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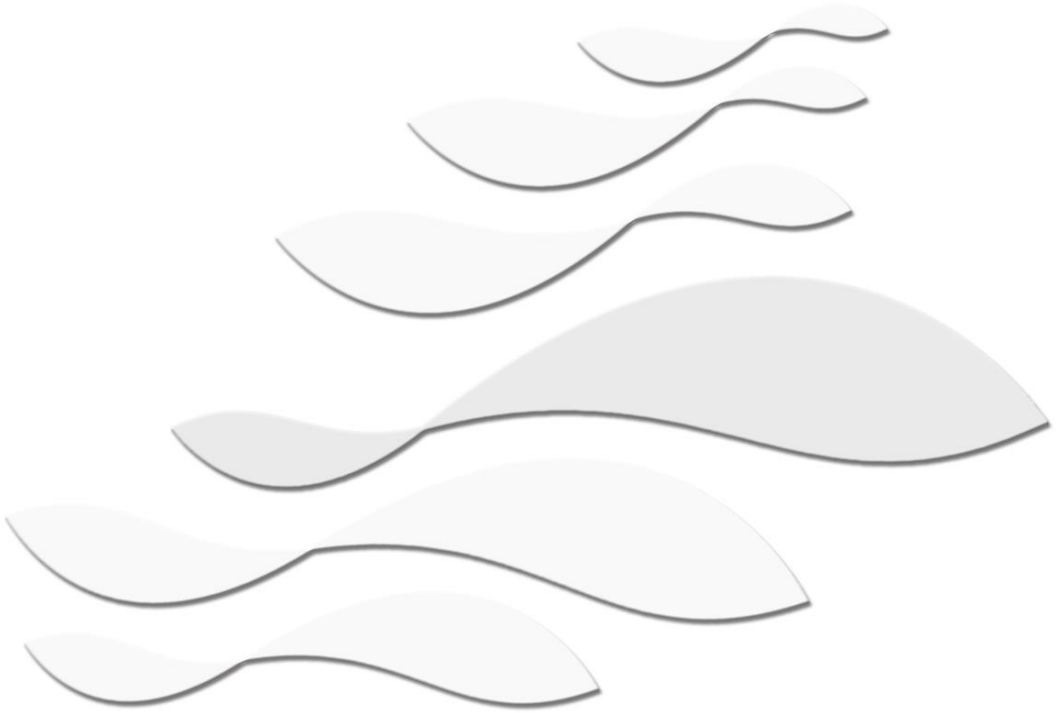

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**RESEARCH ARTICLE** **ARAŞTIRMA MAKALESİ**

# Comparison of polyphenol oxidase activity in different parts of deep water pink shrimp (*Parapenaeus longirostris*) by using L-DOPA substrate in Marmara Sea during the fishing season

## Marmara Denizinde av sezonu boyunca derin su pembe karidesi (*Parapenaeus longirostris*) farklı dokularındaki polyfenol oksidaz enzim aktivitesinin L-Dopa substratı kullanılarak karşılaştırılması

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**Özet:** Melanosis derin su pembe karidesinin pazar kaybı için önemli bir problemdir. Bunun sorumlusu olan polifenol oksidaz (PPO) enzim aktivitesidir. PPO'nun özelliğini daha iyi anlamak ve oluşan aktiviteyi düşürme amacı için, ölüm sonrası derin su pembe karidesi türünün*(Parapenaus longristris)* farklı dokularında polifenol oksidaz (PPO) enzim aktivitelerinin tespiti çalışılmıştır. Aktivite analizleri yedi ayrı dokuda çalışılmıştır: kafa (seflahalotoraks+karapas), karapas, dış iskeletin abdomen bölgesi, yüzme bacakları, yürüme bacakları, uropodlar ve telson bölgelerinde ayrı ayrı analizleri yapılmıştır. Sonuçlar doğrultusunda derin su pembe karidesinde PPO aktivite dağılımının kafadan telsona doğru azaldığı tüm çalışma boyunca tespit edilmiştir. Ayrı dokularda yapılan dağılım incelemesinde %70 amonium sulfat çökeltmesi sonucunda en yüksek aktivite kafa ve abdomen arasında kalan bölgede görülmüştür. Fakat cinsiyetler arasında istatistiksel anlamda önemli bir fark görülmemiştir. Ayrıca PPO aktivite düzeylerinin kıyaslanması tüm av sezonu boyunca yapılmıştır. Türün önemi bu türün ekonomik değerinden gelmektedir ıve literatürde Marmara Denizinden avlanan türle ilgili PPO aktivitesi ile ilgili kaynağa rastlanmamıştır. Elde edilen veriler Marmara Ddenizinde bulunan erkek ve dişi karideslerin mevsimsel aktivite düzeylerinide göstermektedir.

***Anahtar kelimeler*:** Karides, PPO aktivitesi, kara benek, melanosis.

**Abstract:** Melanosis is a major problem associated with the marketing loss of deep water pink shrimp. This is mediated by polyphenoloxidase (PPO), activity. To better understanding of PPO characteristics should pave a way for lowering melanosis so tissue distribution of polyphenol oxidase (PPO) activity was studied in deep water pink shrimp (*Parapenaus longristris*) post mortem. Activity analyzed in 7 different tissues; the head (cephalothorax+carapace), carapace, exoskeleton of the abdomen, pereopods, pleopods, uropods and telson individually. Due to the results, PPO activity of deep water pink shrimp was determined to be lower from head to telson during the research period. Partial tissue distribution showed that the highest activity was determined in the parts between head and the abdomen by using 70% ammonium sulfate fractions. But statistical significant correlation cannot be detected between the genders. And also comparison between the PPO levels of deep water pink shrimp during the fishing season was performed. The importance of these species came from their economic values, and no available data about the PPO activity in the literature could be observed in Marmara Sea. The determined data showed us the seasonal activity levels of male and female shrimps in Marmara Sea.

***Keywords*:** Shrimp, PPO activity, black spot, melanosis.

## INTRODUCTION

Discoloration in crustaceans, called melanosis or black spot, is a natural post-mortem process caused by the polymerization of phenols into insoluble black pigments which were the melanins (Zamarano et al., 2009). Phenol polymerization is catalyzed by polyphenol oxidase (also called phenol oxidize), an enzymatic complex found in almost all organisms. The term polyphenol oxidase (PPO) is generally used to refer to two similar enzymes involved in phenol oxidation: tyrosinases (EC 1.14.18.1), which catalyze the o-hydroxylation of monohydroxyphenols (i.e. monophenolase or cresolase activity) and the oxidation of o-dihydroxyphenols to o-quinones (i.e. catechol oxidase or diphenolase activity), and catecholoxidases (EC 1.10.3.1) which only catalyze the oxidation of o-dihydroxyphenols. The o-quinones may react nonenzymatically with a variety of compounds in the presence of $O_2$ and form melanins. Monophenol oxidases generally also act as o-diphenoloxidases, as reported in Kim et al. (2000) and Ramírez et al. (2003), often at a faster rate

Deep water pink shrimp (*Panapeanus longristris*) is one of the important products with an increasing exportation value in the Turkish economy. And discoloration in this shrimp specie is an important loss in market value. The presence of

melanins strongly reduces the marketability of the products (Kim et al., 2000). During post-mortem storage of crustaceans, proPPO can be also activated into PPO by the action of proteolytic enzymes leaching from the digestive tract (Ali et al., 1994). And then protein hydrolysis by these proteases generates substrates for active PPO (Ali et al., 1994). This was the reason why PPO has been studied in different tissues in shrimp species.

Sulphites are the most common and effective additives used to prevent melanosis in crustaceans. However, a search for alternative compounds was initiated, after the use of sulphites was found to be related to allergic and asthmatic reactions in some consumers (McEvily et al., 1991). The effectiveness of traditional sulphites and 4-hexylresorcinol as a melanosis-inhibiting chemical has been demonstrated both in laboratory and on board experiments (McEvily et al., 1991; Montero et al., 2001; Martínez-Alvarez et al., 2005). Recently, Montero et al. (2004) reported that deepwater pink shrimp (*Parapenaeus longirostris*) were highly sensitive to melanosis, and that there was an increase in the inhibition of melanosis after the shrimp were treated with increasing concentrations of 4-hexylresorcinol. But there is no published study in the literature that compared the partial tissue distribution of PPO activity of this specie in Marmara Sea during the fishing season. Since in this and other shrimps, as well as in prawns, melanosis is first detected in the head and then down spreads to the other tissues during chilled storage, the aim of the current study was determining PPO activity levels in different tissues. Moreover, determining the activity of PPO could be useful to explain, design, and prepare an appropriate formula of preventers to control melanosis in seasons.

## MATERIAL AND METHODS

### Sampling of shrimp tissues

Deep water pink shrimp (Parapenaus longristris) caught by using a commercial shrimp fishing vessel in Bandırma (in the South coast of Marmara Sea) during the fishing season (except May, June, July and August in 2010). Every month 20 kg of male and 20 kg of female specimens were selected for the research. Samples were placed in polystyrene boxes without using any chemical preventer. And flake ice was used in the polystyrene boxes to keep them cool in transfers. Packages were stored at +4° C immediately after arrival of the vessel to the port (about 5 h after catch), later transported to the processing factory which was located in Izmir by using cool truck. The samples were differentiated from the whole immediately due to their gender after arrival. And head (cephalothorax + carapace), carapace, exoskeleton of the abdomen, pereopods, pleopods, uropods and telson were taken separately (Fig 1) and kept in -80° C deep freezer for a night. The selected tissues were mixed with liquid nitrogen, grounded to a fine powder using a coffee mill and stored at -80° C for enzyme purification.

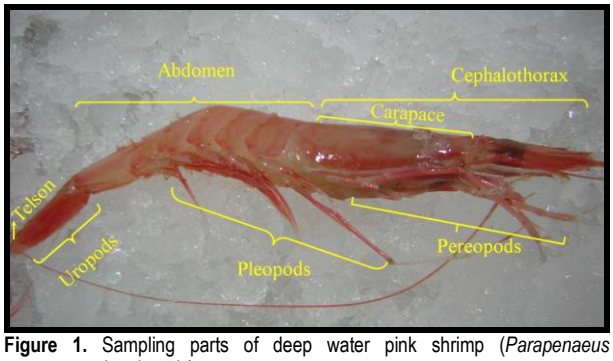


**Figure 1.** Sampling parts of deep water pink shrimp (*Parapenaeus longirostris)*

### Partial purification of PPO

PPO was extracted according to Simpson et al. (1988) with slight modifications. One part of ground powder was added to three parts (w/v) of 0.1 M sodium phosphate buffer (pH 7.2) containing 1 M NaCl, 0.2% Brij 35. The suspension was stirred for 30 min at 4° C and then centrifuged at 8 000g for 30 min at the same temperature (4° C). The supernatant was filtered through 4 layers of muslin and the remaining extract was fractionated with ammonium sulfate ($(NH_4)_2SO_4$). The supernatant was fractionated with ($(NH_4)_2SO_4$) 70% saturation and re-suspended in 0.1 M sodium phosphate buffer (pH 7.2) and protein precipitation was collected by centrifugation at 23 500 g for 30 min (4° C). And the pellet obtained was dissolved in a minimum volume of 0.05 M sodium phosphate buffer, pH 7.2 and dialyzed against 50 volumes of the same buffer at 4° C for 1 day with 3 changes.

### PPO Enzyme activity

PPO activity was determined with using Perkin Elmer Lamda 25 UV Visible spectrometer (USA) equipped with a Nüve circulating water bath (Nüve Co., Turkey) equipped with thermostatic controller. To determine the PPO activity L-DOPA (3,4-Dihydroxy-L–phenylalanin) was used as a substrate. And the enzyme activity was measured continuously at 475nm, 35ºC, for 10 min in a UV-spectrophotometer. One unit of enzymatic activity was defined as an increase in absorbance of 0.001 per minute for 1 ml of enzyme at 35 ºC (Bartolo and Birk, 1998; Cong et al., 2005). And the amount of enzyme which caused an increase in absorbance of 0.001/min. were defined as eu/mL (enzyme unit per mL).

The temperature for PPO activity was used by measuring the enzyme activity at 35ºC temperature using a circulating water bath. The effect of temperature on the activity of PPO was tested in the standard reaction solutions (buffer and substrate) at the appropriate temperature (35ºC) for the enzyme. Three milliliters of reaction mixture contained 0.6 ml of substrate, 2.3 ml of 0.1 M buffer solution, and 0.1 ml of enzyme solution. All assays were performed in triplicate.

### Free L-tyrosine determination

The free L-tyrosine content was measured according to the colorimetric method of Lowry et al. (1951). Using bovine

serum albumin as the standard.The extraction was done by using 6% perchloric acid. 0.4 ml of extraction, 0.2 ml Folin-Ciocalteus-fenol and 0.4 ml of NaOH (1M) were mixed. Then after stabilized in 10 minutes the mixture was read by using UV - spectrophotometer in 578 nm.

### Statistical analysis

Statistical analysis was carried out using SPSS (SPSS, 1999, Version 9.0. Chicago, IL, USA) One way anova by Duncan's multiple range test. This test was used to compare the differences among means between the months on tissues. The results are presented as means ± SD with the significance level set at $p< 0.05$ under varying storage periods. And also data obtained from the samples were subjected to an independent sample - T - test (SPSS 16.0), at a confidence level of 95 %. The test was selected to compare 2 independent shrimp sample groups (male and female shrimps) to estimate the difference in recorded data.

## RESULTS AND DISCUSSION

Study was design to determine the tissue distribution of PPO during the fishing season; therefore differentiation between the genders was also determined. For this aim comparison inside of the gender was investigated with monthly sampling by the researchers. High PPO activities were monitored in the extracts of carapace, cephalothorax, abdomen exoskeleton and preopods. And lower activity was shown by the extract from the uropods to telson. In every month different data were determined in male and female samples extracts (Table 1, Table 2). But it can be said that lower activities were seen in pleopods, uropods and telson extracts.

Data were taken from 7 different tissue in monthly comparison between the male samples tissue and the highest values were taken due to the tissues in months as follows; February in a sequence carapace, uropods and pereopods, in March pereopods, abdomen and head, in April abdomen, pereopods, carapace, in September the sequence was determined as pereopods, abdomen and head, in October pereopods, abdomen and head, in November pereopods, abdomen and head and in December the sequence was abdomen, carapace and head. As mentioned before the first 3 sequences were changed almost in carapace, abdomen, pereopods and head. As expected the spread of the melanosis (browning) was seen between the parts head and pereopods in male samples. In statistically comparison in head tissue activity values only February and December data were significantly different from the other months sampling. The lowest value in head was taken in February and the highest activity value can be seen in December in Table 1. Statistical comparison was performed between the months in the same tissue parts due to the taken data in parts head, carapace and abdomen the highest PPO activity data were taken in December with significant differences ($p<0.05$)On pereopods between March, April, September and October no statistical differences determined ($p>0.05$). The lowest data were taken in February on pereopods in male samples. On tissues pleopods and uropods the highest activity data were taken in October with a significant different ($p<0.05$) then other months. And on telson the highest data was taken in December. PPO from the cephalothoraxes of various crustaceans such as pink shrimp (*Parapenaeus longirostris*; *Penaeus duorarum*) (Zamorano et al. 2009), white shrimp (*Penaeus striferus*) (Chen et al. 1997), prawn (*Penaeus japonicus*) (Montero, 2001b) and lobster (*Nephrops norvegicus; Homarus Americanus*) (Yan et al., 1991) have been purified and characterized.

**Table 1.** PPO enzyme activity of male samples ( eu min $^{-1}$ mL$^{-1}$ )

| Months | Head (cephalothorax + carapace) | Carapace | Exoskeleton of the abdomen | Pereopods | Pleopods | Uropods | Telson |
|---|---|---|---|---|---|---|---|
| **February** | 393.67±3.51$^{a}$ | 595.87±1.63$^{ac}$ | 241.27±2.97$^{a}$ | 446.67±6.66$^{ac}$ | 220.00±3.00$^{a}$ | 467.33±14.47$^{a}$ | 279.33±4.16$^{ab}$ |
| **March** | 465.60±6.92$^{ab}$ | 357.93±6.33$^{b}$ | 468.40±9.61$^{b}$ | 678.13±11.20$^{bc}$ | 281.47±6.22$^{b}$ | 217.87±23.89$^{b}$ | 178.00±7.00$^{a}$ |
| **April** | 482.00±15.72$^{b}$ | 574.00±7.21$^{a}$ | 611.00±11.53$^{bcd}$ | 577.67±9.50$^{abc}$ | 344.07±12.43$^{bd}$ | 266.00±14.00$^{b}$ | 272.67±14.74$^{ab}$ |
| **September** | 500.93±55.62$^{b}$ | 537.33±75.08$^{a}$ | 563.73±157.06$^{bc}$ | 784.13±174.05$^{bc}$ | 315.80±60.25$^{ab}$ | 231.00±46.94$^{b}$ | 211.33±63.89$^{a}$ |
| **October** | 479.67±21.22$^{b}$ | 582.80±18.05$^{a}$ | 731.00±22.11$^{cd}$ | 867.67±38.08$^{b}$ | 708.33±12.74$^{c}$ | 570.33±30.62$^{c}$ | 358.00±16.09$^{bc}$ |
| **November** | 465.60±6.92$^{ab}$ | 372.60±24.50$^{b}$ | 535.07±58.87$^{b}$ | 678.13±11.20$^{bc}$ | 433.67±38.68$^{d}$ | 217.87±23.89$^{b}$ | 178.00±7.00$^{a}$ |
| **December** | 645.67±48.88$^{c}$ | 677.00±19.92$^{c}$ | 774.33±12.86$^{d}$ | 616.67±17.01$^{c}$ | 636.33±54.24$^{c}$ | 535.67±32.62$^{ac}$ | 389.67±73.05$^{c}$ |

$^{x}$ Data are expressed as mean ± SD (n=3)

$^{y}$ Different superscript letters in the same column indicate significant differences ($p < 0.05$)

**Table 2.** PPO enzyme activity of female samples.

| Months | Head (cephalothorax + carapace) | Carapace | Exoskeleton of the abdomen | Pereopods | Pleopods | Uropods | Telson |
|---|---|---|---|---|---|---|---|
| **February** | 464.00±2.0$^{a}$ | 371.93±9.10$^{a}$ | 535.40±2.25$^{a}$ | 483.67±1.53$^{a}$ | 225.20±2.31$^{a}$ | 285.67±4.04$^{a}$ | 429.67±4.51$^{a}$ |
| **March** | 455.93±1.90$^{a}$ | 351.27±5.66$^{a}$ | 417.73±7.51$^{b}$ | 575.20±9.13$^{be}$ | 226.87±7.58$^{a}$ | 226.20±10.30$^{b}$ | 272.47±4.50$^{b}$ |
| **April** | 526.00±11.14$^{a}$ | 479.93±13.01$^{ac}$ | 883.67±23.63$^{c}$ | 383.33±29.37$^{c}$ | 355.27±10.01$^{b}$ | 223.33±10.41$^{b}$ | 255.57±17.83$^{b}$ |
| **September** | 653.33±7.23$^{b}$ | 802.33±175.52$^{b}$ | 761.00±4.58$^{d}$ | 621.67±37.86$^{b}$ | 521.67±37.86$^{c}$ | 499.67±51.19$^{c}$ | 348.33±46.46$^{c}$ |
| **October** | 655.67±17.90$^{b}$ | 463.00±7.55$^{a}$ | 726.33±28.15$^{d}$ | 836.67±2.89$^{d}$ | 544.33±29.26$^{c}$ | 550.67±33.61$^{c}$ | 326.20±26.82$^{cd}$ |
| **November** | 534.27±30.36$^{a}$ | 428.00±63.50$^{a}$ | 528.67±51.39$^{a}$ | 520.00±40.36$^{ae}$ | 520.00±26.91$^{c}$ | 226.20±10.30$^{b}$ | 272.47±4.50$^{bd}$ |
| **December** | 513.00±66.46$^{a}$ | 682.80±91.03$^{bc}$ | 797.67±36.36$^{d}$ | 779.67±12.86$^{d}$ | 625.00±26.06$^{d}$ | 570.33±30.62$^{c}$ | 372.67±28.57$^{ac}$ |

$^{x}$ Data are expressed as mean ± SD (n=3)

$^{y}$ Different superscript letters in the same column indicate significant differences ($p < 0.05$)

In female samples due to the monthly comparison sequence was as follows; on February the highest PPO activity was determined in abdomen, then pereopods and head were the first 3 high activity data. Normally as found in previous studies, the spread of melanosis began from the cephalothorax (Zamarona et al. 2009; Nirmal and Benjakul, 2012), but in our findings the data show the different spread beginning from the abdomen. Between the months March and December higher activity data were taken from the part between head and pereopods. Highest activity of March was determined in pereopods and followed with head and abdomen. When the April data compared with others the highest PPO data was taken from abdomen in female samples. This value was the highest determined PPO activity in female samples. In September the sequence was as follows; carapace, abdomen and head. All the other months the determined activity values were all higher than the previous moths but no correlation was determined between the tissue parts. A recent study by Zamarano et al. (2009) evaluated PPO activity in partially purified extracts from different parts of deep water pink shrimp (*Parapenaus longristris*). They found higher enzyme activity in carapace extracts, but marked melanosis developed on the cephalothorax and head after 1 day at 4°C. Even after 7 days at 4°C there was no melanosis in the carapace, confirming that the development of melanosis in different tissues depend on another factor in addition to PPO levels. When the head activity compared statistically significant differences were determined ($p<0.05$) in February, April, September and December. The highest activity value was determined in December in the head. The reasons for determining different PPO activities depend on the weather conditions and the temperature. Nirmal and Benjakul (2012) found 95.7 (u/mg) specific PPO activity using ammonium sulfate fraction from the cephalothorax of pacific white shrimp (*Litopenaeus vannamei*). When the carapace tissue compared due to the months the highest value determined in September. This value was significantly ($p<0.05$) different than the other months except December activity value. In the abdomen part the highest activity value in the study was determined in April with a significant difference ($p<0.05$). In the months October and December no significant difference was determined in pereopods PPO activities. The highest activity was seen in December on pleopods and in February on uropods. The highest enzyme activity of telson was determined in February in female samples (Table 2).

**Tablo 3.** PPO enzyme activity comparison between the genders( eu min $^{-1}$ mL$^{-1}$ )

| Months | | Head | Carapace | Exoskeleton of the abdomen | Pereopods | Pleopods | Uropods | Telson |
|---|---|---|---|---|---|---|---|---|
| February | M | 393.67±3.51$^{1}$ | 595.87±1.63$^{1}$ | 241.27±2.97$^{1}$ | 446.67±6.66$^{1}$ | 220.00±3.00$^{1}$ | 467.33±14.47$^{1}$ | 279.33±4.16$^{1}$ |
| | F | 464.00±2.00$^{2}$ | 371.93±9.10$^{2}$ | 535.40±2.25$^{2}$ | 483.67±1.53$^{2}$ | 225.20±2.31$^{1}$ | 285.67±4.04$^{2}$ | 429.67±4.51$^{2}$ |
| March | M | 465.60±6.92$^{1}$ | 357.93±6.33$^{1}$ | 468.40±9.61$^{1}$ | 678.13±11.20$^{1}$ | 281.47±6.22$^{1}$ | 217.87±23.89$^{1}$ | 178.00±7.00$^{1}$ |
| | F | 455.93±1.90$^{1}$ | 351.27±5.66$^{1}$ | 417.73±7.51$^{2}$ | 575.20±9.13$^{2}$ | 226.87±7.58$^{2}$ | 226.20±10.30$^{1}$ | 272.47±4.50$^{2}$ |
| April | M | 482.00±15.72$^{1}$ | 574.00±7.21$^{1}$ | 611.00±11.53$^{1}$ | 577.67±9.50$^{1}$ | 344.07±12.43$^{1}$ | 266.00±14.00$^{1}$ | 272.67±14.74$^{1}$ |
| | F | 526.00±11.14$^{2}$ | 479.93±13.01$^{2}$ | 883.67±23.63$^{2}$ | 383.33±29.37$^{2}$ | 355.27±10.01$^{1}$ | 223.33±10.41$^{2}$ | 255.57±17.83$^{1}$ |
| September | M | 500.93±55.62$^{1}$ | 537.33±75.08$^{1}$ | 563.73±157.06$^{1}$ | 784.13±174.05$^{1}$ | 315.80±60.25$^{1}$ | 231.00±46.94$^{1}$ | 211.33±63.89$^{1}$ |
| | F | 653.33±7.23$^{2}$ | 802.33±175.52$^{2}$ | 761.00±4.58$^{1}$ | 621.67±37.86$^{1}$ | 521.67±37.86$^{2}$ | 499.67±51.19$^{2}$ | 348.33±46.46$^{1}$ |
| October | M | 479.67±21.22$^{1}$ | 582.80±18.05$^{1}$ | 731.00±22.11$^{1}$ | 867.67±38.08$^{1}$ | 708.33±12.74$^{1}$ | 570.33±30.62$^{1}$ | 358.00±16.09$^{1}$ |
| | F | 655.67±17.90$^{2}$ | 463.00±7.55$^{2}$ | 726.33±28.15$^{1}$ | 836.67±2.89$^{1}$ | 544.33±29.26$^{2}$ | 550.67±33.61$^{1}$ | 326.20±26.82$^{1}$ |
| November | M | 465.60±6.92$^{1}$ | 372.60±24.50$^{1}$ | 535.07±58.87$^{1}$ | 678.13±11.20$^{1}$ | 433.67±38.68$^{1}$ | 217.87±23.89$^{1}$ | 178.00±7.00$^{1}$ |
| | F | 534.27±30.36$^{2}$ | 428.00±63.50$^{2}$ | 528.67±51.39$^{1}$ | 520.00±40.36$^{2}$ | 520.00±26.91$^{2}$ | 226.20±10.30$^{1}$ | 272.47±4.50$^{2}$ |
| December | M | 645.67±48.88$^{1}$ | 677.00±19.92$^{1}$ | 774.33±12.86$^{1}$ | 616.67±17.01$^{1}$ | 636.33±54.24$^{1}$ | 535.67±32.62$^{1}$ | 389.67±73.05$^{1}$ |
| | F | 513.00±66.46$^{2}$ | 682.80±91.03$^{1}$ | 797.67±36.36$^{1}$ | 779.67±12.86$^{2}$ | 625.00±26.06$^{1}$ | 570.33±30.62$^{1}$ | 372.67±28.57$^{1}$ |

$^{x}$ Data are expressed as mean ± SD (n=3)

$^{y}$ Different superscript numbers in the same column indicate significant differences between the genders ($p < 0.05$)

**Table 4.** L-Tyrosine content of samples ( eu min $^{-1}$ mL$^{-1}$ )

| Months | | Head | Carapace | Exoskeleton of the abdomen | Pereopods | Pleopods | Uropods | Telson |
|---|---|---|---|---|---|---|---|---|
| February | M | 0.14±0.01$^{a1}$ | 0.16±0.02$^{a1}$ | 0.15±0.02$^{a1}$ | 0.13±0.02$^{a1}$ | 0.15±0.01$^{a1}$ | 0.15±0.03$^{a1}$ | 0.16±0.01$^{a1}$ |
| | F | 0.15±0.03$^{a1}$ | 0.15±0.00$^{a1}$ | 0.14±0.00$^{a1}$ | 0.12±0.01$^{a1}$ | 0.16±0.01$^{a1}$ | 0.15±0.00$^{a1}$ | 0.15±0.00$^{a1}$ |
| March | M | 0.15±0.01$^{a1}$ | 0.16±0.00$^{a1}$ | 0.15±0.01$^{a1}$ | 0.13±0.00$^{a1}$ | 0.16±0.01$^{a1}$ | 0.15±0.00$^{a1}$ | 0.15±0.00$^{a1}$ |
| | F | 0.15±0.01$^{a1}$ | 0.16±0.01$^{a1}$ | 0.16±0.01$^{a1}$ | 0.15±0.01$^{a1}$ | 0.16±0.00$^{a1}$ | 0.16±0.01$^{a1}$ | 0.15±0.00$^{a1}$ |
| April | M | 0.14±0.00$^{a1}$ | 0.15±0.01$^{a1}$ | 0.14±0.00$^{a1}$ | 0.1a1±0.00$^{a1}$ | 0.14±0.00$^{a1}$ | 0.14±0.00$^{a1}$ | 0.14±0.01$^{a1}$ |
| | F | 0.14±0.01$^{a1}$ | 0.15±0.01$^{a1}$ | 0.13±0.01$^{a1}$ | 0.10±0.00$^{a1}$ | 0.14±0.00$^{a1}$ | 0.14±0.01$^{a1}$ | 0.13±0.01$^{a1}$ |
| September | M | 0.14±0.02$^{a1}$ | 0.15±0.00$^{a1}$ | 0.14±0.01$^{a1}$ | 0.13±0.01$^{a1}$ | 0.15±0.01$^{a1}$ | 0.13±0.01$^{a1}$ | 0.15±0.03$^{a1}$ |
| | F | 0.13±0.01$^{a1}$ | 0.15±0.01$^{a1}$ | 0.15±0.02$^{a1}$ | 0.13±0.01$^{a1}$ | 0.14±0.03$^{a1}$ | 0.14±0.0$^{a1}$ | 0.14±0.02$^{a1}$ |
| October | M | 0.15±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.13±0.01$^{a1}$ | 0.14±0.03$^{a1}$ | 0.14±0.01$^{a1}$ | 0.13±0.02$^{a1}$ | 0.14±0.02$^{a1}$ |
| | F | 0.13±0.02$^{a1}$ | 0.14±0.01$^{a1}$ | 0.14±0.01$^{a1}$ | 0.12±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.13±0.01$^{a1}$ | 0.14±0.01$^{a1}$ |
| November | M | 0.14±0.01$^{a1}$ | 0.14±0.01$^{a1}$ | 0.14±0.01$^{a1}$ | 0.13±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.14±0.01$^{a1}$ | 0.13±0.01$^{a1}$ |
| | F | 0.14±0.02$^{a1}$ | 0.14±0.02$^{a1}$ | 0.14±0.01$^{a1}$ | 0.14±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.16±0.01$^{a1}$ | 0.12±.02$^{a1}$ |
| December | M | 0.13±0.01$^{a1}$ | 0.15±0.02$^{a1}$ | 0.14±0.01$^{a1}$ | 0.13±0.01$^{a1}$ | 0.14±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.14±0.02$^{a1}$ |
| | F | 0.14±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.14±0.01$^{a1}$ | 0.15±0.03$^{a1}$ | 0.14±0.01$^{a1}$ | 0.14±0.02$^{a1}$ | 0.14±.01$^{a1}$ |

$^{x}$ Data are expressed as mean ± SD (n=3) $^{y}$ Different superscript letters in the same column indicate significant differences between the months and different superscript numbers in the same column indicate significant differences between the genders ($p < 0.05$).

Table 3 was performed to compare the activity differences of genders in samples. On the month February except the uropod values, all the data from the tissues were determined significantly different ($p<0.05$) in samples. Table 3 shows that on head, abdomen, pereopods, and telson female samples PPO activities were determined higher than male samples. Pleopods activity value were statistically same ($p>0.05$). In March sampling period on the parts head, carapace and uropods no significant difference was determined($p>0.05$) but on the other hand on abdomen, pereopods and pleopods higher PPO activity and lower PPO activity can be seen on male shrimps($p<0.05$). In April sampling male shrimps activity values were found significantly higher on carapace, pereopods and on uropods. And in female samples activities were determined higher on head, abdomen tissues. Previously in the study of Bono et al. (2010) which were monitored the PPO activity of deep water pink shrimp due to the gender and seasons, in all groups(male and female) PPO activity was higher in the late warm season(August and September) in Italy. And the activity was lowest between February and March Also similar pattern was observed by Zamarano et al. (2009) for samples of the same specie caught in December and April along the cost of Spain. These data strongly support the hypothesis that PPOactivity is influced by seasonal changes. In the current study due to the September results on head, abdomen, pleopods and uropods tissues results showed that female samples were all gave the higher values ($p<0.05$). And abdomen, pereopods, uropods and telson activities were all determined statistically the same not only in September but also in October ($p>0.05$) between the genders. In November sampling period except the pereopods tissue female activity values were found allmost higher or equal on the rest tissues of the study($p\leq0.05$). On the last month of the study in December when head PPO activity was found higher on male shrimps, pereopods PPO activity were higher on female shrimps($p<0.05$) and the rest tissues were similar ($p>0.05$). In the study of Bono et al. (2010) weak PPO activity was observed in the females but those results were unexpected for the researchers of that study. Ogawa et al. (1984) found a well established link between PPO activity, greater body growth and high mean discoloration grade in females. Also in the current study higher PPO activity was found in female samples like Ogawa et al. (1984) and as a inverse of Bono et al. (2010).

Table 4 shows the result of L-tyrosine contents in both genders. No statistical differences determined not only between the genders but also between the monthly periods.

As mentioned in the study of Zamarano et al., (2009) generally reaction of PPO with phenolic substrates during enzyme extraction and the subsequent polymerization of the intermediate products can lead to enzyme precipitation and loss of enzymatic activity (Chen et al., 1997). Most researchers, including Chen et al. (1997) and Rolle et al. (1991) did not include any protective agents so in the current study no protective agent were used like polyvinylpolypirrolidone (PVPP). But no significant correlation was detected between the PPO activities of the tissues. A comment can be suggested about the data in both genders the tissues which had similiar L-tyrosine contents in all months but different PPO activities were determined. This results explain that there were different reasons effected the PPO activities like; temperature, nutrition, catching area. But as Zamarano et al. (2009) mentioned mostly the high activity values were determined in the tissues of head, carapace, abdomen and the pereopods. But no linear correlation was found between the male and female samples based on the tissues and the activity values. Overall, increasing trend in PPO with an increasing weather temperature in both samples generally showed the spread of melanosis th parts between the cepholatorax and the abdomen but also pereopods and pleopods have high PPO activity in some months.

## CONCLUSION

This study provides evidence of gender and tissue variability of PPO activity in the fishing season of deep water pink shrimp. Partial tissue distribution showed that the highest activity was determined in the parts between head and the abdomen by using 70% ammonium sulfate fractions. But statistical significant correlation cannot be detected between the genders. In future projects, the aim may be to determine the exact amount of sulfites to prevent the evaluation of browning in this specie.

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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

# Effects of Baku-Tbilisi-Ceyhan crude oil pipeline on the water quality in Yumurtalık Coast of the Iskenderun Bay

## Bakü-Tiflis-Ceyhan petrol boru hattının İskenderun Körfezi, Yumurtalık kıyılarında su kalitesi üzerindeki etkileri

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**Özet**: Bakü-Tiflis-Ceyhan Petrol Boru Hattı (BTCOP) Hazar Denizi petrolünü Türkiye'nin Ceyhan Limanına, oradan da Avrupa pazarına ulaştırmak için inşa edilmiştir. Projenin amacı petrolün güvenli ve ekonomik olarak ulaştırılmasıdır. Bu çalışmanın amacı ise, BTC boru hattının ulaştığı Yumurtalık kıyılarında yer alan Ceyhan Deniz Terminalinin su kalitesi üzerindeki etkilerinin izlenmesidir. Bu amaçla, Temmuz 2007, Ağustos 2009 ve Temmuz 2011'de ikisi referans istasyonu olmak üzere dört istasyondan örneklemeler yapılmıştır. Tuzluluk, sıcaklık ve yoğunluğun derinliğe bağlı değişimleri CTD cihazı ile ölçülmüştür. Ayrıca su kolonunda pH, berraklık, çözünmüş oksijen (DO), besleyici elementler (nitrit+nitrat-azotu, amonyum-azotu, fosfat fosforu ve silis) ve klorofil a değerleri ölçülmüştür. Sonuç olarak, çalışma alanında ötrofikasyon riski görülmemiştir. Fosfat limitleyici besleyici elementtir. Söz konusu alanda BTCOP faaliyetlerinin su kalitesi üzerinde önemli bir etkisi yoktur. Bununla birlikte, su kalitesinde meydana gelebilecek bozulmanın fark edilmesi ve gerekli önlemlerin alınabilmesi için sürekli izlemenin yararı büyüktür.

***Anahtar kelimeler***: Su Kalitesi, izleme, klorofil a, Yumurtalık, Bakü-Tiflis-Ceyhan

**Abstract:** The Baku-Tbilisi-Ceyhan Oil Pipeline (BTCOP) was constructed to transport oil from the Caspian Sea to the Ceyhan Port of Turkey and from there to European markets. The aim of the project is the establishment of a safe and economically viable transport system of oil. The purpose of this study is monitoring of the effects of Ceyhan Marine Terminal of BTCOP on water quality characteristics in the Yumurtalık Coast. With this aim, samplings were accomplished in July 2007, August 2009 and July 2011 at four stations, two of them served as reference. Salinity, temperature and density variations with depth were measured with CTD device. In addition, pH, turbidity, dissolved oxygen (DO), Nutrients (nitrite+nitrate-nitrogen, ammonium-nitrogen, phosphate-phosphorus and silicate) and chlorophyll-a were measured along the water column. In conclusion, there is no eutrophication risk at the study area in light of our findings. Phosphate is the limiting nutrient. There was no evident impact of BTCOP activities on water quality at the area concerned. Nevertheless, continuous monitoring is essential to detect any deterioration on the water quality and to take necessary measures.

***Keywords***: Water quality, monitoring, chlorophyll a, Yumurtalık, Baku-Tbilisi-Ceyhan

## INTRODUCTION

Turkey forms a natural energy bridge between the source-rich countries of the Caspian basin, Middle East and the world markets. With this vision, the East-West Energy Corridor Project was elaborated. The East-West Energy Corridor aims at transporting the Caucasian and Central Asian energy resources to western markets through safe and alternative routes. The East-West Energy Corridor Project mainly includes the Baku-Tbilisi-Ceyhan Oil Pipeline (BTCOP), the South Caucasian Natural Gas Pipeline (Baku-Tbilisi-Erzurum Natural Gas Pipeline) and the Turkmenistan-Turkey-Europe Gas Pipeline projects (Anonymous, 2013). BTCOP was constructed to transport the Azeri oil from the Caspian Sea to the Ceyhan Port of Turkey and from there to European markets. The construction began in April 2003 and was completed in 2005. BTCOP is a 1,768 kilometers long crude oil pipeline. The first oil was loaded at the Ceyhan Marine Terminal (Haydar Aliyev Terminal) onto a tanker in June 2006. There are two jetties for loading at the Terminal (Fig 1).

The project area is located in the northern coast of Iskenderun Bay. The Bay is presently experiencing rapid industrial growth and increase in population. Population expansion, increased industry, agriculture and tourism create significant environmental impacts on the coastal ecosystem. Present industrial activities include chemical plants, steel, fertilizer, soda, glass, paper, textile, mechanical and energy production. Untreated or pre-treated municipal wastewaters from various settlements along the coast and the major towns of Iskenderun and Antakya via Asi River are potential sources of marine pollution (Anonymous, 2011). The Ceyhan River which is one of the main rivers on the Mediterranean coast of Turkey discharges its nutrient reach waters into the bay (Polat, 2002). Civilian and military marine transport linked to the harbours of Mersin, İskenderun and Taşucu, shipbuilding activities, oil storage and pipeline terminals at Yumurtalık, Ceyhan and Dörtyol are other activities with potential impact on the marine environment (Anonymous, 2011).

The purpose of this study is monitoring of the effects of BTCOP on water quality characteristics at the Ceyhan Marine Terminal located in Yumurtalık Coast.

## MATERIALS AND METHOD

### Study Area

The study area is located in the northern coast of Iskenderun Bay. The bottom topography of the Bay varies linearly, increasing from 20 m in the inner part to 90 m towards the mouth. Depths at the study area are between 24 to 38 meters. There are two jetties at the Terminal.

In order to determine physical and chemical properties of the study area, 2 stations (St. 1 and 2) were chosen around the two jetties. Additionally, 2 reference stations (St. R1 and R2) were also selected to be able to compare the results (Figure 1).

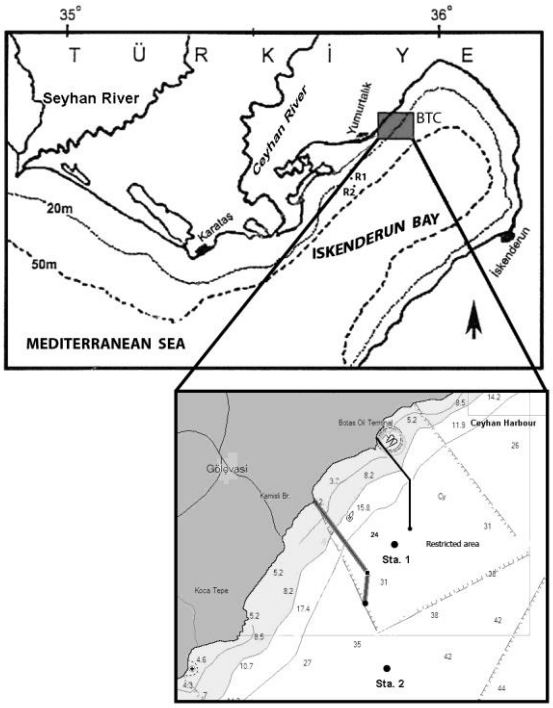


**Figure 1**. Location of the study area and the sampling stations in the Yumurtalık Coast of the Iskenderun Bay

### Collecting samples

Samplings were performed in July 2007, August 2009 and July 2011 at the stations. Seawater samples were taken from surface, mid water and bottom by Nansen sampling bottle to determine pH, turbidity, dissolved oxygen (DO), basic nutrients (nitrite+nitrate-nitrogen, ammonium-nitrogen, phosphate-phosphorus and silicate) and chlorophyll-a. In addition, Salinity, temperature and density values were measured with CTD device regarding the water depth (water column).

### Methods

pH was measured by handheld pH meter (YSI 100), turbidity was measured by turbidimeter (WTW, Turb 355 IR/T) while DO was measured according to Winkler Titration Method on the site. Collected water samples were then taken to the laboratory in cold chain for further analyses. Samples were kept in the refrigerator until analyses. Nutrients were determined spectrophotometrically using HACH DR 2000. Chlorophyll a values were determined spectrophotometrically using acetone extraction method (Strickland and Parsons, 1972).

Normal distribution of the data was tested by Kolmogorov-Smirnov and homogeneity of the variances tested by Levene Statistical analyses. Kruskal-Wallis and Mann Whitney U Tests were performed to detect differences between sampling stations, sampling years and surface and bottom water.

## RESULTS

### CTD data

Results of sea water physical parameters measured with CTD device at four stations with respect to vertical profiles are presented in Figures 2 and 3. Water temperature values ranged from 25.84-30.55°C throughout the monitoring period in the study area. Average and standard error values were calculated as 28.51±0.04°C. Minimum temperature was observed at station 2 bottom water in 2007, maximum was at station 1 surface water in 2009. Salinity along the water column ranged from 39.19 to 40.05 PSU. Average value was 39.66±0.00 PSU. Minimum value was observed at station R1 surface water in 2009, maximum at station 2 bottom water in 2011. Density values changed between 24.84 and 26.71 kg/m$^3$ with average value of 25.76±0.01 kg/m$^3$.

### Physico-chemical parameters

Some physico-chemical parameters measured during 2007, 2009 and 2011 are given in Table 1.

During the three sampling period, pH values ranged from 7.93 to 8.58 (average: 8.28±0.04). Minimum value was recorded at station 2 mid-water, while maximum pH value was measured at station 2 surface water. Statistical differences between the sampling years were important for pH values ($p<0.001$).

Dissolved oxygen concentrations varied between 5.60 and 7.60 mg/L (average: 6.55±0.08 mg/L). Minimum value was measured at station 2 mid and bottom water. Maximum concentration of DO was measured at station R1 bottom water. Station 2 DO values were found to be significantly different from that of stations R1 and R2 ($p<0.05$). Significant difference between the sampling years was also found for DO values. DO concentrations of 2011 sampling was different from that of 2007 and 2009 ($p<0.01$)

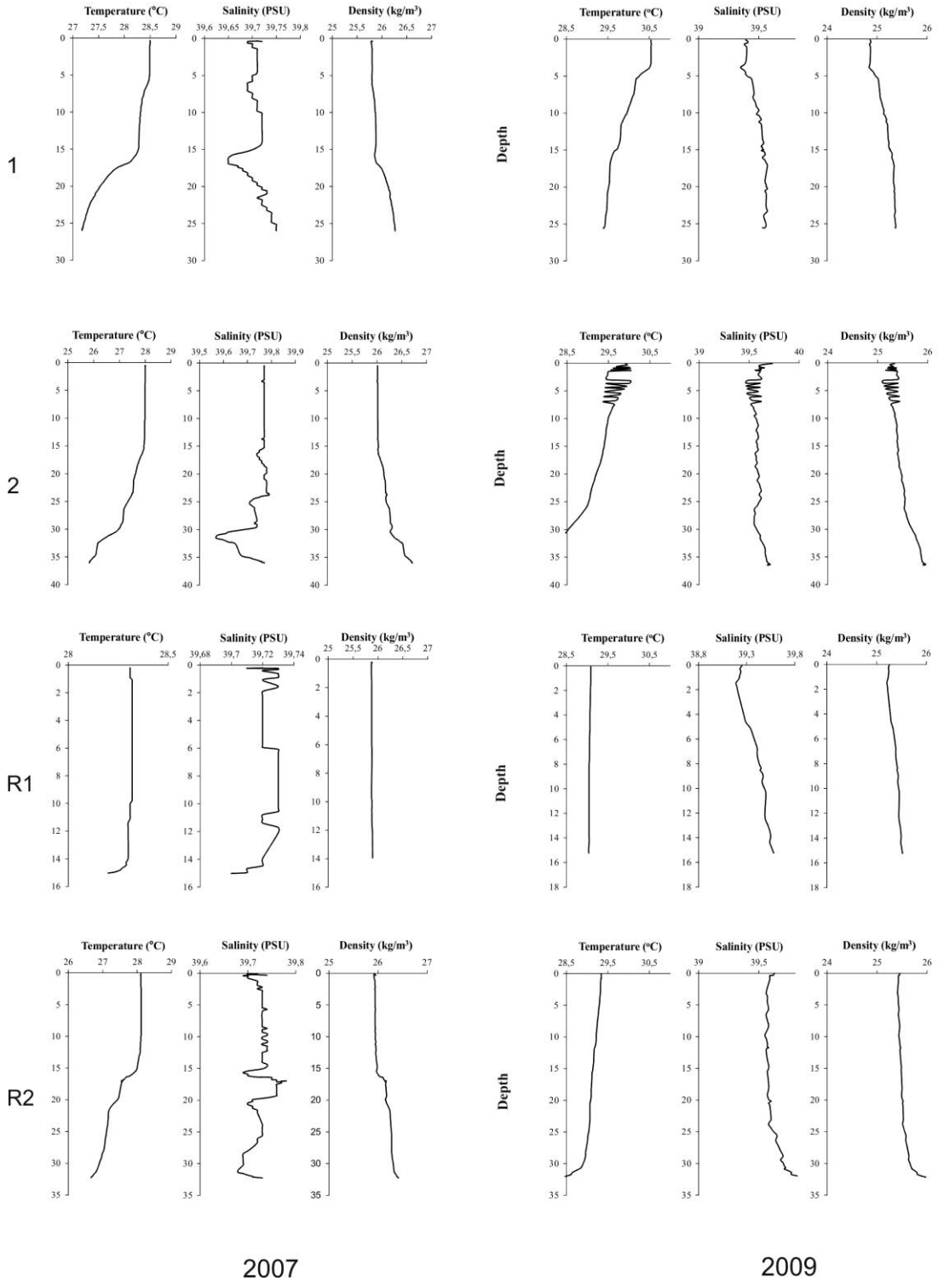


**Figure 2.** CTD results of sampling stations in 2007 and 2009 in the Yumurtalık Coast of the Iskenderun Bay

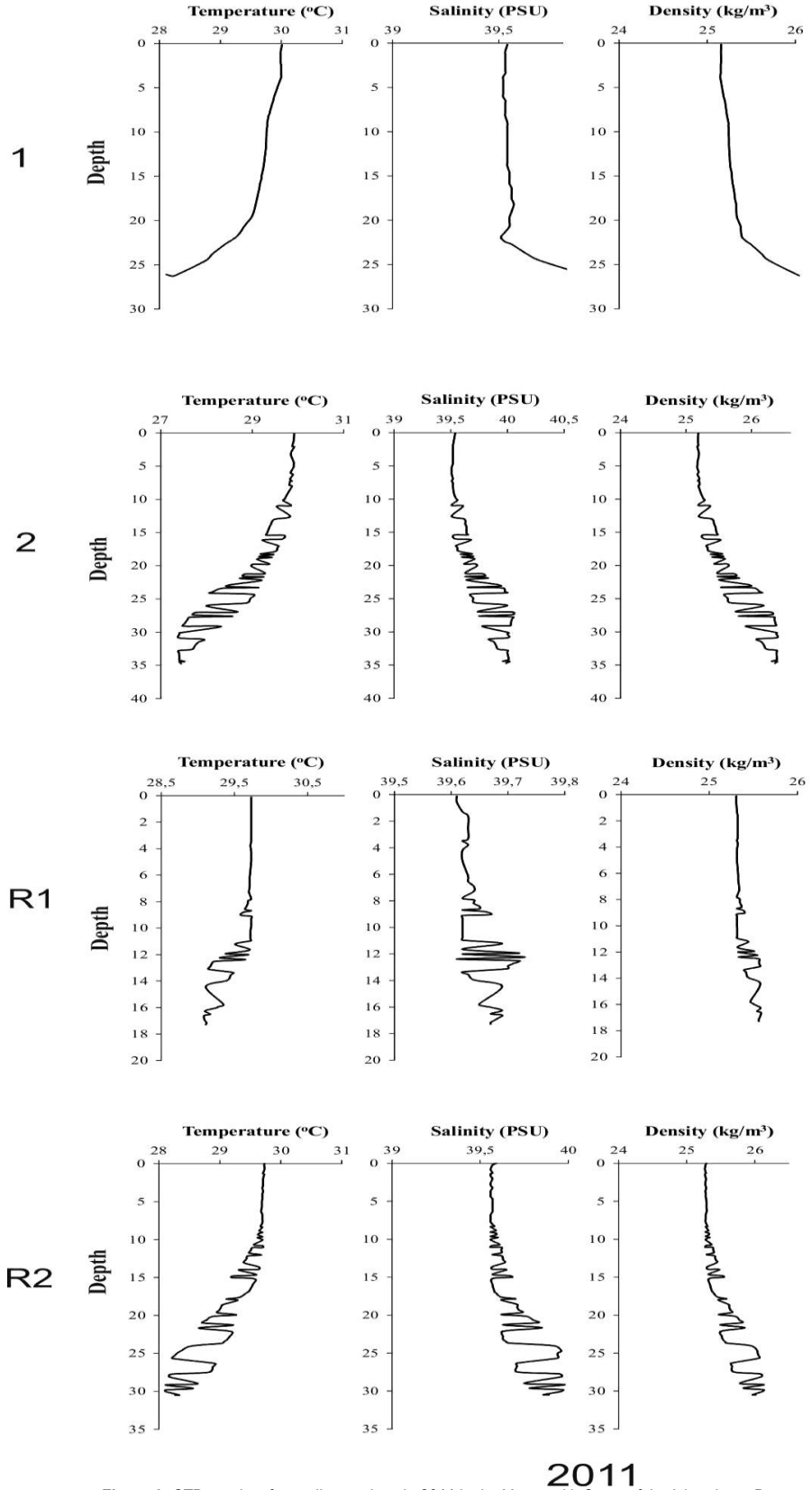


**Figure 3**. CTD results of sampling stations in 2011 in the Yumurtalık Coast of the Iskenderun Bay

**Table 1.**Variations of pH, DO and turbidity values along the water column during the sampling period in the Yumurtalık Coast of the Iskenderun Bay

| Stations | Depths | pH | | | DO (mg/L) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 |
| **1 surface** | 0.5 | 8.54 | 8.32 | 7.99 | 6.0 | 6.0 | 6.8 | 0.81 | 1.41 | 3.50 |
| **1 mid- water** | 12.0 | 8.52 | 8.35 | 7.99 | 6.0 | 6.0 | 7.2 | 0.67 | - | 4.29 |
| **1 bottom** | 25.0 | 8.49 | 8.40 | 7.95 | 6.4 | 6.4 | 7.2 | 0.34 | - | 6.30 |
| **2 surface** | 0.5 | 8.58 | 8.32 | 7.97 | 6.0 | 6.0 | 6.8 | 0.70 | 2.24 | 3.03 |
| **2 mid-water** | 12.0 | 8.52 | 8.32 | 7.93 | 5.6 | 5.6 | 6.4 | 0.54 | - | 4.49 |
| **2 bottom** | 37.0 | 8.57 | 8.30 | 8.04 | 5.6 | 5.6 | 6.4 | 0.90 | - | 13.53 |
| **R1 surface** | 0.5 | 8.50 | 8.29 | 8.00 | 7.2 | 7.2 | 6.8 | 0.92 | 2.37 | 10.57 |
| **R1 mid-water** | 8.0 | 8.52 | 8.34 | 8.00 | 7.2 | 7.2 | 6.8 | 0.38 | - | 4.47 |
| **R1 bottom** | 16.0 | 8.52 | 8.32 | 8.08 | 6.4 | 6.4 | 7.6 | 0.95 | - | 3.72 |
| **R2 surface** | 0.5 | 8.51 | 8.32 | 7.98 | 6.4 | 6.4 | 6.8 | 0.79 | 1.57 | 9.30 |
| **R2 mid-water** | 15.0 | 8.52 | 8.36 | 8.00 | 6.8 | 6.8 | 7.2 | 0.59 | - | 5.65 |
| **R2 bottom** | 30.0 | 8.50 | 8.34 | 7.97 | 6.8 | 6.8 | 6.8 | 0.68 | - | 10.56 |

**Table 2.** Variations of nitrite+nitrate, ammonium and phosphate concentrations during the sampling period in the Yumurtalık Coast of the Iskenderun Bay

| Stations | Depths | $NO_2$+$NO_3$-N (µM) | | | $NH_4$-N (µM) | | | $PO_4$-P (µM) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 |
| 1 surface | 0.5 | 0.31 | 4.44 | 3.97 | 0.17 | nd | 0.34 | 0.07 | 0.14 | 0.21 |
| 1 mid- water | 12.0 | 5.67 | 5.04 | 4.78 | nd | 1.93 | 0.34 | 0.07 | 0.14 | 0.21 |
| 1 bottom | 25.0 | 2.77 | 5.64 | 5.00 | 0.09 | 0.57 | 0.34 | 0.07 | 0.21 | 0.14 |
| 2 surface | 0.5 | 2.90 | nd | 5.13 | 0.34 | 1.04 | 0.77 | nd | 0.07 | 0.28 |
| 2 mid-water | 12.0 | 11.29 | 7.58 | 5.31 | 0.09 | 1.25 | 1.03 | nd | nd | 0.21 |
| 2 bottom | 37.0 | 9.42 | 1.10 | 4.55 | 0.34 | 0.99 | 1.20 | 0.07 | 0.07 | 0.21 |
| R1 surface | 0.5 | 2.99 | 1.07 | 4.42 | 0.69 | 1.56 | 2.32 | 0.21 | 0.14 | nd |
| R1 mid-water | 8.0 | 19.24 | 7.40 | 4.96 | 0.26 | 0.89 | nd | 0.21 | 0.21 | 0.14 |
| R1 bottom | 16.0 | 26.11 | 1.76 | 5.22 | 0.26 | 0.05 | 1.81 | 0.21 | 0.21 | 0.07 |
| R2 surface | 0.5 | 1.38 | 1.89 | 4.96 | 0.17 | 1.41 | 0.17 | 0.07 | 0.28 | 0.07 |
| R2 mid-water | 15.0 | 10.27 | 8.04 | 4.29 | 0.09 | 0.99 | 0.17 | 0.07 | 0.55 | 0.14 |
| R2 bottom | 30.0 | 10.85 | 2.02 | 4.11 | 9.80 | 1.35 | 0.34 | 0.07 | 0.21 | 0.14 |

nd: non detected

**Table 3.** Silicate and chlorophyll a variations during the sampling period in the Yumurtalık Coast of the Iskenderun Bay.

| Stations | Depths | $Si(OH)_4$-Si (µM) | | | Chlorophyll a (µg/L) | | |
|---|---|---|---|---|---|---|---|
| | | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 |
| 1 surface | 0.5 | 1.42 | 11.28 | 0.32 | nd | 0.130 | 0.650 |
| 1 mid- water | 12.0 | 4.93 | 14.12 | 0.21 | nd | 0.610 | 0.650 |
| 1 bottom | 25.0 | 3.24 | 8.04 | 0.21 | 0.310 | 1.300 | 1.170 |
| 2 surface | 0.5 | 3.38 | 5.61 | 0.21 | nd | 0.302 | nd |
| 2 mid-water | 12.0 | 10.95 | 9.73 | 0.42 | nd | 0.413 | 0.260 |
| 2 bottom | 37.0 | 8.24 | 5.95 | 0.21 | nd | 0.650 | 0.910 |
| R1 surface | 0.5 | 3.45 | 13.99 | 0.11 | nd | 0.260 | 0.260 |
| R1 mid-water | 8.0 | 13.04 | 7.37 | 0.00 | nd | 0.420 | 0.130 |
| R1 bottom | 16.0 | 22.30 | 3.99 | 0.11 | nd | 0.780 | 0.910 |
| R2 surface | 0.5 | 3.24 | 5.81 | 0.11 | nd | 0.114 | 0.650 |
| R2 mid-water | 15.0 | 7.5 | 8.11 | 0.21 | nd | 0.116 | 0.390 |
| R2 bottom | 30.0 | 10.41 | 3.92 | 0.21 | nd | 0.253 | 1.040 |

nd: non detected

Turbidity values ranged from 0.34-13.53 NTU. In 2009 survey only surface water turbidity values were measured. Minimum value was observed at station 1 bottom water, maximum was at station 2 bottom.

**Nutrients and Chlorophyll a**

Nutrients and chlorophyll a variations during the study are presented in Tables 2 and 3.

Nitrite+nitrate concentrations changed between 0.31 and 26.11 µM (average: 5.71±0.85 µM) during the study. Minimum value was detected at station 1 surface water in 2007. Maximum concentration was found at station R1 bottom water in 2007. At station 2 surface water, nitrite+nitrate concentration was not detected (nd) due to lower concentration than the detection limit of the method.

Ammonium-nitrogen values ranged from 0.05 to 9.80 µM (average: 0.92±0.27 µM). Minimum concentration was measured at R1 bottom water in 2009. Maximum value was recorded at R2 bottom water in 2007. The statistical differences between the sampling years were important ($p<0.05$).

Phosphate-phosphorus concentrations varied between 0.07 and 0.55 µM (average: 0.14±0.01 µM), showed no significant statistical differences between the years ($p>0.05$). Minimum values were observed mostly in 2007 (Table 2). On

the other hand, maximum value was measured at R2 mid water in 2009.

Silicate concentrations ranged from 0.11 to 22.30 µM (average: 6.79±1.24 µM) in the area concerned. Lowest values were observed in 2011 sampling. Maximum concentration was recorded at R1 bottom in 2007. Significant differences were found between the sampling years ($p<0.001$).

Chlorophyll a concentrations varied between 0.114 and 1.300 µg/L (average: 0.35±0.06 µg/L) during the study. In 2007, chlorophyll a concentrations were under the detection limit at all the sampling stations, accept station 1 bottom water. In accordance, statistical differences between the years were found to be significant ($p<0.001$). Maximum value was recorded at station 1 bottom water in 2009

## DISCUSSION

Turbidity of seawater shows the condition that degree of optical clearness of seawater is affected by the existence of dissolved matters and suspended particles. Turbidity values throughout sampling period varied between 0.34 and 13.53 NTU (average: 2.72±0.59 NTU). Although higher values were measured in 2011 than that of other years, it was found that there was no important impact according to water quality criteria for turbidity (Anonymous, 2011).

The surface water temperatures at all stations were almost identical, with only a minor difference. There was 1-2 °C difference between the surface and the bottom water temperatures at station 2 and R2. There were no differences between surface and bottom water at station R1 due to its lower depth as compared to the other stations. Salinity and density values were homogenous through the water column at this station (Salinity: 39.7 PSU, Temperature: 28.3 °C, Density: 25.8 kg/m$^3$). No significant differences between the stations were recorded for salinity values. The variances (0.1-0.2 PSU) between the surface and bottom water salinities were unimportant. Salinity levels in the study area ranged from 39.19 to 40.05 PSU (average: 39.66±0.00 PSU).

pH values for this region varied from 7.93 to 8.58 (average: 8.28±0.04). According to guidelines for interpreting water Quality data, pH criteria for aquatic life varies between 6.5-9.0.

In the study area, it was observed that surface waters were rich in DO and the water column was almost saturated with it. Yılmaz et al. (1992) reported that the İskenderun Bay was physically dynamic, the oxygen-rich Mediterranean open seawaters enter the bay, circulate and return by flushing the Bay. During the monitoring period of 2007-2011, the dissolved oxygen concentrations exhibited slight decrease through the water column but the values were not under 5 mg/L even at the depth close to bottom. Tuğrul et al. (2011) reported that DO concentrations varied between 180-250 µM in the Northeastern Mediterranean which is compatible with our results.

The three nutrient elements: ammonium, nitrate, silicate have their lowest concentration at the surface (except phosphate max. 0.55 µM). Nutrient concentrations in fact did not increase much with depth (Tables 2-3). In this study the maximum concentration level of available nutrients are relatively high when compared with the open sea values (6 µM nitrate, 0.25 µM phosphate, 10-12 µM silicate) of the Eastern Mediterranean Sea (Krom et al. 2010). Some relatively high values of nutrients observed during the monitoring period are believed to be resulting from river discharges and agricultural activities. The Ceyhan river discharges nitrate rich water into the Iskenderun Bay. Nitrate concentrations of Ceyhan River are higher than those of the other rivers of the area (Tuğrul et al. 2007). The inorganic N concentrations found during our study were higher than recorded by Polat, 2002. In this study nitrate concentrations ranged from 0.31 -26.11 µM. Kontas et al. (2004) (0.13 – 27.0 µM) and Sunlu et al. (2012) (nd – 21.35 µM) reported similar nitrate concentrations in the Izmir Bay.

The eastern Mediterranean has oligotrophic characteristics mainly due to low levels of available nutrients which are essential for primary producers (Krom et al. 1991). Specially, phosphate levels were very low. Atmospheric deposition of ammonia and phosphate are 5 times higher than those of river discharges in the Eastern Mediterranean. Accordingly ratio of N/P after atmospheric inputs (N/P: 117) is higher than the redfield ratio of 16:1 for N/P. (Krom et al. 2010). When ratios of N/P examined, higher values were found at R1 (N/P: 56) and R2 (N/P: 73) than those at stations 1 (N/P: 37) and 2 (N/P: 25). In addition, observing ratios of N/P greater than 16 at all stations show that primary production in the area was controlled by phosphate ions and terrestrial inputs were not important at the time of the study. Consequently, nutrient loads are not likely to be resulting from the Ceyhan Terminal.

Higher ammonium concentrations than ours were reported by Kukrer (2009) (0.23-22.8 µM) and Sunlu et al. (2012) (nd-40.94 µM) in the Izmir Bay. Aksu (2012), reported lower concentrations (nd-5.42 µM) in the Iskenderun Bay than that of this study: 0.05-9.8 µM.

Doğan-Sağlamtimur and Tuğrul (2006), investigated river discharges in the Mersin Bay and reported that inorganic phosphate concentration varied between 0.01-0.08 µM. Polat and Uysal (2009) reported that phosphate varied between 0.05-0.76 µM in the Iskenderun Bay. In this study phosphate concentrations varied between 0.07-0.55 µM. Higher phosphate concentrations (nd-31.43 µM) than ours were reported by Sunlu et al. (2012) in the Izmir Bay.

Chlorophyll a, an indicator of biological production ranged from 0.114 to 1.300 µg/L in the study which was performed in summer months. Mean value of three years calculated as 0.35±0.01 µg/L. Polat and Uysal (2009) reported chlorophyll a values between 0.11-2.86µg/L in the Iskenderun Bay. Aksu (2009) measured chlorophyll a concentrations between 0.07-

4.59 µg/L in Izmir Bay, Aegean Sea. Yılmaz et al. (1992) reported chlorophyll a values between 0-6.5 µg/L and commented that "In summer months the water stratified and nutrients are made available by active regeneration at deeper layers; the chlorophyll a concentration is relatively low in this season". Consequently, the Eastern Mediterranean show ultra-oligotrophic feature and its annual primary production is 60-80 mgC/m$^2$year (Psarra et al. 2000).

In the study area, silicate concentrations varied between 0.11-22.30 µM (mean of three years: 6.97±1.2µM). The silicate ions come from terrestrial inputs and are high in the Eastern Mediterranean Rivers. In this study, performed in summer months, measuring highest concentration at station R1 bottom water indicate that there is terrestrial input near to the station and since this station is shallower than the others silicate ions dissolving from sediment with the increasing temperature may also contribute to the amount of silicate. Kaymakçı-Basaran and Egemen (2007) in a study performed in summer time in the Mediterranean Coast of Turkey reported that mean silicate value was 10.97±2.1 µM.

In conclusion, there was no eutrophication risk at the study area in light of our findings. Phosphate was the limiting nutrient. There was no evident impact of BTCOP activities on water quality at the area concerned. Nevertheless, continuous monitoring is essential to be able to detect any deterioration on the water quality and to take necessary measures.

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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

# Contribution to the knowledge on distribution of water boatmen (Heteroptera: Corixidae) in Turkey

## Türkiye Corixidae (Heteroptera: Corixidae) dağılım bilgilerine katkılar

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**Özet:** Türkiye'nin batısındaki 35 farklı lokaliteden toplanan Corixidae örnekleri sistematik açıdan değerlendirilmiştir. Çalışma sonucunda, üç altfamilyaya (Micronectinae, Cymatiainae, Corixinae) ait 11 tür ve 2 alttüre dahil toplam 3222 birey incelenmiştir. Yedi tür ve iki alttür araştırma bölgesindeki bazı lokaliteler için ilk kez tespit edilmiştir.

***Anahtar kelimeler*:** Heteroptera, Corixidae, Micronectinae, Cymatiainae, Corixinae, Türkiye

**Abstract:** In this study, Corixidae samples were collected from 35 different aquatic localities in Western Turkey and evaluated systematically. As a result of the study, 3222 individuals were found, and 11 species and 2 subspecies belong to 3 subfamilies (Micronectinae, Cymatiainae, Corixinae) were identified in the laboratory. 7 species and 2 subspecies have been reported for the first time for some of the localities in the study area.

***Keywords*:** Heteroptera, Corixidae, Micronectinae, Cymatiainae, Corixinae, Turkey

### INTRODUCTION

The Corixidae (water boatmen) are the largest family of aquatic Hemiptera and contains more than 500 species on a worldwide basis, they are found in virtually all aquatic habitats (ponds, lakes, streams, brackish water, salt-marsh pools and dykes near the sea) (Poisson, 1957; Southwood and Leston, 1959; Stonedahl and Latin, 1986; Jansson, 1986; Savage, 1989, 1990; Topkara et al., 2010).

Corixidae family is divided into six subfamilies (Diaprepocorinae, Micronectinae, Cymatiainae, Stenocorixinae, Heterocorixinae and Corixinae) (Stonedahl and Lattin, 1986; Schuh and Slater, 1995). Members of subfamilies Micronectinae, Cymatiainae and Corixinae exist in Europe and adjacent regions (Jansson, 1986).

In the latest study, 28 species and 9 subspecies were reported from Turkey (Fent et al. 2011).

Despite the gradually increasing efforts over recent years, knowledge of the distribution of Corixidae fauna in Turkey still not enough. This study will contribute an amount subject.

### MATERIALS AND METHOD

In this study, specimens of the family Corixidae sampled from lakes, streams, ponds and puddles in the Central Anatolia, Western Black Sea and Mediterranean regions of Turkey between 2002 and 2008 were investigated.

A total of 3222 specimens of 11 species and 2 subspecies were collected from thirty-five localities.

The Corixidae specimens were collected by hand-net with a mesh size of 500 µm and were fixed in jars filled with 4% formaldehyde solution in the field and they were washed by tap water in laboratory and stored in sampling tubes as dry. The male genital segment was cut off, the segment was placed on slide in a drop of water. The left and right parameres were then separated and were examined under a stereo-microscope.

For taxonomical identification of the corixid specimens, the following publications were used: Poisson (1957), Jansson (1986), Savage (1989). All samples were preserved in the Ege University, Faculty of Fisheries Museum (ESFM).

### RESULTS AND CONCLUSION

Corixidae sampled thirty-five different localities in western Turkey specimens of the eleven species and two subspecies in Turkey and worldwide distribution is as follows:

Ordo: Heteroptera

Infraordo: Hydrocorisae

Family: Corixidae Leach 1815

Subfamily: Micronectinae Jaczewski 1924

***Micronecta (s.str.) anatolica anatolica*** Lindberg 1922

**Materials:** 3♂4♀, Akçabel Stream (Doğanyurt-Kastamonu), 41°59'28"N 33°31'53"E, 15.06.2005.

**Previous records from Turkey:** Adana, Antalya, Burdur, Denizli, Isparta, İzmir, Kahramanmaraş, Muğla, Van (Lindberg 1922; Hoberlandt 1948; Önder et al. 2006; Kıyak et al. 2007; Dursun 2011).

**Distribution of the World:** Afghanistan, China, Iran, Iraq, Israel, Kaukasia, Saudi Arabia, Syria, Tadzhikistan, Turkey, Uzbekistan, Vietnam, Yemen (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks**: First record of this species from Kastamonu.

***Micronecta (Dichaetonecta) scholtzi*** (Fieber 1860)

**Materials:** 5♂5♀, Lake Yeniçağa (Yeniçağa-Bolu), 40°46'N 32°01'E, 990 m a.s.l., 14.08.2002; 1♂2♀, Akpınar Springs (Akpınar-Başmakçı-Denizli), 37°51'11"N 29°58'59"E, 780 m a.s.l., 31.05.2007.

**Previous records from Turkey:** Edirne, Sakarya (Hoberlandt 1948; Önder et al. 2006; Fent et al. 2011).

**Distribution of the World:** Albania, Algeria, Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Great Britain, Greece, Hungary, Italy, Luxembourg, Moldavia, Morocco, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Switzerland, Tunisia, Turkey, Ukraine, Yugoslavia (Aukema and Reiger 1995; Önder et al. 2006).

**Remarks**: First record of this species from Bolu and Denizli.

Subfamily: Cymatiainae Walton 1940

***Cymatia rogenhoferi*** (Fieber 1864)

**Materials:** 1♂5♀, Adıyan Stream (Ortaca-Akşehir-Konya), 38°15'23"N 31°36'44"E, 1000 m a.s.l., 23.06.2006.

**Previous records from Turkey:** Ankara, Konya, Van (Hoberlandt, 1948, Önder et al., 2006)

**Distribution of the World:** Algeria, Armenia, Austria, Azerbaijan, Bulgaria, China, Czech Republic, France, Georgia, Germany, Hungary, India, Iran, Iraq, Italy, Kyrgyzstan, The Netherlands!, Mongolia, Poland, Romania, Russia, Saudi Arabia, Slovakia, Spain, Tadzhikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006)

Subfamily: Corixinae Leach 1815

***Corixa affinis*** Leach 1817

**Materials:** 1♂1♀, Avşar Stream (İscehisar-Afyon), 38°50'02"N 30°°46'27"E, 980 m a.s.l., 23.06.2006; 1♂1♀, Akarçay Stream (Gebeceler-Afyon), 38°46'40"N 30°46'50"E, 960 m a.s.l., 23.06.2006; 577♂546♀, Kaliçayı Stream (Pazarağaç-Çay-Afyon), 38°36'04"N 30°53'37"E, 940 m a.s.l., 23.06.2006; 2♂3♀, Gediz River (Kula-Manisa), 38°37'58"N 28°57'05"E 480 m a.s.l., 24.06.2006; 1♂, Saltık Stream (Saltık-Sandıklı-Afyon), 38°29'05"N 30°04'26"E, 920 m a.s.l., 24.06.2006; 4♂3♀, spring near Ephesus (Efes-Selçuk-İzmir), 37°56'35"N 27°19'46"E, 10 m a.s.l., 20.04.2007.

**Previous records from Turkey:** Adana, Afyon, Ağrı, Ankara, Antalya, Aydın, Burdur, Çanakkale, Çorum, Denizli, Diyarbakır, Edirne, Erzincan, Eskişehir, Hatay, Isparta, İzmir, Kırklareli, Kocaeli, Konya, Mersin, Muğla, Osmaniye, Samsun, Sivas, Tekirdağ, Zonguldak (Hoberlandt 1948; Wagner 1966; Önder and Adıgüzel 1979; Kıyak et al. 2004, 2007; Önder et al. 2006; Dursun 2011; Salur and Mesci 2011; Fent et al. 2011).

**Distribution of the World:** Albania, Algeria, Armenia, Austria, Azerbaijan, Azores, Belgium, Bulgaria, Canary Islands, Croatia, Cyprus, Czech Republic, Denmark, Egypt?,France, Georgia, Germany, Great Britain, Greece, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, Libya, Madeira Archipelago, Malta, Macedonia, Morocco, The Netherlands, Poland, Portugal, Romania, Russia, Slovakia, Spain, Syria, Tadzhikistan, Tunisia, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yemen, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks**: Firstly recorded from Manisa.

***Corixa panzeri*** (Fieber 1848)

**Materials:** 1♂, Bedir Stream (Çavdarhisar-Kütahya), 39°12'02"N 29°36'44"E, 20.08.2004.

**Previous records from Turkey:** Ankara, Edirne, Erzurum, Isparta, İzmir, Konya, Samsun (Wagner, 1966; Yıldırım et al., 1999; Önder et al., 2006; Dursun, 2011; Fent et al., 2011).

**Distribution of the World:** Algeria, Austria, Azerbaijan, Belgium, Bulgaria, Denmark, France, Georgia, Germany, Great Britain, Greece, Hungary, Iran, Ireland, Italy, Latvia, Liechtenstein, Morocco, The Netherlands, Poland, Portugal, Russia, Slovakia, Spain, Sweden, Tadzhikistan, Tunisia, Turkey, Ukraine (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks:** Fist record of this species from Kütahya.

***Corixa punctata*** (Illiger 1807)

**Materials:** 1♂1♀, Bayındır Stream (Kızılcahamam-Ankara), 40°19'21"N 32°27'53"E, 880 m a.s.l., 18.08.2004.

**Previous records from Turkey:** Adana, Afyon, Ağrı, Ankara, Antalya, Ardahan, Aydın, Burdur, Çankırı, Çorum, Denizli, Edirne, Erzurum, Isparta, İstanbul, İzmir, Kırklareli, Kocaeli, Kastamonu, Kayseri, Konya, Samsun (Hoberlandt 1948; Linnavouri 1965; Aukema and Rieger 1995; Yıldırım et al. 1999; Kıyak et al. 2004; Önder et al. 2006; Dursun 2011; Salur and Mesci 2011; Fent et al. 2011).

**Distribution of the World:** Albania, Algeria, Armenia, Austria, Azerbaijan, Belgium, Bosnia Hercegovina, Bulgaria, China, Croatia, Denmark, Finland, France, Georgia, Germany, Great Britain, Greece, Hungary, India, Iran, Ireland, Italy,

Kyrgyzstan, Liechtenstein, Luxembourg, Macedonia, Moldovia, Morocco, The Netherlands, Norway, Poland, Portugal?, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tadzhikistan, Tunisia, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006).

***Hesperocorixa linnaei*** (Fieber 1848)

**Materials:** 2♂1♀, Kurttepe Stream (Kurttepe Village, Pınarbaşı-Kayseri), 38°35'08"N 36°08'40"E, 1380 m a.s.l., 01.06.2005.

**Previous records from Turkey:** Adana, Adapazarı, Ağrı, Ankara, Antalya, Aydın, Bolu, Burdur, Bursa, Denizli, Düzce, Isparta, Kayseri, Sakarya, Sivas (Hoberlandt 1948; Poisson 1957; Özesmi and Önder 1988; Önder et al. 1981, 2006).

**Distribution of the World:** Algeria, Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Byelorussia, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Great Britain, Germany, Greece, Hungary, Iran, Ireland, Italy, Kyrgyzstan, Liechtenstein, Lithuania, Luxembourg, Macedonia, Moldavia, The Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tadzhikistan, Tunisia, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006).

***Sigara (s.str.) striata*** (Linnaeus 1758)

**Materials:** 1♂, Lake Yeniçağa (Yeniçağa-Bolu), 40°46'N 32°01'E, 990 m a.s.l., 14.08.2002; 10♂, Ibid., 26.06.2003; 3♂, Küçük Akgöl (Sakarya), 40°52'N 30°26'E, 15 m a.s.l., 26.06.2003; 7♂, Kırkpınar springs (Ilgaz-Çankırı), 41°00'41"N 33°36'51"E, 1650 m a.s.l., 16.06.2005; 1♂2♀, Örenşehir Stream (Pınarbaşı-Kayseri), 38°59'17"N 36°39'40"E, 1520 m a.s.l., ,02.06.2005; 1♂2♀, Lake Beyşehir (Kurucaova village, Beyşehir-Konya), 15.09.2005; 17♂10♀, Ağcaşar stream (Yahyalı-Kayseri), 38°07'18"N 35°21'54"E, 1080 m a.s.l., 30.05.2006; 1♂, Göksu River (Antalya), 36°51'51"N 30°37'05"E, 60 m a.s.l., 20.06.2006; 3♂, Kökez stream (Kadınhanı-Konya), 38°21'32"N 32°18'54"E, 940 m a.s.l., 03.06.2006; 2♂3♀, Köprü stream (Serik-Antalya), 36°57'13"N 31°10'29"E, 50 m a.s.l., 21.06.2006; 2♂2♀, Aksu Çayı (Antalya), 36°57'52"N 30°54'11"E, 40 m a.s.l., 21.06.2006; 2♂4♀, Dragon stream (Anamur-Mersin), 36°10'19"N 32°53'48"E, 100 m a.s.l., 22.06.2006; 16♂10♀, Kali stream (Pazarağaç-Çay-Afyon), 38°36'04"N 30°53'37"E, 940 m a.s.l., 23.06.2006; 31♂20♀, Akpınar springs (Akpınar-Başmakçı-Denizli), 37°51'11"N 29°58'59"E, 780 m a.s.l., 31.05.2007; 1♂6♀, Lake Gölmarmara (Tekelioğlu village, Salihli-Manisa), 38°35'49"N 27°59'57"E, 160 m a.s.l., 28.06.2007; 2♂, Lake Gölmarmara (Akpınar springs-Manisa), 38°42'09"N 27°58'08"E, 180 m a..s.l., 28.06.2007; 7♂9♀, Lake Eğirdir (Akkeçili village, Eğirdir-Isparta), 30°08'02"N 30°47'28"E, 910 m a.s.l., 29.05.2007.

**Previous records from Turkey:** Afyon, Ağrı, Ankara, Antalya, Ardahan, Aydın, Burdur, Çanakkale, Çorum, Denizli, Edirne, Erzurum, Isparta, İzmir, Kayseri, Konya, Muğla, Samsun, Van (Yıldırım et al. 1999; Özesmi and Önder 1988; Kıyak et al. 2004, 2007; Önder et al. 2006; Dursun 2011; Salur and Mesci 2011; Fent et al. 2011).

**Distribution of the World:** Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia Hercegovina, Bulgaria, Byelorussia, China, Croatia, Denmark, Estonya, Finland, France, Georgia, Germany, Great Britain, Greece, Hungary, Iran, Italy, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Moldavia, The Netherlands, Norway, Poland, Romania, Russia, Slovakia, Slovenia, Sweden, Switzerland, Turkey, Ukraine, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks:** Fist record of this species from Bolu, Çankırı, Manisa, Mersin, Sakarya.

***Sigara (s.str.) assimilis*** (Fieber 1848)

**Materials:** 2♂, Adıyan Stream (Ortaca-Akşehir-Konya), 38°15'23"N 31°36'44"E, 1000 m a.s.l., 23.06.2006; 5♂17♀, Cebişli stream (Argıthanı-Ilgın-Konya), 38°17'03"N 31°42'07"E, 1040 m a.s.l., 23.06.2006; 34♂52♀, Lake Burdur (Burdur), 37°41'45"N 30°11'21"E, 800 m a.s.l., 30.05.2007.

**Previous records from Turkey:** Bitlis, İzmir, Konya, Van (Seidenstücker 1958; Önder et al. 2006).

**Distribution of the World:** Azerbaijan, Afghanistan, China, Bulgaria Croatia, Georgia, Hungary, Iran, Iraq, Kyrgyzstan, Moldavia, Mongolia, Romania, Russia, Saudi Arabia, Tadzhikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks:** Fist record of this species from Burdur.

***Sigara (Pseudovermicorixa) nigrolineata nigrolineata*** (Fieber 1848)

**Materials:** 4♂4♀, Terme stream (Çayyaka village, Cide-Kastamonu), 41°57'33"N 33°12'34"E, 14.06.2005; 3♂1♀, Şehriban stream (Şenpazar-Kastamonu), 41°47'22"N 33°10'36"E, 250 m a.s.l., 14.06.2005; 13♂15♀, Kirazlı stream (Çatalzeytin-Kastamonu), 41°57'22"N 34°11'35"E, 15.06.2005; 48♂47♀, Değirmendere stream (Akçakoca-Düzce), 41°06'10"N 31°15'07"E, 5 m a.s.l., 30.06.2004; 1♂2♀, Kireç stream (İskilip-Çorum), 19.07.2008.

**Previous records from Turkey:** Adana, Adapazarı, Afyon, Ağrı, Ankara, Antalya, Ardahan, Artvin, Aydın, Bolu, Burdur, Bursa, Çorum, Denizli, Diyarbakır, Düzce, Edirne, Erzincan, Erzurum, Eskişehir, Gaziantep, Hatay, Isparta, Iğdır, İstanbul, İzmir, Kars, Kocaeli, Konya, Mersin, Muğla, Rize, Trabzon, Tunceli, Sakarya, Samsun, Sivas, Şanlıurfa, Tokat, Van (Hoberlandt 1948; Seidenstücker 1958; Linnavouri 1965; Kıyak et al. 2004, 2007; Önder et al. 1981, 1984, 2006; Dursun 2011; Salur and Mesci 2011; Fent et al. 2011).

**Distribution of the World:** Albania, Algeria, Andorra, Armenia, Austria, Azerbaijan, Belgium, Bosnia Hercegovina,

Bulgaria, Byelorussia, Czech Republic, Cyprus, Denmark, Estonya, Finland, France, Georgia, Germany, Great Britain, Hungary, Iran, Iraq, Ireland, Italy, Latvia, Liechtenstein, Luxembourg, Malta, Macedonia, Moldavia, Morocco, The Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine, Yugoslavia (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks:** First record of this species from Kastamonu.

***Sigara (Subsigara) iactans*** Jansson 1983

**Materials:** 2♂, Lake Yeniçağa (Yeniçağa-Bolu), 40°46'N 32°01'E, 990 m a.s.l., 14.08.2002; 29♂, Ibid., 26.06.2003; 1♂, Lake Küçük Akgöl (Sakarya), 40°52'N 30°26'E, 15 m a.s.l., 26.06.2003; 7♂5♀, Lake Gölcük (Bolu), 40°39'N 31°37'E, 1080 m a.s.l., 26.06.2003; 82♂372♀, Kırkpınar springs (Ilgaz-Çankırı), 41°00'41"N 33°36'51"E, 1650 m a.s.l., 16.06.2005.

**Previous records from Turkey:** Edirne, Çorum, Kırklareli (Jansson 1983; Önder et al. 2006; Salur and Mesci 2011).

**Distribution of the World:** Belgium, Bulgaria, Denmark, Germany, Greece, Macedonia, The Netherlands, Poland, Romania, Russia, Sweden, Turkey, Ukraine (Aukema and Rieger 1995).

**Remarks**: First record of this species from Bolu, Çankırı, Sakarya.

***Sigara (Subsigara) kervillei*** (Poisson 1927)

**Materials:** 9♂, Kökez stream (Kadınhanı-Konya), 38°21'32"N 32°18'54"E, 940 m a.s.l., 03/06/2006.

**Previous records from Turkey:** Adana, Afyon, Ankara, Antalya, Konya, Kütahya (Hoberlandt 1948; Seidenstücker 1958; Önder et al. 2006; Fent et al. 2011).

**Distribution of the World:** Turkey (endemic species) (Aukema and Rieger 1995).

***Sigara (Vermicorixa) lateralis*** (Leach 1817)

**Materials:** 1♂, Lake Yeniçağa (Yeniçağa-Bolu), 40°46'N 32°01'E, 990 m a.s.l., 14.08.2002; 7♂18♀, Kirazlı stream (Çatalzeytin-Kastamonu), 41°57'22"N 34°11'35"E, 15.06.2005; 2♂2♀, Avşar Stream (İscehisar-Afyon), 38°50'02"N 30°46'27"E, 980 m a.s.l., 23.06.2006; 2♂1♀, Demirlik stream (Aşağıçiğil-Ilgın-Konya), 38°04'11"N 31°49'51"E, 1120 m a.s.l., 23.06.2006; 74♂64♀, Adıyan Stream (Ortaca-Akşehir-Konya), 38°15'23"N 31°36'44"E, 1000 m a.s.l., 23.06.2006; 37♂124♀, Akarçay Stream (Gebeceler-Afyon), 38°46'40"N 30°46'50"E, 960 m a.s.l., 23.06.2006; 7♂8♀, Cebişli stream (Argıthanı-Ilgın-Konya), 38°17'03"N 31°42'07"E, 1040 m a.s.l., 23.06.2006; 4♂13♀, Kökez stream (Kadınhanı-Konya), 38°21'32"N 32°18'54"E, 940 m a.s.l., 03/06/2006; 19♂3♀, Battal stream (Ilgın-Konya), 38°16'08"N 31°53'50"E, 980 m a.s.l., 23.06.2006; 498♂403♀, Ağcaşar stream (Yahyalı-Kayseri), 38°07'18"N 35°21'54"E, 1080 m a.s.l., 30.05.2006; 2♂, spring near Ephesus (Efes-Selçuk-Izmir), 37°56'35"N 27°19'46"E, 10 m a.s.l., 20.04.2007.

**Previous records from Turkey:** Adana, Afyon, Ağrı, Amasya, Ankara, Antalya, Artvin, Aydın, Bitlis, Burdur, Bursa, Çanakkale, Çorum, Denizli, Diyarbakır, Edirne, Eskişehir, Gaziantep, Iğdır, Isparta, İstanbul, İzmir, Karabük, Kars, Kayseri, Kırklareli, Kocaeli, Konya, Muğla, Mersin, Niğde, Osmaniye, Rize, Samsun, Sinop, Tekirdağ, Tunceli, Van, Zonguldak (Hoberlandt 1948; Seidenstücker 1958; Linnavuori 1965; Wagner 1966; Özemsi and Önder 1988; Kıyak et al. 2004, 2007; Önder et al. 2006; Dursun 2011; Salur and Mesci 2011; Fent et al. 2011).

**Distribution of the World:** Albania, Algeria, Armenia, Austria, Azerbaijan, Belgium, Bosna Hercegovina, Bulgaria, Byelorussia, Canary Islands, China, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Finland, France, Georgia, Germany, Great Britain, Greece, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, Kyrgyzstan, Liechtenstein, Luxembourg, Macedonia, Malta, Moldovia, Mongolia, Morocco, The Netherlands, Norway, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovakia, Spain, Sweden, Switzerland, Syria, Tadzhikistan, Tunisia, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yemen, Yugoslavia, Tropical Africa (Aukema and Rieger 1995; Önder et al. 2006).

**Remarks:** Fist record of this species from Bolu and Kastamonu.

The following species are firstly recorded from the listed localities; *M. anatolica anatolica* and *S. nigrolineata nigrolineata* from Kastamonu; *M. Scholtzi* from Bolu and Denizli; *C. affinis* from Manisa; *C. panzeri* from Kütahya; *S. striata* from Bolu, Çankırı Manisa, Mersin and Sakarya; *S. assimilis* from Burdur; *S. iactans* from Bolu, Çankırı and Sakarya; *S. lateralis* from Bolu and Kastamonu.

In this study, the most common species was found as S. striata at 17 localities and it was followed by *S. lateralis* at 11 localities, *M. anatolica anatolica*, *C. rogenhoferi*, *C. panzeri*, *C. punctata*, *H. linnaei*, *S. kervillei* have been observed at only one locality.

As a consequence of my study, I showed that *S. (Subsigara) iactans* distributes in the northern parts of Anatolia and Turkish Thrace and this result agrees with previously given data.

*M. (s.str.) anatolica anatolica* was recorded from Ege, Mediterranean (including the Lake District) and Eastern Anatolian parts of Turkey (Lindberg 1922; Hoberlandt 1948; Önder et al. 2006; Kıyak et al. 2007; Dursun 2011). As a result, I also reported that this species distributes in the North-Eastern parts of Turkey.

More detailed studies are necessary to understand distribution of the members of Corixidae. By the way, Corixidae family which is represented by 28 species and 9 subspecies for Turkish fauna, the distribution of the known species can be explained with more data and new species may be determined.

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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

# Effects of 2-Phenoxyethanol on cuttlefish *Sepia officinalis* L. (Cephalopoda: Sepiidae)

## 2-Fenoksietanolün sübye *Sepia officinalis* L. üzerine etkisi

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**Özet:** *Sepia officinalis* üzerine 2-fenoksietanolün (2-PhOH) etkisi incelenmiştir. 2-PhOH'ün farklı dozları (0,10; 0,15; 0,20; 0,25 ve 0,30 ml/L) 15 litrelik şeffaf cam akvaryumun içinde bulunan ve sürekli havalandırılan 10 litre deniz suyunda (pH 7,68; $O_2$ 6,8 mg/L; sıcaklık 19,7°C ve tuzluluk ‰37) çözündürülmüştür. 2-PhOH uygulamalarından sonra sübyeler hemen içinde 450 litre iyi havalandırılmış deniz suyu bulunan polyester ayıltma tanklarına nakledilmiştir, burada 48 saat boyunca ölüm olup olmayacağı gözlenmiştir. Ortalama vücut ağırlığı 224,46 ± 56,20 gr (n=30) olan sübyelerden her deneme grubu için tek tek olacak şekilde 6 birey kullanılmıştır. Elde edilen sonuçlara göre, 0,10 ml/L 2-PhOH konsantrasyonunda ne anestetik etki nede ölüm gözlenmiştir, ama 0,15 ile 0,30 ml/L 2-PhOH konsantrasyonlarında %50'nin üzerinde ölüm olmuştur. Yaşama yüzdeleri 0,10 ml/L için %100, 0,15 ve 0,20 ml için %33,3 ve 0,25 ve 0,30 ml/L için %16,7 olarak hesaplanmıştır ($P<0,05$). Hayatta kalanlar 5 dakika içinde ayılmıştır ve 48 saatten fazla yaşamışlardır. Sonuç olarak, 2-PhOH anestetik olarak etkisiz oluşu ve toksisitesi nedeniyle *S. officinalis* için önerilmemektedir.

***Anahtar kelimeler*:** 2-Phenoxyethanol, anestezi, sübye, *Sepia officinalis*, toksisite.

**Abstract:** Effects of 2-Phenoxyethanol (2-PhOH) on cuttlefish *Sepia officinalis* (L.) were investigated. The five concentrations (0.10, 0.15, 0.20, 0.25 and 0.30 ml/L) of 2-PhOH were dissolved directly into 15 L transparency glass aquarium containing of 10 L continuously aerated seawater (pH 7.68, $O_2$ 6.8 mg/l, salinity 37‰ at 19.7°C). After 2-PhOH treatments, the cuttlefishes were transferred immediately to a polyester recovery tank with 450 L of well-aerated seawater, where they were observed in 48-h due to any mortality. Six cuttlefishes, the mean body weight was 224.46 ± 56.20 g (n=30) were used individually in each experiment. According to the present results, at 0.1 ml/L of 2-PhOH level neither anesthetic effects nor mortality occurred on the cuttlefish, but more than 50% mortality occurred between 0.15 and 0.30 ml/L of 2-PhOH concentrations. The percentages of survival were 100% for 0.10 ml/L, 33.3% for 0.15 and 0.20 ml/L, and 16.7% for 0.25 and 0.30 ml/L of 2-PhOH concentrations ($P<0.05$). The reminders recovered within 5 minutes and survived over 48 hours. Finally, the current study demonstrated that 2-PhOH could not be recommended for *S. officinalis* due to its inefficiency and toxicity.

***Keywords*:** 2-Phenoxyethanol, anaesthesia, cuttlefish, *Sepia officinalis*, toxicity.

### INTRODUCTION

Anesthetic agents are widely used fisheries and aquaculture to immobilize animals for transport, vaccination, measuring or weighing, sorting and tagging, sampling for blood or gonadal biopsies, and collection of gametes, besides to comfortable handling, permit the performance of painful procedures and decrease stress (Le Bras, 1982; Summerfelt and Smith, 1990; Kreiberg and Powell, 1991; Gewick et al., 1999; Ross and Ross, 1999; Small, 2003). Several anesthetic such as MS222, 2-Phenoxyethanol, clove oil, etc. has been commonly used in fish or fisheries operations (Summerfelt and Smith, 1990; Guilderhus and Marking, 1987; Maylonas et al., 2005). Among them 2-Phenoxyethanol is considered very suitable for aquaculture practices because of its easy preparation, low price, rapid action, fast and uneventful recovery (Pucéat et al., 1989; Weyl et al., 1996) and bactericidal and fungicidal characteristics (Jolley et al., 1972). It is well recorded that the effective anesthetic concentrations of 2-PhOH in several of species of fish have been reported and ranged from 0.2-0.6 ml/L (Summerfelt and Smith, 1990; Guilderhus and Marking, 1987; Mattson and Riple, 1989; Josa et al., 1992; Hseu et al., 1996, 1997, 1998; Kaminski et al., 2001; Ortunõ et al., 2002; Maršic et al., 2005; Tsantilas et al., 2006). However, scarce data are available about the effects of 2-PhOH in terms of appropriate anesthetic and its doses or its toxicity for cephalopods, especially the cuttlefish *Sepia officinalis*.

The cuttlefish, *S. officinalis* is one of the most easily cultured cephalopods (Richard, 1971; Pascual, 1978; Boletzky and Hanlon, 1983; Forsythe and., 1994; Lee et al., 1998; Domingues et al., 2001a, 2001b, 2002, 2003a), and is a commercially important species throughout the world (Roper et al., 1984). Furthermore, it is highly adaptable to life in captive conditions (Forsythe et al., 1994; Domingues et al., 2001a, 2001b, 2002, 2003a, 2003b, 2005, 2006; Sykes et al., 2006; Şen, 2009). The animals are particularly difficult to handle as they are not only quick but also have a very sensitive skin. Even, due to its habit to grab and hold things, the animal is not easy to handle all along treatment. Records

are needed on the toxicity or safety exposure times and concentrations of 2-Phenoxyethanol in aquaculture applications such as transportation, measuring or weighing and sorting of *S. officinalis*. Therefore, this study was, first, designed to evaluate effects of 2-PhOH on adult *S. officinalis*.

## MATERIALS AND METHOD

A total of 52 specimens of *S. officinalis* (L., 1758), were captured off the Izmir Bay by trammel nets on April 2, 2012. The individuals were acclimatized in an open flow-through filtered seawater (pH 8.2, salinity 37 ± 0.2‰, dissolved $O_2$ 7 ± 0.5 mg/L, temperature 15.5 ± 0.5°C by Extech® DO700 Multiparameter instrument) system and cylindrical polyester tanks (450 L volume) were placed in the PhD. H. Okan KAMACI Aquaculture Investigation and Application Unit of the Fisheries Faculty of Ege University (Urla, Izmir, TURKEY) one month before the application. The specimens were fed ad-libitium with low market price pieces of fish species (i.e. *Sardina pilchardus*, *Engrualis encrasicolus*) by hand. The following day, uneaten part or remains were removed by siphoning. Photoperiod was adjusted naturally.

The mean body weight of 30 cuttlefishes was 224.46 ± 56.20 g (n= 30; ANOVA, P > 0.05) were used in the experiment. The five concentrations (0.1, 0.15, 0.2, 0.25, and 0.3 ml/L of 2-PhOH) were selected, and also maximum exposure time was applied as 15 minutes. In order to determine the effects of 2-PhOH, six cuttlefishes were used individiually in each dose of the agent. The 2-PhOH concentrations were dissolved directly into 15 L transparency glass aquarium containing 10 L of continuously aerated seawater (pH 7.68, $O_2$ 6.8 mg/L, salinity 37‰ at 19.7°C). After the treatments, cuttlefishes were instantly transferred to a polyester recovery tank with 450 L of well-aerated seawater, where they were observed in 48-h due to any mortality.

The criteria for anesthetic effects were evaluated to Seol et al. (2007) and where loss of sucking intensity under anesthesia (Stage A3) and recovery of regular breathing (R4). Anesthetizing the cuttlefish involved several stages, beginning with a change in body color (Stage A1) to the loss of sucking intensity (Stage A3), at which stages the specimen was immediately transferred to a recovery tank were considered. Recovery time was estimated from the point at which the cuttlefish recovered normal activity (Stage R3) and regular breathing (Stage R4).

One-way analysis of variance and Duncan's multiple range tests were applied to determine the statistical significance of the differences among the induction time means and among the recovery means for the species, using the SPSS 15.0 package program. Furthermore, transformation to $\sqrt{x+0.1}$ was applied when non-parametric statistical conditions occurring. Additionally, the survival rates of the groups were statistically tested by chi-square test. Level of significance was taken at $P < 0.05$.

## RESULTS

The major point of this study was that 2-PhOH acted like toxic affects and did not anesthesia on the cuttlefish in these experimental conditions. At among 0.15 and 0.30 ml/L of 2-PhOH concentrations, more than 50% mortality occurred within 3-5 minutes. Toxic affect of 2-PhOH was increased by dosages and observed shorter than 5 minutes at 0.15 and 0.20 ml/L of 2-PhOH, and 3 minutes at 0.25 and 0.30 ml/L of 2-PhOH. On the other hand, at 0.1 ml/L of 2-PhOH concentration neither anesthetic affects nor mortality occurred on the cuttlefishes within the 15-minute treatment period. The percentages of survival rates were estimated at 100% for 0.10 ml/L, 33.3% for 0.15 and 0.20 ml/L or 16.7% for 0.25 and 0.30 ml/L of 2PhOH concentrations. There were significant differences among the survival rates of the treatments ($P<0.05$). Additionally, the recovery stages of *S. officinalis* were, first described, and the survivor cuttlefish recovered within 5 minutes and survived over 48 hours. The induction time and the recovery time among the trials were not significantly different ($P>0.05$). The 2-PhOH doses caused hyperactivity and trauma such as violently inking, sudden swimming movements, hit to the aquarium walls of itselves, and trying to jumping out of the aquarium, etc, in the cuttlefishes. Affects of 2-PhOH treatments depend on exposure time and concentrations on *S. officinalis* were shown in the Table 1. Its noted that A3 criteria could not be showen at the Table 1, because the anaesthetic effects of 2-PhOH was not observed.

## DISCUSSION

It is well known that 2-PhOH is a safely and effectively anesthetic at lower doses (0.2 - 0.6 ml/L) for fish (Guilderhus and Marking, 1987; Maylonas et al., 2005; Weyl et al., 1996; Josa et al., 1992; Hseu et al., 1996, 1997, 1998; Kaminski et al., 2001; Ortunõ et al., 2002; Maršic et al., 2005; Tsantilas et al., 2006), but it works for the cephalopod (e.g. *Eledone moschata*) at higher concentrations (1.2 - 1.6 ml/L) (Şen and Tanrıkul, 2009). On the other hand, it is recorded that anesthesia with 2-PhOH under controlled conditions, and its fatality or toxicity is mainly depends on the exposure time and the concentration (Şen and Tanrıkul, 2009). Additionally, Basaran et al. (2007) showed that the toxicity of 2-PhOH was clearly depended on the dose and exposure time on European sea bass, *Dicentrarchus labrax*, juvenile. Furthermore, in the current study, 2-PhO H did not run as an anesthetic even in the minimum concentrations (0.15 - 0.30 ml/L), and acted toxic on the adult *S. officinalis*.

Messenger et al. (1985) pointed out that magnesium chloride is an effective anesthetic and narcotizing agent for several cephalopods (e.g. *Sepia officinalis*, *Loligo forbesi*, *Alloteuthis subulata*, *Octopus vulgaris*, *Eledone cirrhosa*) at temperatures ranging from 13 to 22°C. Although the authors reported that achieving to the anesthesia of *S. officinalis* without any mortality and trauma, they could not determine to recovery stages for *S. officinalis*.

**Table 1**. Effects of 2-PhOH treatments on *S. officinalis* L depends on exposure time and concentrations.

| Description | Remarkable behaviour | 0.15 ml/L Time (sec)* | 0.20 ml/L Time (sec) | 0.25 ml/L Time (sec) | 0.30 ml/L Time (sec) |
|---|---|---|---|---|---|
| **Change in body colour and activity** | The chromatophores showed quickening waves of colour change, and start hyperactivity | 63±12 | 41.7±33 | 5.5±1.0 | 43.8±4.8 |
| **Change in mantle cavity shape and colour** | Shrinkage of body and fins, and colour becomes pale and darkish brown colour | 168.8±111.6 | 183.2±56.6 | 16.3±9.2 | 66.2±22.5 |
| **Body spasm** | Close the eyes and violently ejecting ink | 256.7±205.8 | 194±57.8 | 82±35.6 | 78±22.2 |
| **Cessation of movement (death)** | Become variegated of body colour, full blossomed the arms, contraction of the whole body, and also closing of the funnel | 256.7±205.8 | 231.7±91.2 | 138.8±79.9 | 93.5±19.0 |
| **Recovery of activity** | Recovery of activity; start of the arm movement following to the fin movement, but breathing is labored | 96.7±34.1 | 271.8±235.6 | 11±24 | - |
| **Recovery of body colour** | The start of the chromatophores showed quickening waves of colour change and originating of two dark spots on the posteriodorsal of the mantle | 155.3±25.8 | 237.8±990.6 | 128±70.4 | - |
| **Recovery of regular swimming and colorization (R3)** | Start swimming and go down, brownish colour of the body | 292.5±6.9 | 106.7±165.7 | 230.3±16.8 | 30±73.5 |

However, only two anesthesia stages (the chromatophores showed quickening waves of color change, and cessation of movement (death) also closing of the funnel) were observed during the study among the criteria described by Messenger et al. (1985). Additionally, the recovery criteria (a-Recovery of activity; start of the arm movement following to the fin movement, but breathing was labored; b-Start of the chromatophores showed quickening waves of color change and originating of two dark spots on the posteriodorsal of mantle; c- Start swimming and sink, brownish color on the body) were, first recorded in *S. officinalis* in the present study.

As reported by O'Dor et al. (1977), for squid, 2-3% urethane as an anesthetic agent, is effective in seawater, providing handling ability after only a few minutes' exposure and a recovery period of 3–15 minutes. Unfortunately, urethane is now considered unsuitable material because of its carcinogenic properties (Ross and Ross, 1999). It should be noted that both these materials cause initial hyperactivity, which can be traumatic. Moreover, the present results clearly showed that 2-PhOH cause hyperactivity and trauma in the cuttlefishes.

In conclusion, according to the present results, the 0.10 ml/L of 2-PhOH concentration did not cause any mortality or toxicity on *S. officinalis* within 48-hour. However, at the same dose, the individuals' body color became pale and monitored partial sedation, only. By the way, toxic effect of 2-PhOH was monitored at among concentrations 0.15 and 0.30 ml/L in this species. Finally, the current study demonstrated that 2PhOH could not be recommended for *S. officinalis* due to its inefficiency as an anesthetic and/or its toxicity. At the same time, it needs to more detailed studies should be performed related to physiological effects of 2-PhOH on cuttlefish.

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**ARAŞTIRMA MAKALESİ** **RESEARCH ARTICLE**

# İstanbul balık halinin fiziki koşulları ve pazarlanan türler (2007–2011)

## The physical conditions of Istanbul fish market and the marketed fish species (2007–2011)

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**Abstract**: This study reports the current status and annual amounts of fish which are marketing in Istanbul wholesale fish market between 2007 and 2011, and also some structural and hygienic problems of fish market were determined. The annual average sales of fish in the market reached to about 40000 tons. The average 90 species are being sold in the fish market. The greatest amounts of fish, sold in the market were concerning with anchovy, horse-mackerel, reared bass and gilthead sea bream, and bluefish, respectively.

***Keywords*:** Fish market, marketing, Istanbul

**Özet:** Bu çalışma, 2007–2011 yılları arasında İstanbul balık halinde pazarlanan balıkların miktarını ve halin mevcut durumunu rapor etmektedir. Ayrıca halin bazı yapısal ve hijyenik problemleri de saptanmıştır. Halde yıllık ortalama balık satışı yaklaşık 40000 tona ulaşmıştır. Halde ortalama 90 tür su ürünü işlem görmektedir. Satış miktarlarına göre en çok pazarlanan balıklar sırasıyla hamsi, istavrit, kültür çipura ve levrek ile lüferdir.

***Anahtar kelimeler*:** Balık hali, pazarlama, İstanbul

## GİRİŞ

Türkiye'de günümüzde 13 adet su ürünleri toptan satış yeri bulunmaktadır. İstanbul'da bulunan bir özel girişim hariç, tüm su ürünleri satış yerleri Belediyelerce kurulmuş ve işletilmektedir (BSGM, 2012). Yıllık yaklaşık 200–300 bin ton civarında su ürünü, toptan satış yerleri olan balık hallerinde satılmaktadır (TÜİK, 2012). Su ürünleri dağıtım sisteminde balık halleri, hem balıkçılık yönetimi için gerekli olan balıkçılık bağımlı verilerinin sağlanmasında, hem de satılan ürünlerin orijini, av alanı ve boy yasakları, tazelik, hijyen ve gıda güvenilirliği kriterleri bakımından kontrol altında tutulabilmesi açısından çok önemli merkezlerdir.

İstanbul balık hali, Türkiye'nin en büyük balık halidir ve Türkiye'nin geçmişten bugüne en eski kayıtlarının neşredilmesi gibi önemli bir özelliğe de sahiptir. Geçmişte İstanbul'da iki balık pazarı vardı. Biri Eminönü'ndeki balıkhanenin çevresinde, diğeri ise Beyoğlu'nda Galatasaray'ın hemen gerisindeydi. Eminönü'ndeki balıkhane 17 Kasım 1902'de büyük bir merasimle açılmış, 1957 yılında ise yıkılarak, yeri Eminönü meydanına dâhil edilmiştir. Balıkhanenin istimlâkini müteakip, bu faaliyetlerin aksatılmamasını teminen önce meyve ve sebze hali yanındaki eski bir binaya taşınan ve sonra belediyece yeniden inşa ve tanzim ettirilen hal, Azapkapı'daki mahalde 20.10.1964 tarihinden itibaren faaliyete geçmiştir. Bu balıkhane 3000 $m^2$'lik bir sahayı kapsamaktaydı ve balıkhane idaresine ait bürolar, balıkçı kooperatiflerine, balıkçılar cemiyetine, balık komisyoncularına ve balık esnafı derneğine ayrı ayrı yer tahsis edilmişti (Dozbay, 1970). Bugün İstanbul'un en ünlü balık pazarı Sultan Abdülaziz zamanında kurulan, İstiklal Caddesi Sahne Sokağında bulunan Beyoğlu balık pazarıdır. Kıdem ve önem olarak Köyişi Caddesi'ndeki Beşiktaş balık pazarı, Beyoğlu balık pazarının hemen ardından gelir. Ayrıca Kumkapı, İstinye ve Sarıyer'de kurulmuş önemli balık pazarları bulunur (Akçiçek 1998). Son olarak 29 Eylül 1983'te Kumkapı'ya taşınan büyük balık halinin yapımında deniz kısmen doldurularak daha geniş bir alan elde edilmiştir (Erdoğan-Sağlam vd., 2008).

İstanbul balık halinin Türkiye balık pazarındaki önemine karşın, hal üzerine yapılmış az sayıda araştırma bulunmaktadır. XX. yüzyılın başında Deveciyan (1926)'ın, Türkiye balıkları ve av araçlarını da tanıttığı, ayrıca balık hallerine giren balık miktarlarını karşılaştırdığı kapsamlı eser ilklerdendir. Türkmen (1953) ise İstanbul Balıkhanesi ve Av Vergileri Dairesi kayıtlarına göre 1928 yılından 1952 yılına kadar balıkhanede birinci derecede rol oynayan 13 balık cinsinin miktarlarını grafiklerle yayınlamıştır. Bunlara ilaveten, Dozbay (1970), İstanbul balık hallerinin faaliyet bölgelerini ve pazarlama yöntemlerini özetlemiştir. Baysal (1971) ise, balık hallerinin ekonomik ve yasal çalışma prensiplerini derlemiştir. Daha sonra uzun bir boşluk döneminin ardından, İstanbul

balık halinde 1996–1997 yıllarında pazarlanan balıklar üzerine bir çalışmaya rastlanmaktadır (Timur ve Doğan, 1999). Mol ve Sağlam (2004), Avrupa ve Türkiye'deki bazı önemli balık hallerinin fiziksel koşullarının yasalarla uyumunun karşılaştırmalı olarak yapıldığı bir çalışmada, İstanbul balık halini de incelemişlerdir. Erdoğan ve Düzgüneş (2006), İstanbul balık halinde önemli ekonomik balık türlerinin yıllara göre satış miktarlarını inceleyerek, Türkiye balıkçılığına katkısı, pazarda satış şekli ve pazarlama standartları ve halin teknik şartları açısından değerlendirmişlerdir. Özden ve Tosun (2006), Türkiye'deki toptan ve perakende satış yerlerinin değerlendirmesini yapmışlar; bu kapsamda İstanbul ve Rungis balık hallerinin bazı özelliklerini karşılaştırmış, "*Toptan ve Perakende Satış Yönetmeliği*"nde yer alan teknik ve hijyenik şartlar sıralanmış, balık hallerimizin bu şartlara uygun bir şekilde yönetiminin ve işletilmesinin sağlanması gerektiği üzerinde durmuşlardır. Erdoğan-Sağlam vd. (2008), on yıllık dönemde (1998 – 2007) İstanbul balık halinde işlem gören türler üzerine çalışmışlar, sonuçları hem İstanbul balık halinin eski dönem raporları hem de İzmir ve Çanakkale balık halleriyle karşılaştırmışlardır.

Bu çalışmada, Kumkapı'daki İstanbul balık halinin mevcut son durumunu ortaya koymak için 2007–2011 yılları arasındaki pazarlanan türlerin cins ve miktarlarının derlenmesiyle en çok işlem gören türlerin belirlenmesi, halin fiziksel şartlarının ve buna bağlı sorunlarının ortaya konması amaçlanmıştır.

## MATERYAL VE YÖNTEM

Bu çalışmanın verileri, 2007–2011 yılları arasında tüm aylık satış miktarlarının değerlendirilmesiyle ve halin fiziki koşullarının belirlenmesi için halde yapılan iki çalışmayla elde edilmiştir. Balık haline 2007–2011 yıllarında giren, avcılık ve yetiştiricilik yoluyla elde edilen türlerin listesi ve miktarları balık hali satış istatistiklerinin derlenmesiyle elde edilmiştir. Aynı zamanda, balık halinin fiziksel özellikleri ile günlük çalışma koşullarının ve sorunların belirlenmesi için hal müdürü, bazı hal çalışanları, komisyoncular ve balıkçılarla yüz yüze görüşmeler yapılmıştır.

## BULGULAR

### *Balık halinin personel, teknik ve sıhhî şartları*

Kıyıya bitişik olarak kurulan hal, yaklaşık 10.000 m$^2$ kapalı, 17.000 m$^2$ açık alana sahiptir. Kapalı alan içerisinde 4800 m$^2$ müzayede alanı olarak ayrılmıştır. Halin kıyısında uzunluğu 45 m olan üç adet kazıklı iskele ürün boşaltma amaçlı kullanılmaktadır. Oldukça geniş bir personelle hizmet veren halde, toplam 167 personel (Tablo 1), 69 müstahsil, 101 adet komisyoncu, 448 alıcı esnaf vardır. İstanbul balık halinin teknik özellikleri ise Tablo 2'de gösterilmiştir.

Balık depolamada, ahşap, plastik ve strafor kasalar kullanılmaktadır. Kırık buzlama ve komisyoncuların kendi bürolarında depoda soğutma yöntemleriyle soğuk zincirin korunması sağlanmaktadır. Balık boylama ve iç organ çıkartma yapılmamaktadır. Balıklar zeminle temas etmekte ve deniz suyuyla sulama yapılmaktadır. Mezat bittikten sonra genel temizlik yapılmakta ancak deterjan kullanılmamaktadır. Mezat sırasında avlanmasına izin verilen minimum boyun altında yakalanan ürünlere sıklıkla rastlanmıştır. Müdüriyet ile yapılan ankette fare ve haşere bulunmadığı, fare ve haşere kontrolünün Büyükşehir Belediyesi Çevre Koruma Müdürlüğü tarafından yaz aylarında yapıldığı ifade edilmiştir.

Balık halinde dezenfektan olarak etanol kullanılmaktadır. Hal bünyesinde personel giysileri yıkanmamakta, özel giysi sadece hal müdürlüğünde görevli güvenlik görevlileri ve komisyoncularla çalışmakta olan bazı personel için mevcuttur. Giysilerin temizliği çalışanların kendi inisiyatiflerindedir. Çöp kovaları için özel bir uygulama bulunmamakta, belediye tarafından sağlanan konteynırlar açık alanda bulunmaktadır.

Hal içerisinde alaturka ve alafranga tuvaletlerde her gün temizliğin yapıldığı, klor kullanımının olduğu ancak tuvalete giriş çıkışta her hangi bir önlemin alınmadığı ayakkabılar için bir antiseptik madde kullanımının olmadığı tespit edilmiştir.

**Tablo 1.** İstanbul balık halinde çalışan personel ve nitelikleri
**Table 1.** Personnels and their qualifications, laboring in Istanbul fish market

| BİRİM | ÜNVANI | ADET |
|---|---|---|
| MEMUR | Su Ürünleri Mühendisi | 10 |
| | Veteriner Hekim | 6 |
| | Memur | 17 |
| SÖZLEŞMELİ | Su Ürünleri Mühendisi | 6 |
| | Gıda Mühendisi | 1 |
| | Tekniker | 4 |
| | Teknisyen | 4 |
| | Memur | 2 |
| İŞÇİ | İşçi | 35 |
| ZABITA AMİRLİĞİ | Zabıta | 23 |
| GÜVENLİK | Güvenlik Personeli | 28 |
| TEMİZLİK | Temizlik Personeli | 26 |
| İŞTİRAK | Sağlık A.Ş. | 2 |
| DIŞ GÖREV | 2 Veteriner, 1 Memur | 3 |
| TOPLAM | | 167 |

**Tablo 2.** İstanbul balık halinin teknik özellikleri
**Table 2.** Technical characteristics of Istanbul fish market

| İSTANBUL | Var | Yok | Özellikleri |
|---|---|---|---|
| Kapalı alan | √ | | 10000 m$^2$ |
| Açık alan | √ | | 17000 m$^2$ |
| Soğutucu depo | √ | | 700 m$^2$ |
| Şoklama | √ | | |
| Buz makinesi | √ | | 1 |
| WC | √ | | 2 adet |
| Duş | √ | | |
| Bina Havalandırması | √ | | |
| İdari bürolar | √ | | 1350 m$^2$ |
| Büro (kabzımal) | √ | | 101 |
| Otopark | √ | | 50 araç |
| Elektronik mezat | | √ | |
| Perakende Satış Ünitesi | | √ | |
| Arıtma Ünitesi | | √ | |
| Sosyal alan | √ | | 1 kahvehane |
| Konferans Odası | √ | | 50 kişilik |
| Sağlık odası (ilkyardım) | √ | | |
| Tamirat Odası | √ | | |

| İSTANBUL | Var | Yok | Özellikleri |
|---|---|---|---|
| Laboratuar | √ | | |
| Lokanta | √ | | |
| Büfe | √ | | |
| Berber | √ | | 1 adet |
| Kanalizasyon | √ | | |
| Arabadan satış | √ | | |
| Zabıta | √ | | 23 adet |
| Güvenlik Birimi | √ | | 28 adet |
| Sağlık Görevlisi | √ | | |

Personel için genel bir sağlık kontrolü yapılmamaktadır. Balıkhanede hijyen denetlemesi balık halinde görevli su ürünleri mühendisleri ve veteriner hekim tarafından zaman zaman da Gıda, Tarım ve Hayvancılık İl Müdürlüğü kontrolörleri tarafından yapılmaktadır. Personele ilk yardım konularında eğitim verilmektedir. Bu kapsamda tüm çalışanların sağlıkları ile ilgilenebilecek bir sağlık merkezi vardır ve bünyesinde ecza dolabı bulunmaktadır. Balık halinde zaman zaman çeşitli iş kazaları meydana geldiği ifade edilmiştir.

***Balık halinde mezat ve pazarlanan türler***

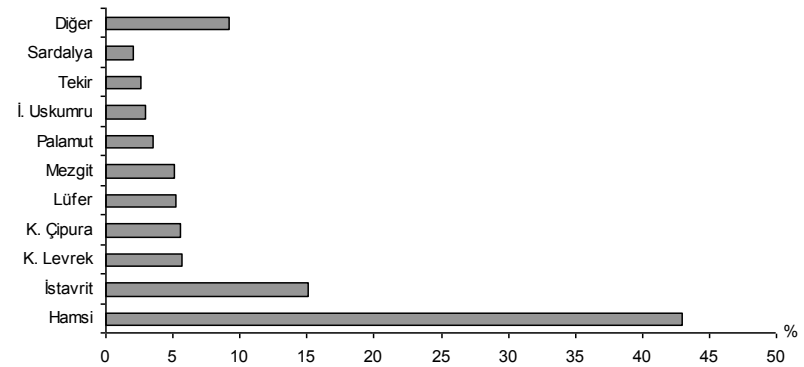
İstanbul balık halinde satışlar, açık arttırma usulüyle saat 04.00'te başlamaktadır. Etkili pazarlama öğle saatlerine dek azalarak sürmektedir. Balık hali 7 gün 24 saat faaliyet göstermektedir. Hale balık girişi balıkhane iskelesine yanaşan balıkçı tekneleri ve balıkhane içine kadar girebilen kamyonlardan el arabalarıyla yapılmaktadır. Günlük satış çizelgeleri istatistik birimine gönderilmekte ve balık halinin veri tabanına kaydedilmektedir. İstanbul balık halinde toplam 126 ürün çeşidi ve ortalama 90 tür su ürünü satıldığı tespit edilmiştir. Bu ürünler içerisinde deniz, iç su, donmuş, ithal ve kültür balıkları bulunmaktadır.

İstanbul balık halinde 2007 – 2011 yılları arasında en çok işlem gören ilk on türün satış miktarının toplam türler içerisindeki payı %91 olmuştur. En çok işlem gören türler sırasıyla hamsi (%43), istavrit (%15,1), kültür levrek (%5,7) ve çipura (%5,6), lüfer (%5,2), mezgit (%5,1), palamut (%3,5), ithal uskumru (%3), tekir (%2,6) ve sardalya (%2) olarak tespit edilmiştir (Şekil 1). 2006–2010 yılları arasındaki toptan balık fiyat ortalamalarına göre en yüksek fiyattan satış yapılan türler ıstakoz, jumbo karides, deniz levrek, sinarit, lüfer, böcek, kalkan şeklinde sıralanmıştır (Şekil 2). Balık hali istatistik birimi günlük balık fiyatlarını İstanbul Belediyesi 'Balık Hali' resmi internet adresinde yayınlamaktadır. Toplam satış bedellerinin %3'ü rüsum kesintisi olarak komisyonculara tahakkuk ettirilmektedir.

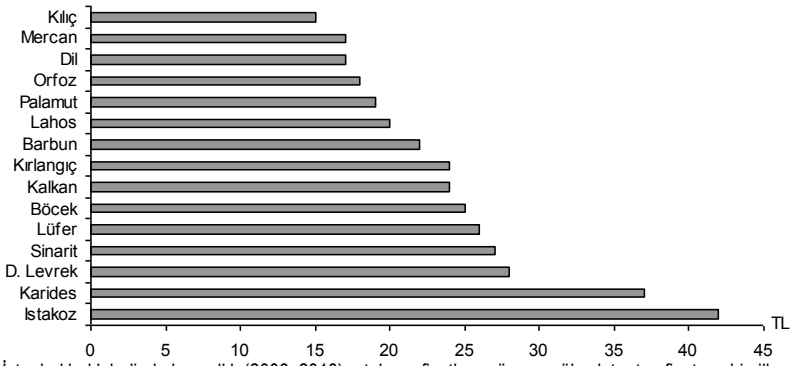
## TARTIŞMA VE SONUÇ

Türkiye'nin işlem hacmi bakımından en büyük su ürünleri hali olan İstanbul balık hali üzerine yapılan bu çalışmada, halin teknik, hijyenik durumu, personel çeşitliliği ile en çok satışı yapılan türler ve fiyatları üzerinde durulmuştur.

Halde 2007–2011 yılları arasında pazarlanan balık miktarının yıllık ortalaması yaklaşık kırk bin ton olup, en çok satışı yapılan türlerin hamsi (%43), istavrit (%15,1), kültür çipura ve levrek (11,3), lüfer (5,2), mezgit (%5,1), palamut (%3,5) şeklinde sıralandığı belirlenmiştir. Timur ve Doğan (1999), İstanbul balık halinde 1996–1997 yılları arasında 73 türün işlem gördüğünü ve her iki yıl için bin tonun üzerinde pazarlanan balıkları sırasıyla hamsi (%49 ve %56), istavrit (%17 ve %13), palamut (%10), mezgit (%10 ve %8), sardalya (%8 ve %10), lüfer (%6 ve %7) olarak rapor etmişlerdir. Erdoğan ve Düzgüneş (2006), 1998–2001 yılları arasında 86 türün pazarlandığını belirterek, halde pazarlanan ürünlerin toplam üretimdeki payının %4–6 arasında değiştiğini hesaplamışlardır.




**Şekil 1.** İstanbul balık halinde en çok işlem gören ilk on türün beş yıllık (2007–2011) ortalamalarına göre satış oranları
**Figure 1.** The sales ratio of the first ten species, the most traded according to five year averages (2007-2011)




**Şekil 2.** İstanbul balık halinde beş yıllık (2006–2010) ortalama fiyatlara göre en yüksek toptan fiyata sahip ilk on beş tür
**Figure 2.** The first fifteen species with the highest wholesale prices according to five year averages (2006-2010)

Erdoğan-Sağlam vd. (2008), İstanbul balık halinde 1998–2007 döneminde, 72 tür deniz, 7 tür tatlı su balığı ile 14 tür omurgasızdan oluşan en az 93 türün işlem gördüğünü; bunlar içerisinde sırasıyla hamsi (%43,5), istavrit (%17), palamut (%11,4), lüfer (%9), kültür çipura-levrek (%3,7) ve mezgit (%3,3)'in üst sıralarda satışı olduğunu tespit etmişlerdir. Burada son beş yıllık periyotta (2007–2011) ilk iki sıra benzer bulunmakla birlikte üç ve dördüncü sıraya kültür çipura-levrek balıklarının yerleştiği ve satış oranının toplamda %11,3'e ulaştığı görülmektedir. Bu durum, kültür balıklarına olan ilginin son yıllarda gittikçe arttığını göstermektedir. Buna ilaveten ithal uskumru'nun payı da %3'e kadar çıkmıştır ki, bunun nedeni İstanbul'un önemli nostaljilerinden biri olan kıyıda balık-ekmek faaliyetlerinde artan tercih sebebiyle olabilir. Balık halinde 2007 öncesi %9'larda olan lüferin payı ise azalarak günümüzde %5,2'ye gerilemiştir. Bu durum ise lüfer balığının av istatistiklerinde görülen azalmayla doğru orantılıdır.

Deveciyan (1926), İstanbul balık halinde 1909–1923 dönemi toplamında ilk sırayı midye-pina-akivades (%36)'in aldığını, onu sırasıyla palamut (%24), istiridye-tarak (%15), uskumru-çiroz (%10), hamsi-çaça (%3) ve istavrit-izmarit (%3) izlemiştir. Bu eski kayıtlarda satışların %50'sinden fazlasını çift kabuklu yumuşakçaların oluşturması dikkat çekicidir. Türkmen (1953), 1928–1952 periyodunda İstanbul balıkhanesinde satılan 13 balık cinsinin yirmi beş yıllık ortalamasına göre sırasıyla uskumru (%49,7), istavrit (%12,4), lüfer (%6,7), kefal (%6,3), kılıç (%6,1), sardalya (%4,8), kalkan (%4,3), izmarit-istrongilos (3,8), barbun-tekir (%3,2), gümüş (%0,8), levrek (%0,8) şeklinde vermiştir. Burada palamut ve torik sayısal ve çift olarak bildirilmiş olup, her ikisi toplanarak yıllık ortalaması 3.228.584 çift olarak hesaplanmıştır. Buradan anlaşılacağı üzere o yıllarda başat tür palamut ve sonrasında uskumru olduğu anlaşılmaktadır. Ancak balık halinde yerli uskumrunun günümüzde artık %0,2'lik paya sahip olması nedeniyle talebin artık ithalat yoluyla karşılanıyor olması ise üzücüdür.

Balık halinde, halen ahşap kasa kullanımı ve bazı hijyen kurallarının (antiseptik banyo, uygun kıyafet, çöp depolama, araçtan satış, vb.) tam olarak uygulanmaması gibi önemli sorunları devam etmektedir. İlgili mevzuatta (Anonim, 2002) "*satılacak ve sergilenecek su ürünleri için yeterli miktarda ve uygun nitelikte, plastik ve strafor muhafaza kapları kullanılmalıdır*" ifadesine rağmen, strafor ve plastik kasaların kullanımı yetersizdir ve çoğunlukla tahta kasa kullanılmakta, bu kasaların tekrar tekrar kullanımından dolayı kontaminasyon riski artmaktadır. Üçok (2003), İstanbul balık halinde tahta kasalardan yaptıkları örneklemelerde bakteri yükünün fazla olduğunu ve bu kasalarda ortalama 12 saat bekletilen su ürünlerinin halk sağlığı açısından risk teşkil ettiğini bildirmiştir.

Mol ve Sağlam (2004), İstanbul balık halinde ahşap kasa kullanımın ucuz malzeme olması nedeniyle halen kullanımda tercih edildiği, çalışanların soyunma odalarının hijyenik olmadığı, işçi sağlığının kontrol altında olmadığı, sıcaklık kontrol sistemi, hijyenik atık sistemi, böcek, kuş, vb. kontrolünün olmadığı gibi pek çok eksikliği ifade etmişlerdir. Bu çalışmada, atıkların halk sağlığını tehdit etmeyecek şekilde uzaklaştırıldığı ifade edilmesine karşın, çöplerin gelişigüzel atıldığı bazı noktalarda müzayede alanında balıklarla aynı ortamda olduğu görülmüştür.

Erkan (2010), İstanbul Balık Halinde ürünlerin taşınmasında tek kullanımlık strafor kutular ve tahta kasalarla yapıldığını tahta kasa kullanımının %30 civarında olduğunu tamamen strafor kasa kullanılmasının hedeflendiğini bildirmiştir. Ancak bu çalışmada tahta kasa kullanımının %50'den fazla olduğu, özellikle hale giriş yapan ürünlerin tamamına yakınının tahta kasalarla giriş yaptığı gözlenmiştir.

Sonuçta, 'Asgari Teknik ve Hijyenik Şartlar' uyarınca hem kontaminasyon hem de çapraz kontaminasyon olması nedeniyle ahşap kasaların kullanılmaması gerektiği ifade edilmesine rağmen, İstanbul ve diğer tüm balık hallerimizde balıklar çoğunlukla ahşap kasalarda muhafaza edilmekte ve satışa sunulmaktadır. Halde araç, kasa yıkama ve dezenfeksiyon alanları olmadığı; plastik kasa, kutu, palet ve tank kullanımının yetersiz olduğu tespit edilmiştir. Hijyenik bir depolama ve müzayede için yönetmeliğe uygunluğun etkin bir şekilde denetlenmesi ve insan sağlığını tehdit eden durumların önüne geçilmesi için caydırıcı cezalar belirlenmelidir. Toptan satış yeri içerisindeki insan gücüne dayanan ürün taşıma sistemleri yerini taşıma ekipmanlarına

bırakmalıdır. İzlenebilirliği sağlayıcı tartım, etiket, barkot sistemlerinin kurulması gerekmektedir.

Su ürünleri yaşadığı ortam, avlandığı araç, karaya çıkarma, balık haline ve satış noktasına nakliyat sırasında birçok dış etmen dolayısıyla mikrobiyolojik bulaşmaya maruz kalabilmektedir. Bu nedenle bulaşmanın nerede gerçekleştiğinin ortaya konulabilmesi için her aşamada ve muhtemel risklere karşı kontrol edilmesi gereklidir. Tüm bu kontaminasyonları belirlemeye yönelik gelişmiş bir mikrobiyoloji laboratuarının kurulumu ve ilgili personelinin balık halinde istihdamı mutlaka gerçekleştirilmelidir.

Gürpınar'a taşınması söz konusu olan halin kurulumunda standartlara uygun, hijyenin ön planda tutulduğu, ahşap kasa kullanımının terk edildiği, tüm kapalı alanın seramikle kaplı olduğu, atık suyun sağlıklı toplanarak arıtıldığı, satışın yerlerde değil krom tezgâhlarda yapıldığı, elektronik mezat ve barkot sisteminin uygulandığı, tek tip iş elbiseli personelin çalıştığı, iş güvenliğinin ön plana çıktığı, mikrobiyojik analiz laboratuarına sahip, yeterli soğuk depolarıyla, paketleme üniteleriyle, sosyal alanlarıyla ve (mümkünse) müzesiyle düşünülmüş örnek bir hal binası olarak tasarlanmalıdır.

Bu çalışmayla İstanbul balık halinin önceki çalışmalar da dâhil edildiğinde, geçmişteki ve 1996 yılından başlayarak 2011 yılına kadar kesintisiz son 15 yıllık sürecinin bir tartışması yapılmıştır. Kuşkusuz bundan sonraki yıllarda da bu izleme çalışmaları, aynı zamanda balıkçılığın bir yansıması olarak hal kayıtlarının değerlendirilmesi ile pazarlama/tüketim tercih eğilimlerinin belirlenmesi bakımından önemli olmaya devam edecektir.

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**RESEARCH ARTICLE** **ARAŞTIRMA MAKALESİ**

# Otolith morphometry and population parameters of red porgy, *Pagrus pagrus* (Linnaeus, 1758) in Saros Bay (North Aegean Sea)

## Saroz Körfezi'nde fangri [*Pagrus pagrus* (Linnaeus, 1758)] 'nin otolit morfometrisi ve populasyon parametreleri

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**Özet:** Bu çalışmada, Kuzey Ege Denizi'nde (Saroz Körfezi) Fangri balığının toplam boy (TL) ile toplam ağırlık (TW) arasındaki ilişki, yaş, büyüme ve otolit boyu (OL) - otolit ağırlığı (OW), balık boyu (TL) - otolit boyu (OL), balık ağırlığı (TW) - otolit boyu (OL), otolit boyu (OL) - otolit genişliği (OWi) arasındaki morfometrik ilişkiler incelenmiştir. Toplam 100 adet balık üzerinde yapılan ölçümlerde minimum boy 9,6 cm, maksimum boy 44,4 cm; minimum ağırlık 17,1 g, maksimum ağırlık 1372,5 g olarak tespit edilmiştir. Otolit ağırlığı minimum 0,0181 g, maksimum 0,1456 g; otolit boyu minimum 0,52 cm, maksimum 1,17 cm olarak ölçülmüştür. Boy-ağırlık ilişkisi $TW=0,021*TL^{2,885}$ ($r^2$=0,98), otolit boyu - otolit ağırlığı $OW=0,105*OL^{2,609}$ ($r^2$=0,92), toplam boy - otolit boyu $OL=0,024*TL+0,249$ ($r^2$=0,83) otolit boyu - toplam ağırlık $OL=0,235*TW^{0,237}$ ($r^2$=0,81) otolit boyu - otolit genişliği $OWi=0.501*OL+0.116$ ($r^2$=0.832) ilişkileri tespit edilmiştir. En büyük yaş 9 olarak belirlenmiş, von Bertalanffy büyüme parametreleri $L_\infty$=51,59 cm, K=0,12 yıl$^{-1}$ve $t_0$= -1,13 yıl olarak hesaplanmıştır.

***Anahtar kelimeler*:** *Pagrus pagrus,* yaş, büyüme, otolit, boy-ağırlık ilişkisi

**Abstract:** In this study, total length (TL) – total weight (TW) relationship, age, growth, and the morphometric relationships of otolith between otolith length (OL) and otolith weight (OW), total length (TL) and otolith length (OL), total weight (TW) and otolith length (OL), otolith width (OWi) and otolith length (OL) of *Pagrus pagrus* were investigated in Saros Bay (North Aegean Sea). A total of 100 specimens were measured as minimum TL 9.6 cm, maximum TL 44.4 cm, and minimum TW 17.1 g and maximum TW 1372.5 g. A total of 55 otoliths were measured as minimum OL 0.52 cm, maximum OL 1.17 cm, minimum OW 0.0181 g, and maximum OW 0.1456 g. The relationships between TL and TW, OL and OW, TL and OL, OL and TW, OL and OWi were determined as $TW=0.021*TL^{2.885}$ ($r^2$=0.98), $OW=0.105*OL^{2.609}$ ($r^2$=0.929), $OL=0.024*TL+0.249$ ($r^2$=0.839), $TW=0.235*OL^{0.237}$ ($r^2$=0.814), and $OWi=0.501*OL+0.116$ ($r^2$=0.832), respectively. Maximum age was 9 years for *P. pagrus* and von Bertalanffy growth parameters were estimated as $L_\infty$=51.59 cm, K=0.12 year$^{-1}$ and $t_0$=-1.13 year.

***Keywords*:** *Pagrus pagrus*, age growth, otoliths, length-weight relationship

## INTRODUCTION

The red porgy is sublittoral (at dephts ranging from 18 – 185 m) demersal species that commonly found over rock or sandy and hard bottom (young frequently found on seagrass beds and the continental shelf) and a variety of temperate to subtropical habitats in the Atlantic and Mediterranean Sea (Manooch and Hassler, 1978; Vaughan *et al.* 1992, Labropoulou *et al.* 1999). *Pagrus pagrus* commonly feeds on crustaceans, fishes, and mollusca. This species is widely distributed in the Atlantic Ocean including Strait of Gibraltar, Medarie and Canary islands, Mediterranean and northward to the British Isles and northern Gulf of Mexico to Argentina (Froese and Pauly, 2012).

In the Mediterranean *Pagrus pagrus* is frequently caught by bottom trawls and long lines. Total landings of *Pagrus pagrus* was reported as 1221 tonnes in 2010 in the Mediterranean (Turkey and Greece) (FAO, 2012). Red Porgy is an endangered species in Red List (IUCN, 2012). However its importance and commercial value, the life history and distribution of *P. pagrus* poorly known in Aegean Sea but it is mentioned in numerous papers about it around the Atlantic, that have reported on population structure (Afonso *et al*. 2008; Vaughan *et al*. 1992; Ball *et al*. 2007), and the other studies about on habitat selection (Labropoulou *et al*. 1999), lenght weight relationship of *P.pagrus* (Dulcic and Kraljevic, 1996; Gonçalves *et al*. 1997; Moutopoulos and Stergiou 2002; Santos *et al*. 2002; Morey *et al*. 2003; Rosa *et al*. 2006). In addition, age, growth, life history and otolith morphometry of *Pagrus pagrus* were examined in the Atlantic and Mediterranean (Potts and Manooch, 2002; Harris and McGovern, 1997; Manooch and Huntsman, 1977; Pajuelo and Lorenzo, 1996; Hood and Johnson, 2000; Machias *et al.* 1998).

There are a few studies about this species in the Aegean Sea that refer to aspects of lenght-weight relationships and otolith characters (Moutopoulos and Stergiou, 2002; Ozaydın *et al*. 2007, Kınacigil *et al*. 2000). In addition, biology, age, growth parameters and otolith morphometry of *P. pagrus* is unknown in the Turkish Aegean Sea.

The main purpose of this study was to estimation of growth parameters, lenght weight relationship and otolith morphometry of red porgy in Saros Bay. Consequently, this study is important of the fisheries assesment of *P. pagrus* in the study area.

## MATERIALS AND METHOD

A total of 100 *P. pagrus* were collected between October 2006 to July 2008 from monthly samplings at depths ranging from 0 to 500 m (0-50, 50-100, 100-200, 200-500 m depth contour) in Saros Bay, Aegean Sea, using a commercial bottom trawl net (Figure 1). The bottom trawl net with a 44 mm stretched mesh size at the cod-end was towed for 30 min at approximately 2.5 knots h-1.

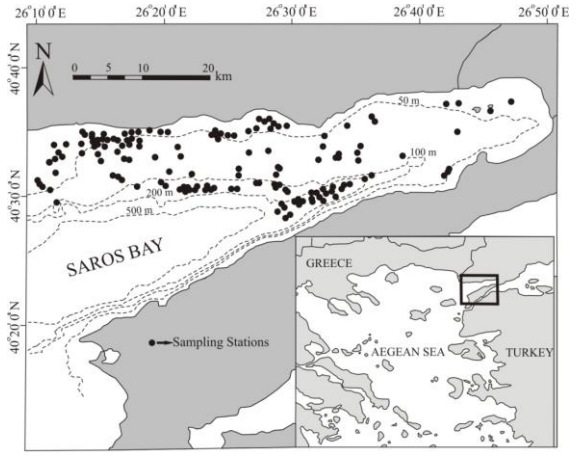



**Figure 1.** Trawl sampling stations in Saros Bay, the North Aegean Sea.

Total lengths (TL) and total weight (TW) were determined to the nearest 1 mm and 0,01g respectively. The length-weight relationships were determined according to the allometric equation (Sparre et al., 1989): $W = aL^b$, where W is the total body weight (g), L is the total length (cm) while *a* and *b* are constants.

The age was determined using the otoliths. Sagittal otoliths from each fish were removed, cleaned and stored in small, labelled plastic tubes. Size of the otoliths was measured by stereomicroscope with camera sensitive to 0.01 mm (Figure 2) and weighed with the precision of 0.0001 g by balance. Annual rings on the whole otolith were counted in glycerin under a stereomicroscope. Estimation of age was based almost exclusively on interpretation of otolith structures for the presence of hyaline and opaque zones which are assumed to represent winter and summer growth periods.

Growth parameters were determined using von Bertalanffy equation (Beverton and Holt, 1957): $L_t = L_\infty (1\text{-}e^{-K(t-t_0)})$, where $L_\infty$ is the asymptotic total length, $L_t$ the total length at age t, K the growth curvature parameter and $t_0$ is the theoretical age when fish would have been at zero total length. Growth parameters were estimated according to the non-linear method by using the FISAT program package (Sparre *et al.*, 1989). For the sake of comparison, the index of overall growth performance φ', proposed by Pauly and Munro (1984). This test provided an indication of the reliability of age estimates since it had been suggested that phi-prime test values were similar for the same species and genera. The test was based on $\varphi' = \log K + 2*\log L_\infty$ (Pineiro and Sainza, 2003).

## RESULTS

The length and weight of the *P. pagrus* ranged from 9.6 cm to 44.0 cm in total length (TL) and from 17.1 g to 1372.5 g in weight, respectively. Most of the fishes were between 15 and 20 cm TL, accounting for 62%. Otolith length, weight and width measurements are given in Table 1.

**Table 1.** Length- weight and otoliths measurements of *P. pagrus* in Saros Bay

| | N | Min. (cm) | Max (cm) | Mean (cm) |
|---|---|---|---|---|
| **Fish length** | 100 | 9.6 | 44.4 | 18.23±0.53 |
| **Fish weight** | 100 | 17.1 | 1372.5 | 121.0±17.0 |
| **Otolith length** | 55 | 0.52 | 1.17 | 0.70±0.01 |
| **Otolith weight** | 55 | 0.0181 | 0.1456 | 0.0533±0.005 |
| **Otolith width** | 55 | 0.34 | 0.68 | 0.47±0.01 |

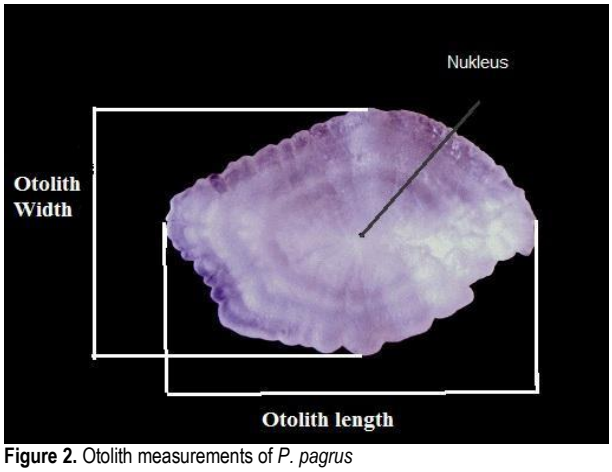



**Figure 2.** Otolith measurements of *P. pagrus*

Length-weight relationships were estimated of $TW=0.021*TL^{2.885}$, $r^2=0.985$, n=100 (Figure 3). Value of the exponent *b* was 2.885 ($r^2=0.984$) which indicated a negative allomethric growth. Otolith length - otolith weight, total length - otolith length, otolith length - total weight, otolith length - otolith width relationships were found $OW=0.105*OL^{2.609}$ ($r^2=0.929$), $OL=0.024*TL+0.249$ ($r^2=0.839$), $TW=0.235*OL^{0.237}$ ($r^2=0.814$), $OWi=0.501*OL+0.116$ ($r^2=0.832$) on the total of 55 specimens, respectively (Figure 4).

The age was determined by counting the annual ring marks on the surface of the otoliths in 55 specimens. The von Bertalanffy population growth parameters for *P. pagrus* were estimated as $L_\infty$=51.59 cm, K=0.12 year$^{-1}$ and $t_0$=-1.13 year (Figure 5).

The maximum age of fish calculated was 9 years. The age group 2 (60 %) were dominant and it was followed by age groups 3 (25 %) and age group 1, 4 and 9 have two specimen (Table 2).

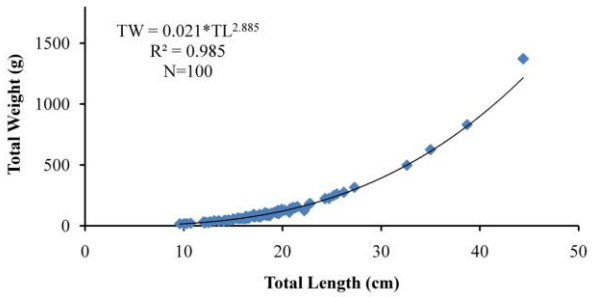
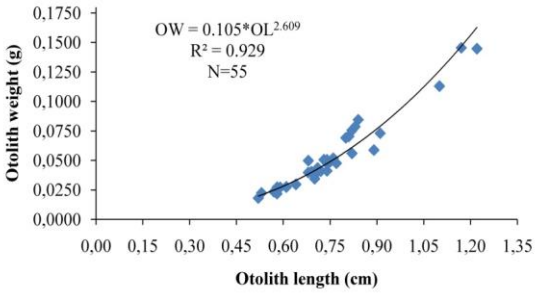
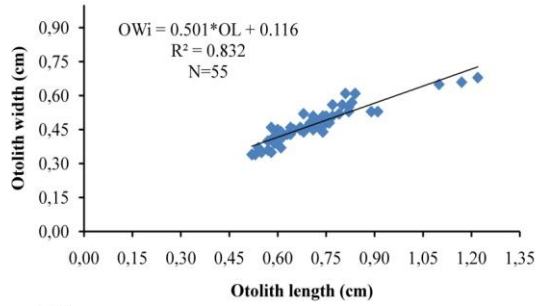
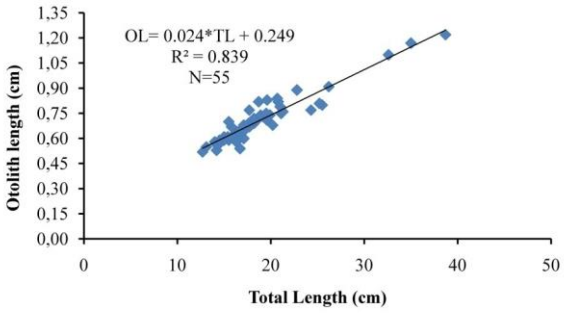



**Figure 3.** Length-weight relationships of *P. pagrus*



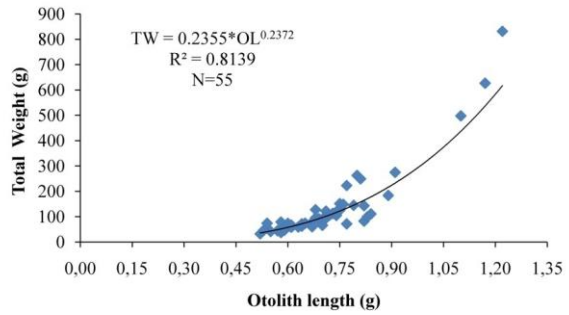




**Figure 4.** OL-OW (a), OL-OWi (b), TL-OL (c), OL-TW (d) relationships of *P. pagrus.*

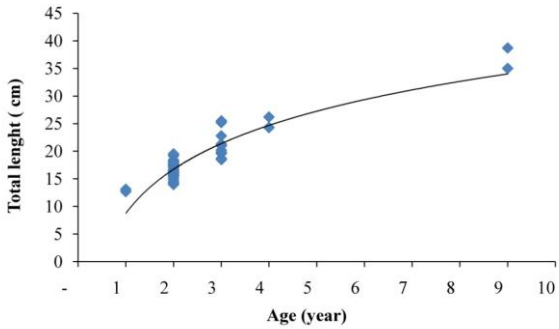



**Figure 5.** The von Bertalanffy growth curve of *P. pagrus*

**Table 2.** The mean lengths by ages of *P. pagrus*

| Age | N | Length (cm) | Mean Length(cm) |
|---|---|---|---|
| **1** | 2 | 12.7-13.1 | 12.9 |
| **2** | 35 | 14.0-18.4 | 16.4 |
| **3** | 14 | 18.5-25.5 | 20.7 |
| **4** | 2 | 24.3-26.2 | 25.2 |
| **5** | - | - | - |
| **6** | - | - | - |
| **7** | - | - | - |
| **8** | | | |
| **9** | 2 | 35-38.7 | 36.8 |

## DISCUSSION

The red porgy is rather long-lived and shows a slow, steady rate of growth, reflecting not only its genetic capabilities but also the type of environment in which it occurs. *P. pagrus*, which are relatively sedentary and live in a stable environment, therefore are able to expend more energy on growth than species which migrate extensively and must compensate for physiological stresses produced by salinity and temperature changes or seasonal availability of food. In order to compare the growth of the red porgy population with others, all available literature data of von Bertalanffy growth parameters and φ values, including results from the present study are reported in Table 3.

In this paper, theoretical growth as described by the von Bertalanffy equation predicts an asymptotic length of 51.59 cm and a growth coefficient, K, of 0.12 $y^{-1}$. Φ-test indicated that there was not significant differences between other studies ($t_s < t_t$).

Previous studies providing length-weight relationships for P. pagrus are given in Table 4 for comparative purposes. The length ranges covered for red porgy should be considered when using parameters of weight-length relationships, as to some extent the smallest specimens may change the parameters. The differences between b values are due to one or more factors: the season and effects of areas of origin, sex, and the food availability. Differences in the sampling design may also affect the relationships, as the numbers of specimens and length ranges of the species were distinct among localities (Tesch, 1971; Sparre *et al.* 1989; Moutopoulos and Stergiou, 2002).

**Table 3.** Parameters of von Bertalanffy growth equation (K, $L_\infty$, $t_0$) obtained by different authors

| Author | $L_\infty$ | K | $t_o$ | φ | Region |
|---|---|---|---|---|---|
| Manooch *et al.* (1977) | 76.3 | 0.1 | -1.88 | 2.75 | North and South Carolina |
| Nelson (1988) | 55.4 | 0.28 | 0.06 | 2.93 | Western Gulf of Mexico |
| Haimovici (1991) | 44.6 | 0.24 | -0.55 | 2.67 | Southeastern region |
| Vassilopoulou and Papaconstantinou (1992) | 45.1 | 0.24 | - | | Greece |
| Serafim and Krug (1995) | 118 | 0.07 | -1.20 | 2.96 | Azores Island |
| Avila-da-silva (1996) | 54.6 | 0.20 | -0.24 | 2.77 | Sao Paulo |
| Pajuelo and Lorenzo (1996) | 59.6 | 0.17 | -0.74 | 2.77 | Canary ısland |
| Harris and McGovern (1997) | 35.6 | 0.28 | - | 2.55 | Cape Fear, NC to Cape Canaveral |
| Cotrina and Raimondo (1997) | 47.3 | 0.15 | -2.89 | 2.53 | Buenos Aires |
| Costa *et al.* (1997) | 52.9 | 0.11 | -2.78 | 2.48 | Cabo Frio, Rio de Janeiro |
| Machias *et al.* (1998) | 43.9 | 0.30 | -0.54 | 2.77 | Greece |
| Hood and Johnson (2000) | 45.9 | 0.11 | -6.6 | 2.37 | Eastern Gulf of Mexico |
| Potts and Manooch (2002) | 64.5 | 0.15 | -0.76 | 2.80 | North Carolina to Southeast Florida |
| This study | 51.6 | 0.12 | -1.13 | 2.52 | Saros Bay |

**Table 4.** Total length – total weigth relationships of *P. pagrus* obtained by different authors.

| Author | N | a | b | $R^2$ | Region |
|---|---|---|---|---|---|
| Vassilopoulou and Papaconstantinou (1992) | 1142 | 0.02796 | 3.105 | 0.98 | Crete |
| Vassilopoulou and Papaconstantinou (1992) | - | 0.02796 | 2.993 | 0.98 | Kastelloriza Island |
| Dulcic and Kraljevic (1996) | 15 | 0.0000053 | 3.343 | 0.98 | Adriatic |
| Pajuelo and Lorenzo (1996) | 758 | 0.0133 | 3.030 | 0.98 | Canary Island |
| Gonçalves *et al.* (1997) | 23 | 0.000035 | 2.860 | 0.98 | Portugal |
| Moutopoulos and Stergiou (2002) | 35 | 0.0152 | 3.005 | 0.98 | Kyklades |
| Moutopoulos and Stergiou (2002) | - | 0.0152 | 3.005 | 0.98 | Aegean Sea |
| Santos *et al.* (2002) | 75 | 0.025 | 2.855 | 0.99 | Portugal |
| Morey *et al.* (2003) | 127 | 0.282 | 2.803 | 0.95 | Mediterranean |
| Rosa *et al.* (2006) | 884 | 0.0388 | 2.850 | 0.99 | Portugal |
| Ozaydın *et al.* (2007) | 60 | 0.0605 | 2.570 | 0.96 | Mediterranean |
| This study | 100 | 0.028 | 2.885 | 0.98 | Saros Bay |

The description of otolith morphometry provided in this study for *P. pagrus* is given for the first time in this study area. The results suggest that the relationships between OL-OW and OL-OWi are interspecific characteristics that could be related the structure of the species. Therefore, their incorporation in the description of sagitta otolith is suggested. The results of the study indicated that the age composition of *P. pagrus* ranged between 1 to 9 years. The oldest age class reported in the literature was 18 and 17 years old (Potts and Monooch III, 2002; Jarzhombek, 2007).

Consequently, studies on the fish morphometry, age and growth of this species are generally insufficient, but in considering the Aegean Sea, studies are particularly rare. Thus the biological characteristics of *P. pagrus* in the North Aegean Sea given in this study provide some basic fundamental knowledge related to the species and may aid in future studies.

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KISA ARAŞTIRMA SHORT COMMUNICATION

# İç Anadolu Bölgesi'ndeki bazı baraj göllerinde (Kütahya-Eskişehir/Türkiye) zooplankton türleri üzerine bir ön araştırma

## A preliminary investigation on zooplankton species in some of the dam lakes in Central Anatolia (Kütahya-Eskişehir/Turkey)

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**Abstract**: Seasonal fluctuations in the zooplankton species of Enne (Kütahya), Kayaboğazı (Kütahya) and Porsuk (Eskişehir) Dam Lakes were investigated between Spring 2007 and Winter 2007. In total, 27 species were determined, including 21 Rotifera, 4 Cladocera and 2 Copepoda. All taxa were first records for the Enne, Kayaboğazı and Porsuk Dam Lakes.

***Keywords*:** Zooplankton, Dam, Porsuk, Enne, Kayaboğazı, Turkey

**Özet:** Enne (Kütahya), Kayaboğazı (Kütahya) ve Porsuk (Eskişehir) Baraj Gölleri'nin zooplankton türlerindeki mevsimsel değişimler 2007 İlkbahar ve 2007 Sonbahar arasında incelendi. 21 tür Rotifera, 4 tür Cladocera ve 2 tür Copepoda olmak üzere toplam 27 tür tespit edildi. Tespit edilen türlerin tamamı Enne, Kayaboğazı ve Porsuk Baraj Gölleri'nden ilk kez bildirilmektedir.

***Anahtar kelimeler*:** Zooplankton, Baraj, Porsuk, Enne, Kayaboğazı, Türkiye

## GİRİŞ

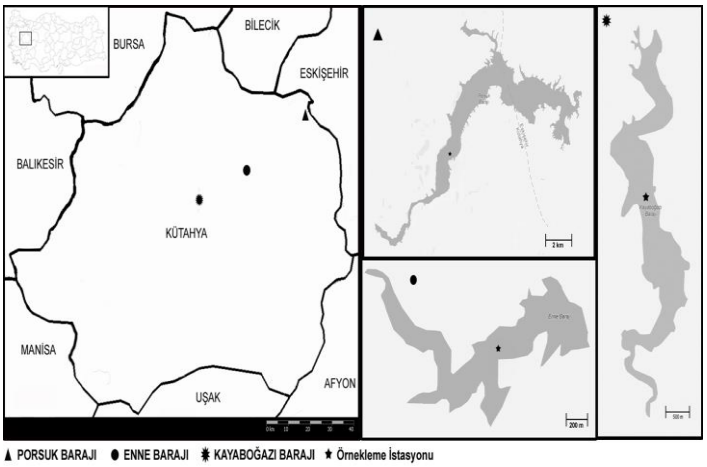
Zooplankton akuatik ekosistemin çeşitli önemli fonksiyonlarını yerine getiren ayrılamaz bir parçasıdır. Zooplankton ilk önce mikroorganizmalar ve fitoplanktonla beslenir ve suyu temizleme özelliğine sahiptir. Aynı zamanda zooplankton balık larvaları ve bazı olgun balık türleri için besin kaynağıdır. Buna ilave olarak zooplanktonun bioması, yoğunluğu ve tür çeşitliliği akuatik ekosistemdeki balık üretimini belirlemektedir (Pliûraité, 2003).

Enne barajı; 1969-1972 yılları arasında içme suyu temini amacı ile inşa edilmiş olup Kütahya ilinin batısında şehir merkezine 18 km uzaklıktadır. Enne barajı Porsuk Çayının bir kolu olan Felent Çayı üzerinde kurulmuştur. Seyit Ömer Termik Santrali'nin su ihtiyacını karşılamaktadır. Baraj Gölü havzası, Yoncalı köyü içinde bulunan termal kaplıcalar ve çevreden gelen küçük derelerin suları ile beslenir. Kurak geçen yaz ayları sonunda Kayaboğazı barajından su pompalanarak takviye yapılmaktadır. Enne baraj gölü alanı 0.94 $km^2$ olup, yılda 6 $hm^3$ içme-kullanma suyu sağlanmaktadır (Köse ve Uysal, 2008).

Kayaboğazı barajı; Kütahya'da Kocaçay üzerinde sulama ve taşkın kontrolü amacıyla yapılan bir barajdır. Kayaboğazı baraj gölü alanı 3 $km^2$ olup, baraj 7080 hektarlık bir alana sulama hizmeti vermektedir (Anonim, 2013). Porsuk barajı; Eskişehir'de Porsuk çayı üzerinde, sulama taşkın kontrolü ve içme suyu temini amacı ile inşa edilmiş bir barajdır. Murat dağı'nın kuzeydoğusundan çıkan kaynakların, Altıntaş ilçesinin kuzeyinde birleşmesi ile oluşur. Kütahya ovasının kuzeydoğusundan geçerken Felent çayı ile birleşir. Porsuk baraj gölü alanı 27.70 $km^2$ olup, 26970 hektarlık bir alana sulama hizmeti vermekte, yılda 206 $hm^3$ içme ve kullanma suyu sağlamaktadır (Anonim, 2013).

Türkiye de Baraj Gölleri'nden, Demirköprü Barajı'nda (Demirhindi, 1990; Ustaoğlu vd., 2001), Kunduzlar ve Çatören Barajları'nda (Altındağ ve Özkurt, 1998), Göksu Barajı'nda (Bekleyen, 2003), Doğu Akdeniz Bölgesinin bazı Barajları'nda (Bozkurt, 2004), Hirfanlı Barajı'nda (Yiğit ve Altındağ, 2005), Gelingüllü Barajı'nda (Kaya ve Altındağ, 2007), Birecik Barajı'nda (Bozkurt ve Sagat, 2008), Kepektaş Barajı'nda (Saler, 2009), Tahtalı Barajı'nda (Özdemir Mis vd., 2009), Zernek Barajı'nda (Yıldız, 2012) zooplankton konusunda çalışmalar gerçekleştirilmiştir.

Kayaboğazı, Enne ve Porsuk Baraj Gölleri'nde zooplanktonla ilgili çalışmaya rastlanmamıştır. Enne, Kayaboğazı, Porsuk Baraj Gölleri'nin zooplankton faunasının ortaya çıkarılabilmesi amacıyla yapılan bu çalışma, gelecekte bu baraj göllerinde yapılacak çalışmalara veri oluşturacaktır.




**Şekil 1.** Çalışma sahaları
**Figure 1.** Study areas

## MATERYAL VE YÖNTEM

Enne, Kayaboğazı ve Porsuk Barajı'ndan ilkbahar, yaz ve sonbahar mevsimlerinde toplam 9 örnek alınmıştır. Her bir barajdan tek bir istasyondan örnekleme gerçekleştirilmiştir (Şekil 1). Kış mevsiminde hava şartlarından dolayı zooplankton örnekleri alınamamıştır. Zooplankton örnekleri 25 cm çapında, 55 µm göz açıklığında Hydro-bios marka plankton kepçesi ile 10 dakika süreyle çekilerek toplanmış ve örnekler % 4'lük formolde tespit edilmiştir.

Tespit edilen örneklerin sistematik tür teşhisleri binoküler invert ve ışık mikroskobunda Dussart (1969), Ruttner-Kolisko (1974), Koste (1978), Negrea (1983), Korovchinsky (1992), Segers (1995), Einsle (1996), Nogrady ve Segers (2002), Ustaoğlu (2004) yararlanılarak yapılmıştır. Bazı fiziko-kimyasal parametrelerden çözünmüş oksijen ve çözünmüş oksijen doygunluğu YSI 55 model oksijenmetre ile, pH, kondüktivite ve sıcaklık YSI 63 model multimetre ile arazide ölçülmüştür.

**Tablo 1.** Enne, Porsuk ve Kayaboğazı Baraj Gölleri'ndeki mevsimsel zooplankton kompozisyonu (**PB**: Porsuk Barajı, **KB**: Kayaboğazı Barajı, **EB**: Enne Barajı)
**Table 1.** Seasonal composition of zooplankton in Enne, Porsuk and Kayaboğazı Dam Lakes (**PB**: Porsuk Dam,**KB**: Kayaboğazı Dam,**EB**: Enne Dam)

| | 02.05.2007 | | | 29.08.2007 | | | 22.11.2007 | | |
|---|---|---|---|---|---|---|---|---|---|
| | **PB** | **KB** | **EB** | **PB** | **KB** | **EB** | **PB** | **KB** | **EB** |
| **ROTIFERA** | | | | | | | | | |
| *Rotaria neptunia* (Ehrenberg, 1830) | + | - | - | - | - | - | - | - | - |
| *Brachionus angularis* Gosse, 1851 | - | - | + | - | - | + | - | - | + |
| *Brachionus calyciflorus* Pallas, 1766 | - | - | + | + | - | + | - | - | - |
| *Brachionus urceolaris* Müller, 1773 | - | - | + | - | - | - | - | - | - |
| *Keratella cochlearis* (Gosse, 1851) | + | + | + | - | - | + | + | + | + |
| *Keratella tecta* (Gosse, 1851) | - | - | + | + | + | + | + | + | - |
| *Keratella quadrata* (Müller, 1786) | + | - | - | - | - | - | + | - | - |
| *Notholca acuminata* (Ehrenberg, 1832) | - | + | + | - | - | - | - | - | - |
| *Notholca squamula* (Müller, 1786) | - | + | - | - | - | - | - | - | - |
| *Euchlanis dilatata* Ehrenberg, 1832 | + | + | + | - | - | - | - | - | - |
| *Lecane bulla* (Gosse, 1886) | - | - | - | - | - | + | - | - | - |
| *Lecane clostrocerca* (Schmarda, 1859) | - | - | - | - | - | + | - | - | - |
| *Trichocerca similis* (Wierzeski, 1893) | - | - | - | - | - | + | - | - | + |
| *Trichocerca bicristata* (Gosse, 1887) | - | - | - | - | - | + | - | - | - |
| *Synchaeta pectinata* Ehrenberg, 1832 | - | - | + | - | - | + | - | - | + |
| *Polyarthra dolichoptera* Idelson, 1925 | - | + | + | - | - | + | + | - | + |
| *Polyarthra vulgaris* Carlin, 1943 | - | - | | + | - | - | + | - | - |
| *Asplanchna priodonta* Gosse, 1850 | - | + | + | - | - | - | - | - | + |
| *Asplanchna sieboldi* (Leydig, 1854) | - | - | - | - | - | - | + | - | - |
| *Pompholyx sulcata* Hudson, 1885 | - | + | - | + | + | - | + | - | + |
| *Filinia longiseta* (Ehrenberg, 1834) | - | + | + | - | - | - | - | - | + |
| **CLADOCERA** | | | | | | | | | |
| *Diaphanosoma mongolianum* Ueno, 1938 | - | - | - | - | - | - | + | + | - |
| *Daphnia galeata* Sars, 1864 | + | + | + | - | - | - | + | - | - |
| *Bosmina longirostris* (O.F.Müller, 1785) | + | + | - | + | + | + | + | + | + |
| *Chydorus sphaericus* (O.F.Müller, 1776) | + | - | - | - | - | - | + | + | - |
| **COPEPODA** | | | | | | | | | |
| *Cyclops strenuus* Fischer, 1851 | + | + | - | + | - | - | + | + | - |
| *Cyclops vicinus* Uljanin, 1875 | - | - | + | - | - | - | - | - | + |

**Tablo 2.** Enne, Porsuk ve Kayaboğazı Baraj Gölleri'nde bazı su kalitesi parametreleri
**Table 2.** Some parameters of water quality in Enne, Porsuk and Kayaboğazı Dam Lakes

| Baraj Gölleri | Tarih | Sıcaklık (°C) | pH | $O_2$ (mg/L ) | % OS | İletkenlik (µS, 20ºC) | Derinlik (m) | Seki disk derinliği (cm) |
|---|---|---|---|---|---|---|---|---|
| Enne | 03.05.2007 | 13.6 | 8.39 | 11.94 | 129.3 | 518 | 5.50 | 30 |
| | 28.08.2007 | 23.2 | 8.82 | 9.40 | 121.8 | 448 | 6.90 | 110 |
| | 20.11.2007 | 10.2 | 8.10 | 6.44 | 63.7 | 506 | 10.00 | 110 |
| Kayaboğazı | 02.05.2007 | 13.3 | 8.24 | 10.65 | 113.6 | 448 | 6.20 | 200 |
| | 30.08.2007 | 22.5 | 8.60 | 9.75 | 128.7 | 338 | 8.50 | 90 |
| | 22.11.2007 | 8.5 | 8.40 | 8.77 | 82.5 | 422 | 10.00 | 100 |
| Porsuk | 04.05.2007 | 12.8 | 8.44 | 9.40 | 98.1 | 603 | 4.70 | 200 |
| | 29.08.2007 | 23.1 | 9.70 | 7.98 | 102.6 | 526 | 10.00 | 70 |
| | 21.11.2007 | 8.6 | 8.65 | 7.60 | 73.1 | 601 | 8.50 | 130 |

## BULGULAR

Çalışma sonucunda toplam 27 zooplankton türü belirlenmiştir. Tür zenginliği açısından en zengin baraj Enne Barajı olup (19 tür), bunu sırası ile Porsuk Barajı (15 tür) ve Kayaboğazı Barajı (14 tür) izlemektedir (Tablo 1). Su kalitesi parametrelerinden pH 9.70 ile yaz mevsiminde Porsuk Barajı'nda maksimum, pH 8.10 ile sonbahar mevsiminde Enne Barajı'nda minimum tespit edilmiştir (Tablo 2). Rotifera, Cladocera ve Copepoda'ya ait türlerin mevsimsel dağılımı Tablo 1'de, bazı su kalitesi parametreleri Tablo 2' de gösterilmiştir.

## TARTIŞMA VE SONUÇ

Porsuk Baraj Gölü'nde Rotifera % 66.7, Cladocera % 26.7, Copepoda % 6.6 oranında; Enne Baraj Gölü'nde Rotifera % 84.2, Cladocera % 10.6, Copepoda % 5.2 oranında; Kayaboğazı Baraj Gölü'nde ise Rotifera % 64.2, Cladocera % 28.6, Copepoda % 7.2 oranında bulunmuştur. Her üç baraj gölünde de baskın gurup Rotifera'dır. Porsuk ve Kayaboğazı Baraj Gölü zooplanktonik organizmaların guruplarının (Rotifera, Cladocera ve Copepoda) yüzde dağılımı açısından benzer iken, Enne Barajı Rotifera gurubu organizmaların daha baskın olması nedeniyle farklılık göstermiştir. Çalışma periyodunda *Keratella cochlearis, Keratella tecta ve Bosmina longirostris* türleri üç baraj gölünde de bulunmuştur. Porsuk ve Kayaboğazı Barajı'nda ise *Chydorus sphaericus* türü baskındır. Rotifera'dan *Notholca squamula* yalnızca Kayaboğazı Barajı'nda, *Asplanchna sieboldi, Polyarthra vulgaris* ve *Rotaria neptunia* yalnızca Porsuk Barajı'nda, *Trichocerca similis, Trichocerca bicristata, Lecane bulla, Lecane clostrocerca, Brachionus angularis* ve *Synchaeta pectinata* yalnızca Enne Barajı'nda bulunmuştur. Ayrıca Copepoda'dan *Cyclops vicinus* yalnızca Enne Barajı'nda belirlenmiştir. Üç baraj gölünde, Rotifera'nın İlkbahar mevsiminde, Cladocera'nın Sonbahar mevsiminde, Copepoda'nın İlkbahar ve Sonbahar mevsimlerinde yoğun oldukları gözlenmiştir.

Çalışmada belirlenen *Lecane bulla* oligotrof, *Brachionus* ve *Keratella* türleri mesotrof, *B. angularis, Brahionus urceolaris, Brachionus calyciflorus, Keratella quadrata, Euchlanis dilatata, Filinia longiseta, B. longirostris, C. sphaericus* ve *C. vicinus* ötrof suların indikatörüdür (Ruttner-Kolisko, 1974; Saksena, 1987; Koste, 1978; Kiefer, 1978). Bu çalışmada seki disk görünürlüğü en düşük Mayıs ayında (30 cm) Enne Barajı'nda belirlenmiştir. Bu dönemde mesotrof suların indikatörü *Brachionus* ve *Keratella* türleri baskındır. Enne Baraj Gölü'nde bulunan *B. angularis, B. urceolaris, L. bulla, L. clostrocerca, T. similis* türleri littoral zon türleridir. Bunların dışında üç Baraj Gölü'nde belirlenen *E. dilatata* türüde littoral zonda bulunmaktadır. Bununla birlikte Enne ve Porsuk Barajı'nda bulunan *B. calyciflorus* türü littoral ve pelajik zon türü olarak bilinmektedir. Kayaboğazı Barajı'nda bulunan *N. squamula* littoral zon türü iken, her üç Baraj Gölü'nde bulunan *K.cochlearis, K. tecta* türleri pelajik zon türleridir.

Ayrıca çalışmada tespit edilen Rotifera türlerinden *B.angularis, B.calyciflorus, B. urceolaris, E. dilatata, K.quadrata, K.cochlearis, N. squamula, P. vulgaris, S.pectinata* ve *F.longiseta* türleri Türkiye'deki baraj göllerinde en sık rastlanılan türlerdir (Altındağ ve Özkurt, 1998; Bekleyen, 2003; Kaya ve Altındağ, 2007; Bozkurt ve Sagat, 2008; Saler, 2009; Yıldız, 2012). Buna ilave olarak, Copepoda ve Cladocera türlerinden *B.longirostris, C.sphaericus* ve *C.vicinus* yaygın türlerdir (Demirhindi, 1990; Ustaoğlu vd., 2001; Bozkurt, 2004; Yiğit ve Altındağ, 2005; Özdemir Mis vd., 2009). Demirhindi (1990) ve Bozkurt ve Sagat (2008) tarafından bildirilen *C.strenuus* türü; Yiğit ve Altındağ (2005) tarafından bildirilen *N.acuminata* türü; Kaya ve Altındağ (2007) tarafından bildirilen *D.galeata* türü; Özdemir Mis vd., (2009) tarafından bildirilen *D.mongolianum* türü baraj gölü çalışmalarında daha az rastlanılan türlerdir. Rotifera'nın dağılımında pH önemli iken, alkali sınırın pH>8 üzeri olduğu, asidik sınırın ise pH<5.5'in altında olduğu bildirilmektedir (Berzins ve Pejler, 1987). *S.pectinata, P.vulgaris, P.dolichoptera, K.cochlearis* türleri pH>8 üzeri sularda bulunmakla birlikte (Berzins ve Pejler, 1987), çalışmada bu türlerin pH 8.44-8.82 arasında olması literatür ile uyumlu olduğunu göstermektedir. Enne Barajı'na yakın olan Yoncalı köyü nüfusunun yaz aylarında artmasıyla birlikte evsel atıklar baraja dökülmektedir. Termal suların kükürtlü ve özellikle Yoncalı sıcak sularının çamur sedimentleri oranının yüksek olması baraj havzasında su kalitesini etkilediği bildirilmektedir. (Koyun, 1999). Çalışma sırasında Enne Barajı'nın etrafında insan faaliyetlerinin (evsel ve endüstriyel) yoğun olduğu gözlenmiştir. Özellikle Rotifera tür fazlalılığı açısından, Enne Baraj Gölü'nün trofik yapısının yüksek olduğu söylenebilir. Bu çalışma Enne, Porsuk ve Kayaboğazı Baraj Gölleri'nde yapılacak olan detaylı çalışmalara katkı sağlayabilecektir.

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**KISA ARAŞTIRMA** **SHORT COMMUNICATION**

# Türkiye'nin 7 akarsu havzasında horozbina, *Salaria fluviatilis* (Asso,1801), balığına ait boy–ağırlık ilişkisi

# The length-weight relationship of freshwater blenny, *Salaria fluviatilis* (Asso, 1801) in 7 drainage basin of Turkey

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**Abstract**: The present work aimed at determining the length-weight relationship of freshwater blenny (*Salaria fluviatilis*) in the 7 drainage basins of Turkey. For this purpose, total of 652 freshwater blenny specimens were examined belonging to the Marmara, Küçük Menderes, Western Black Sea, Antalya, Eastern Mediterranean, Seyhan and Ceyhan basins. Total lengths ranged from 2.0 to 12.9 cm and total weights ranged from 0.10 to 33.82 g. Length-weight relationship parameters were computed as a=0.0135, b=3.004, $r^2$=0986 for all individuals of the species in the freshwater of Turkey. In addition, growth type were determined isometric in 5 basin, positive allometric in 1 basin and negative allometric in 1 basin.

***Keywords*:** *Salaria fluviatilis*, freshwater blenny, length-weigh relationship, freshwater of Turkey

**Özet:** Bu çalışmada Türkiye'nin 7 akarsu havzasından toplanmış olan Horozbina Balığı (*Salaria fluviatilis*)'na ait boy-ağırlık ilişkisinin ortaya çıkarılması amaçlanmıştır. Marmara, Küçük Menderes, Batı Karadeniz, Antalya, Doğu Akdeniz, Seyhan ve Ceyhan havzalarına ait akarsulardan toplanmış olan 652 birey incelenmiştir. Tüm bireyler dikkate alındığında türün Türkiye içsularındaki total boy dağılımı 2.0-12.9 cm, total ağırlık dağılımı 0.10-33.82 g, boy-ağırlık ilişkisi parametreleri a= 0.0135, b= 3.004, $r^2$= 0.986 olarak hesaplanmıştır. Ayrıca, büyüme tipi havzaların 5'inde izometrik, 1 havzada pozitif allometrik ve 1 havzada da negatif allometrik olarak belirlenmiştir.

***Anahtar kelimeler*:** *Salaria fluviatilis*, Horozbina Balığı, Boy-Ağırlık İlişkisi, Türkiye içsuları

## GİRİŞ

Kaynaklarda total boy uzunluğunun en fazla 15 cm olduğu bildirilen (Krupp ve Schneider, 1989) *S. fluviatilis*, tatlısulara adapte olmuş bir tür olup, genellikle sahile yakın göllerde ve az derin akarsularda bulunur. Özellikle temiz akarsuların taşlık ve kayalık zonlarını tercih eden tipik bir zemin balığıdır. Beslenme yönünden karnivor olup başlıca gıdasını çeşitli su böcekleri, Krustaseler ve küçük balıklar oluşturur. Üreme periyodu Nisan-Haziran arasıdır. Genellikle bütün Güney Avrupa ve Kuzeybatı Afrika sahillerinde yayılış gösteren bu tür, ülkemizin sadece Ege ve Akdeniz sahilleri, Asi nehri ve kolları ile İznik gölünden rapor edilmiştir. İnsan gıdası yönünden hiçbir ekonomik önemi olmamakla beraber, başka balıklara yem hazırlamada hayvansal protein kaynağı olarak kullanılırlar. Ayrıca, süslü renklerinden dolayı akvaryumlarda beslenebilirler (Geldiay ve Balık, 2007).

Boy-ağırlık ilişkisi, balık biyolojisi açısından son derece önemlidir. Boy-ağırlık ilişkisi parametreleri (a ve b), balığın boyundan ağırlığının tahmin edilmesine, kondisyon indeksinin hesaplanmasına, farklı habitatlardaki populasyonların morfolojilerinin ve yaşam süreçlerinin karşılaştırılmasına imkan verir. Ayrıca boy-ağırlık ilişkileri ile balık büyümesinin izometrik veya allometrik olup olmadığı ifade edilir.

## MATERYAL VE YÖNTEM

Çalışma konusu örnekler Ege Üniversitesi Su Ürünleri Fakültesi Müzesi İçsu Balıkları Kolleksiyonundan temin edilmiştir (ESFM/PISI). Çalışmada, müzede yer alan 7 farklı havzanın akarsularından toplanmış olan balık örnekleri incelenmiştir. Eşey ayrımı gözetilmeden incelenen örneklerin boy ölçümleri 1 mm hassasiyetli ölçüm cetveli, ağırlık ölçümleri ise 0.01 g hassasiyetli dijital terazi ile yapılmıştır. Boy ağırlık ilişkisinin incelenmesinde $W=aL^b$ denkleminden yararlanılmıştır (Ricker, 1975). Burada 'W' gram cinsinden balığın total ağırlığını, 'L' cm cinsinden balığın total uzunluğunu, "a" ve "b" katsayıları ise büyüme parametrelerini ifade etmektedir. Türün büyüme tipini belirlemek amacıyla; $t_s$=b-3/se(b) eşitliğinden yararlanılmıştır (Sokal ve Rohlf 1987). Burada $t_s$; t-test değeri, b; eğim değeri ve se(b); ise (b) eğim değerinin standart hatasıdır. Büyümenin izometrik ya da allometrik olduğuna karar vermek için, hesaplanan t-test değeri tablodaki kritik değerle karşılaştırılmıştır.

## BULGULAR

Türkiye'nin 7 akarsu havzasından örneklenmiş olan toplam 652 Horozbina balığının incelenmesi sonucunda total boy dağılımının 2.0-12.9 cm, total ağırlık dağılımının ise 0.1-

33.82 g arasında değiştiği görülmektedir. İlgili türün incelenen periyottaki kondisyonunu da ifade eden "a" değeri tüm bireyler için 0.0135 olarak hesaplanmıştır. Ayrıca, eğim "b" değeri Marmara, Küçük Menderes ve Batı Akdeniz havzalarında 3'ün üzerinde bir değere sahipken, Antalya, Doğu Akdeniz, Seyhan ve Ceyhan havzalarında ise söz konusu değer 3'ten daha küçüktür. Havza ayrımı yapılmaksızın tüm bireyler dikkate alındığında *S. fluviatilis* türünün büyüme modelinin izometrik tipte olduğu görülmüştür (t-test=0.275, $t < t_{0.05}$, n>200 = 1.65). Havzalar dikkate alınarak yapılan ayrımda ise 5 havzada izometrik tipte büyüme modeli gözlenirken, 1 havza örnekleri pozitif allometrik, 1 havzada da negatif allometrik büyüme modeli tespit edilmiştir (Tablo 1).

## TARTIŞMA VE SONUÇ

Kaynaklarda total boylarının 15 cm'ye erişebildiği belirtilen (Krupp ve Schneider, 1989) *S.fluviatilis* üzerine yapılmış çalışmalar incelendiğinde söz konusu değere en yakın boy değeri 12.9 cm ile bu çalışmada elde edilmiştir. Önceki yıllarda ülkemizde İznik Gölü'nde, Avrupa'da Yunanistan kıyılarından elde edilen örneklerde en fazla 7 cm kadar bireyler bildirilmiştir (Tablo 2).

Türe ait boy-ağırlık ilişkisi parametrelerinden "a" değeri 0,0135; eğim "b" değeri 3,004; korelasyon katsayısı "$R^2$" 0,986 olarak hesaplanmıştır. Hem Türkiye iç suları hem de Yunanistan kıyılarında yapılmış çalışmalarda da söz konusu parametre değerleri birbirine yakın değerler göstermektedir (Tablo 2).

Çalışma sonucunda her ne kadar havzalar arasında büyüme tipi farklılıkları gözlenmiş olsa da tüm bireyler dikkate alındığında *S. fluviatilis* türünün Türkiye içsularında izometrik büyüme gösterdiği anlaşılmıştır. Benzer durum İznik Gölü populasyonu için de geçerli iken, Yunanistan'da yapılmış olan çalışmalarda büyüme tipi ile ilgili bir bilgi yer almamaktadır (Tablo 2).

Aynı türe ait populasyonlarında gözlenen bu farklı büyüme modellerinin, birey sayıları, bölge veya mevsim, habitat, midenin dolu veya boş olması, gonadların olgunluğu, eşey, balığın kondisyonu ve yakalanan balıkların boy gruplarındaki farklılıklardan kaynaklandığı bildirilmiştir (Tesch, 1971).

**Tablo 1.** *S. fluviatilis* türünün farklı havzalardaki populasyonlarına ait boy-ağırlık ilişkisi parametreleri
**Table 1.** The length-weight relationship parameters of *Salaria fluviatilis* in different basins

| Havza | N | Total boy Min-Mak (Ort±GL) | Total ağırlık Min-Mak (Ort±GL) | a | b | SH (b) | $R^2$ | t-test |
|---|---|---|---|---|---|---|---|---|
| Marmara | 16 | 2.0-6.0 (4.07±0.470) | 0.10-3.57 (1.10±0.403) | 0.0104 | 3.206 | 0.1184 | 0.981 | 1.740$^{I}$ |
| K.Menderes | 69 | 3.0-11.0 (5.44±0.393) | 0.41-16.30 (2.72±0.676) | 0.0127 | 3.015 | 0.0505 | 0.982 | 0.290$^{I}$ |
| B.Akdeniz | 175 | 3.5-12.9 (6.21±0.246) | 0.56-33.82 (4.13±0.668) | 0.0108 | 3.125 | 0.0346 | 0.979 | 3.601$^{A+}$ |
| Antalya | 332 | 2.3-12.0 (5.24±0.206) | 0.23-23.83 (2.87±0.408) | 0.0140 | 2.990 | 0.0171 | 0.989 | -0.610$^{I}$ |
| D.Akdeniz | 39 | 4.7-9.5 (6.51±0.302) | 1.48-11.34 (3.83±0.601) | 0.0205 | 2.759 | 0.1337 | 0.920 | -1.806$^{A-}$ |
| Seyhan | 3 | 6.1-7.3 (6.63±1.239) | 2.87-4.79 (3.61±2.098) | 0.0136 | 2.942 | 0.5307 | 0.969 | -0.109$^{I}$ |
| Ceyhan | 18 | 4.5-8.3 (6.43±0.478) | 1.30-7.94 (4.01±0.938) | 0.0138 | 2.998 | 0.2590 | 0.893 | -0.007$^{I}$ |
| Tümü | 652 | 2.0-12.9 (5.61±0.138) | 0.10-33.82 (3.24±0.289) | 0.0135 | 3.004 | 0.0141 | 0.986 | 0.275$^{I}$ |

N: Birey sayısı, Total boy (cm), GL, Güvenirlik limiti, a ve b büyüme parametreleri, SH (b): eğimin standart hatası, R2: Korelasyon katsayısı, t-test, I: İzometrik, A+: Pozitif allometrik, A-: Negetif allometrik

**Tablo 2.** Farklı lokalitelerde yapılmış çalışmalarda *S. fluviatilis* türüne ait boy-ağırlık ilişkisi parametreleri
**Table 2.** The length-weight relationship parameters of *Salaria fluviatilis* in different localities

| Lokalite | N | Total boy (cm) | a | b | se (b) | $R^2$ | Büyüme tipi | Kaynak |
|---|---|---|---|---|---|---|---|---|
| **Yunanistan** | 441 | 2.0-7.0 | 0.0102 | 3.08 | --- | 0.970 | --- | Kleanthidis vd. 1999 |
| **Yunanistan** | 409 | 2.0-7.0 | 0.0068 | 3.33 | --- | 0.990 | --- | Kleanthidis vd. 1999 |
| **Yunanistan** | 5 | 2.4-6.5 | 0.0122 | 2.986 | --- | 0.993 | --- | Koutrakis ve Tsikliras 2003 |
| **İznik Gölü** | 92 | 2.3-4.8 | 0.0096 | 3.060 | 0.0959 | 0.933 | I | Tarkan vd. 2006 |
| **Türkiye içsuları** | 652 | 2.0-12.9 | 0.0135 | 3.004 | 0.0141 | 0.986 | I | Bu Çalışma |

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# *İÇİNDEKİLER CONTENTS*

## ARAŞTIRMA MAKALESİ RESEARCH ARTICLE



## KISA ARAŞTIRMA SHORT COMMUNICATION