### Mediterranean Marine Science

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#### New Fisheries-related data from the Mediterranean Sea (April 2014)

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<td>VILIZZI L.</td>
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New Fisheries-related data from the Mediterranean Sea (April, 2014)

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Abstract

As part of its policy, Mediterranean Marine Science started from 2014 to publish a new series of collective article with fisheries-related data from the Mediterranean Sea. In this first collective article we present length frequencies and weight-length relationships for the northern brown shrimp Farfantepenaeus aztecus in the Eastern Mediterranean, weight-length relationships for 10 fish species in the North Aegean Sea, the feeding habits for 11 sparid fishes in the North Aegean Sea, a review of the existing literature on the feeding and reproduction of common carp Cyprinus carpio in Anatolia (Turkey) and mouth dimensions and the relationships between mouth area and length for seven freshwater fishes from Lake Volvi (Northern Greece).

Keywords: Weight-length relationships, reproduction, feeding, mouth dimension, invertebrates, fishes, Aegean Sea, Eastern Mediterranean.

Introduction

As part of its policy, Mediterranean Marine Science started from 2014 to publish a new series of collective article, twice a year, with fisheries-related data from the Mediterranean Sea, notably contributions on topics such as weight-length relationships, length-length relationships, length-frequency distributions, age and growth information, spawning and reproduction, diet, feeding habits and trophic level of fish and other marine animals in the Mediterranean Sea.

This decision was taken because in the last two decades there is a drastic decline in the number of fish and fisheries related journals that consider for publication articles with such basic data. It is worthy to point out that the relative frequencies of occurrence of fish-related 2-word phrases in the corpus of digitized books such as ‘fish growth’, ‘fish feeding’, ‘fish spawning’, ‘fish reproduction’, ‘fish biology’, ‘fish ecology’, ‘fish physiology’, ‘fish genetics’ ‘fish taxonomy’ ‘fish biogeography’ and ‘fish biochemistry’ all increase from 1800 to a peak in about 1980-1990 and decline thereafter, with the relative frequencies of ‘fish growth’, ‘fish feeding’ and ‘fish spawning’ being higher than those of the remaining ones (Fig. 1).

Yet, such basic data are essential for fish and fisheries biology and ecology for a plethora of reasons. For instance, such data are useful for: (i) studying patterns and propensities in the life-history of marine animals (e.g. trade-offs); (ii) testing whether life histories change...
spatio-temporally or not (e.g. bigger-deeper hypothesis, shifting baselines, nanism); (iii) estimating the position of marine animals in the ecosystems (i.e. trophic level) as well as other ecological indices (e.g. resilience, vulnerability to fishing); (iv) estimating the productivity of species; (v) estimating year class strength, which can then be used for studying variations in abundance and, thus, recruitment to the fishery; (vi) developing empirical relationships between life-history parameters with maximum length in order to estimate the former for less studied, rare, non-commercial species for which maximum length is available; (vii) stock structure identification (based on life–history traits); (viii) stock assessment; (ix) developing ecological models (e.g. Ecopath with Ecosim); and eventually (x) for management.

In this collective article we present length frequencies and weight-length relationships for the northern brown shrimp *Farfantepenaeus aztecus* (Ives, 1891) in the Eastern Mediterranean Sea. The study was carried out in the Gulf of Finike (36°13.21′N, 33°48.225′E), Antalya (36°50′N, 30°34′E - 36°45′N, 30°55′E), Mersin (36°10′N, 33°55′E) and Adana - İskenderun (36°28’N, 35°23’E - 36°45’N, 35°53’E) during June 2011 - January 2013. Monthly trawling operations (mesh size 22 mm, knot-to-knot) were performed at depths ranging from 25 to 150 m, for 1-3 hours using commercial and research vessels. Female and male individuals were identified by visible thelycum or petesma. All individuals were weighed to the nearest 0.1 g and measured for total length (i.e. from tip of the rostrum to end of the telson). A total of 1271 individuals were caught of which 834 (65%) were females and 437 (35%) males. The sex ratio differed significantly (*P* < 0.05) from the theoretical 1:1. The mean length was 19.3 ± 1.7 cm (range 11.5-30 cm) for females and 15.6 ± 1.3 cm for males (range: 12.2-20.7 cm) (Fig. 2). The mean length of females was significantly (*t* test, *P* < 0.05) larger than that of males. The mean weight of females (67.2 ± 19.4 g, range: 12-240 g) was significantly (*t* test, *P* < 0.05) larger than that of males (30.68 ± 8.7 g range: 14-66 g). The weight-length relationship did not significantly (*t* test, *P* < 0.001) differ between males and females and thus the weight-length relationship was estimated for sexes combined (Fig. 3).

Holthuis (1980) reports that the maximum observed total length of males and females was 19.5 and 23.6 cm, along the Atlantic coasts of USA and Mexico, respectively, which are both smaller than those found in the present study. Although this species has been recently established off the Mediterranean coasts of Turkey (Deval et al., 2010), it appears that it can reach a larger size than in the Atlantic.

1. Biological data on northern brown shrimp *Farfantepenaeus aztecus* (Ives, 1891) (Decapoda: Penaeidae) in the Eastern Mediterranean Sea

By Y. Özvarol and M. Gökoğlu

The northern brown shrimp *Farfantepenaeus aztecus* (Ives, 1891) is a Mediterranean penaeid shrimp of Atlantic origin. It reaches sexual maturity at about 14 cm total length and can reach maximum standard length 22 cm (=23.6 cm total length) (Cook and Lindner, 1970; Saoud & Davis, 2003). This study provides biological data on *F. aztecus* in the Eastern Mediterranean. The study was carried out in the Gulf of Finike (36°13.21′N, 33°48.225′E), Antalya (36°50′N, 30°34′E - 36°45′N, 30°55′E), Mersin (36°10′N, 33°55′E) and Adana - İskenderun (36°28’N, 35°23’E - 36°45’N, 35°53’E) during June 2011 - January 2013. Monthly trawling operations (mesh size 22 mm, knot-to-knot) were performed at depths ranging from 25 to 150 m, for 1-3 hours using commercial and research vessels. Female and male individuals were identified by visible thelycum or petesma. All individuals were weighed to the nearest 0.1 g and measured for total length (i.e. from tip of the rostrum to end of the telson).

A total of 1271 individuals were caught of which 834 (65%) were females and 437 (35%) males. The sex ratio differed significantly (*P* < 0.05) from the theoretical 1:1. The mean length was 19.3 ± 1.7 cm (range 11.5-30 cm) for females and 15.6 ± 1.3 cm for males (range: 12.2-20.7 cm) (Fig. 2). The mean length of females was significantly (*t* test, *P* < 0.05) larger than that of males. The mean weight of females (67.2 ± 19.4 g, range: 12-240 g) was significantly (*t* test, *P* < 0.05) larger than that of males (30.68 ± 8.7 g range: 14-66 g). The weight-length relationship did not significantly (*t* test, *P* < 0.001) differ between males and females and thus the weight-length relationship was estimated for sexes combined (Fig. 3).

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2. Weight-length relationships for ten commercial fish from the North Aegean Sea, Greece

By G. Minos

Weight–length relations are very useful to fisheries biology research since they are used for converting lengths into biomass, determining fish condition and comparing fish growth among areas (Froese et al., 2011). In the present study, weight–length relationships were established for 10 commercial fish in the North Aegean Sea. Samples were collected from one commercial bottom trawler (monthly samples, during October 2004-April 2005) and longlines (for the large pelagics Thunnus alalunga and Thunnus thynnus; monthly samples, during September 2003 - February 2004). Total length (TL), or fork length (FL), was measured to the nearest 0.1 cm and total body weight (W) to the nearest g. t-test was used to identify isometric or allometric growth.

Overall, 2629 individuals were measured for length and weight. The number of individuals ranged from 48 individuals, for T. thynnus, to 383, for Merluccius merluccius. All \( r^2 \) values of the weight-length relationships were greater than 0.90, and all regressions were highly significant \( (P<0.001) \). The values of the exponent \( (b) \) ranged between 2.53, for T. alalunga, to 3.24, for Microbesistus poutassou. For Lophius budegassa and Physic blennoides, growth was isometric \( (P>0.05) \) (Table 1). For all remaining species \( b \) values differed significantly \( (P<0.05) \) from 3, implying allometric growth (Table 1). It is worthy of mention that the maximum length (52.5 cm TL) recorded in this study for Lepidorhombus boscii is higher than that \( (i.e. 40 \text{ cm SL} \approx 47.3 \text{ cm TL}) \) reported in Fishbase (Froese & Pauly, 2013).

For five species \( (L. piscatorius, L. budegassa, M. poutassou, Z. faber and T. trachurus) \) the parameters \( b \) of the weight-length relationships presented here are generally similar with those reported by other authors (Stergiou & Moutopoulos, 2001; Moutopoulos & Stergiou, 2002; Froese & Pauly 2013) for the Aegean Sea.

Fig. 2: Monthly length frequency distribution of female (upper, \( n=437 \)) and male (lower, \( n=834 \)) Farfantepenaeus aztecus, during June 2011 - January 2013.

Fig. 3: Weight-length relationship of Farfantepenaeus aztecus, sexes combined.
3. Natural diet of common carp (Cyprinus carpio L., 1758) in Anatolia (Turkey): a review

By L. Vilizzi, F.G. Ekmekçi and A.S. Tarkan

Freshwater fish affect several components of the aquatic ecosystems (e.g. nutrients, primary and secondary production; Matthews, 1997). This is especially true of omnivorous species such as the common carp (Cyprinus carpio L., 1758), whose ‘middle-out’ role in the aquatic ecosystems has been widely documented (Weber & Brown, 2009). Herein we provide a review of the natural diet of common carp in Anatolia (Turkey), where the species is widely distributed following translocation for fisheries and aquaculture (Çetinkaya, 2010).

We obtained data from the literature and assigned individual food items into three general taxa (i.e. phytoplankton, zooplankton, benthic invertebrates) and three ‘generic’ groups (i.e. detritus, plant material, fish eggs and parts). Because of the different reporting formats of the feeding data in the original studies, we present food items in the form of a presence/absence matrix. For the studies providing food items at the genus level, we also tested for any differences in diet composition between waterbody types (details in online Supplement 1), and estimated trophic level following Stergiou & Karpouzi (2002).

In total, 12 studies covering 16 waterbodies were collected (Table S1, in online Supplement 2). Eight out of the 12 studies provided taxon-level data (Table 2) and four studies only summary data (Table S1 in online Supplement 2). Monthly and seasonal diet data were reported in ten and two studies, respectively (Table 2). With the exception of 0+ fish, feeding mainly on zooplankton (Gelingüllü Reservoir: mirror carp), no other age/length-related difference in diet was found in the remaining studies. Diet composition did not differ significantly (F1,7 # = 1.42; r2 = 0.136; # = permutational value) between waterbody types (Fig. 4). Trophic level was generally similar across waterbody types, ranging from 2.2 to 2.6 (mean 2.39 ± 0.05). Thus, common carp can be characterized as an omnivore with a preference for vegetable material (see Stergiou & Karpouzi, 2002).

**Table 1.** Sample size (n), length range (minimum-maximum) and parameters of the total weight (g) - total length (cm) relationship (W=aLb) for 10 fish species, Northern Aegean Sea. SE(b) = Standard error of slope b; r2 = coefficient of determination; Growth= A+, positive allometry; A-, negative allometry; I, isometry; P= P-value.

<table>
<thead>
<tr>
<th>Species</th>
<th>n</th>
<th>Length min-max</th>
<th>a</th>
<th>b</th>
<th>SE(b)</th>
<th>r2</th>
<th>Growth (P)</th>
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</thead>
<tbody>
<tr>
<td>Lepidorhombus boscii</td>
<td>322</td>
<td>16.5-52.5</td>
<td>0.015</td>
<td>2.82</td>
<td>0.053</td>
<td>0.90</td>
<td>A- (&lt;0.05)</td>
</tr>
<tr>
<td>Lophius budugassa</td>
<td>121</td>
<td>19.7-66.5</td>
<td>0.0156</td>
<td>2.96</td>
<td>0.047</td>
<td>0.97</td>
<td>A- (&lt;0.05)</td>
</tr>
<tr>
<td>Lophius piscatorius</td>
<td>179</td>
<td>20.0-47.2</td>
<td>0.026</td>
<td>2.82</td>
<td>0.037</td>
<td>0.97</td>
<td>A- (&lt;0.05)</td>
</tr>
<tr>
<td>Merluccius merluccius</td>
<td>383</td>
<td>19.2-81.0</td>
<td>0.016</td>
<td>2.77</td>
<td>0.030</td>
<td>0.96</td>
<td>A- (&lt;0.05)</td>
</tr>
<tr>
<td>Micromesistius poutassou</td>
<td>298</td>
<td>15.3-32.0</td>
<td>0.0034</td>
<td>3.24</td>
<td>0.049</td>
<td>0.94</td>
<td>A+ (&lt;0.05)</td>
</tr>
<tr>
<td>Physic blennoides</td>
<td>333</td>
<td>15.8-45.0</td>
<td>0.0087</td>
<td>2.97</td>
<td>0.040</td>
<td>0.94</td>
<td>A- (&lt;0.05)</td>
</tr>
<tr>
<td>Thunnus alalunga*</td>
<td>371</td>
<td>70.5-92.4</td>
<td>0.0001</td>
<td>2.52</td>
<td>0.040</td>
<td>0.91</td>
<td>A- (&lt;0.05)</td>
</tr>
<tr>
<td>Thunnus thynnus*</td>
<td>48</td>
<td>72.7-171.0</td>
<td>4.5×10^-4</td>
<td>2.80</td>
<td>0.045</td>
<td>0.99</td>
<td>A- (&lt;0.05)</td>
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<td>Trachurus trachurus</td>
<td>367</td>
<td>16.0-30.2</td>
<td>0.006</td>
<td>3.11</td>
<td>0.045</td>
<td>0.93</td>
<td>A+ (&lt;0.05)</td>
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<td>Zeus faber</td>
<td>207</td>
<td>14.2-59.2</td>
<td>0.023</td>
<td>2.84</td>
<td>0.046</td>
<td>0.95</td>
<td>A- (&lt;0.05)</td>
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* Fork length

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Table 2. Data on the natural diet of common carp in waterbodies of Anatolia (taxon-level studies only). For taxon-level groups, the number of taxa is indicated; for generic groups, presence (+) or absence (−) is provided, along with the source reference (Table S1 in online Supplement 2). Summary data are also provided, i.e. number of fish examined, size and age range, reported monthly (M) or seasonal (S) and ontogenetic differences in diet (Yes = difference; No = no difference) and trophic level (computed after Stergiou & Karpouzi, 2002). n/a = data not available. Taxonomy of groups after http://www.itis.gov (accessed 08/01/2014). Complete list along with source references in Table S1 in online Supplement 2.

<table>
<thead>
<tr>
<th></th>
<th>Man-made reservoirs</th>
<th>Natural lakes</th>
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<tbody>
<tr>
<td>Number of fish (full gut/total)</td>
<td>167/179</td>
<td>92/97</td>
</tr>
<tr>
<td>Size range (mm)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Age range (years)</td>
<td>0–6</td>
<td>1–7</td>
</tr>
<tr>
<td>Monthly/seasonal variation</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Ontogenetic variation</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Trophic level (±SE)</td>
<td>2.60 ± 0.19</td>
<td>2.40 ± 0.15</td>
</tr>
</tbody>
</table>

**Taxon-level groups**

**Phytoplankton**

- *Bacillariophyta* 13 12 17 20 14 15 16 5 7
- *Charophyta* 1 2 1 5 3 1 6 3 3
- *Chlorophyta* 3 4 4 7 5 4 6 3 3
- *Cryptophyta* 1 1 3 8 6 10 4 4 2
- *Euglenophyta* 1 1 2 2 1 0 1 1 1
- *Pyrrhophyta* 0 0 0 2 1 0 1 0 0
- *Rhodophyta* 0 1 0 0 0 0 0 0 0
- *Xanthophyta* 0 0 0 0 0 0 1 0 0

**Zooplankton**

- *Cladocera* 5 5 5 4 5 2 1 3 5
- *Copepoda* 2 2 2 2 2 2 1 0 2 2
- *Malacostraca* 0 0 0 0 0 0 1 3 0
- *Ostracoda* 1 1 1 1 1 0 0 2 1
- *Rotifera* 3 2 0 3 3 9 1 0 4

**Benthic invertebrates**

- *Coloptera* 0 0 0 0 0 0 1 0 0
- *Diptera* 1 1 1 2 2 2 0 1 1 2
- *Gastropoda* 0 0 0 1 1 0 0 2 0
- *Nematoidea* 0 1 0 0 0 0 1 0 0
- *Oligochaeta* 0 0 0 1 1 0 0 0 1

**Generic groups**

- Detritus − − − − − + − + − −
- Plant material + − − + − + − + − +
- Fish + + − − − − − − − −
- Eggs + + − − − − − − − −
- Various parts − − − + − − − − + −
The present findings confirm the opportunistic feeding of common carp, with spatial variation (i.e. waterbody level) indicating flexible dietary requirements, and temporal variation (i.e. monthly/seasonal) most probably related to overwintering and spawning movements (Numann, 1958). The presence of detritus and plant material reflects its typical bottom-feeding behaviour, i.e. mouthfuls of sediment are sucked into the oral cavity and separated from food in the pharyngeal slits, with food items retained and other particles expelled (Sibbing, 1988). The presence of fish eggs in its diet suggests that common carp indirectly feeds upon other fish when burrowing through the sediment in search for food.

4. Feeding habits for eleven sparids from the N-NW Aegean Sea

By P.K. Karachle

Feeding habits of fishes in the Mediterranean Sea have been reviewed by Stergiou & Karpouzi (2002). In this study, information on the feeding habits of 11 species of Sparidae, in N-NW Aegean Sea, are presented. For four species, namely Diplodus vulgaris, Oblada melanura, Sarpa salpa and Spondylusoma cantharus, there is no information on their feeding habits from the Hellenic seas.

Sampling was conducted on a seasonal basis (spring 2001–winter 2006), using professional fishing vessels (see Karachle & Stergiou 2008, for a detailed account on sampling and stomach content analyses).

In total, 960 individuals were examined. The number of individuals ranged from 10, for Dentex dentex and Pagrus pagrus, to 427 for Diplodus annularis (Table 3). The feeding habits and trophic level of Pagrus pagrus differed from those previously reported (data from Stergiou & Karpouzi, 2002; Froese & Pauly, 2013), a fact that could be attributed to the smaller lengths of the individuals examined in the present study, compared to those in other studies. In general, no differences were found in the feeding habits of the remaining species with those reported in the literature.

Based on the results presented here, the 11 sparids prey on a great variety of food items and their trophic levels span over a wide range of values, from 2.0 to 4.5 (Karachle & Stergiou, 2008). Indeed, the 11 species prey on algae (herbivores: S. salpa) and invertebrates (omnivores: B. boops; D. annularis, D. vulgaris, O. melanura, Pagellus erythrinus, P. hofgaravo, S. cantharus), to fish and cephalopods (carnivores: D. dentex, P. acarne, P. pagrus) (Table 3), a fact indicating their high adaptability and competent exploitation of resources.

5. Reproductive biology of common carp (Cyprinus carpio L., 1758) in Anatolia (Turkey): a review

By L. Vilizzi, A.S. Tarkan and F.G. Ekmekçi

This study provides a synopsis of the reproductive biology of common carp (Cyprinus carpio L., 1758) in Anatolia (Turkey). Common carp is a native species to the northernmost areas of the region that was 'naturalised' elsewhere in Turkey following translocation for fisheries and aquaculture (Çetinkaya, 2010).

We obtained data from the literature. We evaluated the relationships of mean age at maturity, spawning period duration, absolute fecundity, relative fecundity and egg diameter with mean annual water temperature using linear regression. We tested for differences in the above-mentioned parameters with waterbody types (i.e. man-made reservoirs and natural lakes) using permutational univariate analysis of variance (PERMANOVA). We also evaluated trends in the monthly gonadosomatic index (GSI) data using dynamic factor analysis (DFA) in order to identify the waterbodies where GSI was highest in a certain month (all tests at $p = 0.05$; details in online Supplement 3).

In total, 30 studies covering 26 waterbodies were collected (Table 4). Mean sex ratio was $1.01 \pm 0.06$ SE and age at maturity ranged between 2 and 4 years. Spawning began between March and June, and the spawning period lasted for 2–7 months. Mean absolute and relative fecundity were $306,124 \pm 57,645$ eggs/fish and $132,782 \pm 10,379$ eggs/kg, respectively, and mean egg diameter was $1.151 \pm 0.042$ mm. No significant relationships were found between mean age at maturity ($r = 0.001$, $p = 0.934$), spawning period duration ($r = 0.168$, $p = 0.081$), absolute fecundity ($r = 0.18$, $p = 0.017$, $p = 0.608$), relative fecundity ($r = 0.17$, $p = 0.085$, $p = 0.255$) and egg diameter ($r = 0.25$, $p = 0.066$, $p = 0.214$) with mean annual water temperature. In addition, no significant differences were found in mean age at maturity ($F_{1,12} = 0.01$, $p^* = 1.000$; * = permutational), spawning period duration ($F_{1,11} = 0.53$, $p^* = 0.632$), absolute fecundity ($F_{1,16} = 0.33$, $p^* = 0.566$), relative fecundity ($F_{1,13} = 0.06$, $p^* = 0.810$) and egg diameter ($F_{1,23} = 3.44$, $p^* = 0.080$) with waterbody types. However, there was a peak in GSI in July in the Almus Reservoir (Fig. 5a: Trend 1), and a peak in May in all remaining waterbodies with the exception of Altınkaya, Bayramiç and Çamlidere Reservoirs as well as Bafra Balk Lakes (1993 study) (Fig. 5b: Trend 2), where GSI remained relatively high also in late summer and/or autumn (Table 4).

The present findings indicate that the reproductive features of common carp are largely homogeneous across Anatolia, as has been found for the condition factor (Vilizzi et al., 2014). Although spawning occurred mainly in late spring, relatively high GSI values in other months indicate potential for protracted spawning (cf. Smith & Walker, 2004).
Table 3. Food items and their contribution (expressed as % wet weight) for eleven sparids in the N-NW Aegean Sea, Greece, spring 2001- winter 2006. Bb=Boops boops; Dd=Dentex dentex; Da=Diplodus annularis; Dv=Diplodus vulgaris; Om= Oblada melanura; Pa=Pagellus acarne; Pb=Pagellus bogaraveo; Pe=Pagellus erythrinus; Pp=Pagonia pagrus; Ss=Sarpla salpa; Sc=Spondiyosoma cantharus; N.i.=not identified; N=number of individuals; TL=total body length; ±SE=trophic level ± standard error. Asterisk (*) denotes presence in the diet with % weight contribution < 0.0001.

<table>
<thead>
<tr>
<th>Taxonomic groups</th>
<th>Bb</th>
<th>Dd</th>
<th>Dv</th>
<th>Om</th>
<th>Pa</th>
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| Macroalgae       | 13.5| 21.5| 70.3| *
| Cladophora spp.  | *| *| 3.3|
| Cystosira spp.   | *| *| *| *
| Dycotia spp.     | *| *| *| *
| Sphacelaria spp. | *|
| Asparagopsis spp.| *| *| *| *
| Asparagopsis armata | *| *| *| *
| Ceramium spp.    | *| *| *| *
| Ceramium codii   | *| *| *| *
| Chondrus spp.    | *| *| *| *
| Laurencia spp.   | *| *| *| *
| Polypodium spp.  | *| *| *| *
| Pterosiphonia spp.| *| *| *| *
| Ageiopoma        | 3.1| *|
| Cymosia spp.     | *| *| 25.8|
| Posidonia oceanica | *| 55.8| 2.7| 1.5|
| Cnidaria         | 1.4| 1.7| 4.2|
| Nematoda         | *| |
| Polycheata       | 3.6| 8.4| 90.2| 42.2| 12.7| 1.3| 32.1| 4.0|
| Sipuncula        | 3.0| |
| Molusca          | 0.8| 5.3| 6.6| 0.2|
| Polynocephora    | 2.6| 0.9| 5.7| 7.6| 6.8| 0.5|
| Bivalvia         | n.i. | |
| Gastropoda       | 19.6| 6.8| 0.8|
| Cephalopoda      | 6.8| 0.8|
| Crustacea        | 0.3| *| 0.5|
| Ostracoda        | *| |
| Cypridina mediterranea | *| |
| Cidarocen        | *| |
| Evadne spp.      | *| |
| Podon spp.       | *|
| Copepoda         | 0.1| 0.6| *| |
| Candacia spp.    | *| |
| Centropages spp. | *| |
| Oncoclosspp.     | *| |

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<td>τ±SE (from Karachle &amp; Stergiou, 2008)</td>
<td>3.52±0.52</td>
<td>4.49±0.80</td>
<td>3.20±0.43</td>
<td>3.08±0.28</td>
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<td>3.70±0.56</td>
<td>3.40±0.5</td>
<td>3.70±0.6</td>
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Table 4. Review of data on the reproductive biology of common carp in Anatolia. The following parameters are provided for each waterbody: water temperature (Tw), sample size (n), male to female ratio (M/F), age class at maturity (M, F, in years), spawning period (monthly range), monthly female gonado-somatic index (GSI), fecundity and egg diameter.

<table>
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<tr>
<th>Waterbody</th>
<th>Tw (°C)</th>
<th>n</th>
<th>M/F</th>
<th>M (years)</th>
<th>F (years)</th>
<th>Spawning Period</th>
<th>GSI (%)</th>
<th>Fecundity</th>
<th>Egg Diameter (mm)</th>
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<td>3.4</td>
<td>3.4</td>
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<td>950</td>
<td>9.08</td>
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<td>3.3</td>
<td>Apr-Jun</td>
<td>2.17</td>
<td>571</td>
<td>7.75</td>
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<td>Apr-Jun</td>
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<td>571</td>
<td>7.75</td>
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<tr>
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<td>13</td>
<td>1.22</td>
<td>3.0</td>
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<td>Apr-Jun</td>
<td>2.17</td>
<td>571</td>
<td>7.75</td>
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<td>15.4</td>
<td>13</td>
<td>1.22</td>
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<td>2.17</td>
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<td>3.0</td>
<td>3.1</td>
<td>Apr-Jun</td>
<td>2.17</td>
<td>571</td>
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Note: See online Supplement 4 for full references.
6. Mouth dimensions for seven freshwater fishes

By P.K. Karachle, I. Salvarina and D. C. Bobori

Feeding habits, diet composition and food consumption in fishes have been related to various morphological characteristics, with mouth being of primary importance for understanding predator-prey interactions (e.g. Karppouzi & Stergiou, 2003; Karachle & Stergiou, 2011; and references therein). In this report, we present relationships of horizontal (HMO) and vertical (VMO) mouth openings, and mouth area (MA) with total length (TL) for seven freshwater species, two of which, *Alburnus volviticus* Freyhof & Kottelat, 2007 and *Vimba melanops* (Heckel, 1837) are endemics to Greece and the Balkan Peninsula, respectively.

Samples were collected seasonally (summer 2005-summer 2006) in Lake Volvi (Northern Greece), by deploying gillnets (mesh sizes 12-60 mm; knot-to-knot) at sunset until next sunrise. Specimens were directly preserved in 10% formalin solution. All individuals were identified and total body length (TL, in cm), horizontal (HMO, in cm) and vertical (VMO, in cm) mouth openings were measured. Consequently HMO and VMO were used for estimating mouth area (MA, in cm²), based on the assumption that MA shape could be that of an ellipse (Erzini et al., 1997):

\[
MA = \pi \left( \frac{HMO^2}{2} + \frac{VMO^2}{2} \right), \quad \text{where } \pi = 3.14.
\]

The relationships of HMO, VMO and MA with TL were described using power regression (\( Y = aX^b \)), which is appropriate for describing morphometry relationships (Lleonart et al., 2000).

Overall, 754 individuals were examined, covering, per species, a wide length range (Table 5). Sample size ranged from 16, for the Greek endemic *A. volviticus*, to 203 for *Perca fluviatilis* Linnaeus, 1758 (Table 5). All relationships were significant (\( p < 0.01 \); Table 5). For the same TL, MA was higher for *P. fluviatilis*, which is a piscivorous species (Bobori et al., 2013). The remaining six species that generally have an omnivorous diet (Bobori et al., 2013) showed similar MA for the same TL and lower than that of *P. fluviatilis* (Fig. 6). This agrees with the findings of Karachle & Stergiou (2011), who report that for the same TL piscivores have bigger MA than omnivores, and the latter bigger MA than herbivorous species. For the species examined here no such information is available, as is generally the case for freshwater species for which such relationships are generally scarce. Mouth area relationships will contribute to the quantification of prey-size related feeding patterns and interpretation of the high interspecific and intraspecific dietary diversity observed in Lake Volvi (Bobori et al., 2013)

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Fig. 5: Dynamic factor analysis (DFA) trends (A) and factor loadings (B) for gonado-somatic index (GSI) monthly values of female common carp in 14 waterbodies of Anatolia. Alm = Almus Reservoir; Alt = Altunkaya Reservoir; Apa = Apa Reservoir; Baf.92 = Bafra Balık Lakes (1992); Baf.93 = Bafra Balık Lakes (1993); Bay = Bayramiç Reservoir; Bey = Lake Beyşehir; Çam = Çamlıdere Reservoir; Cav = Lake Çavuşcu; Egr = Lake Eğridir; Hir = Hirfanlı Reservoir; Kap = Kapılıkaya Reservoir; Keb = Keban Reservoir; Mog = Lake Mogan; Sak = Sakarya River. Factor loadings for Altunkaya and Bayramiç Reservoirs are in italics because they are averages also including non-mature individuals.

Fig. 6: Regressions between total length (cm) and mouth area (cm²) for seven fish species from Lake Volvi, Greece. Equations are given in Table 1. Ab: *Abramis brama*, Av: *Alburnus volviticus*, Cc: *Carassius gibelio* Freyhof & Kottelat, 2007 and *Vimba melanops* (Heckel, 1837) are endemics to Greece and the Balkan Peninsula, respectively.
Table 5. Relations between horizontal mouth opening (HMO), vertical mouth opening (VMO) and mouth area (MA) with total body length (TL) for seven fishes from the Lake Volvi (North Greece). n = number of individuals; SE = standard error of slope b; r = coefficient of determination. All relationships were highly significant (p<0.01).

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<th>TL range (cm)</th>
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<th>VMOa/TLa</th>
<th>MOHa</th>
<th>MAa</th>
<th>$b$</th>
<th>SE</th>
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<tr>
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<td>0.095</td>
<td>0.0015</td>
<td>0.9019</td>
<td>0.095</td>
<td>0.20</td>
<td>0.73</td>
</tr>
<tr>
<td>Carassius gibelio</td>
<td>19.7-19.8</td>
<td>174</td>
<td>0.193</td>
<td>0.0036</td>
<td>0.9019</td>
<td>0.193</td>
<td>0.20</td>
<td>0.73</td>
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<tr>
<td>Cyprinus carpio</td>
<td>13.2-32.1</td>
<td>141</td>
<td>0.059</td>
<td>0.0009</td>
<td>0.9019</td>
<td>0.059</td>
<td>0.20</td>
<td>0.73</td>
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<tr>
<td>Perca fluviatilis</td>
<td>14.4-40.0</td>
<td>223</td>
<td>0.170</td>
<td>0.0032</td>
<td>0.9019</td>
<td>0.170</td>
<td>0.20</td>
<td>0.73</td>
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<tr>
<td>Scardinius erythrophthalmus</td>
<td>8.9-38.0</td>
<td>23</td>
<td>0.064</td>
<td>0.0012</td>
<td>0.9019</td>
<td>0.064</td>
<td>0.20</td>
<td>0.73</td>
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<tr>
<td>Dactylichthys argenteus</td>
<td>16.6-29.6</td>
<td>56</td>
<td>0.131</td>
<td>0.0025</td>
<td>0.9019</td>
<td>0.131</td>
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