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Sexual dimorphism of the broad-nosed pipefish, *Syngnathus typhle*, from Aegean Sea (Turkey)

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Abstract. Females of *Syngnathus typhle* have larger mouth structure than males, resulting in pronounced sexual dimorphism with respect to the mouth width/mouth height in length group II (0.54 and 0.67 respectively). The mouth was relatively wider in females compared with males (1.32mm female; 1.25mm male) and higher (2.67mm female; 2.33mm male). Additionally other measurements, such as head length (L_H) and body width (W_B) were significantly different between males and females. Reasons for these differences are discussed.

Keywords: *Syngnathus typhle,* sexual dimorphism, morphometric features, Aegean Sea.

Introduction

Sexual dimorphism is generally based on three major characteristics (Berglund et al. 1986*a;* Zuffi et al., 2011): (a) different fecundity models can be formed between both sexes (Wotton 1979; Stojković & Savković 2011) due to the fecundity affected by natural selection, (b) natural selection decreases competition for food and thus larger individuals move to bigger prey, and (c) sexual dimorphism can result in competition for and/or possibility of mating (Berglund et al. 1986*a;* Godfrey and Watson 2009). Variation between males and females in *Syngnathus* spp. can be explained by proper interpretation of the relationships between morphology and reproduction of both sexes (Rispoli & Wilson 2008). Sexual dimorphism in body size oppositely affects multiple mating intervals in male broad nose pipefish while it influences fecundity of females irregularly (Rispoli & Wilson 2008).

Sexual dimorphism can be seen in various forms and shapes among pipefish species. Sexual dimorphism of *S. typhle* begins at age of two, which males are smaller sex (Berglund & Rosenqvist 1990). *Syngnathus acus,* for example, shows no obvious sexual dimorphism (Gurkan et al., 2009), whereas female *S. typhle* are longer and brighter (Vincent et al. 1995). Males prefer to mate with larger females (Berglund et al. 1986*a*). Thus, male *S. typhle* could face both natural and sexual selection for increased body size (Berglund et al. 1989).

Morphological variations are basic criteria in taxonomic identification of pipefish species (Takahasi et al. 2003). However, mouth height, one of the morphological characteristics, is believed not to affect sexual dimorphism in nutritional niche separation between the sexes (Berglund et al. 1986*a*).Nonetheless, body forms and snout morphologies of syngnathid fishes play an active role in catching prey and feeding behaviours (Kendrick & Hyndnes 2005). Thus the diets of syngnathid fishes are related to factors that influence both their foraging capabilities and catching. The objective of the present study is to provide information on various morphological characteristics of female and male *S. typhle* to determine if sexual dimorphism is present.

Materials and methods

A total of 174 *Syngnathus typhle* were sampled in Izmir Bay, Aegean Sea, Turkey. Specimens were caught by (120 X 1200 cm in size.) beach seine net at depths of not over 1.5 m with vegetation. Ten morphometric measurements (five in head and five in body sections) were taken in the study (Fig. 1). Total length (L_T), head length (L_H), occipital head height (H_{OH}), mouth height (H_M), mouth width (W_M), eye diameter (D_E), body height (H_B), body width (W_B), pectoral fin length (L_{PF}) and dorsal fin length (L_{DF}) were measured in mm. All calculations were transformed into total length percentage (L_T %) for statistical analyses (Lourie et al. 1999). The *t-test* calculated mean W_M / L_T, H_M /L_T and W_M / H_M values as significant intersexual variations (Sokhal & Rohlf 1981). To determine ontogenetic evolution and establish differences both between sexes and length groups, all data were divided into three length groups (90–169, 170–249, >250 mm).

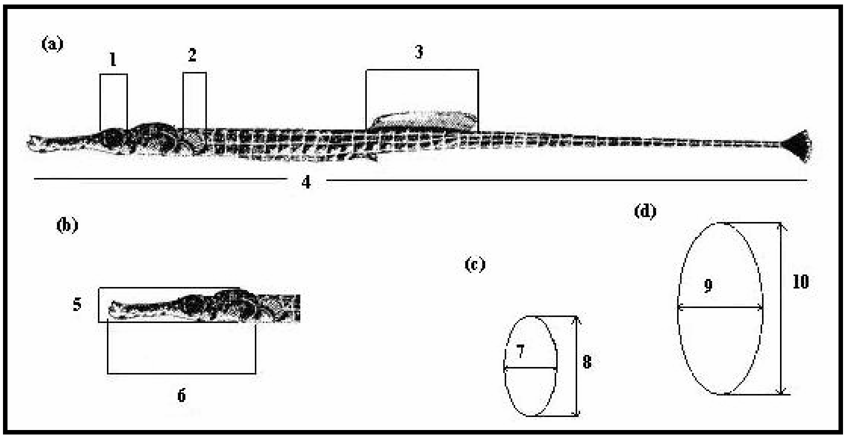

Figure 1. Morphometric measurements of *Syngnathus typhle* used in the study as follows: (a) 1, eye diameter (DE); 2, pectoral fin length (LPF); 3, dorsal fin length (LDF); 4, total length (LT); (b) 5, occipital head height (HOH); 6, head length (LH); (c) 7, mouth width (WM); 8, mouth height (HM); (d) 9, body width (WB); 10, body height (HB) (Figure was illustrated by Arias & Drake 1990, in www.fishbase.org).

Results

The mouth was relatively wider (1.32mm female; 1.25mm male; L_T % p =0.390, p >0.05) and higher (2.67mm female; 2.33mm male; L_T % p=0.091, p>0.05) in females than in males, resulting in significantly different W_M / H_M ratios in length group II (0.54 female, 0.67 male, p=0.035, p<0.05, Table 1). W_M / H_M ratio was almost constant in length group I (90-169 mm) for both sexes, but it was significantly decreased for females in length group II (170-249 mm) but increased for males. In length group III (250> mm), W_M / H_M ratio [0.60±0.21] decreased for males but increased for females, and W_M / H_M ratios significantly differentiated males from females in length groups of II and III (Table 1). However, sample size of length group III was small, statistical significance were seen for gender.

For intersexual differences, significant variations were found based on length groups. W_M / H_M of males are within the range of 0.26–1.27 (Table 1) with the difference being considerable in length group II (W_M / H_M p=0.035, p<0.05) (Table 1), which can be explained by the fact that mouth width in females increased rapidly with body length (Table 1). Differences between I-II (p =0.000001, p <0.05) and I-III (p =0.000001, p <0.05) groups of males were significant; thus, this can be interpreted as a slow increase in W_M and H_M values. H_M values were not positively correlated with L_T for sexes (Fig. 2.A-B). The head length (L_H) of females was greater than that of males (p =0.0058, p <0.05) and also their body width is larger than that of males (p = 0.046, p <0.05) (Table 2).

Discussion

The degree of specialization in snout morphologies (Kendrick & Hydnes 2005) and degree of sexual dimorphism among pipefish differs from species to species (Vincent et al. 1995).These divergences may cause natural selection (fecundity increases in females, not males based on length) and sexual selection (males choose larger females) in *S. typhle* (Berglund et al. 1986*a*; Berglund & Rosenqvist 2000). Previous studies show that one-year-old *S. typhle* do not exhibit sexual dimorphism in length, whereas older females become much larger than equal-aged males, and consequently males prefer larger females (Berglund et al. 1986*b*; Berglund & Rosenqvist 1990). This argument may be supported by both total length and body width of females being more than those of males in the present study. However, the females caught could all be older than the males. One important effect of sexual dimorphism is closely associated with food sharing, and it decreases competition for food between sexes, leading larger individuals to feed on bigger prey (Temeles 1985).

Evidence between snout length and kinetics of prey capture was established in pipefish species (Bergert & Wainwrigth 1997). Snout length of *S.*

Table 1. Mouth width (W_M), mouth height (H_M), and ratio of mouth width to mouth height and sexual differences according to total length percentage ($L_{T\,\%}$). Mean±S.D [range] and probability values showing statistical differences of between mouth width (W_M), mouth height (H_M), and W_M/H_M ratios between sexes of *Syngnathus typhle* of different length groups.

L_T (mm)	Males				Females			
	N	W_M	H_M	W_M/H_M	N	W_M	H_M	W_M/H_M
90-169	45	1.08±0.32 [0.60-1.58]	2.01±0.89 [0.69-3.85]	0.58±0.16 [0.26-1.07]	53	1.08±0.22 [0.71-1.82]	2.14±1.00 [0.68-4.52]	0.58±0.18 [0.36-1.04]
170-249	16	1.37±0.26 [1.07-1.13]	2.59±1.40 [0.88-4.89]	0.67±0.33 [0.32-1.27]	52	1.49±0.40 [1.07-3.71]	3.09±1.36 [1.00-5.79]	0.54±0.17 [0.38-1.07]
250>	3	3.31± 1.00 [2.17-4.00]	5.59±0.47 [5.09-6.02]	0.60±0.21 [5.09-6.02]	5	2.02±0.14 [1.92-2.17]	4.03±1.65 [2.82-6.00]	0.56±0.17 [0.36-0.68]
Total	64	1.25±0.59 [0.60-1.41]	2.33±1.27 [0.69-4.14]	0.61±0.22 [0.26-1.27]	110	1.32±0.41 [0.71-3.71]	2.67±1.32 [0.68-6.00]	0.55±0.15 [0.36-1.04]

L_T (mm)	*p* values		
	W_M	H_M	W_M/H_M
90-169	0.883	0.506	0.970
170-249	0.266	0.214	0.035*
250>	0.023*	0.171	0.744
Total	0.390	0.091	0.075

Table 2. Descriptive statistics of eight measurements (mm) (Mean ± SD and range) of male and female *Syngnathus typhle.*

Measurements	Males	Females	*P* >0.05
	Mean±SD [Range]	Mean±SD [Range]	
Total body length (L_T)	162.20±38.24 [97.00-304]	172.49±36.77[112.00-302.00]	0.081
Head length (L_H)	27.10±5.59 [11.50-36.31]	30.11±6.05[17.03-46.71]	0.005*
Occipital head height (H_{OH})	4.10±0.94 [2.14-6.02]	4.49±1.28 [2.70-9.17]	0.083
Eye diameter (D_E)	1.54±0.32 [1.11-2.35]	1.59±0.42 [1.01-3.08]	0.425
Body width (W_B)	3.72±1.00 [1.45-5.53]	4.18±1.39 [1.98-9.53]	0.046*
Body height (H_B)	3.54±0.97 [1.70-5.65]	3.90±1.43 [1.88-12.53]	0.136
Dorsal fin length (L_{DF})	17.46±3.81 [10.02-28.14]	18.01±3.49 [10.91-26.32]	0.416
Pectoral fin length (L_{PF})	1.97±0.66 [1.10-4.44]	2.00±0.49 [1.15-3.36]	0.743

SD, Standard Deviation; *p <0.05

typhle increases linearly depending on growth (Oliviera et al. 2007). Increased mouth width and snout length causes enlarged intraoral walls, thus increasing volume of water sucked in during ingestion (Oliviera et al. 2007). Therefore, capacity to catch prey can vary based on snout length due to total volume of water sucked into the mouth (Muller & Osse 1984). *Syngnathus typhle,* with a snout longer than other pipefish, has an advantage of catching relatively fast prey (Franzoi et al. 1993; Oliviera et al. 2007). Both mouth width and height of females are greater than that of males, providing a larger oral cavity, and thus vacuuming more water and more prey (Oliviera et al. 2007). In the present study, mouth heights of females were larger than those of males. H_M values of females and males were not positively correlated with those of L_T. However, head morphology in females can be claimed to have been further differentiated than in males due to sexual development.

Prominence of reproductive organs (gonads and testes) and presence of brood pouch are suggestive of sexual maturity in male *S. typhle* (Monterio et al. 2005). Gurkan (2004) suggests that female *S. typhle* reach sexual maturity at the lengths of 20 mm. Berglund et al. (1989) found that females reach sexual maturity in approximately 25.7 mm. Variations in oral morphometric measurements are associated with habitats they choose and certain types of prey they catch as well as their sexual development (Ben Amor et al. 2007; Kendrick & Hyndes 2005). In addition, sexual size dimorphism is absent in *S. typhle* of one year of age but increases with age. Thus, older females are larger than similar aged males (Berglund et al. 1986*b*; Berglund & Rosenqvist 1990).

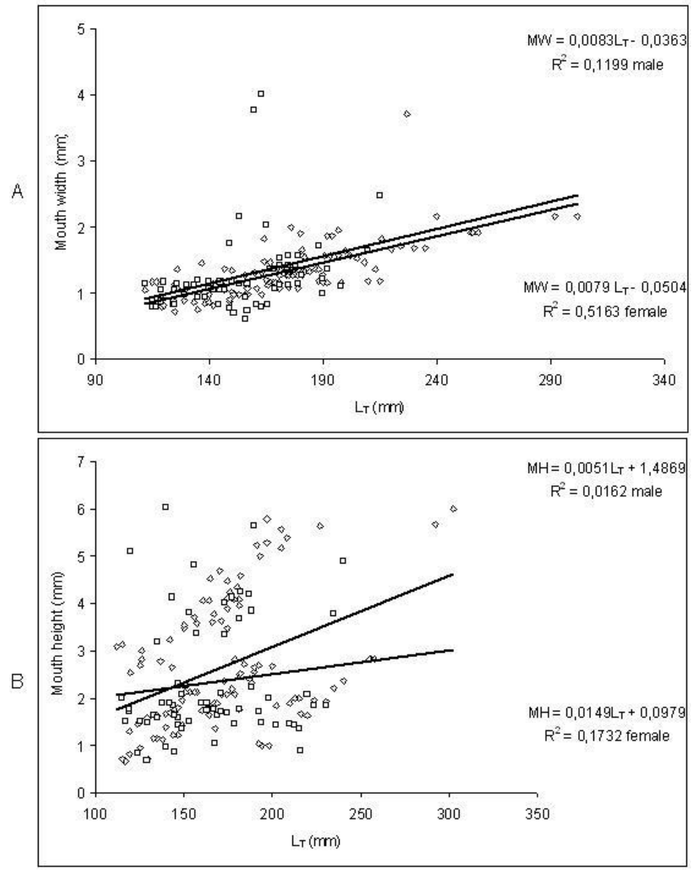

Figure 2. Graphs showing the linear relationships between mouth width (W_M)-total length (L_T) (A) and mouth height (H_M)-total length (L_T) (B) for male and female *Syngnathus typhle* (□=male, ◊=female).

W_M/H_M ratio in the length group II (170-249 mm) was significantly different between males and females. It suggests presence of sexual selection, a degree of sexual dimorphism (Berglund et al. 1986*a*). Age of *S. typhle* was not determined in this study, but length group II had bigger specimens than group I. Sexual differences can not be determined for length of group I (Berglund & Rosenqvist 1990).

In the present study, we also found that other morphometric characteristics of the body (head length, body width) in females were unexpectedly greater than those in males, as sexual dimorphism was pronounced in female (Berglund et al. 1986*b*; Berglund & Rosenqvist 1990; Oliviera et al. 2007).

Local environmental conditions such as water temperatures may influence both morphological and life-history traits (Rispoli & Wilson 2008). Sexual difference theory suggests that potential for sexual dimorphism (in both morphology and behaviour) depends on the difference in strength of sexual selection acting on each sex (Lorch et al. 2007). Variation established above can be attributed to sexual differences developed during growth.

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