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Length-weight relationships (LWRs) of endemic and introduced freshwater fish species in 13 Tunisian reservoirs

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Abstract - A study was conducted during 2013-2015 in 13 Tunisian reservoirs. A total of six fish species belonging to three families were collected using multi-mesh gill nets (EN 14575 amended) for the first time. Fish sampling was made in the most important Tunisian reservoirs for analysis of fish length-weight relationships (LWRs). Analyses included species for which no previous LWR information was available. Ranges of parameters "a" and "b" of the 6 species were from 0.0016 to 0.1774 and 2.859 to 3.260, respectively.

Keywords: Length-weight relationships, freshwater fish, Tunisian reservoirs.

Résumé - Un total de six espèces de poissons dulçaquicoles, appartenant à trois familles, ont été collectées entre 2013 et 2015 dans le but d'analyser leurs relations Taille-poids. L'échantillonnage a été effectué, en utilisant des filets maillants à mailles multi-mailles (EN 14575 modifié), au niveau des retenues de barrages les plus importantes en Tunisie. Cette étude a permis de déterminer les relations tailles-poids pour les espèces ichtyques dulçaquicoles pour lesquelles aucune information antérieure n'existe. Les intervalles de variabilité des paramètres « a » et « b » chez les 6 espèces étudiées sont respectivement de 0,0016 à 0,1774 et de 2,859 à 3,260.

Mots clés: Relation taille-poids, poissons dulçaquicoles, barrages tunisiens.

1. Introduction

Freshwater fish farming is a recent activity in developing Tunisia that began with the experimental stocking of reservoirs with brood stock and fry of freshwater fish. With the majority of reservoirs located in the northern part of the country (Mili et al. 2015), 450 fishermen and 232 boats are currently involved in this activity (DGPA 2015). The fishing activity in Tunisian reservoirs concern especially 9 species: carp (*Cyprinus carpio*), pike-perch (*Sander lucioperca*), mullet (*Mugil cephalus and Liza ramada*), eel (*Anguilla Anguilla*), catfish (*Silurus glanis*), roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus)*, barbell (*Luciobarbus callensis*) and tilapia (*Oreochromis niloticus)*. Production was around 1034 tons in 2014 and mullet was the most abundant fished species and represents 30% of the total landing (DGPA 2015). Despite numerous cited studies on the biology of freshwater fishes in Tunisian reservoirs (Djemali 2005; Kraim 1994; Mili et al. 2015; Mili et al. 2016; Tlili et al. 2010; Toujani et al. 2000), few detailed information related to length-weight relationships are available. Knowledge of length-weight relationships (LWRs) allow to compare the condition factor and ontogenetic allometric changes of different populations (Froese et al. 2011), and to convert fish length into absolute biomass which is essential in fisheries management.

The present study describes the length-weight relationships (LWRs) for the most abundant fish species in 13 Tunisian man-made lakes (Fig. 1). The data is believed to be the first published reference on LWRs for fishes in Tunisian reservoirs.

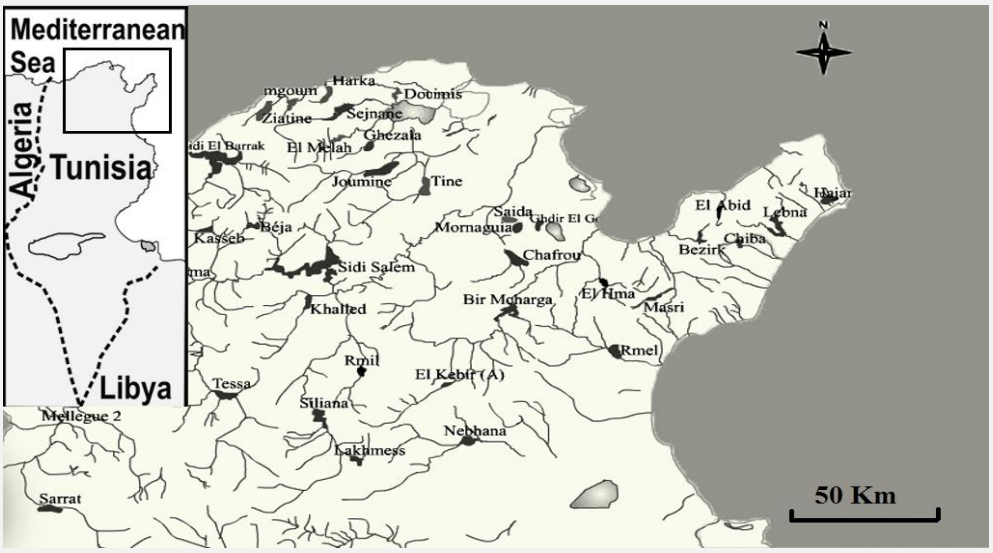

Figure 1. Study areas and locations of the most important Tunisian reservoirs

2. Material and methods

Fishes are caught using multi-mesh gillnets during fishing surveys between May 2013 and June 2015. The gill nets used for sampling have 8 different mesh sizes ranging between 18 mm to 80 mm. All specimens were identified to species level and validated following FishBase (Froese and Pauly 2013), measured for total length (TL to nearest 1 mm) and weighed (to 0.1g accuracy). The relationships between total length and weight were determined by linear regression. In this study we adopted the regression equation $W = aL^b$ to fit the length-weight relationships (LWRs) where W is the total weight (g), L is the total length (cm), "a" and "b" are regression parameters (Ricker 1973). Additionally, we calculated the 95% confidence limits for "a" and "b"(CL 95%) to determine if the hypothetical value of isometry fell between these limits (Froese 2006).The correlation between W and L is evaluated by the coefficient of determination r^2. For LWRs with $r^2 < 0.95$ the regression was repeated after removing outliers (Froese 2006). The model fit to the data was measured by the coefficient of the Pearson r-squared (r^2) test. Outliers observed in the log-log plots of all species were excluded from the regression.
The LWRs were analyzed by STATISTICA software Origin version 8.0.

3. Results and discussion

The number of samples, degree of threat, range of standard length and total weight, estimated parameters of length-weight relationships for 6 fish species from 13 Tunisian man-made lakes, the 95% confidence interval (CL) of a and b, as well as the determination coefficient (r^2) were listed in Table 1.The allometry was negative, for all species in the 13 reservoirs except for roach form Ghezala and Bekbeka where which was symetric and presented a coefficient of allometry statistically equal to 3. Additionally a positive allometry was detected for mullet (*L. ramada*) from Sidi Barrak and Seliana and for rudd in Laabid reservoir. The r^2 values for all species were ranged between 0.868 and 0.994, and b values varied from 2.859 to 3.260. The LWR parameters of the species in previous studies in Fishbase had been compared to our results in order to indicate relationships of body shape between related species.
The application of the Bartlett test associated with t-Student test showed that there is a significant difference between LWRs for each species in all dams except for *Cyprinus carpio* (Table 2).
LWRs for six species from 13 Tunisian reservoirs are published for the first time in scientific literature as shown in Table 1 in order to create a useful reference for future similar studies. As established by Froese (2006), the range of b values oscillates between 2.5 and 3.5, inside the normal range. LWRs showed a high determination coefficient, indicating the reliability of our results for the estimation of the length-weight relationships. The parameters of the LWR can be used safely within the indicated length range. The differences between LWRs could be explained by the growth phase, genetic discrepancy, the gonad maturity, stomach fullness, the local nutrition conditions and preservation techniques of the

captured specimens (Froese 2006; Mousavi-Sabet et al. 2015; Wootton 1998), which were not considered in the present study. Thus, differences in LWRs between the results and other studies could be potentially attributed to the combination of one or more of the factors given above. The comparison of LWRs parameters with previous studies (FishBase) indicates that these species have a negative allometry in the Tunisian reservoirs which differed from the prediction in the European lakes that estimated a positive allometry of LWRs.

This observation confirms that the environmental factors such as temperature have a direct effect on the relative growth of fish. As the dominant species, these fishes are important in maintaining the ecological balance in the Tunisian reservoirs.

Table 2. Comparison of length-weight relationships for 6 species in 13 Tunisian reservoirs (Confidence interval 95%).

		Comparing slopes		Comparing positions	
Species	**Bartlett test**	**Student-t test**	**Significant difference**	**Student-t test**	**Significant difference**
Rutilus rutilus	+	4.679	+		
Scardinius erythrophthalmus	+	7.746	+		
Sander lucioperca	+	6.261	+		
Cyprinus carpio	+	0.253	-	0.782	-
Liza ramada	+	5.958	+		
Luciobarbus callensis	+	4.144	+		

4. Conclusion

These results contribute to the knowledge of the species from the most important reservoirs in Tunisia where species had no previous length-weight relationships estimates.

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Table 1. Descriptive statistics and estimated parameters of length-weight relationships (W = aLb) for 6 fish species from 13 Tunisian reservoir.

Species	Reservoir	N	Total length (cm)		Weight (g)		a	95% CI of a	b	5% CI of b	r^2
			Min	Max	Min	Max					
Rutilus rutilus	Sidi Salem	358	12.5	20.5	21	108	0.0161	0.0130-0.0241	2.859	2.596-3.094	0.868
	SidiSaâd	37	14.7	86	40	86	0.0213	0.0191-0.0240	2.766	2.692-2.852	0.833
	Siliana	46	13.4	19	30	88	0.0137	0.0012-0.0260	2.986	2.832-3.083	0.873
	Bekbeka	34	15	22	32	90	0.0101	0.0070-0.0144	3.005	2.951-3.041	0.936
	Bezirek	46	14.5	23.5	34	167	0.0170	0.0123-0.0237	2.850	2.584-3.072	0.946
	Lahjar	339	17	28	71	196	0.0980	0.0860-0.1141	2.678	2.583-2.771	0.924
	Ghezela	38	14	25	26	152	0.0108	0.0102-0.0118	3.022	2.958-3.036	0.861
	Mellegue	781	12	29.8	12	29.8	0.0208	0.0087-0.0410	2.745	2.664-2.873	0.877
	Bouheurtma	52	12.1	22.5	20	114	0.0205	0.0201-0.0208	2.797	2.652-3.025	0.933
Scardinius erythrophthalmus	Sidi Salem	129	12.2	22.5	17	135	0.0132	0.0016-0.0248	2.975	2.791-3.173	0.868
	Siliana	871	11	31	17	293	0.0220	0.0203-0.0302	2.874	2.781-2.914	0.856
	Bezirek	110	12	25.5	18	212	0.0162	0.0142-0.0186	2.856	2.724-2.996	0.937
	Laabid	30	13.5	34	28	523	0.0070	0.0051-0.0100	3.221	3.141-3.322	0.981
Sander lucioperca	Sidi Salem	102	13.2	52	26	1500	0.0106	0.0062-0.0161	2.974	2.794-3.174	0.924
	Siliana	199	8.5	53.5	44	1150	0.1774	0.1340-0.2230	2.937	2.856-3.022	0.898
	Lahjar	36	19	52	86	301	0.1626	0.1108-0.2201	2.610	2.331-2.882	0.880
Cyprinus carpio	Sidi Salem	64	21	50	100	1800	0.0580	0.0354-0.0912	2.764	2.668-2.876	0.865
	Siliana	33	14.2	55	34	1700	0.1244	0.067-0.1750	2. 623	2.547-2.728	0.834
	Bir Mchergua	254	11	45	22	973	0.0269	0.0229-0.0324	2.734	2.608-2.817	0.963
	SidiSaâd	30	18	27	63	220	0.0173	0.0131-0.0226	2.873	2.729-2.928	0.867
Liza ramada	Sidi Salem	33	22.5	49	188.9	1000	0.0051	0.0442-0.0596	2.998	2.816-3.173	0.856
	SidiSaâd	531	14.7	37.3	39	506	0.0169	0.0127-0.0229	2.777	2.693-2.854	0.912
	Siliana	36	23.5	32	124	292	0.0053	0.0043-0.0060	3.189	3.121-3.261	0.923
	Kasseb	30	19.6	43	71	688	0.0267	0.0225-0.0316	2.876	2.786-2.918	0.994
	Sidi El Barrak	46	32	52	269	1422	0.0016	0.0011-0.0022	3.260	3.238-3.297	0.957
	Lahjar	32	22	30	118	1005	0.0175	0.0147-0.0235	2.856	2.616-3.113	0.871
Lucibarbus callensis	Mellegue	30	14	65	14	26.4	0.0143	0.0064-0.0244	2.820	2.722-2.922	0.972
	Sidi El Barrak	250	26	44	186	1180	0.0227	0.0187-0.0262	2.984	2.911-3.033	0.944
	Ghezela	70	27.6	33.8	192	371	0.0161	0.0120-0.0218	2.866	2.722-3.024	0.896
	Bir Mchergua	41	12	36	20	531	0.0196	0.0157-0.0222	2.816	2.622-3.002	0.926
	Mellegue	287	16.1	24.6	46	135	0.0184	0.0148-0.0228	2.895	2.736-3.097	0.939
	Kasseb	37	21.9	44.9	30.8	858	0.0309	0.0274-0.0368	2.713	2.621-2.782	0.970

N: Number of individuals; a: intercept; b: slope; r^2: coefficient of determination; CIs: confidence limits.

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