.38/
PFL	1.1/	10.3/*	1.98/
DFL	0.7/	35.8/*	0.55/
DFH	0.005/	32.6/*	9.91/*
VFL	5.93/	7.91/*	0.64/
AFL	8.36/*	1.6/	0.16/
AFH	27.56/*	38.25/*	2.2/
CFL	0.83/	10.84/*	1.22/
BLD	24.38/*	33.48/*	1.78/
BA	6.57/	5.64/*	0.69/
BD	17.18/*	33.17/*	2.51/

Table 3.— Morphometric variables showing significant sexual dimorphism (p<0.01). Values are means and between brackets maximum y minimum values. Abbreviations are described in the Material and Methods epigraph.

Tabla 3.— Variables morfométricas que muestran dimorfismo sexual significativo (p<0.01). Los valores representan medias y entre paréntesis valores máximos y mínimos. Las abreviaturas están descritas en el epígrafe de Material y Métodos.

Variables (mm)	Males (n=119)	Females (n=38)
PrOL	7.7 (35.4-3.3)	8.04 (19.9-4.3)
EDH	7.9 (16.5-4.7)	9.52 (13.1-5.9)
EDV	6.9 (14.3-3.9)	8.51 (12.5-6)
AFL	13.6 (47.1-7)	16.12 (33.1-8)
AFH	22 (59.9-12.4)	25.99 (45.3-13.8)
BLD	14.2 (40.2-8.1)	16.52 (29.7-9.1)
BD	33.6 (100.9-17.5)	39.44 (80.6-20.6)

According to these analyses, morphological differences in body shape were found in almost all morphometric measurements (Appendix 1). The population from Isli Lake showed the largest body size compared to the remaining populations. Otherwise, the maxilla in the Isli population was long but not significantly larger than in the other populations (Table 4). In Isli Lake trout, the size of the eye was smallest of all populations studied, but since mature individuals from this population exhibited the largest body size of all studied populations, the smaller size eye found in this population could reflect allometric growth (Table 4). The Isli Lake individuals showed the smallest pectoral fin in comparison to other populations. The population of Miaami Lagoon in the upstream Chbouka River also had a long preorbital distance, which is in agreement with a well-developed maxilla in length and height. Trout of Miaami Lagoon were shorter, which is revealed in body depth and caudal

Table 4.— Values of the means and between brackets maximum and minimum, to different ratios of the morphometric variables and scales count. Abbreviations are described in the Material and Methods epigraph.

Tabla 4.— Valores de la media, y entre paréntesis valores máximos y mínimos, para diferentes proporciones de las variables morfométricas y número escamas. Las abreviaturas están descritas en el epígrafe de Material y Métodos.

Measurements	Ziz n=8	Dades n=23	Lahkdar n=22	Melloul n=20	Miaami n=14	Isli n=15	Ifni n=17	Moulouya n=12	Tensift n=11
HL/PrOL	5.2 (5.7-4.7)	5.1 (5.5-4.7)	4.7 (5.3-4.3)	4.6 (6.3-3.9)	3.4 (3.6-3.1)	3.7 (4.5-2.9)	4.8 (5.3-4.4)	5.1 (5.6-4.6)	5.3 (5.6-5)
HL/ML	2.1 (2.2-2)	2 (2.2-1.9)	2.1 (2.3-2)	2.1 (2.3-1.9)	2 (2.1-1.9)	2 (2.2-1.7)	1.9 (2.2-1.7)	2.1 (2.2-2)	2.1 (2.2-2)
HL/UJL	3.2 (3.4-2.9)	3.2 (3.5-2.9)	2.9 (3.1-2.6)	2.8 (3.1-2.5)	2.4 (2.5-2.2)	2.4 (2.6-2.2)	2.2 (2.5-2)	2.8 (3-2.6)	2.8 (2.9-2.6)
ML/UJD	3.9 (4.5-3.7)	4.5 (4.9-4)	3.8 (4.3-3.1)	4 (4.7-3.3)	3.6 (3.9-3)	4.3 (5.3-3.5)	4.9 (5.6-4.1)	4.6 (5.4-3.6)	5.1 (5.7-4.7)
SL/PFL	4.5 (5.3-3.9)	4.8 (5-4.6)	4.9 (5.4-4.2)	4.9 (5.6-4.1	4.2 (4.6-3.8)	5.7 (6-5.2)	4.6 (5-4.6)	5 (5.6-4.4)	5 (5.2-4.7)
HL/EDV	4 (4.5-3.8)	3.8 (4.1-3.3)	4.3 (5.1-3.8)	4.8 (5.6-3.8)	5.3 (6-4.4)	6 (7.2-5)	4.7 (5-4.5)	4.5 (5-3.9)	4.6 (4.9-4.3)
HL/EDH	3.4 (4-3.1)	3.2 (3.5-3)	3.8 (4.2-3.3)	4.1 (4.6-3.5)	4.9 (6.3-3.4)	5.4 (6.4-4.4)	3.5 (4.7-3.1)	3.8 (4-3.5)	3.6 (3.8-3.4)
SL/CPL	2.4 (2.5-2.3)	2.4 (2.6-2.3)	2.3 (2.6-2.1)	2.2 (2.3-2.1)	2.2 (2.3-2.1)	2.2 (2.4-2)	2.5 (2.6-2.4)	2.2 (2.3-2.1)	1.6 (1.7-1.5)
SL/APL	4.9 (5.1-4.7)	5 (5.4-4.7)	4.8 (5.2-4.5)	5.1 (5.8-4.6)	4.9 (5.2-4.6)	5.4 (5.9-4.9)	5.7 (6.3-5.3)	4.6 (4.9-4.3)	4.7 (5-4.5)
APL/BLD	1.8 (1.9-1.7)	1.9 (2.1-1.7)	2 (2.2-1.8)	1.8 (2-1.6)	1.8 (1.9-1.7)	1.9 (2.1-1.8)	1.5 (1.6-1.4)	2 (2-1.8)	1.9 (1.7-1.4)
CPL/BLA	1 (1-0.9)	1 (1.1-0.9)	1 (1.1-0.9)	1.1 (1.4-1)	1.1 (1.3-1)	1.2 (1.3-1.1)	1.1 (1.2-1)	2.4 (2.7-2.1)	1.6 (1.7-1.5)
SL/BLD	8.9 (9.3-8.5)	9.4 (9.8-9)	9.6 (10.4-8.9)	9 (10-8.4)	8.7 (8.8-8.2)	10.4 (11.1-9.6)	8.6 (9.1-8.3)	9.2 (9.8-8.6)	9 (9.3-8.4)
SL/BD	4 (4.1-3.7)	4.2 (4.5-3.9)	4.1 (4.3-3.7)	3.9 (4.4-3.6)	3.7 (4.3-3.4)	4 (4.3-3.7)	4.1 (4.3-3.8)	3.6 (4.1-3.3)	3.7 (3.8-3.6)

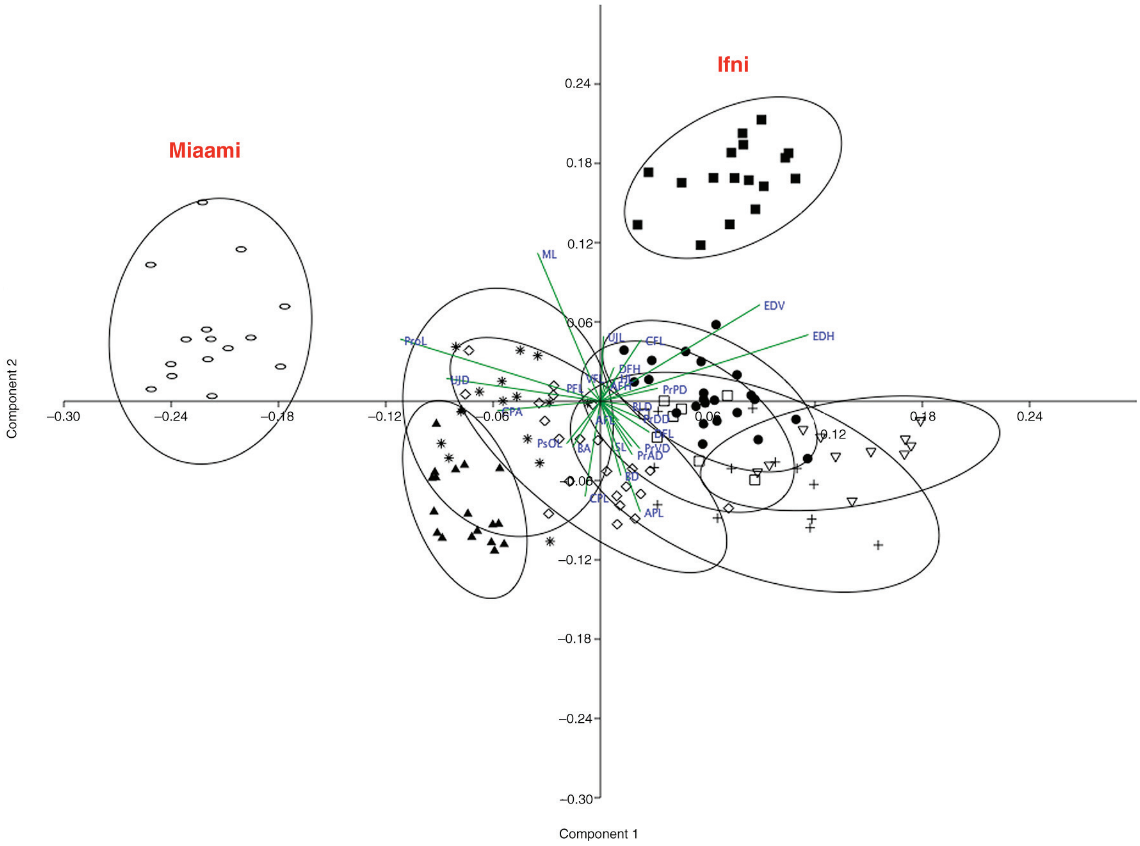

Fig. 2.— Variables that most contributed to the PCA analysis. Square, Ziz population. Dot, Dades population. Filled Triangle, Melloul population. Diamond, Lakhdar population. Oval, Miaami population. Star, Isli population. Filled Square, Ifni population. Plus, Moulouya population. Inverted triangle, Tensift population. Abbreviations are described in the Material and Methods epigraph.

Fig. 2.— Variables que más contribuyen al ordenamiento en el PCA. Cuadrado vacío, población del Ziz. Puntos negros, población del Dades. Triángulo relleno, población del Melloul. Rombos, población del Lakhdar. Óvalos, población de Miaami. Estrellas, población de Isli. Cuadrados negros, población de Ifni. Signo de mas, población del Moulouya. Triángulo invertido. Población del Tensift. Las abreviaturas están descritas en el epígrafe de Material y Métodos.

peduncle measurements. The Ifni Lake population, a trout population having small-sized mature individuals, presented the largest eye size in adult specimens (Table 4). The maxilla was very long and narrow and the caudal peduncle was shorter and deeper in the Ifni population than in other populations (Table 4). Dades, Moulouya, Ziz and Tensift populations were characterized by having shorter preorbital length and Dades and Ziz populations by shorter maxillary length. The height of maxilla was largest in the Dades population. Moulouya and Tensift populations showed long caudal peduncle in relation to the body height considered from the origin of the anal fin. The upper mandibular length was largest in the Moulouya and Tensift populations with respect to head length. The Tensift population had a smaller dorsal fin relative to the remaining populations.

The PCA divided the *Salmo* populations into three groups that correspond to those of Ifni Lake, those of Miaami Lagoon and a third large group containing the remaining *Salmo* populations (Fig. 2). The eigenvalues for the two first Principal Components, with the Burnaby-corrected matrix for removing size effect, mostly explained the variance (Table 5). The variables that contributed most to the ordination in the PCA were orbital and preorbital lengths, caudal peduncle lengths, size and height of the maxilla and length of the dorsal fin (Table 5).

With regard to meristic characters, we found no significant differences according to Kruskal-Wallis and Mann-Whitney non parametric analyses for the following traits: number of vertebrae, number of scales in lateral line, number of scales in transversal on adipose fin, number of rays in dorsal and anal fins, number of procurrent rays on the caudal fin and number of branchyostegal rays. Only two traits showed significant differences, dorsal and anal pterygophores (Table 6). The number of pterygophores in dorsal fin had its highest value in *Salmo akairos* and its lowest value in the Isli Lake population (Fig. 3). Likewise, the number of pterygophores in the anal fin presented its highest value in *Salmo pallaryi* from Sidi Ali Lake comparing with the remaining populations studied (Fig. 3). The species *Salmo akairos* (Ifni population) also showed significant differences in relation to the other populations in anal fin pterygophores.

Table 5.— Eigenvalues and eigenvectors for the first three principal components (PC1-PC3) from 26 morphometric variables for *Salmo* populations. Abbreviations are described in the Material and Methods epigraph. In bold, variables with the highest eigenvectors for each PC.

Tabla 5.— Eigenvalores y eigenvectores para los tres primeros componentes principales (CP1-CP3) de 26 variables morfométricas para las poblaciones del género *Salmo*. Las abreviaturas están descritas en el epígrafe de Material y Métodos. En negrita, variables con los eigenvectores más altos para cada CP.

	PCI	**PCII**	**PCIII**
Eigenvalue	0.0104	0.0062	0.0023
% variance	36.9	21.9	8.1
	Eigenvectors		
SL	0.0771	−0.1514	−0.0995
PrOL	**−0.4919**	−0.2065	0.0099
EDH	**0.5113**	−0.2211	0.1297
EDV	**0.3921**	**−0.3209**	0.0051
PsOL	−0.0826	−0.1408	−0.0858
HL	0.0383	0.07642	−0.0367
ML	−0.1543	**−0.4928**	**−0.3069**
UJL	0.0073	−0.2163	0.0366
UJD	**−0.3787**	−0.0756	**0.5507**
PrDD	0.0954	−0.0553	−0.2162
PrPD	0.1411	0.0431	−0.0750
PrVD	0.0965	−0.1573	−0.1716
PrAD	0.0781	−0.1777	−0.1449
CPL	−0.0375	**0.317**	−0.1039
CPA	−0.2534	−0.0311	**−0.3269**
APL	−0.0979	**0.3675**	0.2367
PFL	−0.0298	−0.0432	0.1755
DFL	−0.1207	0.1032	**0.3579**
DFH	0.3336	−0.1125	0.1111
VFL	0.0087	−0.0663	0.2682
AFL	0.0450	0.0558	0.2872
AFH	0.0343	−0.0697	0.1134
CFL	0.0999	−0.2044	−0.0057
BLD	0.0679	−0.0124	−0.0947
BA	−0.0679	−0.1518	0.1115
BD	−0.0504	0.2473	−0.0186

MOLECULAR APPROACHES

The concatenated matrix including both mitochondrial genes rendered a total of 2088bp (*MT-CYTB*: 1140bp+*CR*: 947bp including gaps). Bayesian tree reconstruction revealed well-supported phylogenetic relationships among trout populations from Morocco and demonstrated the early divergence of the Dades population (Draa basin) from the others (Fig. 4). In fact, the genetic distances between Dades and the remaining populations, including the recognized species *Salmo akairos* (Ifni), were the highest recorded for both genes and for all comparisons (Table 7). The Dades populations also showed nine autapomorphies in the *MT-CYTB*, all of them transitions (Table 9). Genetic distances among the rest of trout populations from Morocco ranged from 0.2-0.6% for *MT-CYTB* and 0.2-0.5% for *CR* (Table 7). Autapomorphies in the *MT-CYTB* gene, although not so numerous as in the Dades population, were found in the Ifni, Isli, Lakhdar and Tensift populations (Table 8).

Table 6.— Non-parametric Kruskal-Wallis test and Mann-Whitney's *post hoc* comparisons for testing significant differences in pterygophores in dorsal fin (above diagonal) and anal fin (below diagonal) among Atlantic Moroccan trout populations. Significant values are presented in bold.

Tabla 6.— Test no paramétrico de Kruskal-Wallis y comparaciones *post hoc* de Mann-Whitney para testar diferencias significativas en los pterigóforos de la aleta dorsal (sobre la diagonal) y de la aleta anal (debajo de la diagonal) entre las poblaciones atlánticas de truchas de Marruecos. Valores significativos se representan en negrita.

Population	Ziz N=20	Lakhdar N=10	Isli N=10	Dades N=15	Miaami N=10	Sidi Ali N=19	Ifni N=20	Tensift N=11	Moulouya N=12
Ziz	-	0.765	**0.003**	0.354	0.464	**0.007**	**0.00002**	0.085	0.267
Lakhdar	0.582	-	**0.022**	0.343	0.833	0.098	**0.0008**	0.137	0.219
Isli	0.902	0.568	-	**0.0008**	**0.018**	0.140	**0.0003**	**0.0006**	**0.0009**
Dades	0.974	0.617	0.955	-	0.120	**0.0005**	**0.00004**	0.365	0.812
Miaami	0.683	0.398	0.849	0.767	-	0.089	**0.0001**	**0.029**	0.097
Sidi Ali	**0.0001**	**0.0001**	**0.0002**	**0.0005**	**0.0007**	-	**0.00001**	**0.0001**	**0.0006**
Ifni	**0.019**	0.096	**0.041**	**0.031**	**0.020**	**0.0001**	-	**0.0003**	**0.0001**
Tensift	0.702	0.396	0.875	0.787	0.978	**0.0001**	**0.015**	-	0.542
Moulouya	0.218	0.134	0.387	0.323	0.483	**0.0001**	**0.005**	0.419	-

PIGMENTATION PATTERNS

The Isli population showed a pigmentation pattern without spots and parr marks, as also occurred in *Salmo pallaryi*. The Dades population showed numerous irregular parr marks, usually greater to or equal than 14, which usually are retained in adult specimens. In the Dades population, the body is covered by small and numerous red and black spots that sometimes extend to the caudal fin and opercular area. Adult specimens from the Moulouya, Ziz and Oum er Rbia basins usually retained large and scarce parr marks. Adults from the Tensift population did not retain parr marks and showed a dark coloration (Fig. 5).

OSTEOLOGICAL REMARKS

Vomer teeth in Moroccan trout were arranged in zigzag with the exception of the Isli population, whose teeth were placed in one row within a narrow vomer. The vomer length was lesser than half of the parasphenoid length in all the studied populations except for the Ifni population. In this last population vomer length was greater than half of the parasphenoid length (Appendix 2).

For Dades individuals, the lateral processes of the ethmoid bone were extended, conferring a T shape to the bone, and the upper process of the premaxilla bone was small and laterally inclined. In comparison to other populations studied, where the upper maxillary

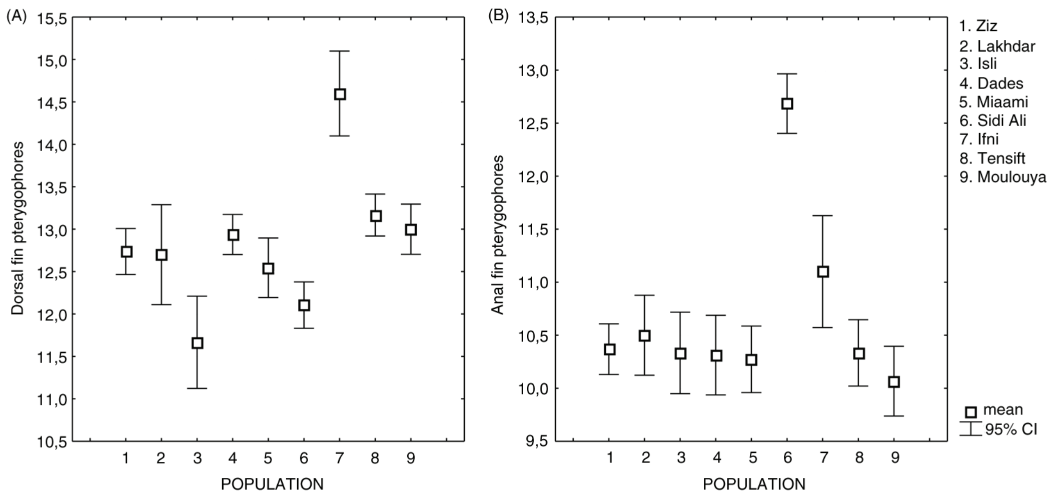

Fig. 3.— Boxplot of dorsal fin (A) and anal fin (B) pterygophores.

Fig. 3.— Boxplot de los pterigóforos de las aletas dorsal (A) y anal (B).

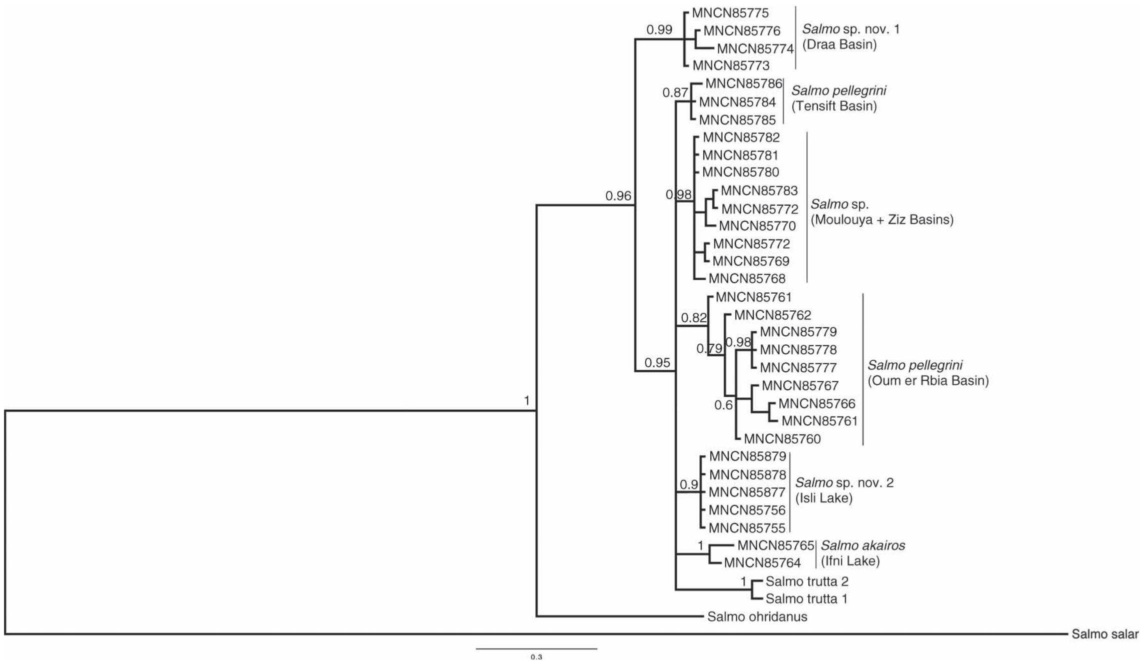

Fig. 4.— Phylogenetic tree rendered by Bayesian inference based on the concatenated matrix of both mitochondrial genes (*MT-CYTB+CR*). Numbers on branches indicate posterior probability values.

Fig. 4.— Árbol filogenético obtenido mediante inferencia Bayesiana a partir de la matriz concatenada de los dos genes mitocondriales (*MT-CYTB+CR*). Los números sobre las ramas indican valores de probabilidad posterior.

process was greater than 47%, we found that the height of the upper maxillary process in the Ifni population was less than 45%, with respect to the length of the basal plate. Most individuals of the Isli population had the premaxilla strongly ossified and extended over the maxilla (Appendix 2).

The upper jaw in the Dades, Ziz and Oum er Rbia basins was shorter than in the other populations. In the Ifni and Isli populations upper jaw length usually exceeded the posterior border of the eye. The Ifni population had the lowest maxilla, while the Miaami and Moulouya populations had the deepest. The skull was narrower in the Isli population and the snout was more pointed in Isli and Ifni lakes, in comparison to the other populations (Appendix 2).

The anterior maxillary process in the Isli population was thinner than in the remaining Moroccan populations and the inflection of this process, in relation to the

Table 7.— Uncorrected-*p* genetic distances, in percentage, among Atlantic Moroccan trout populations based on *MT-CYTB* gene (below diagonal) and the *CR* (above diagonal). In bold on diagonal uncorrected-*p* genetic distances within populations on the left *MT-CYTB* and on the right *CR*.

Tabla 7.— Distancias genéticas no corregidas, en porcentaje, entre las poblaciones atlánticas de trucha de Marruecos basadas en el gen *MT-CYTB* (debajo de la diagonal) y la *CR* (encima de la diagonal). En negrita en la diagonal distancias dentro de poblaciones, a la izquierda valores para el gen *MT-CYTB* y a la derecha valores de la *CR*.

Populations	**Ifni**	**Isli**	**Melloul**	**Miaami**	**Dades**	**Lakhdar**	**Ziz**	**Moulouya**	**Tensift**	***S. trutta* (Austria)**
Ifni	**0.1/0.1**	0.21	0.34	0.32	0.53	0.32	0.30	0.21	0.32	0.48
Isli	0.53	**0.1/0.0**	0.32	0.32	0.42	0.32	0.08	0.00	0.11	0.37
Melloul	0.55	0.20	**0.1/0.0**	0.29	0.42	0.21	0.40	0.32	0.42	0.53
Miaami	0.61	0.26	0.07	**0.1/0.0**	0.21	0.32	0.40	0.32	0.42	0.48
Dades	1.14	0.96	0.99	1.05	**0.1/0.0**	0.53	0.51	0.42	0.53	0.58
Lakhdar	0.61	0.26	0.11	0.18	1.05	**0.0/0.0**	0.40	0.32	0.42	0.69
Ziz	0.56	0.39	0.41	0.47	1.00	0.47	**0.1/0.1**	0.08	0.06	0.33
Moulouya	0.55	0.37	0.39	0.46	0.99	0.46	0.40	**0.4/0.0**	0.11	0.37
Tensift	0.47	0.29	0.31	0.38	0.91	0.38	0.33	0.31	**0.6/0.0**	0.27
***S. trutta* (Austria)**	1.11	0.92	0.94	1.00	1.36	1.01	0.96	0.94	0.86	**0.1/0.1**

Table 8.— Autapomorphies in the *MT-CYTB* gene in Atlantic Moroccan populations of trout.

Tabla 8.— Autopomorfías en el gen *MT-CYTB* en las poblaciones de truchas atlánticas de Marruecos.

Population\MT-CYTB Position	**60**	**144**	**216**	**234**	**447**	**474**	**504**	**508**	**616**	**732**	**849**	**915**	**990**	**1090**
Ifni	T	A	T	C	**C**	T	C	G	**T**	G	C	T	A	G
Isli	T	A	T	C	T	T	C	**A**	A	G	C	T	A	G
Melloul	T	A	T	C	T	T	C	G	A	G	C	T	A	G
Miaami	T	A	T	C	T	T	C	G	A	G	C	T	A	G
Dades	**C**	A	**C**	C	T	**C**	**T**	G	A	**A**	**T**	**C**	**G**	**A**
Lakhdar	T	A	T	**T**	T	T	C	G	A	G	C	T	A	G
Ziz	T	A	T	C	T	T	C	G	A	G	C	T	A	G
Moulouya	T	A	T	C	T	T	C	G	A	G	C	T	A	G
Tensift	T	**G**	T	C	T	T	C	G	A	G	C	T	A	G

main axis of the maxilla, formed an angle greater than 135°, while in other trout populations from Morocco it was less than 135° (Appendix 2).

DESCRIPTION OF POPULATIONS OF GENUS *SALMO* FROM MOROCCO

Our morphological and molecular analyses revealed that the population from Ifni Lake, recently described as a different species (*Salmo akairos*), had a high degree of distinct morphological features and moderate genetic differentiation in mitochondrial genes. The populations from the Oum er Rbia Basin showed scarce morphological and genetic differentiation relative to the Tensift Basin, where the species *Salmo pellegrini* was described (Delling & Doadrio, 2005; Geiger *et al*., 2014); therefore we provisionally assigned populations from Oum er Rbia basins to *Salmo pellegrini*. However, one of the populations of this latter basin (Miaami Lagoon) showed differential morphological traits, particularly in the length and height of the maxilla and premaxilla bones, but it was nested within the Oum er Rbia Basin mitochondrial clade and therefore this population should be also provisionally assigned to *S. pellegrini*.

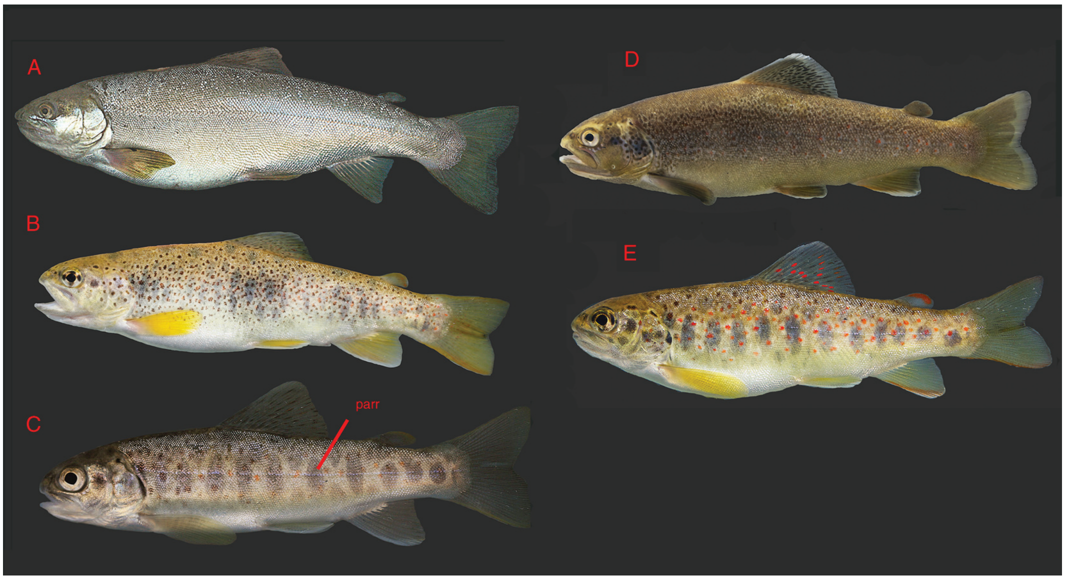

Fig. 5.— Isli, SL 222.6 mm (A), Dades, SL 128.5 mm (B), Ziz, SL 99.1 mm (C), Tensift, SL 200.9 mm (D) and Moulouya, SL 107.8 mm (E). Isli without parr marks and spots. Dades presents irregular and narrow parr marks in adults and multiple spots on the body. Ziz and Moulouya have large parr marks in adults. Tensift does not present parr marks in adults. parr=parr marks

Fig. 5.— Detalle del patrón de pigmentación en las poblaciones estudiadas de las truchas de Marruecos: Isli, SL 222.6 mm (A), Dades, SL 128.5 mm (B), Ziz, SL 99.1 mm (C), Tensift, SL 200.9 mm (D) and Moulouya, SL 107.8 mm (E). Isli no presenta las "*rayas de pinto*" ni manchas en el cuerpo. Dades presenta "*rayas de pinto*" irregulares y estrechas en los adultos y multiples puntos en el cuerpo. Poblaciones de Ziz y Moulouya tienen "*rayas de pinto*" grandes en los adultos. Los ejemplares adultos del Tendift no presentan "*rayas de pinto*". parr=parr marks.

The populations of the Ziz and Moulouya basins showed moderate genetic differentiation for the *MT-CYTB* gene; genetic differences in allozyme markers had also been previously reported for the Ziz population (Lbadaoui *et al*., 2011). Nevertheless, no morphological differentiation was detected when compared to other populations from the Oum er Rbia Basin, and so in the absence of the inclusion of other Mediterranean populations in the morphological and genetic analyses, we named these two populations as *Salmo* sp. The populations from Isli Lake and the Dades Basin showed a high degree of morphological and genetic differentiation that justifies their consideration as distinct species. No available name for these populations exists at present, and therefore the two new species are described in this study.

Salmo multipunctata Doadrio, Perea & Yahyaoui, **sp. nov.**

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Holotype: Figure 6, Table 9. MNCN 290753, 126.3 mm (SL). Female. Dades River, Draa Basin, Aït Aatou O'Moussa (31.871776, -5.738205), Morocco; 21/10/2014. Collected by Doadrio, I; Yahyaoui, A; Garzón, P; Perea, S.

Paratypes: Table 9. MNCN 290751-290752, MNCN 290754-290785: Thirty-four specimens from the Dades River, Draa Basin, Aït Aatou O'Moussa (31.871776, -5.738205), Morocco; 21/10/2014. Collected by Doadrio, I; Yahyaoui, A; Garzón P; Perea, S.

Holotype and a series of paratypes (35 specimens) have been deposited at the Fish Collection of the Museo Nacional de Ciencias Naturales, (Madrid, Spain).

DIAGNOSIS: Differs from other known species of the genus *Salmo* in the numerous irregular narrow parr marks, usually ≥14, in the lateral line. Upper row of parr marks ≥10. Lower row of parr marks variable, usually ≥5. Two conspicuous black spots placed at the right and left sides of the iris and two less visible spots at the upper and lower sides of the iris. Numerous black, small spots placed at the upper side of the body and several red ocellated and non ocellated spots placed in middle of the body. Black spots sometimes extended to the opercular region and the caudal fin. Ethmoid bone with a characteristic T shape. Premaxilla bone with small and inclined upper process. From 14 to 16 (Median=14) scales from base of adipose fin to lateral line. From 12 to 14 dorsal fin pterygophores (Median=13). Nine molecular autopomorphies in *MT-CYTB* gene in the nucleotide positions 60, 216,474, 504, 732, 849, 915, 990, 1090.

DESCRIPTION: LL 104-112 ($\bar{x}$=108.5 Median=108). RSA 14-16 ($\bar{x}$=14.3; Median=14). AP 9-11 ($\bar{x}$=10.3, Median=10). AR iv 7-8 ($\bar{x}$=7.8, Median=8). DP 12-14 ($\bar{x}$=12.9, Median=13). DR v (iv) 9-10 ($\bar{x}$=9.3, Median=9). Bq 9-10 ($\bar{x}$=9.5, Median=9.5). C 19. Cpr 10-13 ($\bar{x}$=11.5, Median=11). Ve 53-55 ($\bar{x}$=54.1, Median=54). It is a small-sized species that rarely reaches 250 mm standard length. The body is slightly more elongated in comparison to other trout populations, with maximum body depth, at the level of the anal origin, ranging from 16.1-18.7% SL in females and 15.5-18.5% SL in males. The head is large in relation to the body, in comparison to all trout populations except those of the Ifni and Miaami populations, with head length 22.6-24.9% SL in females and 23.7-25.8% SL in males. The anterior part of the head shows a flat snout. The preorbital distance is the shortest of the populations studied and the proportion with respect to the head length is 18.6-20.7% HL in females and 18.1-21.3% HL in males. The fourth and fifth infraorbitals are narrow and sparsely extend over the hyomandibular bone (Fig. 7). The eye size in *Salmo multipunctata* and *Salmo akairos* is the largest in relation to other populations studied, and in *Salmo multipunctata* the horizontal diameter of the eye is 29.4-31.8% HL in females and 28.5-33.5% HL in males.

The supramaxilla is large and slender; its length is more than half of the maxilla. The maxilla is short and the proportion, with respect to the head length, is 46.3-53.2% SL in females and 48.9-52.3% SL in males. The upper jaw is deep as in the populations of the Ziz and Oum er Rbia river basins, except for the

Fig. 6.— Holotype of *Salmo multipunctata* from the Dades River, Draa Basin, Aït Aatou O'Moussa, Morocco. MNCN 290753. SL 128.5 mm.

Fig. 6.— Holotipo de *Salmo multipunctata* del río Dades, Cuenca del Draa, Aït Aatou O'Moussa, Marruecos. MNCN 290753. SL 128.5 mm.

Table 9.— Morphometric and meristic measurements of the holotype and paratypes of *Salmo multipunctata*.

Tabla 9.— Medidas morfométricas y merísticas del holotipo y paratipos de *Salmo multipunctata*.

Morphometric variables	Holotype MNCN 290753	Paratypes n=34 MNCN 290751-290752, 290754-290785		
	Measurement in mm	Range	Mean	Standard Deviation
SL	128.5	161.7-52.5	87.3	20.4
PrOL	4.4	7-2.8	4.4	1
EDH	8.2	8.9-4.4	5.7	0.9
EDV	7.5	8-3.4	5.2	0.9
PsOL	17.2	22.1-8.4	13	2.8
HL	29	35.7-15.5	22.8	4.4
ML	10.4	14.5-6	8.5	2
UJL	13.8	16.7-7	10	2.2
UJD	2.9	4.3-1.8	2.7	0.5
PrDD	58.2	76.1-25.7	41.3	9.3
PrPP	25.3	30-13.2	19.4	3.4
PrVD	65.7	82.9-29	45.7	10.1
PrAD	91	115.2-38.2	62.2	14.4
CPL	57.8	70.6-21.6	37	9
CPA	25.5	29.9-9.9	17.8	4
PFL	22.4	26.9-12.4	18.4	3.2
DFL	16.2	23.1-6.8	12.1	3.1
DFH	23	29.2-10.6	16.4	3.4
VFL	16.8	24.9-8.3	13.4	3
AFL	15.3	19.2-5.6	9.2	2.5
AFH	22.1	29.1-9.7	14.9	3.7
CFL	19.5	27.6-10.4	15.3	3.3
BLD	14.5	18-6.2	10.2	2.2
BA	24.1	31.9-9.2	16.4	4.2
BD	32.8	44.1-12	21.8	5.8
AP	10	9-11	10.3	0.7
DP	13	12-14	12.9	0.4
LL	111	112-104	108.5	2.1
RSA	16	14-17	15.2	0.8
Ve	53	53-55	54.1	0.8

Miaami population that has the significant deepest upper jaw. The maximum height of the upper jaw, in proportion to its length, is 33-38.4% UJL in females and 31.8-38.7% UJL in males. The caudal peduncle (CPL) is slightly deeper than in other populations, except that of Ifni Lake (*S. akairos*), and the proportion of the body at the least depth, with respect to caudal peduncle length, is 23.6-26.9% CPL in females and 24-28% CPL in males. The teeth in vomer, premaxilla and glossohyal are very robust, as those of the Ziz and Moulouya populations.

The coloration is slightly yellow, lighter in the ventral area, and brownish in the dorsal region. The fins are slightly yellow with orange marginal borders of caudal and adipose fins. Dorsal, pelvic and anal fins in adults have white anterior edges. The dorsal fin presents a black line below the white mark. The dorsal fin has small black and red spots. Body with numerous small spots, which are black and slightly ocellated in the dorsal region and red spots (not ocellated) in the middle of the body. The iris has two black, conspicuous lateral spots and two less conspicuous above and below the iris. Parr marks are narrow, irregular and numerous, placed in the middle of body, sometimes divided into two marks. The species has a characteristic opercular black spot, and another spot just above it (usually ocellated). There are usually numerous black spots in the opercular area and the caudal fin. There are eight or nine black spots on the dorsal body, very conspicuous in juveniles, which tend to disappear in adults.

ETYMOLOGY: The species name "*multipunctata*" refers to its diagnostic pigmentation pattern, which is constituted by numerous spots and marks along the body.

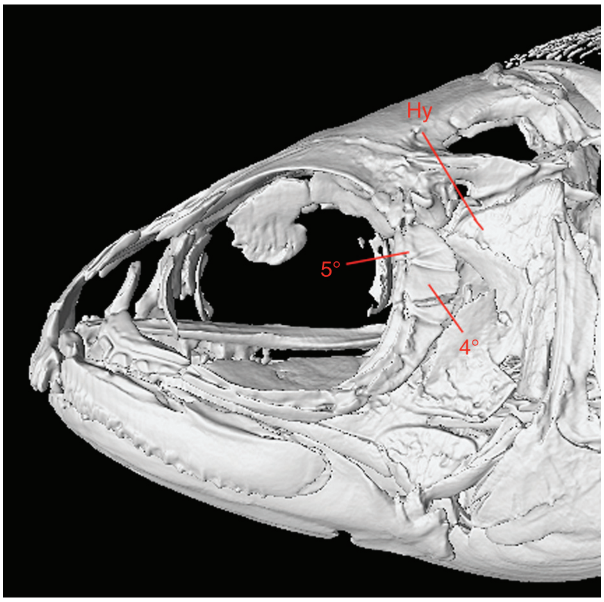

Fig. 7.— Narrow Infraorbital 4° and 5° not extended over the Hyomandibular (Hy). MNCN 290.754. SL. 98.5 mm.

Fig. 7.— Infraorbitales 4° y 5° estrechos que no se extienden por encima del hiomandibular (Hy). MNCN 290.754. SL. 98.5 mm.

DISTRIBUTION: This new species is endemic to the Draa Basin in southern Morocco, inhabiting the headwaters of the Dades and M'Goum rivers. In the Draa basin the species usually co-occurs with the cyprinid fish *Luciobarbus lepineyi* (Pellegrin, 1939).

COMMON NAME: We propose the English common name "Draa trout" for this species.

HABITAT AND BIOLOGY: Similar to other riverine trout of Morocco, this species inhabits small and shallow streams with clear and cold waters. No information about spawning season is available.

CONSERVATION: The habitat of this species suffers catastrophic seasonal floods that influence dramatically the demography of the population. The continuous deforestation of the Atlas Mountains and the disappearance of the riparian vegetation, increase the adverse effect of the overflows over the small Atlas rivers. Overfishing is also a problem for a small population such as the one from the Dades River. For this reason, we suggest that this species should be included in the IUCN category of Endangered (EN).

GENETICS: Uncorrected genetic distances between *Salmo multipunctata* and other studied populations of trout for the *MT-CYTB* gene ranged from 0.9 to 1.4%. *Salmo multipunctata* is phylogenetically basal to *S. trutta* from Europe and other *Salmo* populations from Morocco assigned to *S. akairos, S. pellegrini* and *S. macrostigma*.

Salmo viridis Doadrio, Perea & Yahyaoui, **sp. nov.**

urn:lsid:zoobank.org:act:A6209574-45BE-4A3E-BCB6-DC21AFDC502C

Holotype: Figure 8, Table 10. MNCN 280413, 254.1 mm (SL), Male. Isli Lake, Imilchil (32.217526, -5.548031), Morocco; 30/10/2009. Collected by Doadrio, I; Yahyaoui, A; Garzón, P; Cueva, I.

Paratypes: Table 10. MNCN 281050-281067: Eighteen specimens from Isli Lake, Imilchil (32.217526, -5.548031), Morocco; 31/10/2011. Collected by M. Esteve and F. Melero. MNCN 280414: One specimen from Isli Lake, Imilchil (32.217526, -5.548031) Morocco; 30/10/2009. Collected by (Coll.) Doadrio, I; Yahyaoui, A; Garzón P; Cueva, I.

Holotype and a series of paratypes (20 specimens) have been deposited at the Fish Collection of the Museo Nacional de Ciencias Naturales, (Madrid, Spain).

DIAGNOSIS: Differs from other known species of the genus *Salmo* from Morocco (except *Salmo pallaryi*) by the absence of spots or marks on the body. The species *Salmo viridis* has a lesser number of anal pterygophores (AP 10-11; Median=10) than *Salmo pallaryi* (AP 12-14; Median=13) and shorter orbital length. Horizontal orbital length with respect to the head length is 16-23% HL in *Salmo viridis vs* 25-31% HL in *Salmo pallaryi*. The following combination of characters are also diagnostic to *Salmo viridis*: Vomer teeth in one row, premaxilla extended laterally, supramaxilla short and deep, dorsal fin pterygophores from 11 to 13 (Median=12). One molecular autapomorphy in the *MT-CYTB* gene in the nucleotide position 508.

DESCRIPTION: LL 105-116 ($\bar{x}$=109.4; Median=108). RSA 15-18 ($\bar{x}$=16.9; Median=17). AP 10-11 ($\bar{x}$=10.3, Median=10). AR iv 7-8 ($\bar{x}$=7.6, Median=8). DP 11-13 ($\bar{x}$=11.7, Median=12). DR v(vi) 9-10 ($\bar{x}$=9.7, Median=10). Bq 8-11 ($\bar{x}$=9.2; Median=9). C 19. Ve 53-55 ($\bar{x}$=54.4, Median=54). It is a large-sized species that reaches 500 mm of standard length. The caudal peduncle is more elongated, in comparison to other trout populations, and the proportion of body to least depth, with respect to caudal peduncle length, is 25.3-26% CPL in females and 23.5-27.1% CPL in males. In comparison to all trout populations the head is small, relative to the body, with head length 21.7-24.4% SL in females and 21.4-24.8% SL in males. The skull is narrow with a pointed snout. The preorbital distance is the largest, compared to the populations studied, and the proportion, with respect to head length, is 26-31% HL in females and 21.6-34% HL in males. The fourth and fifth infraorbitals are wide and extended over the hyomandibular bone (Fig. 9).

The supramaxilla is short and deep. The length of the maxilla is variable in this species and usually reaches the edge of the posterior eye orbit (Fig. 10). The length of the maxilla, in proportion and with respect to head length is 44.4-56.3% SL in females and 46.5-52.8% SL in males. The upper jaw is narrower than in other populations except that of Ifni Lake, which belongs to

Fig. 8.— Holotype of *Salmo viridis* from Isli Lake, Imilchil, Morocco. MNCN 280413. SL 254.1 mm.

Fig. 8.— Holotipo de Salmo viridis del Lago de Isli, Imilchil, Marruecos. MNCN 280413. SL 254.1 mm.

Table 10.— Morphometric and meristic measurements of the holotype and paratypes of *Salmo viridis*.

Tabla 10.— Medidas morfométricas y merísticas del holotipo y paratipos de *Salmo viridis*.

Morphometric variables	Holotype MNCN 280413	Paratypes n=21 MNCN 280414, 281050-281067		
	Measurement in mm	Range	Mean	Standard Deviation
SL	254.1	430-186.2	277.7	60.6
PrOL	15.9	35.4-10.7	18.4	6.4
EDH	11.5	16.5-9.4	11.8	1.9
EDV	10.1	14.3-8.2	10.9	1.6
PsOL	35.2	54.3-23.9	35.2	7.9
HL	61.3	103.3-42.4	64.7	15.5
ML	24.0	42.7-16.9	26.9	7.0
UJL	28.5	55.1-20.2	33.2	9.1
UJD	6.9	10.5-5.4	7.6	1.3
PrDD	121.3	177.7-93.3	120.9	22.8
PrPP	57.6	89.2-37.2	59.7	13.3
PrVD	147.6	221-97.5	143.3	29.1
PrAD	192.7	298.7-130	195.6	41.3
CPL	113.6	185.6-94.1	123.8	22.1
CPA	59.4	88.3-44.9	61.3	10.7
APL	46.5	72.7-37.6	51.2	9.3
PFL	40.5	71.6-35.7	48.6	10.6
DFL	32.5	59.8-25.4	38.4	9.2
DFH	42.2	69-34	47.8	9.6
VFL	33.1	53.8-26.2	36.3	7.6
AFL	29.2	47.1-17.4	29.1	6.9
AFH	38.8	59.9-28.4	41.2	7.3
CFL	46.0	64.3-34.1	44.3	8.2
BLD	25.6	40.2-18.9	26.8	5.6
BA	54.1	76.1-36.3	51.4	10.7
BD	64.3	100.9-48.4	70.5	15.6
AP	-	10-11	10.3	0.5
DP	-	11-13	11.7	0.7
LL	108	116-105	108	3.2
RSA	16	15-18	17	0.9
Ve	-	53-55	54.5	0.7

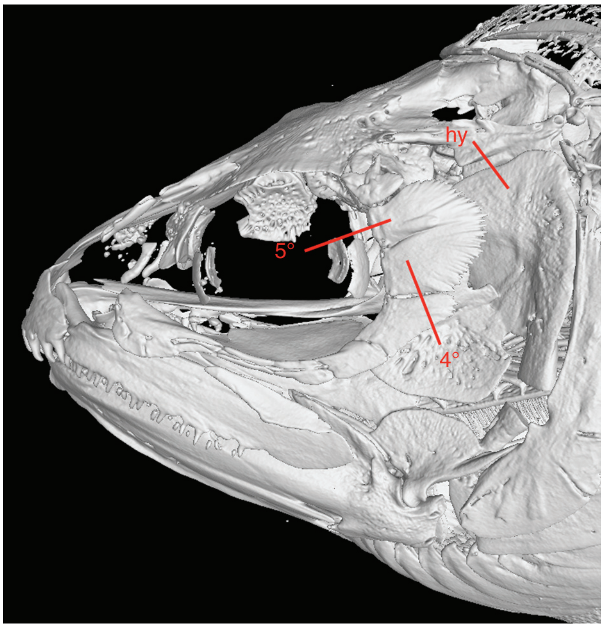

Fig. 9.— Wide Infraorbital 4° and 5° extended over the Hyomandibular (hy). MNCN 280414. SL 222.6 mm.

Fig. 9.— Infraorbitales 4° y 5° anchos que se extienden por encima del hiomandibular (hy). MNCN 280414. SL 222.6 mm.

S. akairos. The maximum height of the upper jaw, in proportion to its length, is 28.4-33.1% UJL in females and 24.6-32.2% UJL in males. The eye orbit is small, in proportion to head length, the horizontal diameter being 17.5-19.4% HL in females and 15.6-22.8% HL in males and the vertical diameter being 16.4-19.8% HL in females and 13.8-20% HL in males (Fig. 10). The vomer teeth are placed in one row and are small and thin.

The coloration is uniformly grayish with some greenish iridizations, paler in the ventral region. The pectoral fins are slightly yellow and caudal, adipose and anal fins are greenish. No spot or marks are found, only some traces in caudal fin and dorsal skull.

ETYMOLOGY: The species name "*viridis*" refers to its diagnostic greenish coloration in some parts of body and fins.

DISTRIBUTION: This new species is endemic to Isli Lake in the Atlas Mountains of Morocco. It is the only fish species inhabiting this lake.

COMMON NAME: We propose the English common name "green trout" for this species.

HABITAT AND BIOLOGY: This species inhabits the Isli Lake (Fig. 11). Isli is situated on a high plateau, 2270 meters above sea level. It is a large and deep (≈2 km of diameter, 92 m deep) oligotrophic lake. The geological origin of this Lake is under debate. Some authors point to its origin as a consequence of a meteorite impact that occurred approximately 40 000 years ago (Ibhi *et al*., 2013; Nachit *et al*., 2013), while others consider a tectonic origin during the Pleistocene period, similar to the one proposed for other Moroccan lakes (Chaabout *et al*., 2013). The presence of a natural population of *Salmo viridis* in Isli Lake is in agreement with the latter hypothesis. The spawning of this species takes place at the end of October and November in the sandy beaches of the lake.

CONSERVATION: The habitat of this species is threatened due to eutrophication, related to intensive overpasture. Overfishing is also a problem due to the low protection of the lake. No juveniles have been observed in the last years and several malformations in fins and skull were observed in this population. For this reason, we suggest that this species should be included in the IUCN category of Endangered (EN).

GENETICS: Uncorrected genetic distances between *Salmo viridis* and other studied populations of trout for the *MT-CYTB* gene ranged from 0.2 to 1 %. The

Fig. 10.— Male of 333.5 mm SL from Isli Lake (MNCN 281058) shows some typical traits of *Salmo viridis*: small eye, pointed snout and maxilla extended to postorbital edge.

Fig. 10.— Macho de 333.5 mm SL del lago de Isli (MNCN 281058) mostrando algunos caracteres típicos de *Salmo viridis*. Ojo pequeño, hocico puntiagudo y maxilar extendiéndose al borde posterior del ojo.

Fig. 11.— Isli Lake, a large and deep lake where *Salmo viridis* lives.

Fig. 11.— Lago de Isli, un lago extenso y profundo donde vive *Salmo viridis*.

divergence degree is similar to that of *Salmo akairos* in comparison to other populations inhabiting Atlas lakes.

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Appendix 1.— Non-parametric Kruskal-Wallis tests and Mann-Whitney's *post hoc* comparisons, for all populations. Values of Kruskal-Wallis test below variables. Values of Mann-Whiney test below diagonal. Medians in the diagonal. Significant differences p<0.01 (*). Abbreviations are described in the Material and Methods epigraph.

Apéndice 1.— Test no paramétrico de Kruskal-Wallis y comparaciones *post hoc* de Mann-Whitney para todas las poblaciones. Valores para el test de Kruskal-Wallis debajo de las variables. Valores de Mann-Whitney por debajo de la diagonal. Valor de la mediana en la diagonal. Diferencias significativas p<0.01 (*). Las abreviaturas están descritas en el epígrafe de Material y Métodos.

Variables (H statistic)	**Populations**	**Ziz N=8**	**Dades N=23**	**Lahkdar N=22**	**Melloul N=20**	**Miaami N=14**	**Isli N=15**	**Ifni N=17**	**Moulouya N=12**	**Tensift N=11**
SL (H=86.49*)	Ziz	103.5								
	Dades	0.35	84.2							
	Lakhdar	0.13	0.001*	118						
	Melloul	0.16	0.002*	0.8	114					
	Miaami	0.10	0.001*	0.82	0.81	115.8				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	278.5			
	Ifni	0.003*	0.001*	0.01*	0.01*	0.002*	0.001*	131.9		
	Mouloya	0.004*	0.001*	0.01*	0.004*	0.01*	0.001*	0.13	148.7	
	Tensift	0.003*	0.001*	0.001*	0.001*	0.001*	0.001*	0.004*	0.44	158.2
SL/PrOL (H=105.2*)	Ziz	21.5								
	Dades	0.18	20.9							
	Lakhdar	0.004*	0.01*	20.2						
	Melloul	0.001*	0.001*	0.04	19.3					
	Miaami	0.001*	0.001*	0.001*	0.001*	13				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	15.7			
	Ifni	0.001*	0.001*	0.001*	0.05	0.001*	0.002*	18.3		
	Mouloya	0.78	0.06	0.003*	0.001*	0.001*	0.001*	0.001*	21.5	
	Tensift	0.71	0.03*	0.001*	0.001*	0.001*	0.001*	0.001*	0.926	21.6
SL/EDH (H=102.9*)	Ziz	14.1								
	Dades	0.02*	13.1							
	Lakhdar	0.001*	0.001*	16.1						
	Melloul	0.001*	0.001*	0.002*	17.3					
	Miaami	0.003*	0.001*	0.02	0.30	18.4				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	23.2			
	Ifni	0.31	0.81	0.001*	0.001*	0.001*	0.001*	13.6		
	Mouloya	0.01*	0.001*	0.34	0.001*	0.01*	0.001*	0.001*	15.8	
	Tensift	0.007*	0.001*	0.014*	0.001*	0.002*	0.001*	0.013*	0.002*	14.9
SL/EDV (H=103.2*)	Ziz	15.6								
	Dades	0.10	15.3							
	Lakhdar	0.01	0.001*	18.5						
	Melloul	0.003*	0.001*	0.003*	20.4					
	Miaami	0.001*	0.001*	0.03	0.55	20				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	25.4			
	Ifni	0.001*	0.07	0.001*	0.001*	0.001*	0.001*	15		
	Mouloya	0.01*	0.001*	0.601	0.03*	0.113	0.001*	0.001*	18.9	
	Tensift	0.004*	0.001*	0.745	0.007*	0.048*	0.001*	0.001*	0.735	18.8
SL/PsOL (H=83.03)	Ziz	7.9								
	Dades	0.38	8.1							
	Lakhdaar	0.53	0.81	8.1						
	Melloul	0.001*	0.001*	0.001*	7.3					
	Miaami	0.001*	0.001*	0.001*	0.001*	6.7				
	Isli	0.88	0.06	0.13	0.001*	0.001*	7.9			
	Ifni	0.54	0.007*	0.10	0.001*	0.001*	0.97	7.8		
	Mouloya	0.07	0.001*	0.006*	0.162	0.001*	0.063	0.097	7.5	
	Tensift	0.003	0.001*	0.001*	0.667	0.001*	0.002*	0.001*	0.166	7.3

Appendix 1.— (*Continued*)

Variables (H statistic)	Populations	Ziz N=8	Dades N=23	Lahkdar N=22	Melloul N=20	Miaami N=14	Isli N=15	Ifni N=17	Moulouya N=12	Tensift N=11
SL/HL (H=72.86*)	Ziz	4.1								
	Dades	0.57	4.1							
	Lakhdar	0.08	0.002*	4.2						
	Melloul	0.16	0.02	0.92	4.2					
	Miaami	0.001*	0.001*	0.001*	0.001*	3.8				
	Isli	0.02	0.002*	0.87	0.75	0.001*	4.3			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.31	0.001*	3.8		
	Mouloya	0.42	0.03	0.417	0.282	0.001*	0.393	0.001*	4.2	
	Tensift	0.65	0.713	0.019*	0.07	0.001*	0.022	0.001*	0.132	4.1
SL/ML (H=109.9)	Ziz	13.8								
	Dades	0.29	12.9							
	Lakhdar	0.2	0.01	12.1						
	Melloul	0.002*	0.001*	0.38	11.9					
	Miaami	0.001*	0.001*	0.001*	0.001*	8.9				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	10.3			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.004*	0.001*	8.6		
	Mouloya	0.003*	0.001*	0.135	0.503	0.001*	0.001*	0.001*	11.6	
	Tensift	0.001*	0.001*	0.025*	0.064	0.001*	0.001*	0.001*	0.479	11.4
SL/UJL (H=91.24)	Ziz	8.5								
	Dades	0.18	8.3							
	Lakhdar	0.002*	0.001*	9						
	Melloul	0.02	0.001*	0.40	8.9					
	Miaami	0.001*	0.001*	0.001*	0.001*	7.4				
	Isli	0.72	0.68	0.004*	0.02	0.001*	8.4			
	Ifni	0.001*	0.001*	0.001*	0.001*	1	0.001*	7.5		
	Mouloya	0.114	0.001*	0.074	0.361	0.001*	0.164	0.001*	8.7	
	Tensift	0.967	0.418	0.003*	0.018*	0.001*	0.716	0.001*	0.07	8.5
SL/UJD (H=71.43*)	Ziz	33.4								
	Dades	0.002*	37.2							
	Lakhdar	0.25	0.002*	34.2						
	Melloul	0.04	0.23	0.21	36.2					
	Miaami	0.001*	0.001*	0.001*	0.001*	26.7				
	Isli	0.004*	0.21	0.14	0.89	0.001*	36.3			
	Ifni	0.02	0.87	0.06	0.61	0.001*	0.71	37.1		
	Mouloya	0.004	0.07	0.003*	0.065	0.001*	0.043*	0.106	40.1	
	Tensift	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	0.148	42.9
SL/PrDD (H=71.15*)	Ziz	2.2								
	Dades	0.001*	2.1							
	Lakhdar	0.94	0.001*	2.3						
	Melloul	0.44	0.005*	0.38	2.2					
	Miaami	0.50	0.001*	0.10	0.78	2.2				
	Isli	0.10	0.001*	0.06	0.03	0.01	2.3			
	Ifni	0.001*	0.13	0.001*	0.002*	0.001*	0.001*	2.1		
	Mouloya	0.034*	0.001*	0.01*	0.01*	0.001*	0.864	0.001*	2.3	
	Tensift	0.901	0.001*	0.985	0.464	0.406	0.12	0.001*	0.06	2.2
SL/PrPD (H=84.24*)	Ziz	4.2								
	Dades	0.06	4.1							
	Lakhdar	0.02	0.001*	4.3						
	Melloul	0.05	0.001*	0.20	4.4					
	Miaami	0.16	0.006*	0.02	0.007*	4.2				

Appendix 1.— (*Continued*)

Variables (H statistic)	Populations	Ziz N=8	Dades N=23	Lahkdar N=22	Melloul N=20	Miaami N=14	Isli N=15	Ifni N=17	Moulouya N=12	Tensift N=11
	Isli	0.001*	0.001*	0.001*	0.002*	0.001*	4.7			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	3.9		
	Mouloya	0.6	0.001*	0.652	0.503	0.048*	0.001*	0.001*	4.3	
	Tensift	0.901	0.303	0.001*	0.028*	0.755	0.001*	0.008*	0.103	4.1
SL/PrVD (H=33.15*)	Ziz	1.9								
	Dades	0.09	1.8							
	Lakhdar	0.12	0.001*	1.9						
	Melloul	0.28	0.90	0.004*	1.8					
	Miaami	0.63	0.001*	0.25	0.03	1.9				
	Isli	0.05	0.001*	0.33	0.002*	0.06	1.9			
	Ifni	0.31	0.51	0.002*	0.8	0.02	0.002*	1.8		
	Mouloya	0.418	0.931	0.022*	0.7	0.213	0.014	0.912	1.8	
	Tensift	0.342	0.31	0.025*	0.491	0.146	0.017	0.742	0.829	1.9
SL/PrAD (H=28.69*)	Ziz	1.4								
	Dades	0.51	1.4							
	Lakhdar	0.006*	0.001*	1.4						
	Melloul	0.3	0.13	0.004*	1.4					
	Miaami	0.03	0.009*	0.67	0.02	1.4				
	Isli	0.04	0.02	0.49	0.01	0.62	1.4			
	Ifni	0.12	0.20	0.10	0.04	0.26	0.15	1.4		
	Mouloya	0.847	0.986	0.015	0.341	0.043*	0.06	0.298	1.4	
	Tensift	0.015*	0.003*	0.775	0.022*	1	0.64	0.1	0.034*	1.4
SL/CPL (H=99.07*)	Ziz	2.4								
	Dades	0.09	2.4							
	Lakhdar	0.003*	0.001*	2.3						
	Melloul	0.001*	0.001*	0.001*	2.2					
	Miaami	0.001*	0.001*	0.001*	0.47	2.2				
	Isli	0.006*	0.001*	0.17	0.30	0.48	2.2			
	Ifni	0.001*	0.002*	0.001*	0.001*	0.001*	0.001*	2.5		
	Mouloya	0.001*	0.001*	0.035*	0.231	0.393	0.788	0.001*	2.2	
	Tensift	0.023*	0.001*	0.113	0.001*	0.001*	0.069	0.001*	0.001*	2.3
SL/CPA (H=117.6*)	Ziz	5.5								
	Dades	0.17	5.6							
	Lakhdar	0.44	0.003*	5.4						
	Melloul	0.001*	0.001*	0.001*	4.7					
	Miaami	0.001*	0.001*	0.001*	0.001*	4.3				
	Isli	0.001*	0.001*	0.001*	0.04	0.01	4.5			
	Ifni	0.001*	0.001*	0.001*	0.04	0.001*	0.001*	4.9		
	Mouloya	0.07	0.001*	0.074	0.001*	0.001*	0.001*	0.001*	5.3	
	Tensift	0.231	0.581	0.041*	0.001*	0.001*	0.001*	0.001*	0.005*	5.6
SL/APL (H=84.47*)	Ziz	4.9								
	Dades	0.67	4.9							
	Lakhdar	0.02	0.001*	4.7						
	Melloul	0.17	0.12	0.001*	5.1					
	Miaami	0.72	0.35	0.009*	0.06	4.9				
	Isli	0.001*	0.001*	0.001*	0.05	0.001*	5.4			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.001*	0.04	5.7		
	Mouloya	0.005	0.001*	0.165	0.001*	0.002*	0.001*	0.001*	4.6	
	Tensift	0.035	0.007*	0.924	0.004*	0.055	0.001*	0.001*	0.31	4.7

Appendix 1.— (*Continued*)

Variables (H statistic)	Populations	Ziz N=8	Dades N=23	Lahkdar N=22	Melloul N=20	Miaami N=14	Isli N=15	Ifni N=17	Moulouya N=12	Tensift N=11
SL/PFL (H=82.09*)	Ziz	4.5								
	Dades	0.01	4.8							
	Lakhdar	0.02	0.14	4.9						
	Melloul	0.02	0.06	0.38	4.9					
	Miaami	0.18	0.001*	0.001*	0.001*	4.2				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	5.7			
	Ifni	0.04	0.007*	0.01	0.01*	0.001*	0.001*	4.7		
	Mouloya	0.01*	0.046	0.397	0.792	0.001*	0.001*	0.011*	5	
	Tensift	0.012*	0.001*	0.294	0.966	0.001*	0.001*	0.001*	0.878	4.7
SL/DFL (H=93.38)	Ziz	6.4								
	Dades	0.001*	7.3							
	Lakhdar	0.001*	0.06	7.1						
	Melloul	0.001*	0.17	0.01	7.8					
	Miaami	0.72	0.001*	0.001*	0.001*	6.4				
	Isli	0.001*	0.70	0.18	0.20	0.001*	7.3			
	Ifni	0.001*	0.002*	0.79	0.003*	0.001*	0.07	7		
	Mouloya	0.969	0.001*	0.001*	0.001*	0.714	0.001*	0.001*	6.4	
	Tensift	0.011*	0.001*	0.001*	0.001*	0.003*	0.001*	0.001*	0.045*	6.1
SL/DFH (H=90.23*)	Ziz	4.8								
	Dades	0.002*	5.4							
	Lakhdar	0.001*	0.23	5.5						
	Melloul	0.001*	0.43	0.82	5.5					
	Miaami	0.97	0.001*	0.001*	0.001*	4.7				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	5.8			
	Ifni	0.47	0.001*	0.001*	0.001*	0.29	0.001*	4.8		
	Mouloya	0.004*	0.875	0.438	0.761	0.001*	0.001*	0.001*	5.4	
	Tensift	0.007*	0.001*	0.001*	0.071	0.001*	0.001*	0.001*	0.052	5.2
SL/VFL (H=93.07*)	Ziz	6								
	Dades	0.01	6.5							
	Lakhdar	0.001*	0.02	6.7						
	Melloul	0.001*	0.001*	0.03	7					
	Miaami	0.46	0.001*	0.001*	0.001*	5.7				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	7.6			
	Ifni	0.05	0.58	0.006*	0.001*	0.001*	0.001*	6.3		
	Mouloya	0.001*	0.002*	0.417	0.085	0.001*	0.001*	0.001	6.8	
	Tensift	0.001*	0.001*	0.35	0.064	0.001*	0.001*	0.001*	0.479	6.8
SL/AFL (H=63.95*)	Ziz	9.9								
	Dades	0.02	10.3							
	Lakhdar	0.09	0.27	10.2						
	Melloul	0.25	0.31	0.89	10.1					
	Miaami	0.001*	0.001*	0.001*	0.001*	9.1				
	Isli	0.23	0.001*	0.01	0.03	0.007*	9.6			
	Ifni	0.07	0.001*	0.005*	0.004*	0.004*	0.97	9.5		
	Mouloya	0.298	0.035	0.288	0.401	0.001*	0.067	0.04	10	
	Tensift	0.001*	0.001*	0.001*	0.001*	0.568	0.003*	0.003	0.001*	9
SL/AFH (H=91.24*)	Ziz	5.5								
	Dades	0.001*	6.1							
	Lakhdar	0.001*	0.20	6.1						
	Melloul	0.001*	0.10	0.38	6.3					

Appendix 1.— (*Continued*)

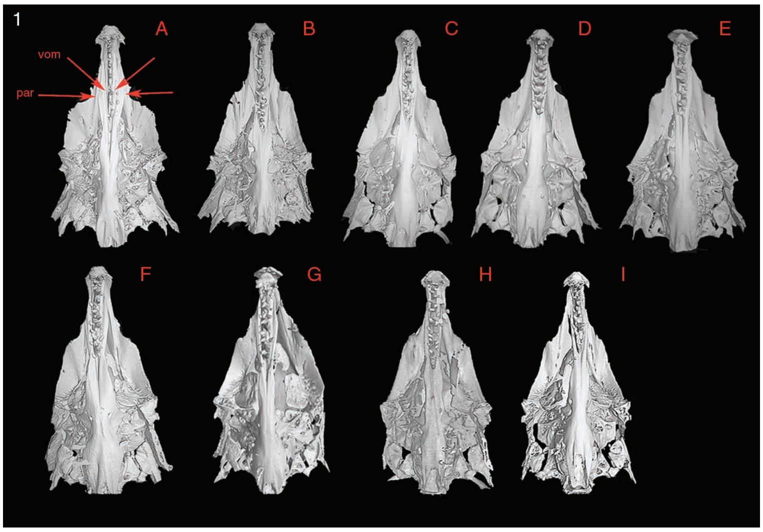
Variables (H statistic)	Populations	Ziz N=8	Dades N=23	Lahkdar N=22	Melloul N=20	Miaami N=14	Isli N=15	Ifni N=17	Moulouya N=12	Tensift N=11
	Miaami	0.15	0.001*	0.001*	0.001*	5.3				
	Isli	0.001*	0.001*	0.001*	0.006*	0.001*	6.7			
	Ifni	0.93	0.001*	0.001*	0.001*	0.02	0.001*	5.5		
	Mouloya	0.002*	0.986	0.322	0.429	0.001*	0.001*	0.001*	6.1	
	Tensift	0.001*	0.269	0.985	0.464	0.001*	0.001*	0.001*	0.479	6.1
SL/CFL (H=84.22*)	Ziz	5.5								
	Dades	0.23	5.6							
	Lakhdar	0.008*	0.001*	5.9						
	Melloul	0.001*	0.001*	0.005*	6.3					
	Miaami	0.5	0.02	0.001*	0.001*	5.3				
	Isli	0.001*	0.001*	0.02	0.89	0.001*	6.2			
	Ifni	0.005*	0.001*	0.01*	0.001*	0.007*	0.001*	5		
	Mouloya	0.153	0.205	0.155	0.005*	0.007*	0.014*	0.001*	5.7	
	Tensift	0.019*	0.001*	0.688	0.064*	0.001*	0.087	0.001*	0.148	5.9
SL/BLD (H=75.63*)	Ziz	8.9								
	Dades	0.001*	9.4							
	Lakhdar	0.001*	0.02	9.6						
	Melloul	0.08	0.001*	0.001*	9.1					
	Miaami	0.2	0.001*	0.001*	0.001*	8.6				
	Isli	0.001*	0.001*	0.001*	0.001*	0.001*	10.4			
	Ifni	0.03	0.001*	0.001*	0.001*	0.43	0.001*	8.6		
	Mouloya	0.002*	0.001*	0.001*	0.001*	0.113	0.001*	0.001*	9.2	
	Tensift	0.002*	0.001*	0.001*	0.001*	0.377	0.001*	0.001*	0.029*	9
SL/BA (H=79.74*)	Ziz	5.4								
	Dades	0.001*	5.9							
	Lakhdar	0.02	0.005*	5.7						
	Melloul	0.17	0.001*	0.001*	5.3					
	Miaami	0.001*	0.001*	0.001*	0.001*	4.8				
	Isli	0.92	0.001*	0.04	0.27	0.001*	5.4			
	Ifni	0.37	0.001*	0.001*	0.41	0.001*	0.57	5.4		
	Mouloya	0.07	0.001*	0.001*	0.7	0.001*	0.196	0.191	5.2	
	Tensift	0.052	0.001*	0.001*	0.9	0.001*	0.35	0.188	0.829	5.3
SL/BD (H=75.63*)	Ziz	4								
	Dades	0.005*	4.2							
	Lakhdar	0.06	0.06	4.1						
	Melloul	0.35	0.001*	0.005*	3.9					
	Miaami	0.02	0.001*	0.001*	0.01	3.7				
	Isli	0.97	0.001*	0.03	0.35	0.003*	3.9			
	Ifni	0.25	0.07	0.62	0.02	0.001*	0.16	4.1		
	Mouloya	0.002*	0.001*	0.001*	0.001*	0.113	0.001*	0.001*	3.6	
	Tensift	0.002*	0.001*	0.001*	0.001*	0.377	0.001*	0.001*	0.029*	3.7
HL/UJL (H=43.73*)	Ziz	3.2								
	Dades	0.73	3.1							
	Lakhdar	0.08	0.01	2.9						
	Melloul	0.23	0.05	0.57	2.8					
	Miaami	0.002*	0.001*	0.001*	0.001*	2.4				
	Isli	0.04	0.03	0.001*	0.007*	0.08	2.4			
	Ifni	0.06	0.02	0.001*	0.003*	0.52	0.54	2.2		
	Mouloya	0.263	0.049*	0.377	0.855	0.001*	0.005*	0.007*	2.1	
	Tensift	0.901	0.357	0.175	0.389	0.001*	0.013*	0.016*	0.518	2.1

Appendix 1.— (*Continued*)

Variables (H statistic)	Populations	Ziz N=8	Dades N=23	Lahkdar N=22	Melloul N=20	Miaami N=14	Isli N=15	Ifni N=17	Moulouya N=12	Tensift N=11
HL/ML (H=120*)	Ziz	2.1								
	Dades	0.57	2							
	Lakhdar	0.001*	0.001*	2.1						
	Melloul	0.001*	0.001*	0.13	2.1					
	Miaami	0.001*	0.001*	0.001*	0.001*	2.4				
	Isli	0.001*	0.001*	0.001*	0.001*	0.16	2			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	1.9		
	Mouloya	0.001*	0.001*	0.482	0.984	0.001*	0.001*	0.001*	2.8	
	Tensift	0.001*	0.001*	0.141	0.966	0.001*	0.001*	0.001*	0.878	2.8
ML/UJD (H=97.67*)	Ziz	3.9								
	Dades	0.001*	4.5							
	Lakhdar	0.62	0.001*	3.8						
	Melloul	0.54	0.001*	0.07	4					
	Miaami	0.009*	0.001*	0.03	0.001*	3.6				
	Isli	0.08	0.28	0.006*	0.14	0.001*	4.3			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	4.9		
	Mouloya	0.001*	0.001*	0.001*	0.004*	0.002*	0.608	0.001*	3.5	
	Tensift	0.001*	0.001*	0.001*	0.001*	0.001*	0.069	0.001*	0.091	3.8
CPL/CPA (H=105.2*)	Ziz	2.3								
	Dades	0.98	2.3							
	Lakhdar	0.06	0.01	2.4						
	Melloul	0.007*	0.001*	0.001*	2.1					
	Miaami	0.001*	0.001*	0.001*	0.001*	1.9				
	Isli	0.001*	0.001*	0.001*	0.02	0.02	2			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.26	0.11	2		
	Mouloya	0.132	0.033*	0.601	0.001*	0.001*	0.001*	0.001*	2.4	
	Tensift	0.035*	0.011*	0.33	0.001*	0.001*	0.001*	0.001*	0.644	2.4
APL/BLD (H=88.11*)	Ziz	1.8								
	Dades	0.02	2.3							
	Lakhdar	0.001*	0.001*	2						
	Melloul	0.47	0.02	0.001*	1.8					
	Miaami	0.42	0.001*	0.001*	0.86	1.8				
	Isli	0.02	0.65	0.008*	0.009*	0.001*	1.9			
	Ifni	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	1.5		
	Mouloya	0.001*	0.009	0.117	0.001*	0.001*	0.092*	0.001*	2	
	Tensift	0.043	0.797	0.005*	0.014*	0.002*	0.716*	0.001*	0.103	1.9
CPL/BA (H=68.42*)	Ziz	0.98								
	Dades	0.004*	1.1							
	Lakhdar	0.01	0.41	1						
	Melloul	0.001*	0.01	0.006*	1.1					
	Miaami	0.001*	0.01	0.003*	0.7	1.1				
	Isli	0.001*	0.001*	0.001*	0.03	0.008*	1.2			
	Ifni	0.001*	0.02	0.01	0.25	0.54	0.001*	1.1		
	Mouloya	0.177	0.114	0.014*	0.503	0.001*	0.164	0.001*	2.4	
	Tensift	0.967	0.002*	0.001*	0.078	0.004*	0.017*	0.001*	0.148	2.3

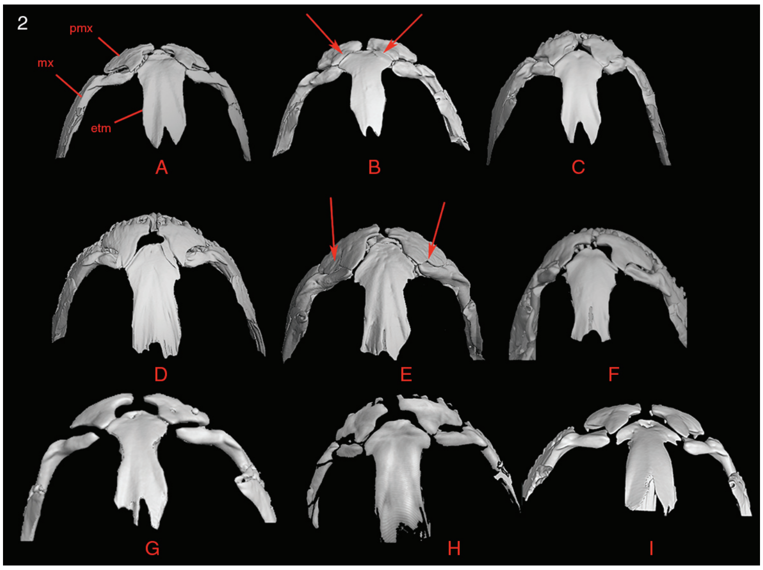
Appendix 2.— Osteological Features.

Apéndice 2.— Características osteológicas.



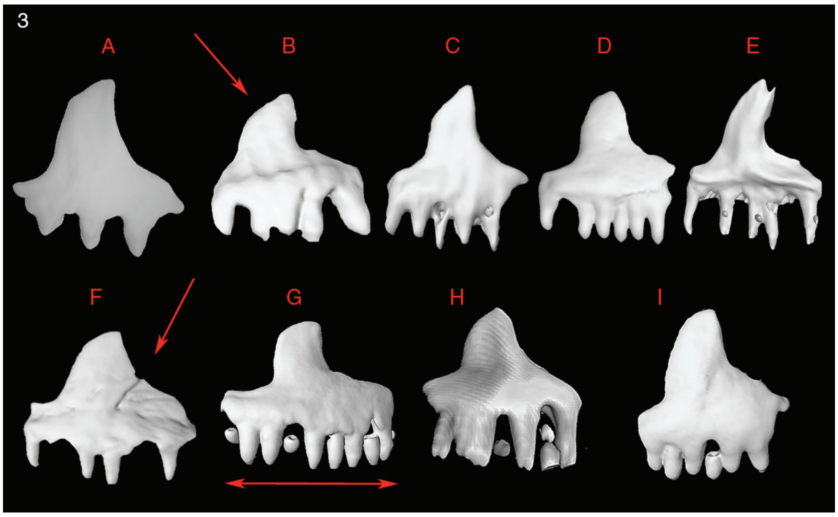
1. Ventral view of the skull showing morphology of parasphenoides (par) and vomer (vom) in *Salmo* populations. Isli Lake population has a single row of teeth (marked with arrows), in the other populations vomer teeth are placed in zigzag. The vomer is longer in Ifni than in the other populations. A=Isli, 222.6 mm SL. B=Ifni, 154.9 mm SL. C=Miaami, 77.1 mm SL. D=Ziz, 97.1 mm SL. E=Dades, 98.6 mm SL. F=Melloul, 105.2 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. All individuals are mature males.

1. Vista ventral del cráneo mostrando la morfología del paraesfenoides (par) y vómer (vom) en las poblaciones de *Salmo*. La población del Lago Isli tiene una única fila de dientes (marcada con flechas), en las otras poblaciones los dientes del vómer están colocados en zigzag. El vómer es más largo que en las otras poblaciones. A=Isli, 222.6 mm SL. B=Ifni, 154.9 mm SL. C=Miaami, 77.1 mm SL. D=Ziz, 97.1 mm SL. E=Dades, 98.6 mm SL. F=Melloul, 105.2 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. Todos los individuos son machos maduros.



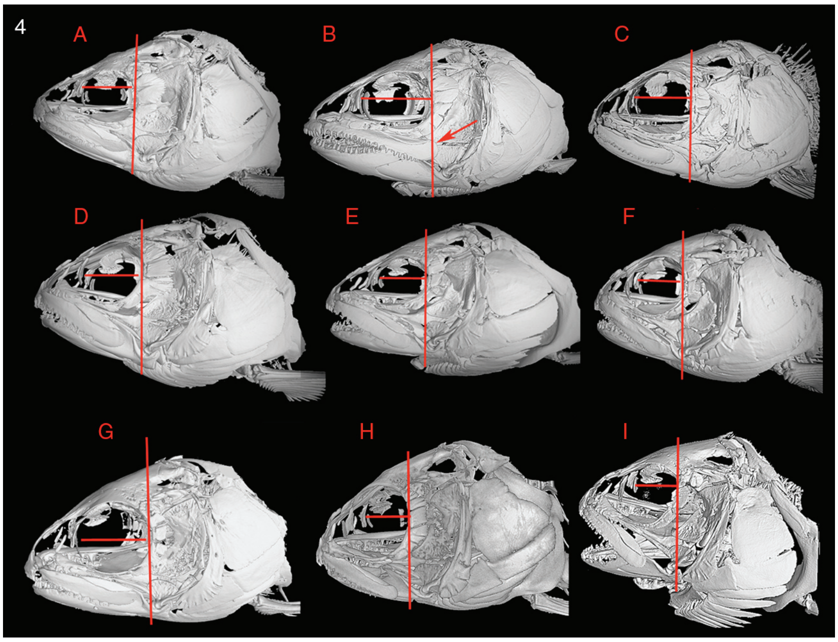
2. Joint of the ethmoid, premaxilla and maxilla bones in Atlantic *Salmo* populations from Morocco. Dades population shows an extended premaxilla processes. Isli population shows a robust and ossified premaxilla. A=Melloul, 105.2 mm SL. B=Dades, 126.4 mm SL. C=Ziz, 97.1 mm SL. D=Miaami, 77.1 mm SL. E=Isli, 222.6 mm SL. F=Ifni, 154.9 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. Etm=ethmoid bone. Pmx=premaxilla. Mx=maxilla. All individuals are mature males

2. Articulación del etmoides, la premaxila y la maxila en las poblaciones atlánticas de *Salmo* de Marruecos. La población del Dades muestra un proceso de la premaxila extendido. La población de Isli muestra una maxila robusta y osificada. A=Melloul, 105.2 mm SL. B=Dades, 126.4 mm SL. C=Ziz, 97.1 mm SL. D=Miaami, 77.1 mm SL. E=Isli, 222.6 mm SL. F=Ifni, 154.9 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. Etm=etmoides. Pmx=premaxila. Mx=Maxilla. Todos los individuos son machos maduros.



3. Premaxilla in Atlantic *Salmo* populations from Morocco. Dades population has a small and inclined upper process. Ifni population has the basal plate longer than the other populations. Isli population is strongly ossified. A=Melloul, 105.2 mm SL. B=Dades, 126.4 mm SL. C=Ziz, 97.1 mm SL. D=Lakhdar, 110.4 mm SL. E=Miaami, 77.1 mm SL. F=Isli, 222.6 mm SL. G=Ifni, 154.9 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. All individuals are mature males.

3. Premaxila en las poblaciones atlánticas de *Salmo* de Marruecos. La población del Dades tiene un proceso superior pequeño e inclinado. La población de Ifni tiene una placa basal más larga que el resto de poblaciones. La población de Isli está fuertemente osificada. A=Melloul, 105.2 mm SL. B=Dades, 126.4 mm SL. C=Ziz, 97.1 mm SL. D=Lakhdar, 110.4 mm SL. E=Miaami, 77.1 mm SL. F=Isli, 222.6 mm SL. G=Ifni, 154.9 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. Todos los individuos son machos maduros.



4. Lateral view of the skull in Atlantic *Salmo* populations from Morocco. Ifni Lake population has the longest maxilla. The orbital space is larger in adult individuals from Ifni Lake and Dades. A=Isli, 222.6 mm SL. B=Ifni, 154.9 mm SL. C=Dades, 126.4 mm SL. D=Miaami, 77.1 mm SL. E=Melloul, 105.2 mm SL. F=Ziz, 97.1 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. All individuals are mature males.

4. Vista lateral del cráneo en las poblaciones atlánticas de *Salmo* de Marruecos. La población del lago Ifni tiene la maxila más larga. El espacio orbital es más grande en los individuos adultos del Lago ifni y Dades. A=Isli, 222.6 mm SL. B=Ifni, 154.9 mm SL. C=Dades, 126.4 mm SL. D=Miaami, 77.1 mm SL. E=Melloul, 105.2 mm SL. F=Ziz, 97.1 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. Todos los individuos son machos maduros.

5. Maxilla in Atlantic *Salmo* populations from Morocco showing the inflection of anterior process from main axis of the maxilla. A=Isli, 222.6 mm SL. B=Melloul, 105.2 mm SL. C=Miaami, 77.1 mm SL. D=Ifni, 154.9 mm SL. E=Ziz, 97.1 mm SL. F=Dades, 126.4 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. All individuals are mature males.

5. Maxila en las poblaciones de *Salmo* mostrando la inflexión del proceso anterior respecto al eje principal de la maxila. A=Isli, 222.6 mm SL. B=Melloul, 105.2 mm SL. C=Miaami, 77.1 mm SL. D=Ifni, 154.9 mm SL. E=Ziz, 97.1 mm SL. F=Dades, 126.4 mm SL. G=Lakhdar, 110.4 mm SL. H=Moulouya, 107.8 mm SL. I=Tensift, 111.9 mm SL. Todos los individuos son machos maduros.