Acta Nat. Sci. (2021) 2(2): 118-123
DOI: 10.29329/actanatsci.2021.350.05
e-ISSN: 2718-0638

Original Research Paper
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ACTA NATURA ET SCIENTIA

Determination of Sexual Dimorphism in the Freshwater Blenny, *Salaria fluviatilis* (Asso, 1801), Distributed in Brackish Water Habitats

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Please cite this paper as follows:
Gurkan, S., & Innal, D. (2021). Determination of Sexual Dimorphism in the Freshwater Blenny, *Salaria fluviatilis* (Asso, 1801), Distributed in Brackish Water Habitats. *Acta Natura et Scientia*, *2*(2), 118-123. https://doi.org/10.29329/actanatsci.2021.350.05

ARTICLE INFO

Article History
Received: 29.09.2021
Revised: 07.10.2021
Accepted: 31.10.2021
Available online: 01.11.2021

Keywords:
Blennid species
Salaria fluviatilis
Dimorphic structure
Morphometric features
Phenotypic response

ABSTRACT

The present study aimed to determine the presence of the sexual dimorphism based on the morphometric measurements in a total of 60 samples (♀: 26; ♂: 14, immature; 20) which were obtained in April 2017 from the population of *Salaria fluviatilis* which shows distribution in the brackish waters in the Karpuzçay Creek (Antalya, Turkey). As a result of the morphometric analysis performed in both sexes of samples, it has been determined that there were differences between body parts in terms of total length (TL), dorsal fin length (DFL), snout length, and eye diameters in the head area. Accordingly, it has been observed that the lengths of allometric growing body parts of males were greater than that of females. The properties of sexual dimorphism in the body parts of freshwater blenny cause significant differences between sexes in brackish water forms. The differences in male individuals such as TL and long DFL are important criteria for the selection of large male individuals for sexual selection in mating. It was thought that the increase in snout length and eye diameter in the head region gives males some advantages in various areas such as feeding performance from the habitat, male selection of females in mating, and swimming performance.

INTRODUCTION

Salaria fluviatilis (Asso 1801), known as the freshwater blenny, is a sensitive endemic species of the streams in the Mediterranean and the Black Sea and is spread in the benthic region (Laporte et al., 2013). In time, these areas may threaten the river populations of the species with factors such as the change in the morphological structure of the river resources or pollution (Crivelli, 1996). Also, the freshwater blenny populations, which show distribution both in the world and in Europe's inland and wetlands, are in the Least Concern (LC) category, which is considered to be the least worrying level (Crivelli, 2006).

The species which are maintaining their lives in the habitats, where they live, have a significant level of sexual dimorphism features (Kottelat & Freyhof, 2007; Laporte et al., 2016a). Among these features are mainly a longer body and a wider head structure of male specimens (Roché, 2001; Alp & Kara, 2007; Keith et al., 2011; Laporte et al., 2018). Sexual dimorphism is the most common feature in the animal world (Shine, 1989), it affects many vital factors such as reproduction, parental care (fry or egg) throughout the life of the individuals, and is considered an important factor in the emergence of sex selection (Laporte et al., 2018). Accordingly, it was determined that sexual dimorphism is different for species in ecological terms of the river and lake blenny populations. It was determined that freshwater blennids

have larger bodies than river populations compared to lake populations (Laporte et al., 2013). Rispoli & Wilson (2008) estimated that local living conditions can affect both morphological and vital characteristics of the species. This estimate was based on Bergmann (1847)'s rule which indicates that the existence of a positive correlation between the size of the organism and the latitude that the organism is distributed at.

Some studies on sexual dimorphism in terms of reproduction and parental care determined that there were cephalic crest and two anal glands around the anal fin in males, especially during the breeding season and parental care (Fabre et al., 2014), and the researchers considered this result a dimorphic structure for sexes (Laporte et al., 2018). Sexual dimorphism, which develops based on the differences in habitat, is considered as an effort to increase the mating chance of females in river form, whose swimming skills are more effective than that of males (Vinyoles & De Sostoa, 2007).

However, the composition of Blennid species in brackish water ecosystems has not been fully clarified (Innal, 2019). The primary objective of the present study was to determine the prominent sexual dimorphism characteristics in specimens of *S. fluviatilis*, a blennid species which shows the distribution in brackish water habitats other than a river or lake form.

MATERIAL AND METHODS

Salaria fluviatilis (Asso, 1801) was used as the research material, caught from the brackish water zone (36°42'56.84" N 31°33'00.95" E) of the Karpuzçay Creek Estuary, which flows into the Antalya Bay, in April 2017, using a beach seine net (10 m long and 2 m high; 1.2 × 2 mm mesh size). The sampling area and Google Earth images are given in Figure 1. Seventy-five samples were fixed in 10% formalin solution, and the species identification was determined as described by Akşiray (1987). Sixty of these samples (♀: 26; ♂: 14, immature; 20) were evaluated in morphometric measurements.

The sex determinations of the specimens were evaluated by the dissection method according to the presence of ovaries and testicles. Specimens' sex ratio (F/M) was determined; however, meristic measurements were not taken into consideration. A total of 11 morphometric measurements, 4 from the head area and 7 from the body region were evaluated for the morphometric study. These are total length (TL), standard length (SL), head length (HL), eye diameter (ED), snout length (SNL), head height (HH), predorsal length (PDL), body height (BH), dorsal fin length (DFL), dorsal fin

Figure 1. Brackish zone of the sampling area (Karpuzçay Creek Estuary)

height (DFH), and caudal peduncle height (CauPH) (Figure 2). A digital compass with a sensitivity of 0.01 mm was used. The height values of morphological characters were evaluated according to total height (TL%). By providing logarithmic transformation of independent variables, linear regression values were calculated using the equation $\log y = \log a + b \log x$ as described by Choo & Liew (2006). The averages of morphometric measurements between sexes were determined using the Student's t-test. The regression relation of morphometric characters and length conversion equations were determined using (r^2) (Gulland, 1969), the significance test (<0.05) was used in the STATISTICA v11 program for the statistical differences.

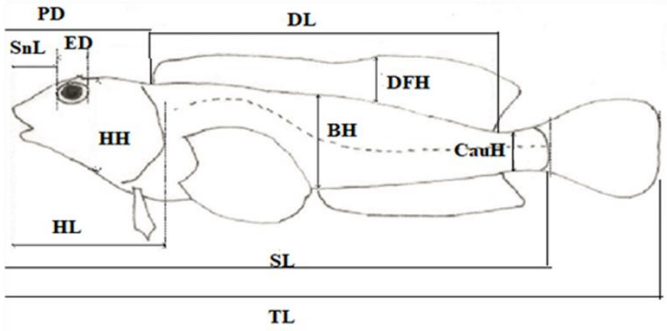

Figure 2. Morphometric measurements of *Salaria fluviatilis*. TL: Total length, SL: Standard length, HL: Head length, ED: Eye diameter, SnL: Snout length, HH: Head height, PDL: Predorsal length, BH: Body height, DL: Dorsal fin length, DFH: Dorsal fin height, CauPH: Caudal peduncle height.

RESULTS

The averages of the morphometric characters of *Salaria fluviatilis* samples according to sex are given in Table 1. The average height value for all specimens obtained in the study was 48.92±11.92 mm. Evaluating the average height according to sex, it was determined that the tallest specimens were male specimens with 57.00±12.00 mm. Therefore, the evaluations made according to the total height values showed that the first difference between the sexes was the total height values (P<0.05) (Figure 3 and Table 1).

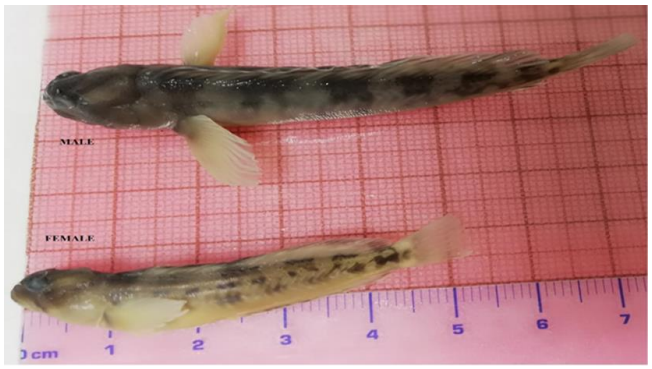

Figure 3. The image of male and female specimens of *Salaria fluviatilis* (upper: male; lower: female)

The average total length value (TL) in all individuals of the species, which shows the distribution in the Karpuzçay River was determined to be 48.92±11.92 mm. It was also seen that males had a longer body length than females. There was a statistical difference between the sexes in terms of total height values (t_{cal}: −2.139, p=0.0038, P<0.05). Dorsal fin length (DFL) values had an average of 25.49±6.70 mm in the whole population and corresponded to 52% of the total length. The dorsal fin length of the sexes was statistically different (t_{cal}: −2.206, p=0.032, P<0.05). These results showed that males had a larger dorsal fin size than females (Figure 3 and Figure 4A). In two important measurements, eye diameter (ED) and snout length (SnL) in the head region had statistically significant differences. Examining the results of the snout length in all specimens, it was determined that the average results were 3.33±0.93 mm in the population and corresponded to approximately 7% of the total length. There was a statistically significant difference in snout length between the sexes (t_{cal}: −2.470, p=0.017, P<0.05), and it was understood that males were more advantageous than females in this difference (Figure 3, Figure 4B and Table 2).

It was determined that the average eye diameter values, another important measurement of the head area, was 1.91±0.44 mm in the whole population, and corresponded to approximately 4% of the total length (t_{cal}: −2.277, p=0.027, P<0.05) (Table 2, Figure 3 and Figure 4C).

Table 2 shows the allometric growth results of the body parts that cause sexual differences depending on the total height. DFL and SnL measurements showed increases in female and male specimens depending on the total height. ED, on the other hand, showed positive allometric growth in males, whereas this growth rate was very low in females.

Table 1. The average morphometric features of *Salaria fluviatilis* (m±sd: mean±standard dev.)

Morphometric features	Male	Female	All	Mean (%)	P
Total Length (TL)	57.00±12.00	49.77±9.59	48.92±11.92	-	P<0.05*
Standard Length (SL)	47.72±11.51	42.35±7.81	42.14±10.15	86.14TL	P>0.05
Head Length (HL)	12.97±3.21	11.49±2.62	11.39±3.08	23.28TL	P>0.05
Head Height (HH)	8.58±4.03	6.74±2.98	6.75±3.38	12.79TL	P>0.05
Snout Length (SnL)	3.94±0.84	3.34±0.75	3.33±0.93	6.80TL	P<0.05*
Eye Diameter (ED)	2.19±0.49	1.90±0.37	1.91±0.44	3.91TL	P<0.05*
Predorsal Length (PDL)	13.62±2.64	12.31±2.24	12.02±2.77	24.58TL	P>0.05
Dorsal fin Length (DFL)	29.85±7.02	25.85±5.03	25.49±6.70	52.11TL	P<0.05*
Dorsal fin Height (DFH)	3.19±1.53	2.81±1.15	2.67±1.30	2.65TL	P>0.05
Body Height (BH)	8.61±2.38	7.51±1.77	7.32±2.19	4.56TL	P>0.05
Caudal Peduncle Height (CauPH)	4.31±1.23	3.74±0.90	3.68±1.10	7.51TL	P>0.05

Note: *P<0.05: statistically difference

Table 2. Allometric growth models of *Salaria fluviatilis* according to the in $L = aTL^b$ equation

	Male			Female			All Sexes		
	a	*b*	*r*	*a*	*b*	*r*	*a*	*b*	*r*
DFL	0.464	1.030	0.93	0.579	0.971	0.96	0.469	1.025	0.96
ED	0.052	0.924	0.82	0.193	0.583	0.61	0.143	0.664	0.74
SnL	0.082	0.958	0.90	0.056	1.040	0.85	0.041	1.125	0.89

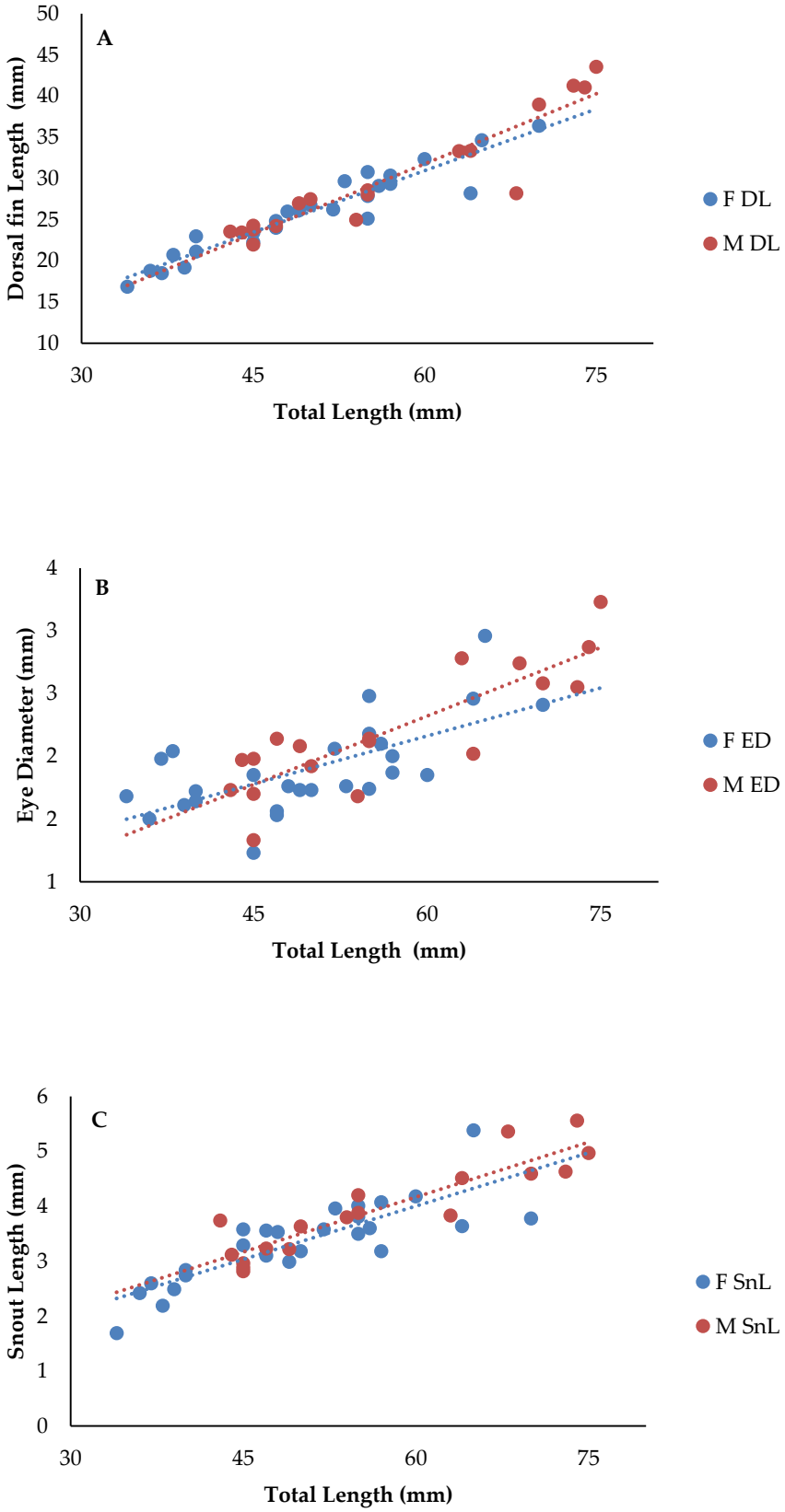

Figure 4. Allometric relations in the sexes of *Salaria fluviatilis* specimens (A: dorsal fin length-total length relation, B: eye diameter-total length relation, C; snout length-total length relation; F: female; M: male)

DISCUSSION

In this study, the sex ratio (♀:♂) was determined to be 1:0.54 in the freshwater blenny population, and it was observed that female individuals were dominant in the habitat. The various studies have reported that females form dominant populations in the Ceyhan River (Alp & Kara, 2007), Kournas, Fango, and Garda rivers (Neat et al., 2003). However, it was thought that the reason for the differences in sex rates of the species was the hiding behavior to protect their eggs and the nest from predators (Côté et al., 1999; Alp & Kara, 2007).

In the present study, it was determined that *S. fluviatilis* male specimens were larger in terms of total length, snout length, eye diameter, and dorsal fin length values. It was also observed that males of freshwater blennid species were larger than females (Rensch, 1950; Roché, 2001; Kottelat & Freyhof, 2007; Alp & Kara, 2007). While these determinations are more common in males in river populations, the opposite was observed in marine forms (Côte & Hunte, 1989). Neat et al. (2003) have stated that lake populations were generally smaller than river populations. As the main reason for the difference between populations was thought to be the preference of blennid species in mating by resorting to sexual selection at the time of reproduction and the preference of larger males in mating (Laporte et al., 2018). According to these evaluations, it was considered that the results obtained in the present study were in line with two different opinions. The first opinion is that males are larger than females and was in line with the basic rule of Rensch (1950), while the second is that the head structure in females is smaller than that of males, in line with that previously described by Laporte et al. (2018).

In the present study, the first sexual difference was determined in total height values, and the results showed that males are larger than females. Rispoli & Wilson (2008) have stated that local living conditions can be effective on both morphological and vital characteristics of the species. As seen clearly in *S. fluviatilis*, this difference in height values may vary according to the rapid growth rate or long life-period determined by the presence of food in the habitats such as rivers or lakes in which the species lives, and the predator effect (Laporte et al., 2018).

In the study, although the head length and height values of the female specimens were determined to be lower than those of the males, they did not show statistically significant differences. However, several studies indicated that the small head structure is related to the hydrodynamics and swimming performance of the fish species (Laporte et al., 2016b). Therefore, this feature is mainly considered a phenotypic approach of *S fluviatilis* in river populations with water current (Laporte et al., 2016a). However, it has been stated that the low growth of the head structure in females affects behavior during the reproductive period (Laporte et al., 2018). That may be effective in the female's mate selection the size of the head profile displayed by the species in different habitats such as a lake or river (Laporte et al., 2018).

In the present study, another important difference in the head of the species was determined in the eye diameter values of the sexes. Neat et al. (2003) have stated that the larger eye diameters of fish in Lake Kournas than other populations may be due to an accidental genetic structure or mutation. However, in this study, differences between the sexes in a population that show the distribution in a brackish water habitat were interpreted as the advantage of adaptation in proportion to body size in male specimens. Differences were also found between the sexes in the head structure, the snout length. Neat et al. (2003) emphasized that in *S. fluviatilis* individuals which shows the distribution in the lake habitat, the snout length in the head region is long and this structure may be related to nutritional adaptation. Accordingly, the results obtained from this study showed that the difference in snout length between sexes can be considered as nutritional adaptation in the habitat in question.

CONCLUSION

Results provided us an insight that freshwater blennids, which show the distribution in brackish waters may continue to differ in terms of total length, dorsal fin length, snout length, and eye diameter values. Therefore, our results showed that sexual selection continues without causing much change for males in brackish water habitats, except for lake and river habitats. However, the results also indicated that the existing differences are a phenotypic response to this type of habitat.

Compliance With Ethical Standards

Authors' Contribution

SG and DI designed the study, SG managed statistical analyses and wrote the manuscript, all authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

REFERENCES

Akşiray, F. (1987). *Türkiye deniz balıkları tayın anahtarı*. İstanbul Üniversitesi Fen Fakültesi Hidrobiologi Araştırma Enstitüsü Yayınları (in Turkish).

Alp, A., & Kara, C. (2007). Distribution pattern and morphological differences between the sexes of river blenny, *Salaria fluviatilis* (Asso, 1801), in the Ceyhan River Basin, Turkey. *Turkish Journal of Zoology, 31*(2), 113-120.

Bergmann, C. (1847). Ueber die Verhältnisse der Wärmeökonomie der Thiere zu ihrer Grösse. Gottinger Studien, vol. 3, pp. 595-708.

Choo, C. K., & Liew, H. C. (2006). Morphological development and allometric growth patterns in the juvenile seahorse *Hippocampus kuda* Bleeker. *Journal of Fish Biology*, 69(2), 426-445. https://doi.org/10.1111/j.1095-8649.2006.01105.x

Côte, I. M., & Hunte, W. (1989). Male and female mate choice in the redlip blenny: why bigger is better. *Animal Behaviour, 38*(1), 78-88. https://doi.org/10.1016/S0003-3472(89)80067-3

Côté, I. M., Vinyoles, D., Reynolds, J. D., Doadrioc, I.,& Perdices, A. (1999). Potential impacts of gravel extraction on Spanish populations of river blennies *Salaria fuviatilis* (Pisces, Blenniidae). *Biological Conservation*, *87*(3), 359-367. https://doi.org/10.1016/S0006-3207(98)00072-X

Crivelli, A. J. (1996). *The freshwater fish endemic to the Mediterranean region. An action plan for their conservation*. Tour du Valat Publication (in French).

Crivelli, A. J. (2006). *Salaria fluviatilis*. The IUCN Red List of Threatened Species 2006: e.T60764A12407160. https://dx.doi.org/10.2305/IUCN.UK.2006.RLTS.T60764A12407160.en. Downloaded on 31 October 2021.

Fabre, N., Oliva, F., Garcia-Galea, E., & Vinyoles, D. (2014). Plasticity in secondary sexual characteristics in male freshwater blenny *Salaria fluviatilis. Canadian Journal of Zoology, 92*(6), 537-543. https://doi.org/10.1139/cjz-2013-0233

Gulland, J. A. (1969). *Manual of methods for fish stock assessment. Part 1. Fish population analysis.* FAO, Rome, Italy.

Innal, D. (2019). Diversity and length-weight relationships of Blennid Species Actinopterygii, Blenniidae) from Mediterranean Brackish Waters in Turkey. *Aquatic Sciences and Engineering, 34*(3), 96-102. https://doi.org/10.26650/ASE2019573052

Keith, P., Persat, H., Feunteun, E., & Allardi, J. (2011). *Les Poissons d'eau douce de France*. Muséum national d'Histoire naturelle, Paris; Biotope, Mèze, 552 p. (Inventaires & biodiversité ; 1).

Kottelat, M., & Freyhof, J. (2007). *Handbook of European freshwater fishes*. Publications Kottelat.

Laporte, M., Berrebi, P., Claude, J., Vinyoles, D., Pourovira, Q., Raymond, J-D. & Magnan, P. (2018). The ecology of sexual dimorphism in size and shape of the freshwater blenny *Salaria fluviatilis. Current Zoology*, *64*(2), 183-191. https://doi.org/10.1093/cz/zox043

Laporte, M., Claude, J., Berrebi, P., Perret, P., & Magnan, P. (2016a). Shape plasticity in response to water velocity in the freshwater blenny *Salaria fluviatilis*. *Journal of Fish Biology, 88*(3), 1191-1203. https://doi.org/10.1111/jfb.12902

Laporte, M., Dalziel, A. C., Martin, N., & Bernatchez, L. (2016b). Adaptation and acclimation of traits associated with swimming activity in Lake Whitefish (*coregonus clupeaformis*) ecotypes. *BMC Evolutionary Biology, 16*, 160. https://doi.org/10.1186/s12862-016-0732-y

Laporte, M., Mattei, J., Perret, P., Roché, B., Vinyoles, D., Goren M., Bacha M., Mourad Z., Pou i Rovira Q., Berrebi P., & Magnan P. (2013). New maximum lengths for freshwater blenny (*Salaria fluviatilis* Asso, 1801) and length comparison between continental and island rivers. *Cybium*, *37*(4), 309-313. https://doi.org/10.26028/cybium/2013-374-013

Neat, F. C., Lengkeek, E. P., Westerbeek, E. P., Laarhoven, B., & Videller, J. J. (2003). Behavioural and morphological differences between lake and river populations of *Salaria fluviatilis*. *Journal of Fish Biology, 63*(2), 374-387. https://doi.org/10.1046/j.1095-8649.2003.00159.x

Rensch, B. (1950). Die Abhängigkeit der relativen Sexualdifferenz von der Körpergröße. *Bonner zoologische Beiträge*, *1*, 58-69 (in German).

Rispoli, V. F., & Wilson, A. B. (2008). Sexual size dimorphism predicts the frequency of multiple mating in the sex-role reversed pipefish *Syngnathus typhle*. *Journal of Evolutionary Biology*, *21*(1), 30-38. https://doi.org/10.1111/j.1420-9101.2007.01470.x

Roché, B. (2001). *Atlas des poissons d'eau douce de Corse*. Direction régionale de l'environnement Corse. Imprimerie Bastiaise, Bastia, Corse.

Shine, R. (1989). Ecological causes for the evolution of sexual dimorphism: a review of the evidence. *Quarterly Review of Biology*, *64*(4), 419-461. https://doi.org/10.1086/416458

Vinyoles, D., & De Sostoa, A. (2007). Life-history traits of the endangered river blenny *Salaria fluviatilis* (Asso, 1801) and their implications for conservation. *Journal of Fish Biology*, *70*(4), 1088-1108. https://doi.org/10.1111/j.1095-8649.2007.01371.x