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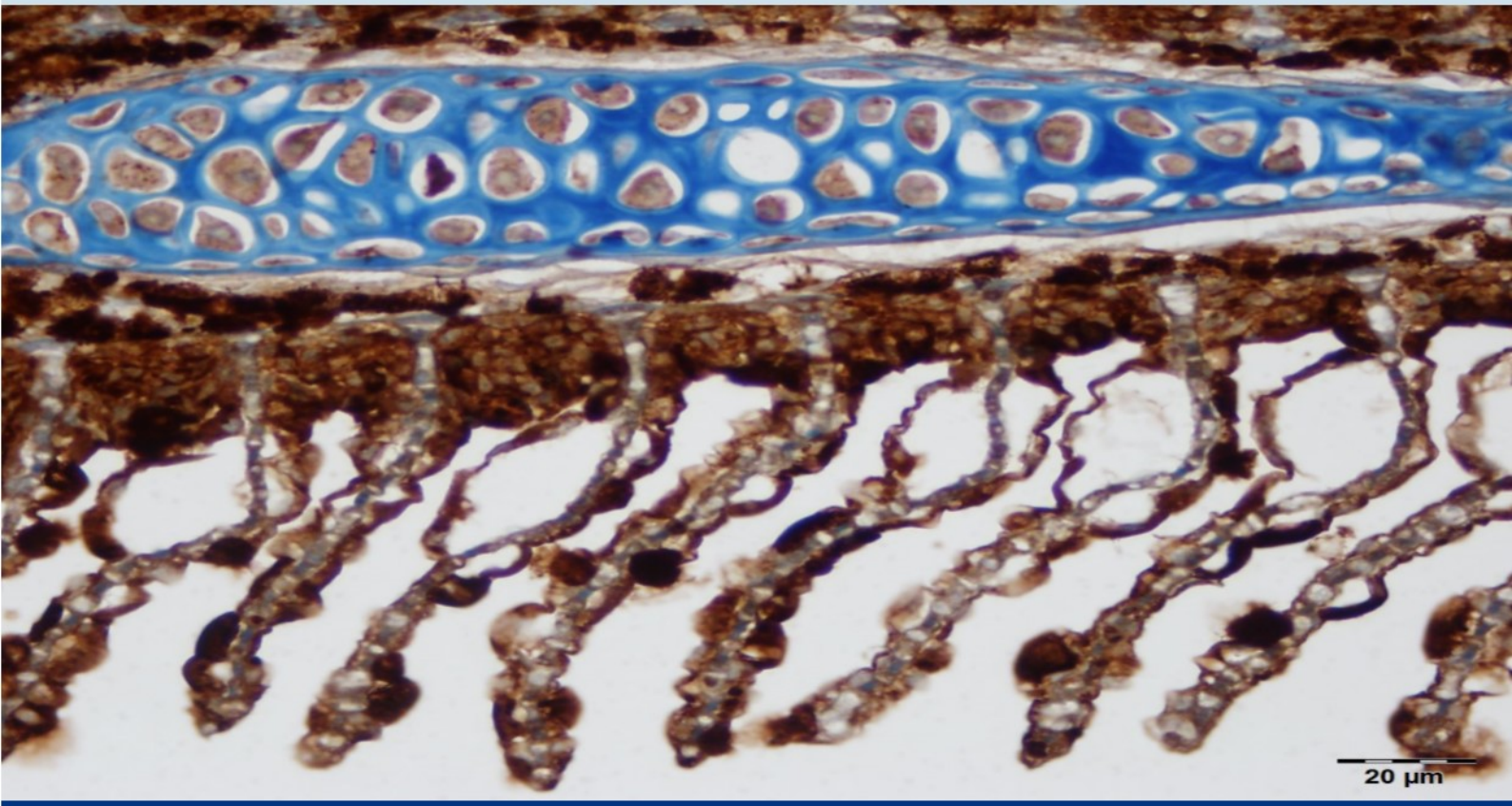

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ORIGINAL ARTICLE/ORİJİNAL ÇALIŞMA

FULL PAPER **TAM MAKALE**

CURİ DERESİ (ORDU) BALIKLARI VE İSTİLACI BİR BALIK TÜRÜ *Carassius gibelio* (Bloch, 1782)

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Öz:

Curi Deresi'nde yaşayan balık türlerini belirlemek amacıyla yapılan bu araştırma, Haziran 2012-Haziran 2013 tarihleri arasında mevsimsel olarak gerçekleştirilmiştir. Balık örneklerinin yakalanmasında; farklı göz açıklığına sahip ağlar, serpme, olta takımı ve elektroşoker cihazı kullanılmıştır. Araştırma alanından yakalanan 190 numunenin değerlendirilmesi sonucu 4 familyaya ait (Cyprinidae, Gobiidae, Mugilidae, Salmonidae) 9 tür teşhis edilmiştir. Bunlar; *Alburnus chalcoides, Barbus tauricus*, *Carassius gibelio, Mugil cephalus, Neogobius cephalarges, Neogobius melanostomus, Squalius cephalus, Vimba vimba* ve *Salmo labrax'*dır. Yakalanan örneklerin değerlendirilmesi sonucu, Türkiye iç sularında yayılışı hızla artan istilacı balık türlerinden *Carassius gibelio*'nun Ordu ili derelerinde de yayılmaya başladığı belirlenmiştir.

Anahtar Kelimeler: Ordu, Curi Deresi, Balık Faunası, Taksonomi, İstilacı Balık Türü

Abstract:

The Fish of the Curi Stream (Ordu) and Invasive Fish Species *Carassius gibelio* (Bloch, 1782)

The research which aims to find out the fish species inhabiting in Curi Stream was done between June 2012 and June 2013 with seasonal. In catches of fish samples; fishing nets with different scales, fishing cast nets, fishing tackle and electroshocker are used. After the evaluation of totally 190 samples caught from the research area, 9 species belonging to 4 families (Cyprinidae, Gobiidae, Mugilidae, and Salmonidae) have been identified. They were determined as *Alburnus chalcoides, Barbus tauricus*, *Carassius gibelio, Mugil cephalus, Neogobius cephalarges, Neogobius melanostomus, Squalius cephalus, Vimba vimba* and *Salmo labrax*. The evaluation of captured specimens' results, *Carassius gibelio* which is rising rapidly spreading invasive fish species from inland water of Turkey, was determined that they have started to spread in the Ordu.

Keywords: Ordu, Curi Stream, Fish Fauna, Taxonomy, Invasive Fish Species

Giriş

İhtiyofauna araştırmaları, biyolojik çeşitliliğin ortaya çıkarılması, gen kaynaklarının korunması ve sürdürülebilirliği açısından önemlidir. Ülkemiz iç su balık faunası, usulsüz yöntemlerle (dinamit, elektrik şoku, sönmemiş kireç, zehirleme) zamansız, aşırı ve üreme periyoduna dayalı avcılık, tatlısu kaynaklarına predatör balıkların aşılanması ve çevre kirliliği gibi faktörlerden dolayı sürekli değişime uğramaktadır. Bunun sonucunda, bir yandan endemik türlerimiz yok olurken, bir yandan da istilacı türler belirmiştir. Bu da elimizdeki bilgilerin sürekli güncellenmesi gerektiğini ortaya çıkarmaktadır. Son yıllarda, bütün dünya ülkelerinde olduğu gibi, ülkemizde de faunanın yeniden belirlenerek tehlikede olan tür ve alttürlerin koruma altına alınmaları için yapılan çalışmalar hız kazanmıştır (Uğurlu ve Polat, 2006).

Araştırma alanında, daha önce balık faunasını belirlemeye yönelik herhangi bir bilimsel çalışma yapılmamıştır. Curi Deresi'nin balık faunası tespit edilerek, mevcut durumun ortaya çıkarılması ile bu konuda ileriki yıllarda yapılacak olan bilimsel çalışmalara katkı sağlanması amaçlanmıştır. Curi Deres'inde yaşayan balıkların, maruz kaldığı son ekolojik durumun belirlenmesi ve Türkiye tatlı su balıkları sistematiğindeki eksik halkalardan birisini oluşturan Ordu ilinde Curi Deresi'ni içine alan tatlı su balık faunasının ortaya çıkarılması planlanmıştır.

Materyal ve Metot

Curi Deresi Ordu ilinin Akkuş ilçesindeki dağların eteklerinden doğar (Şekil 1). İki yandan aldığı küçük kollarla büyüyerek Ünye'den Karadeniz'e dökülür (Anonim, 2012). Çatalpınar ilçesine yakın bir konumdadır. Coğrafi konum olarak; enlem: 41° 08' 36" ve boylam: 37° 13' 41" koordinatlarındadır. Yağış alanı 242 km^2, kolektör uzunluğu 49 km, memba ile mansap arasındaki kot farkı 1620 m olup, debisi Q_{max100}= 485 m^3/s, Q_{max500}= 637 m^3/s' dir. Taşkın ve kıyı oyuntusu zararına neden olabilecek potansiyele sahiptir (ÇDR, 2011).

Curi Deresi'nde yaşayan balık türlerini tespit etmek amacıyla 5 farklı istasyondan balık örnekleri yakalanmıştır. Bu çalışmadaki balık örneklemelerinde; farklı göz açıklığına sahip fanyalı ağlar, serpme ağlar, olta takımı ve "SAMUS 725 MP" elektroşoker cihazı kullanılmıştır. Toplanan örneklerin renk ve desenlerini belirlemek amacıyla fikse edilmeden önce laboratuvarda renkli fotoğrafları çekilmiştir. Balıklar saklama kaplarında yan yatırılarak mümkün olduğunca düzgün şekil verilerek, örneklerin üzerini örtecek şekilde % 4'lük formaldehit çözeltisi ilave edilmiş ve bu şekilde sertleşmeleri sağlanmıştır. Örneklerin diagnostik karakterlerinin tespit edilmesi amacıyla metrik ve meristik ölçümleri alınmıştır. Araştırma alanının sıcaklık, çözünmüş oksijen ve pH değerleri Hach lange multi parametre cihazı ile arazide ölçülmüştür. Diğer analizler Ordu Üniversitesi Hidrobiyoloji araştırma laboratuvarında Hach lange spekrofotometre ile ölçülmüştür.

Araştırma alanından yakalanan balıkların sistematikteki yerlerini belirlemek amacıyla familya, cins ve tür düzeyindeki teşhisleri yapılırken Berg (1962, 1964, 1965), Kuru (1980a, 1980b), Çelikkale (1988), Balık ve ark. (1992), Mater ve ark. (2002), Ekingen (2004), Uğurlu (2006), Geldiay ve Balık (2009), Uğurlu ve Polat (2007)'den yararlanılmıştır.

Şekil 1. Araştırma Sahası ve Örnekleme İstasyonları.

Figure 1. The research area and sampling stations.

Bulgular ve Tartışma

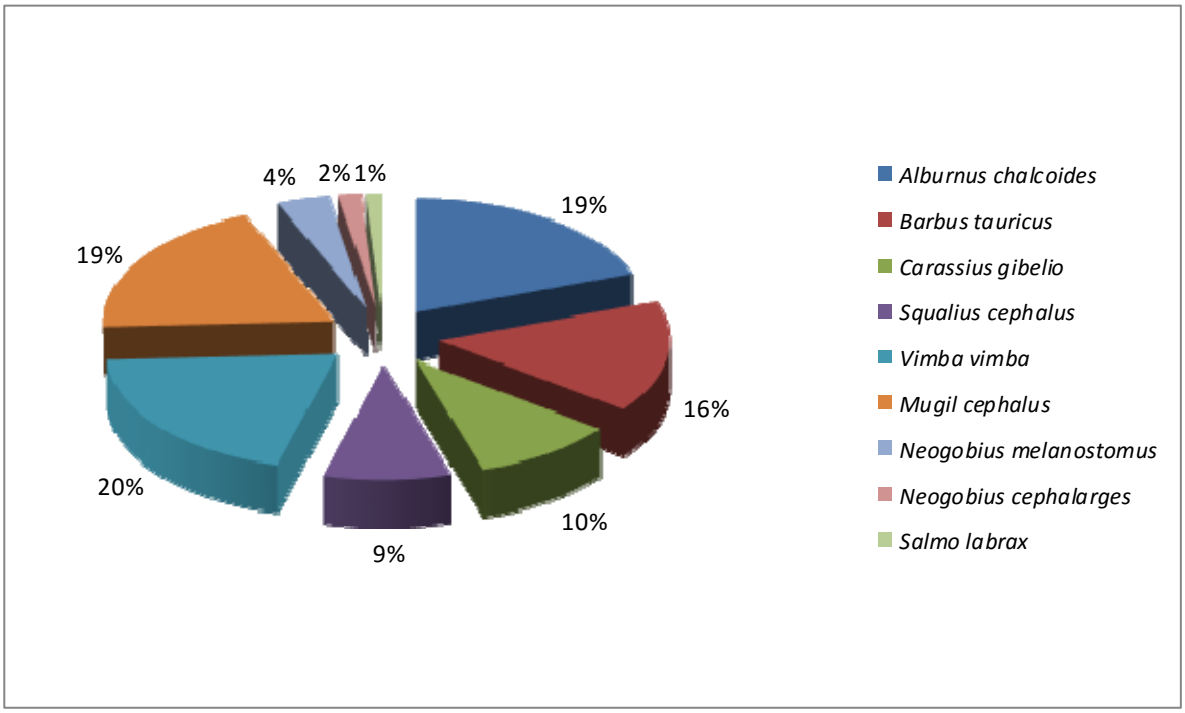
Curi Deresi' nin Bazı Fiziko-Kimyasal Özellikleri

Arazi çalışmaları sırasında istasyonlardan alınan su örneklerinin fiziko-kimyasal özellikleri tablo 1'de görüldüğü şekilde belirlenmiştir.

Curi Deresi'ndeki balıklar ılıman iklim kuşağında yaşayan, sıcaklık istekleri genel olarak 13-20°C, pH aralığı ise 7-7.8, O_2 değerleri 3.6-7.9 arasında değişen türlerdir. Bu çalışmayla birlikte ilk kez belirlenen Curi Deresi' nin fiziko-kimyasal özellikleriyle bu sucul ekosistem sıcaklık ve O_2 bakımından bu balıklar için uygundur. Suyun bazik olduğu görülmektedir.

Balık Faunası

Araştırma bölgesinden yakalanan numunelerin değerlendirilmesi sonucu teşhis edilen türlerin Türkçe isimleri literatürden ve yöre halkından, taksonomik özellikleri ise bulgulardan yararlanılarak verilmiştir. Curi Deresi'nde Haziran 2012-Haziran 2013 tarihleri arasında mevsimlik olarak yürütülen arazi çalışmasında yakalanan balık örneklerinin türlere göre yüzdelik dağılımı şekil 2'de görülmektedir. Derede *V. vimba* (% 20) *A. chalcoides* (% 19) ve *M. cephalus* (% 19) türlerinin daha bol, istilacı tür olan *C. gibelio*'nun ise % 10'luk yoğunlukla bulunduğu görülmektedir.



Şekil 2. Yakalanan balıkların yüzdelik dağılımı.

Figure 2. The percentage distribution of captured fish.

Türlerin Taksonomik Özellikleri

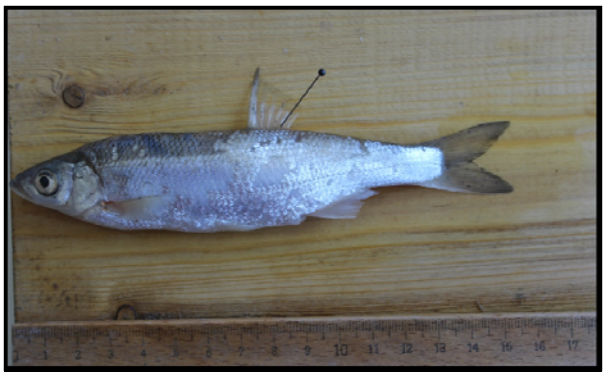
Familya: Cyprinidae

***Alburnus chalcoides* (Güldenstädt, 1772)**

Türkçe Adı: Tuna İnci Balığı

Taksonomik özellikler: (n= 37, şekil 3) SB: 89-151 mm. SB/VY: 4.65-6.44 SB/BB: 4.3-5.04 BB/GÇ: 3.48-4.6 İM/GÇ: 1.05-1.42 D: III (7) 8 A: III 14-15 P: I 14-16 V: II 8-9 L.lat.: 60- 65 L.tran.: 11-12/3-4 FD: 2.5-5.2.

Alburnus chalcoides'in meristik karakterleri Berg (1964), Kuru (1975b), Özuluğ (1999), Sarı ve ark. (2006), İlhan (2006), Geldiay ve Balık, (2009), Uğurlu ve Polat (2007), Polat ve ark. (2008)' nın tespit ettiği değerlerle uyumludur. İlhan (2006), bulduğu L.lat. değerleri bizim bulduğumuz değerlerden daha düşüktür.



Şekil 3. *Alburnus chalcoides* (Güldenstädt, 1772)
Figure 3. *Alburnus chalcoides* (Güldenstädt, 1772)

***Barbus tauricus* Kessler, 1877**

Türkçe Adı: Bıyıklı Balık

Taksonomik özellikler: (n=30, şekil 4) SB: 82-178 mm. SB/VY: 4.53-6.53 SB/BB: 3.2-4.6 BB/GÇ: 4.49-9.13 İM/GÇ: 1.38-3.19 D: IV (7) 8 A: III 5 P: I 15-16 V: II (7)- 8 L.lat.: 56- 62 L.tran.: 11-13/7-9 FD: 2.3.5-5.3.2.

Barbus tauricus'un meristik karakterleri ile Kuru (1975b), Özuluğ (1999), Özdemir ve ark. (2003), Sarı ve ark. (2006), Uğurlu (2006), Polat ve ark. (2008)'nın tespit ettiği değerlerle uyumludur. Özuluğ (1999)'a göre linea lateral pul sayısı, elde ettiğimiz değerlerden daha yüksektir.

Şekil 4. *Barbus tauricus* Kessler, 1877
Figure 4. *Barbus tauricus* Kessler, 1877

***Carassius gibelio* (Bloch, 1782)**

Türkçe Adı: Gümüşi Sazan, Japon Sazanı, Havuz Balığı

Taksonomik özellikler: (n=19, şekil 5) SB: 68-118 mm. SB/VY: 2.56-2.78 SB/BB: 3.21-3.96 BB/GÇ: 3.85-5.03 İM/GÇ: 1.63-2.16 D: IV 17-19 A: II 6 P: I 13-16 V: II 8 L.lat.: 29-30 L.tran.: 7/6 FD: 4.4.

C. gibelio'nun meristik karakterleri Berg (1964), Özuluğ (1999), Şaşı ve Balık (2003), Uğurlu (2006), İlhan (2006), Geldiay ve Balık (2009), Uğurlu ve Polat (2007)'ın bildirdiği değerlerle benzerlik göstermektedir. Şaşı ve Balık (2003)'a göre pektoral yüzgeçteki dallanmış ışın sayısı, elde ettiğimiz değerlerden daha yüksektir.

Tablo 1. Curi Deresi' nin bazı fiziko-kimyasal özellikleri.

Table 1. Some physico-chemical properties of Curi Stream.

	SO_4 mg/L	NO_2 mg/L	PO_4 mg/L	NH_3 mg/L	NH_4 mg/L	FS dH	Sıcaklık °C	pH	O_2 mg/L
1. İstasyon	113	0.031	0.196	0.19	0.20	17.1	20.6	7.7	3.6
2. İstasyon	27	0.013	0.008	0.22	0.23	7.1	18.8	7.6	4.7
3. İstasyon	13	0.031	0.668	0.67	0.71	5.65	17.6	7.5	5.01
4. İstasyon	12	0.40	0.098	0.45	0.48	3.1	16.8	7.5	5.07
5. İstasyon	10	0.003	0.528	0.29	0.30	3.06	13.7	7.8	7.9

Şekil 5. *Carassius gibelio* (Bloch, 1782)

Figure 5. *Carassius gibelio* (Bloch, 1782)

***Squalius cephalus* (Linnaeus, 1758)**

Türkçe Adı: Tatlı su kefali

Taksonomik özellikler: (n=17, şekil 6) SB: 90-162 mm. SB/VY: 4.18-6.05 SB/BB: 3.73-4.38 BB/GÇ: 3.61-5.65 İM/GÇ: 1.42-2.51 D: III 8 A: III (8) 9 P: I (15)16-17 V: II 8 L.lat.: 44-46 L.tran.: 7-7.5/3-4 FD: 2.5-5.2.

Squalius cephalus'un meristik karakterleri Kuru (1975b), Özuluğ (1999), Barlas ve ark (2000), Uğurlu (2006), İlhan (2006), Geldiay ve Balık (2009), Polat ve ark. (2008)'nın bildirdiği değerlerle benzerlik göstermektedir. Barlas ve ark (2000)'nın bildirdiği anal ve ventral yüzgeçlerdeki basit ışın sayısı elde ettiğimiz değerlerden daha düşüktür.

Şekil 6. *Squalius cephalus* (Linnaeus, 1758)

Figure 6. *Squalius cephalus* (Linnaeus, 1758)

***Vimba vimba* (Linnaeus, 1758)**

Türkçe Adı: Eğrez, Karaburun Balığı, Kavinne Balığı

Taksonomik özellikler: (n=38, şekil 7) SB: 83-174 mm. SB/VY: 3.81-5.89 SB/BB: 3.74-4.68 BB/GÇ: 3.27-5.68 İM/GÇ: 1.14-1.96 D: III 8 A: III 18-19 P: I 15-16 V: II 9 L.lat.: 56-59 L.tran.: 9-10/5-6 FD: 5-5.

Vimba vimba'nın meristik karakterleri Kuru (1975b), Özuluğ (1999), Barlas ve Dirican (2004), Uğurlu (2006), İlhan (2006), Geldiay ve Balık (2009)'ın bildirdiği değerlerle benzerlik göstermektedir.

Şekil 7. *Vimba vimba* (Linnaeus, 1758)

Figure 7. *Vimba vimba* (Linnaeus, 1758)

Familya: Mugilidae

***Mugil cephalus* Linnaeus, 1758**

Türkçe Adı: Has Kefal

Taksonomik özellikler: (n=37, şekil 8) SB: 60-137 mm. SB/VY: 4.08-5.64 SB/BB: 3.29-4.33 BB/GÇ: 3.63-7.43 İM/GÇ: 1.38-3.23 D1: IV D2:I (7) 8 A: III 8-(9) P: I-II 15-16 V: I 5 Sq:42-48.

Mugil cephalus'un meristik karakterleri; Berg (1965), Balık ve ark. (1992), Uğurlu ve Polat (2003), İlhan (2006), Uğurlu (2006), Geldiay ve Balık (2009), Uğurlu ve Polat (2008), Kaya (2009)'un bildirdiği değerlerle benzerlik göstermektedir. Ancak Balık ve ark. (1992), İlhan (2006), Geldiay ve Balık (2009), Kaya (2009)'a göre pektoral yüzgeçlerde basit ışın bulunmaması, bulgularımızla uyuşmamaktadır.

Şekil 8. *Mugil cephalus* Linnaeus, 1758

Figure 8. *Mugil cephalus* Linnaeus, 1758

Familya : Gobiidae

***Neogobius cephalarges* (Pallas, 1814)**

Türkçe Adı: Küçük Kaya Balığı

Taksonomik özellikler: (n=3, şekil 9) SB: 104-122 mm. SB/VY: 4.58-5.75 SB/BB: 3.35-3.51 BB/GÇ: 6.05-7.21 İM/GÇ: 1.22-1.51 D1: V-VII D2: I 16-18 A: I 12-13 P: 16-17 V: 5 Sq:57-59.

Neogobius cephalarges'in meristik karakterleri; İlhan (2006), Geldiay ve Balık (2009)'ın bildirdiği değerlerle benzerlik göstermektedir. Fakat Geldiay ve Balık (2009)'a göre ventral yüzgeçlerde basit ışın bulunması, bulgularımızla uyuşmamaktadır.

Şekil 9. *Neogobius cephalarges* (Pallas, 1814)

Figure 9. *Neogobius cephalarges* (Pallas, 1814)

***Neogobius melanostomus* (Pallas, 1814)**

Türkçe Adı: Kum Kaya Balığı, Benekli Kaya Balığı

Taksonomik özellikler: (n=7, şekil 10) SB: 96-116 mm. SB/VY: 4.37-5.46 SB/BB: 3.6-4.11 BB/GÇ: 4.48-5.69 İM/GÇ: 1.08-1.26 D1: (IV)-VI D2: I 14-15 A: I 11-12 P: 17-18 V: I 5 Sq: 45-50.

Neogobius melanostomus'un meristik karakterleri; Kuru (1975a), Uğurlu (2006), İlhan (2006), Geldiay ve Balık (2009), Polat ve ark. (2008)'nın bildirdiği değerlerle benzerlik göstermektedir.

Şekil 10. *Neogobius melanostomus* (Pallas, 1814)

Figure 10. *Neogobius melanostomus* (Pallas, 1814)

Familya: Salmonidae

***Salmo labrax* Pallas, 1814**

Türkçe Adı: Benekli alabalık, Denizalası, Karadeniz alabalığı

Taksonomik özellikler: (n=2, şekil 11) SB: 133-171 mm. SB/VY: 4.86-5.66 SB/BB: 3.89-4.23 BB/GÇ: 3.30-4.55 İM/GÇ: 1.21-1.78 D: IV 10 A: III 7-8 P: I 12 V: II 7-8 L. lat.: 114-116.

Salmo labrax natio fario ekotipinin meristik karakterleri; Berg (1962), Kuru (1975a), Kutrup (1993), Uğurlu (2006), Geldiay ve Balık (2009)'ın bildirdiği değerlerle benzerlik göstermektedir.

Şekil 11. *Salmo labrax* Pallas, 1814

Figure 11. *Salmo labrax* Pallas, 1814

Sonuç

Bu çalışma sonucunda Curi Deresi'nde Cyprinidae familyasından *A. chalcoides*, *B. tauricus, C. gibelio, S. cephalus, V. vimba,* Gobiidae familyasından *N. melanostomus, N. cephalarges*, Mugilidae familyasından *M. cephalus,* Salmonidae familyasından *S. labrax*'ın yaşadığı tespit edilmiştir. Yapılan faunistik çalışmalar sonucu istilacı bir tür olan *C. gibelio*'nun Curi Deresi'nde varlığı tespit edilmiştir. Türkiye içsularında birey sayısı ve coğrafik dağılımı hızla artan *C. gibelio*'yu ülkemize kimin getirdiği veya içsularımıza nasıl girdiği net olarak bilinmemekle birlikte, balıklandırma faaliyetleri yapan kamu ve/veya özel kurumlar ile bireysel balıklandırma yapan kişilerin etkilerinden kaynaklandığı düşünülmektedir. 1980'li yıllarda Meriç Nehri yolu ile Türkiye içsu faunasına katılan *C. gibelio*, özellikle yetkili kamu kurumlarının *C. carpio* ile yaptığı balıklandırma çalışmaları ile neredeyse tüm Türkiye içsularına bulaşmış olabileceği kanısı bulunmaktadır. Benzer şekilde Polat ve Uğurlu (2007) Samsun ilinin tamamında tatlı sularının balık faunasını belirledikleri araştırmalarında arazi çalışmasının yapıldığı 2002-2005 yılları itibariyle toplam 42 farklı göl, gölet, dere, çay, ır-

mak ve baraj gölünde *C. gibelio*'nun yaşadığını tespit etmişlerdir. Ordu iline sınır olan Samsunda bu kadar fazla lokalitede yaşıyor olması doğal yayılış faktörüne ilave olarak balıkçıların dahi kullandıkları ıslak ağlarla bütün ortamlarda avlanma yapmasıyla türün yayılış alanının Ordu iline doğru geçmesinde etkin rolü olduğunu düşündürmektedir.

Canlıların beslenme, üreme ya da olumsuz ekolojik koşullardan korunma amacıyla göç ederek habitat değiştirmeleri aslında bir doğa olayıdır. Sorun antropojenik sebeplerle doğal yayılış alanı içinde olmayan habitatlara taşınan türlerdir. Balıklandırma, yetiştiricilik, biyolojik mücadele çalışmaları doğrultusunda, doğal yayılış alanı içinde olmayan habitatlara taşınan tür ya ortama uyum sağlayıp yeni bir popülasyon oluşturur yada ortama uyum sağlayamayıp yok olur (Geldiay ve Balık 2009). İçsularımıza bilinçsiz, rastgele veya kasten taşınan, hızla yeni popülasyonlar meydana getiren istilacı türler, üreme alanı ve besin rekabetini lehine çevirdiğinde baskın tür haline gelip biyoistila yapabilir. İstilacı türlerin varolan biyoçeşitliliğin azalması, ekolojik değişimler ve ekonomik kayıplar gibi olumsuz etkileri tahmin edilemeyecek boyutlara ulaşabilir. Ekolojik hoşgörüsü geniş, üreme kabiliyeti yüksek, güçlü bir yapıya sahip olan istilacı türler üzerinde yaşayan organizmalar da (parazitler, bakteriler…) yerli türler için, sorunun bir başka boyutudur. *C. gibelio* 1988 yılında Trakya Bölgesi'nde ilk kez bildirilmesinden (Baran ve Ongan, 1988) bu yana geçen sürede yurdumuz tatlı sularında hızla yayılmıştır. Bu tür, ginogenetik üreme stratejisi, yılda birden fazla döl vermesi ve yüksek yumurta verimi (Fan ve Shen 1990, Pipoyan ve Rukhkyan 1998) gibi önemli üreme kabiliyetlerine ilave olarak, doğal türlerle besin ve habitat rekabetine girebilmesi gibi özellikleriyle de, hem durgun hem de yavaş akan sularda kolaylıkla baskın tür olabilmekte ve girdiği ortamlar için istilacı bir özellik gösterebilmektedir (Tarkan ve ark., 2006). Yapılan çalışmalarda *C. gibelio*'nun doğal balık türleri üzerine olan etkilerinin araştırılması sonucunda, türün artan yoğunluğuna karşılık ortamda tabii olarak bulunan diğer balık türlerinin belirgin bir şekilde azaldığı belirlenmiştir (Tarkan ve ark., 2012). Bu çalışmanın örnekleme aşamasında yakalanan ve %10'luk oranda olduğu görülen *C. gibelio*'nun takip edilerek ileriki yıllarda nasıl bir durum sergileyeceği, tabii türleri nasıl etkileyeceği değerlendirilmeli ve ildeki diğer derelerin balık faunası da belirlenerek onlara da bulaşıp bulaşmadığı kontrol edilmelidir. Diğer derelere yayılmasına yol açacak olan özellikle antropojenik etkiyi azaltabilmek için yöre halkı ve kamu kurumları bilgilendirilmelidir.

Asıl sorun kan damarları gibi akarsular aracılığıyla birbirine bağlı içsu kaynaklarımızda hızla yayılarak biyolojik kirlenmeye sebep olan istilacı türlere yönelik koruma, izleme, değerlendirme çalışmalarının yeterli düzeyde olmaması ve bu konuyla ilgili yönetmelik bulunmamasıdır. Yurdumuz gerek lotik gerekse lentik tüm tatlı su habitatlarının öncelikle mevcut fauna elemanlarının belirlenmesi ve hidroelektrik santraller (HES), yasa dışı avcılık, çevre kirliliği gibi faktörlerin oluşturacağı olumsuz etkilerin değerlendirilerek tedbirlerin alınması gerekmektedir.

Kısaltmalar

Araştırma sahasından yakalanan balık örneklerinin metrik ve meristik karakterleri için kullanılan simgeler ve kısaltmalar:

A = Anal Yüzgeç, **BB** = Baş Boyu, **D** = Dorsal Yüzgeç, **D1** = Birinci Dorsal Yüzgeç, **D2** = İkinci Dorsal Yüzgeç, **FD** = Farinks Dişi Sayısı, **GÇ** = Göz Çapı, **İM** = İnterorbiter Mesafe, **L.lat.** = Linea Lateralde bulunan pul sayısı, **L.tran**. = Linea Transversalde bulunan pul sayısı, **P** = Pektoral Yüzgeç, **SB** = Standart Boy, **Sq** = Boyuna pul sayısı, **V** = Ventral yüzgeç, **VY** = Vücut yüksekliği, **Qmax100** =100 yıl frekanslı taşkın pik debisi, **Qmax500** = 500yıl yinelenmeli taşkın pik debisi, **N** = Örnek sayısı.

Teşekkür

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FULL PAPER TAM MAKALE

GROWTH RESPONSE OF *Cyprinus carpio* FINGERLINGS FED DIETS CONTAINING HYDROTHERMALLY PROCESSED *Citrullus lanatus* SEED MEAL

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Abstract:

The effect of incorporating hydrothermally processed watermelon whole seeds in the diet of fish was investigated on growth, feed utilization and body composition of carp (*Cyprinus carpio*) fingerlings. Fish diets (35% crude protein) were formulated using water melon hydrothermally processed for 0 (DT1), 10 (DT2), 20(DT3), 30 (DT4) and 40 minutes (DT5) boiling time. Twenty fingerlings (1.50±0.00g each) were randomly allocated in triplicate to 70 liters plastic bowls, for each treatments, aeration was provided to culture bowls throughout the 12weeks feeding trial. Result of the study reveals that fish fed DT_4 (30 minutes) had the best performance in terms of mean weight gain, feed conversion ratio, feed conversion efficiency, protein efficiency ratio, apparent net protein utilization and specific growth rate ($P>0.05$). Hence, hydrothermal processing of watermelon seeds for 30minutes is recommended for better growth in *C. carpio*.

Keywords: Watermelon seed, Proximate composition, Common carp, Unconventional feeds

Introduction

Common carp (*Cyprinus carpio*) a benthic omnivore, is a native to Asia and Eastern Europe (Taylor, 1977). Carps is the most cultured freshwater fish species all over the world, (FAO, 2012), reputed as a popular food fish and a highly cultivable species with year round breeding under tropical and subtropical conditions. Common carp also plays an important role in polyculture system in seasonal reservoirs and ponds (Chakraborty 1982). It is the only exotic carp that is known to breed naturally in lakes, it has high fecundity and hatchability (Nathaniel, 2001), and can grow to a maximum length of 1.5m and a maximum weight of over 37.5kg (Panek, 1987). Today it remains the best choice for utilizing pond resources (FAO, 2011). Carp represent the species of choice due to their high growth rate, significant tolerance to environmental stresses, easy to reproduce and unquestionable market demand (FAO 2004).

Feed is the main operating cost in fish production and therefore adequate information on the nutritional requirements is necessary in order to formulate and produce economically, balanced and complete diet geared towards satisfying the need of different fish species (Ejidike, 2004). Feed accounts for the highest proportion of operational inputs in fish culture. Hence efforts are geared toward reducing production cost through the Utilization of unconventional feed stuff in animal nutrition.

Watermelon belongs to the genus Citrullus and family Cucurbitaceae (Huxley 1992). The water melon fruit, loosely considered a type of melon, possesses a smooth exterior (green and yellow) and a juicy, sweet, usually red, yellow or orange interior flesh (Jeffrey, 2005). Moreover, they are used as domestic remedy for urinary tract infection, hepatic congestion, catarrh, (Deible, 2001; Amadi et al., 2003). Water melon is rich in minerals, protein, vitamins, carbohydrate and fibre (Duke and Ayensu, 1985; Tarek and Khaled, 2011).

Watermelon seeds are one among the underutilized fruit byproducts (FAO STAT, 2009) despite it presumed high nutrient level.. This study is attempt to investigate the nutritional potential of using different hydrothermally processed watermelon (*Citrullus lanatus*) seed meal as an unconventional and a byproduct protein supplement in the diet of *Cyprinus carpio*.

Materials and Methods

Experimental Site

The feeding trial was carried out at the fish farm of Bauchi State Agricultural Development Programme (BSADP) Bauchi, Nigeria. Circular plastic bowls system of 70 litres capacity were used. The experiment lasted for twelve weeks. Aeration was provided using air pumps and water in bowls was siphoned after every two days to avoid fouling, water was renewed weekly and their quality parameter monitored closely to ensure that each experimental unit remain within the acceptable limits for culture of the fish (e.i. temperature at room temperature, oxygen >5mgL^{-1}, pH between 6.5-7.5).

Experimental Fish

The *Cyprinus carpio* (common carp) fingerlings were obtained from the Fish Farm of Bauchi state Agricultural Development Programme (BSADP) along Dass Road Bauchi. 300 Fingerlings of mean weight 1.50 ±0.00g were acclimated for two weeks. After the period of acclimatization, twenty fingerlings were randomly distributed into each plastic bowls.

Diet Formulation

Raw watermelon seeds (6 kg) were cleaned, sundried and milled, raw meal was obtained and then stored for diets formulation. Soybean used for the study were toasted for 30 minutes in an electric oven set at 100°C and milled after cooling to get soybean meal (SBM). Yellow maize used for the experiment were milled to get yellow maize meal (YMM) all were stored in air tight and moisture free container.

The experimental diets of the feeding trial were formulated using Pearson square method. Isonitrogenous diet of 35% crude protein were formulated with Fishmeal included at 25.72, Maize meal at 27.07, Soybeans meal at 25.72, vitamin/mineral premises at 1, salt at 0.50 while watermelon seed meal at 20.00. The five diets formulated were included with hydrothermally processed watermelon seed meal boiling for 0 minutes (DT_1) i.e. raw watermelon seed meal as control, diet 2 boiled for 10minutes (DT_2), diet 3 boiled for 20minutes (DT_3), diet 4 boiled for 30minutes (DT_4) and diet 5 boiled for 40minutes(DT_5). The feed ingredients for each of the treatment were weighed, ground, mixed thoroughly and warm water was added then stirred to

form consistent dough which was passed through a 2mm die pelleting machine. The pellets produced were collected on a flat sheet of plate for easy spread and sundried to constant weight; the dried pellets were micronized and stored for the feeding trail. Analysis was carried out to determine the nutrient composition of the raw watermelon seed meals soybeans, yellow maize, as well as the experimental fish before and after the experiments.

The dietary treatments were in triplicates using completely randomized design (CRD). After 2weeks period the fish were weighed and randomly distributed in bowls, each treatment was in triplicate with 20 fingerlings of *C. carpio*. The experimental fish were fed twice daily (9.00am and 4.00pm) at 5% body weight for twelve weeks (Eyo, 1999 Ayinla, 2005 and Tiamiyu et. al., 2007).

The fingerlings were weighed every week to determine weight gain and feed quantity given was adjusted accordingly. The growth parameters determined include mean weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio, and apparent net protein utilization and survival rate.

Computation of the Growth Parameters

Calculation of the growth parameters were done following the formulae described by Osborne, *at. al.*, (1919), Brown, (1957) and Balfour, (1998).

Mean Initial Weight: Twenty (20) C. carpio fingerlings were counted and weighed, the total weight obtained was divided by 20, to obtain the mean initial weight of the fingerling.

$MIW = N_W/N$

Where MIW =Mean Initial Weight

N =Number of fingerlings

W = Weight of fingerling

Mean Final Weight: The surviving fingerlings were counted and weighed, the weigh obtained was divided by the number of the surviving fingerlings to obtain the mean final weight.

$MFW = N_{sf}W/N_{sf}$

Where MFW =Mean Final Weight (g)

N_f=No. of surviving fish

W = Weight of the fish

Mean Weight Gain =

Mean Final Weight – Mean Initial Weight

Survival Rate

$$\text{Survival (\%)} = \frac{No - Ne}{No} \times 100$$

No =Initial total number of fingerlings

Ne=Total number of fish mortality at the end of feeding trial (12 wks)

Specific Growth Rate (SGR) This parameter was determined according to Brown (1957).

$$SGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \times 100$$

Where ln = natural logarithm

W_2 = final weight

W_1 = initial weight

$T_2 - t_1$ = time duration (in days)

Feed Conversion Ratio (FCR) According to Balfour (1998).

$$\textbf{FCR} = \frac{Feed\ Intake}{Weight\ Gain}$$

Protein Efficiency Ratio (PER) It was determined according to Osborne, *at. al.* (1919).

$$\textbf{PER} = \frac{Weight\ Gain}{Protein\ IntCake}$$

Where protein

$$\text{Intake} = \frac{\%\ Protein\ in\ Diet \times Total\ Feed\ Consumed}{100}$$

Apparent Net Protein Utilization (ANPU) According to Balfour (1998).

$$\textbf{ANPU} = \frac{Protein\ Gained}{Protein\ Consumed} \times 100$$

Where protein gain= Final Carcass-Initial Carcass Protein

The proximate composition of differently processed watermelon seed meal were carried out at Grand cereals Jos, according standard methods as stated by AOAC (2000).

Data Analysis

Data obtained from the feeding trials were subjected to analysis of variance (ANOVA) and where significant differences were observed be-

tween treatments, the means were compared using Fishers Least Significant Difference of the means (LSD). Genstat Discovery Edition 4 and Minitab 14 software were used for statistical analysis.

Results and Discussion

The proximate composition of the experimental diets containing hydrothermally processed watermelon seed meal is presented in Table 1. The result shows that the contained approximately the same crude protein level of 35%CP. However, the reference diet coppens (DT_6) differed significantly ($P<0.05$) with protein value of 52.24%. The ether extract of the formulated diets ranges from 11.24 ±0.07% to 13.74 ±0.13%. DT_2 (10mins) had the highest ether extract of 13.74 ±0.13% and ash content of 11.81 ±0.07% after DT_6 (reference diet). Conversely, DT_1 (control) contained the least values of 11.24 ±0.07% and 10.25 ±0.07% respectively. Moisture content of the diets differed significantly ($P<0.05$) with highest value in DT_3 (11.37 ±0.10%) while DT_1 (9.98±0.11%) had the lowest value. The highest value of crude fibre was found in DT_4 (9.95 ±0.14%), lowest in DT_1 (8.16 ±0.10) and DT_6 (2.01 ±0.01%) being the least. Nitrogen free extract (NFE) ranged from DT_2 (18.26 ±0.15%) to DT_1 (25.20 ±0.12%) among experimental diets.

The growth parameters for common carp fingerlings in the treatments ($T_1 – T_5$) in terms of mean initial weight (MIW), mean final weight (MFW), mean weight gain (MWG), feed conversion ratio, (FCR), feed conversion efficiency (FCE), protein efficiency ratio (PER), apparent net protein utilization (ANPU), specific growth rate (SGR) and survival rate (SR) are shown in Table 2. The result obtained from the feeding trial varied significantly ($P<0.05$) among the treatments. The mean final weight (MFW) and mean weight gain (MWG) were the highest in DT_6 (14.43 ±0.24g and 12.93 ±0.24g) and DT_4 (12.58 ±0.05g and 11.08 ±0.5g) respectively. DT_5 had least values of MFW 9.78±0.04g and MWG 8.28±0.04g. The feed conversion ratio (FCR) and feed conversion efficiency (FCE) followed similar pattern as observed in MFW and MWG. The best FCR (1.77 ±0.1) and FCE (56.40 ±0.25) were obtained in fish fed DT_4 after the reference (DT_6) values of 1.74 ±0.02 and 57.57 ±0.75 respectively. The worst values of FCR 2.03 ±0.10 and FCE 49.35 ±0.30 were recorded with fish fed DT_5. The protein efficiency ratio (PER), apparent net protein utilization (ANPU) and specific growth rate (SGR) were highest in fish feed DT_4 with the following values 1.62 ±0.01%, 22.98 ±0.49% and 2.53 ±0.00% respectively. The least values were observed in fish fed DT_5 with values 1.39 ±0.01%, 19.03 ±0.32 and 2.23 ±0.00 respectively. All the values of these parameters differed significantly ($P<0.05$). The overall survival rate (SR) ranged from 95.00±2.89% to 100.00 ±0.00%. The fish fed DT_2 and DT_5 had the highest (SR) 100.00 ±0.00%. While fish fed DT_3 had the lowest value of 95.00±2.89%. This showed that the fish fed the experimental diet had good survival rate (SR) as there was no significant difference ($p>0.05$) in the percentage survival rate.

Figure 1 shows the weekly growth trend of common carp fingerlings fed at different period of hydrothermally processed watermelon seed meal diets. It was found that the common carp fingerling gained weight in all the weeks in response to the dietary treatments. Weight gain increased tremendously from week 4 to the end of the feeding trial (Week 12). Fish fed DT_4 picked up from the fifth week and became the best after DT_6 (reference diet). DT_5 progressed hand in hand with DT_1, DT_2 and DT_3 but started declining from the 8^{th} week and ended up with the least growth at the termination of the feeding trial.

The effect of the diets containing varying hydrothermally processed watermelon seed meal on the body composition of the common carp fingerlings at the end of the feeding trial (Table 3) reveals that crude protein, ether extract and ash increased, whereas moisture content, crude fibre and nitrogen free extract decreased at the end of the experiment when compared with their initial composition of the experimental fish ($P<0.05$).

Fish fed DT_3 (20mins) had the highest carcass moisture content of 79.82 ±0.54% while the lowest value of 78.81 ±0.42% was recorded for DT_2 (10mins) and differed significantly ($P<0.05$) among all the treatments. The crude protein in carcass of all the treatments differed significantly ($P<0.05$). The highest crude protein value of 13.92 ±0.19% was found in the carcass of fish fed DT_4 (30mins) followed by DT_2 (10mins) with the value of 13.70 ±0.10% whereas fish fed DT_1 (0min) had the least value of 12.38±0.09%, however, the protein content has improved when compared with the initial protein. There was no significant difference ($P>0.05$) in the carcass of fish fed DT_1, DT_2, DT_3, DT_4 and DT_5, however, fish fed DT_6 (reference diet) and initial carcass differed significantly ($P<0.05$) in terms of ether

extract. The highest ether extract was recorded in carcass of fish fed DT_6 (reference diet) with the value of 4.02 ±0.06% while the lowest value of 1.87 ±0.06 was recorded in the initial carcass. There was significant difference ($p<0.05$) in the crude fibre in the carcass of fish fed the experimental diets. The crude fibre varied from 0.07 ±0.01% to 0.58 ±0.02%. The highest crude fibre was observed for fish fed DT_1 while the least was observed in fish fed DT_5. The initial carcass value was 0.10 ±0.00%. The highest ash content was recorded for fish fed DT_1 with value of 3.35 ±0.05% while the least ash content value of 2.85 ±0.07% was found in fish fed DT_4. The nitrogen free extract (NFE) differed significantly ($p<0.05$), the least value of 1.12±0.03% was observed in fish fed DT_5 (40mins) whereas the highest value 2.05 ±0.05% was recorded in DT_1 (0min). However, the value of 3.93 ±0.02% of nitrogen free extract of the initial carcass was significantly higher than that found in all the treatments.

The proximate composition of the experimental diets of this study revealed that all the diets met the targeted crude protein requirement for common carp. According to Craig and Helfrich (2002) crude protein level in aquaculture feeds generally average 18-20% for marine shrimps 30-40% for catfish, 20-30% for tilapia and 38-42% for hybrid striped bass but protein requirements are usually lower for herbivorous and omnivorous fish species (e.g carp) than carnivorous fish. The protein requirement of carp varies between 25-35%, depending upon age reported by Hossain *et.al.* (1997). However, providing excessive levels of dietary protein is both economically and environmentally wasteful because protein is the most expensive dietary component and excess protein increases the excretion of nitrogenous waste (Hossain *et. al.,* 1997).

Crude fibre in each of the diets exceeded the recommended level of 4% as suggested by Cowey (2007) in the present study. According to Gatlin (2010) the quantity of crude fibre in fish diet is usually less than 7% of the fish diet to limit the amount of undigested materials entering the culture medium. A high fibre and ash content reduces the digestibility of other ingredients in the diets resulting in poor growth of the fish (Abowei *et. al.,* 2011). Despite the higher levels of the crude fibre in the diets than what were reported by the authors mentioned, the growth of the experimental fish was not adversely affected. This might be due to the heat treatment given to the watermelon seed before inclusion into the diets. This is in agreement with the report of Bell, *et. al.,* (1980) that cooking renders feedstuff more palatable, digestible and destroy bacteria, at the same time the fibre shrinks and become softer and looser. In addition Udensi et al., (2007), reported that boiling cowpea seeds in water for 15 to 45 min reduced antinutritional factors. Similarly, Wang et al., (2009) reported that boiling and soaking resulted in reductions of antinutritional factors in flours made from different lentil varieties. Khattab et al., (2009) concluded that there can be a complete removal of trypsin inhibitor activity for pea seeds through roasting or boiling.

The result of the study revealed that the percentage lipid and the carbohydrate that is nitrogen free extract (NFE) differed significantly, however the values fall within the recommended range as stated by Craig and Helfrich (2002) that the lipid content of fish diet is between 10-25%, as well up to about 20% of dietary carbohydrate can be used by fish. Lipid content of diet is important as a sources of dietary energy, but is also fundamental for supplying adequate amount of essential fatty acid (Sargent, *et. al.,* 2002). It was also observed in the result that the moisture contents of the experimental diets were higher than 10%, except in DT_1 (9.98±0.11%) this is contrary to the recommendation of Craig and Helfrich (2002) that the moisture content of fish feed must not exceed 10% dry diet. Andras et al., (2011) reported that moisture content is very critical for fish feed to avoid mould; higher moisture content in diet promote mould and other microbial agent, mould carries risk of contamination and disease factors and may also cause toxicological problems.

In the present study it was observed that the mean weight gain (MWG) of the experimental fish increased with increasing hydrothermal processing duration of the watermelon seed in all the treatment except in DT_5.which might be due longer boiling period. This agrees with the report of Kaankula (1998) who reported that the nutritive value of legume seeds is improved when subjected to heating.

Table 1. Proximate Composition of hydrothermally processed watermelon seed meal diets

Treatment	Moisture %	Crude Protein %	Ether Extract %	Crude Fibre %	Ash %	NFE %
Diet 1	9.98±0.11^{c}	35.16±0.08^{b}	11.24±0.07^{e}	8.16±0.10^{d}	10.25±0.07^{e}	25.20±0.12^{a}
Diet 2	11.02±0.28^{ab}	35.08±0.10^{b}	13.74±0.13^{b}	9.09±0.05^{c}	11.81±0.07^{b}	19.26±0.15^{c}
Diet 3	11.37±0.10^{a}	35.29±0.08^{b}	11.84±0.10^{d}	9.32±0.09^{bc}	11.50±0.10^{c}	20.68±0.24^{b}
Diet 4	10.72±0.10^{b}	34.89±0.08^{b}	12.14±0.07^{cd}	9.95±0.14^{a}	11.39±0.08^{c}	20.93±0.12^{b}
Diet 5	11.23±0.12^{a}	35.41±0.08^{b}	12.34±0.11^{c}	9.38±0.04^{b}	10.63±0.09^{d}	21.01±0.11^{b}
Diet 6	10.97±0.13^{ab}	52.24±0.20^{a}	16.55±0.13^{a}	2.01±0.01^{e}	14.80±0.10^{a}	3.43±0.12^{d}

Means in the same column followed by different superscripts differed significantly ($P<0.05$)

Diet 1 (DT_1): 0% Minutes
Diet 2 (DT_2): 10% Minutes
Diet 3 (DT_3): 20% Minutes
Diet 4 (DT_4): 30% Minutes
Diet 5 (DT_5): 40% Minutes
Diet 6 (DT_6): Coppens as reference diet

Table 2. Growth and Nutrient Utilization of the *C. carpio* Fingerlings Fed hydrothermally processed watermelon seed meal diets

Treatment	MIW	MFW	MWG	FCR	FCE	PER	ANPU	SGR	Survival
Diet 1	1.50±0.00	10.99±0.05^{d}	9.49±0.05^{d}	1.80±0.00^{b}	55.60±0.15^{b}	1.58±0.01^{b}	19.73±0.10^{cd}	2.37±0.01^{d}	96.67±3.33^{ns}
Diet 2	1.50±0.00	11.56±0.07^{c}	10.06±0.07^{c}	1.80±0.02^{b}	55.52±0.58^{b}	1.54±0.02^{c}	21.53±0.18^{b}	2.43±0.01^{c}	100.00±0.00^{ns}
Diet 3	1.50±0.00	11.68±0.03^{c}	10.18±0.03^{c}	1.78±0.01^{b}	56.11±0.18^{b}	1.59±0.00^{a}	20.31±0.15^{c}	2.44±0.00^{c}	95.00±2.89^{ns}
Diet 4	1.50±0.00	12.58±0.05^{b}	11.08±0.05^{b}	1.77±0.01^{bc}	56.40±0.25^{ab}	1.62±0.01^{a}	22.98±0.49^{a}	2.53±0.00^{b}	96.67±3.33^{ns}
Diet 5	1.50±0.00	9.78±0.04^{e}	8.28±0.04^{e}	2.03±0.01^{a}	49.35±0.30^{c}	1.39±0.01^{d}	19.03±0.32^{d}	2.23±0.00^{e}	100.00±0.00^{ns}
Diet 6	1.50±0.00	14.43±0.24^{a}	12.93±0.24^{a}	1.74±0.02^{c}	57.57±0.75^{a}	1.10±0.02^{e}	16.42±0.37^{e}	2.69±0.02^{a}	98.33±1.67^{ns}

Means in the same column followed by different superscripts differed significantly ($P<0.05$)

MIW: Mean Initial Weight
MFW: Mean Final Weight
MWG: Mean Weight Gain
FCR: Feed Conversion Ratio
FCE: Feed Conversion Efficiency
PER: Protein Efficiency Ratio
ANPU: Apparent Net Protein Utilization
SGR: Specific Growth Rate

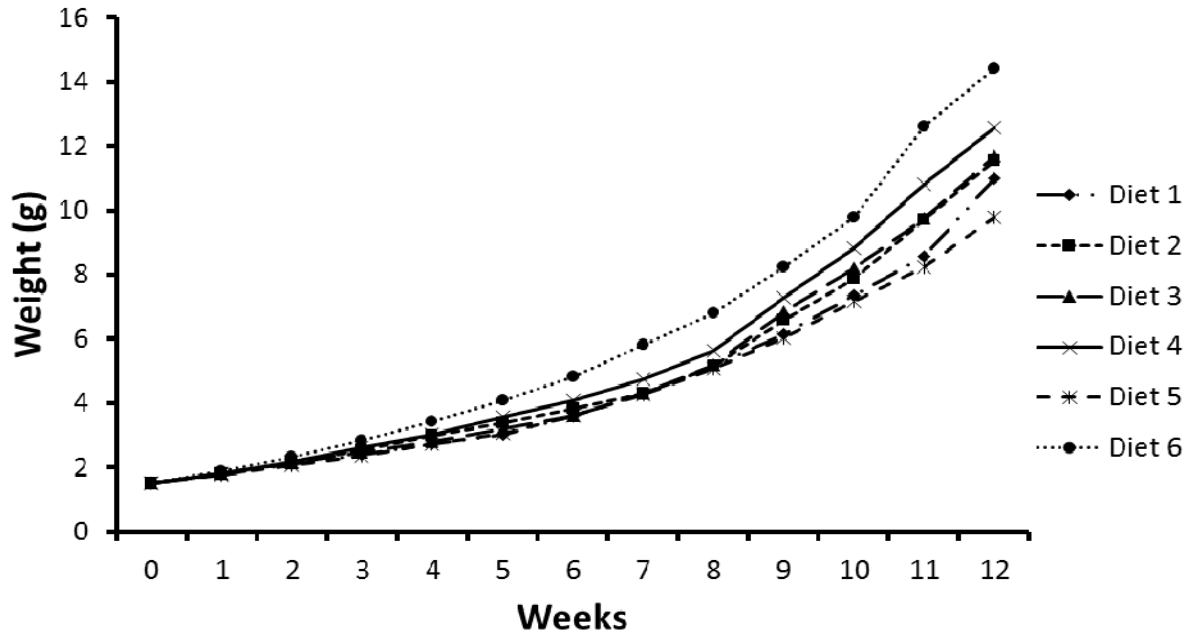

Figure 1. Weekly Weight Gain of *C. carpio* Fed different period of hydrothermally processed watermelon seed meal diets

Table 3. Carcass proximate Composition of *C. carpio* Fingerlings Fed hydrothermally processed watermelon seed meal diets (%).

Treatment	Moisture	Crude Protein	Ether Extract	Crude Fibre	Ash	NFE
Initial	80.20±0.06^{a}	11.75±0.06^{e}	1.87±0.06^{c}	0.10±0.00^{b}	2.15±0.01^{e}	3.93±0.02^{a}
Diet 1	78.94±0.60^{bc}	12.38±0.09^{d}	2.70±0.08^{b}	0.58±0.02^{a}	3.35±0.05^{a}	2.05±0.05^{b}
Diet 2	78.81±0.42^{b}	13.70±0.10^{bc}	2.68±0.09^{b}	0.08±0.01^{bc}	2.93±0.06^{c}	1.80±0.01^{c}
Diet 3	79.82±0.54^{ab}	12.64±0.08^{d}	2.68±0.08^{b}	0.09±0.01^{bc}	2.97±0.08^{bc}	1.80±0.01^{c}
Diet 4	78.90±0.06^{bc}	13.92±0.19^{b}	2.62±0.09^{b}	0.09±0.01^{bc}	2.85±0.07^{c}	1.62±0.01^{d}
Diet 5	79.55±0.23^{abc}	13.36±0.11^{c}	2.70±0.08^{b}	0.07±0.01^{c}	3.20±0.15^{ab}	1.12±0.03^{e}
Diet 6	78.58±0.22^{c}	14.57±0.16^{a}	4.02±0.06^{a}	0.04±0.01^{d}	2.56±0.06^{d}	0.23±0.01^{f}

Means in the same column followed by different superscripts differed significantly (P<0.05)

FCR, FCE, PER, ANPU and SGR followed the same trend with MWG which increased with increasing period of heat treatment of the seeds; however, the increase in heat treatment duration beyond 30miunts was not able to bring further improvement in the growth parameters of the fish, thus a decline in the performance of the experimental fish fed DT_5. This could be due to overheating of the seed which might have reduced or destroyed the amino acids and the micro nutrients content of the watermelon seeds. Tamminga *et. al.,* (2004) reported that if boiling of protein supplement fails to improve or results in decreased animal's performance the reasons might be that boiling condition may not be optimal the feed ingredient being either under boiled or over boiled. Ullah,(1982) reported that heat treatment will affect the nutritional value of legumes through destruction or inactivation of present factors as well as some impairment in the protein value, because over heating may result in damaging the protein quality by lowering digestibility (denaturation) and causing the loss of sulphur amino acids. According to the report of Buyukcapar and Kamalak, (2007) several factors depress growth, including reduced nutrients and

energy digestibility and efficiency of energy utilization.

The result shows an excellent survival rate in all the treatments, which ranged from 95.00 ±2.89 to 100.00 ±0.00% indicating that *C. carp* has high survival rate. Abba (2007) pointed out that a survival rate of 98.30 to 100% can be achieved with C. carp. Similarly, Manjappa et al., (2011) reported survival rate of 96.26 to 98.14%.

Furthermore, EL Adawy and Taha (2001) reported that watermelon seeds are rich in growth and health promoting nutrients which might be the reason for good nutrient utilization and survival rate attained in this feeding trial, in addition the present study revealed that the proximate analysis of the carcass fish fed the experimental diets were affected in terms of crude protein and fat content by the hydrothermally processed watermelon seed meal. Both the crude protein and lipid content of the initial fish carcass were lower compared with carcass of fish fed the trial diets at the end of experiment. This is an indication of protein addition and true growth involving an increase in the structural tissues such as muscles and various organisms (Fafioye et al., 2005). Reinitz and Hitzel (1980) reported that the type of feed ingested and their nutritional quality is known to be one of the main factors affecting fish carcass composition.

Despite the observed differences in the initial compared to final experimental fish fed different hydrothermally processed diet did not show difference in fat content of carcass. This could mean that high lipid of the diets did not affect fat content of the fish carcass. Thus conforming to the report of Izquierdo et al., (2003), that dietary lipid source di not affect lipids deposition in either liver or muscle of Seabass or Seabream. Also according to El- Marakby (2006) no change in total lipid and ash content was observed in fish fed different oil sources. This is contrary to the report of Chou and Shiau (1996); Ahmadi (2004) and Pei *et. al.* (2004), who reported that increase of dietary levels herein is usually associated with an increase in whole-body lipid content, while crude protein decreased.

It was also observed in the result, the fish fed with higher lipid diets (DT_2 and DT_5) contained higher ash content in their carcasses. This agrees with the report of Abbas (2007), that dietary lipid affect ash content slightly.

Conclusion

It is established that feeding Carp hydrothermally processed watermelon seed meal at 30minutes boiling performed better than all the diets. However, all the diets show excellent survival rate ranging from 96.67±3.33% to 100±0.00, which is indicative that the experimental diets were not harmful to the fish and can support their growth. Hydrothermal processing of watermelon seeds for 30minutes is therefore recommended for better growth and cost effective rearing of Carp.

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FULL PAPER TAM MAKALE

İZMİR KÖRFEZİ (EGE DENİZİ)'NİN NERİTİK SULARINDA DAĞILIM GÖSTEREN TİNTİNNİD'LERİN TÜR KOMPOSİZYONU VE MEVSİMSEL DEĞİŞİMİ

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Öz:

İzmir Körfezi'nde Ciliata tür komposizyonu ve bolluğu Kasım 2008 ile Temmuz 2010 tarihleri arasında 9 istasyonda (0.5 m, 5.0 m, 10.0 m ve 15.0 m) mevsimsel olarak incelenmiştir. Yapılan çalışmalar sonucunda Ciliata sınıfına ait toplam 17 taksa saptanmıştır. *Stenosemella nivalis*, *Tintinnopsis cylindrica* ve *Undella hyalina* hemen hemen tüm istasyonlarda gözlenen baskın türlerdir. Çalışmada en düşük tür sayısı 3 tür ile Nisan 2009 döneminde, en yüksek tür sayısı ise 12 tür ile Mart 2010 döneminde saptanmıştır. Ciliata sınıfındaki en düşük hücre yoğunluğu Nisan 2009 döneminde ($0.039x10^3$ hücre lt^{-1}), en yüksek hücre yoğunluğu Temmuz 2010 döneminde ($152x10^3$ hücre lt^{-1}) gözlenmiştir. Bu dönemde, yüksek hücre yoğunluğuna neden olan türler *Helicostomella subulata, Salpingella decurtata* ve *Steenstrupiella steenstrupii*' dir. Bu üç tür de evsel ve endüstriyel atıksuların etkisi altında bulunan iç körfez istasyonlarında en yüksek hücre yoğunluğuna ulaşmışlardır. Shannon- Wiener çeşitlilik indeks değeri 0.032-2.165 bits arasında değişmekte, en düşük çeşitlilik indeks değeri ise 22 nolu istasyonda, en yüksek çeşitlilik indeks değeri ise 20 nolu istasyonda saptanmıştır. Ayrıca yapılan çalışmada tintinnid bolluğunun fitoplankton bolluğu ile negatif yönlü bir ilişki gösterdiği saptanmıştır.

Anahtar Kelimeler: Tintinnid tür komposizyonu, bolluk, çeşitlilik indeksi, İzmir körfezi, Ege Denizi

Abstract:

Species Composition of Tintinnids in the Neritic Water of Izmir Bay (Aegean Sea, Turkey) and Seasonal Variations

Tintinnid species composition and abundance were examined seasonal at 9 stations (0.5 m, 5.0 m, 10.0 m and 15.0 m) in Izmir Bay between November 2008 and July 2010. During the study period, belonging to the class Ciliata, 17 taxa were determined. *Stenosemella nivalis*, *Tintinnopsis cylindrica* and *Undella hyalina* were the dominant species observed in almost all the stations. The lowest number of species was found in April 2009 with 3 species whereas the highest number of species was determined in March 2010 with 12 species. The minimum and the maximum cell density of the class Ciliata were observed in April 2009 ($0.039x10^3$ cell lt^{-1}), and July 2010 ($152x10^3$ cell lt^{-1}) respectively. In this period, the species with respect to the high cell density were *Helicostomella subulata, Salpingella decurtata* and *Steenstrupiella steenstrupii*. These three species reached their maximum cell densities in the stations located in the inner bay where the environment was under the influence of domestic and industrial wastewaters. The Shannon-Wiener diversity index values varied between 0.032 (Station 22) and 2.165 (Station 20). Additionally, a negative relationship was determined between tintinnid and phytoplankton abundance.

Keywords: Tintinnid species composition, abundance, diversity index, Izmir Bay, Aegean Sea

Giriş

Dünya okyanuslarının pelajik besin zincirinde mikrozooplanktonun (20 ile 200 µm) ekolojik önemi kesin olarak tanımlanmıştır. Mikrozooplankton denizel ortamdaki plankton kommunitesinin en önemli bileşenini oluşturmaktadır. Ciliata'lar genellikle mikrozooplanktonda baskın türlerdir, nanoplankton ve pikoplanktonun başlıca tüketicileridir (Fenchel, 1987). Nanopikoplanktonun oluşturduğu fitoplankton artışlarına hızlı bir şekilde cevap verdikleri için planktonik besin zincirinde anahtar role sahiptir. Sert lorikalarından dolayı tintinnidler denizel siliyatların en iyi bilinen grubudur ve farklı su kütlelerinin indikatör türleri olarak tanımlanmaktadır (Kato and Taniguchi, 1993).

Araştırmaların büyük bir kısmı siliyatların beslenme aktivitesi ve büyüme oranı ile fitoplanktona eşdeğer olduğunu göstermiştir (Hansen ve ark., 1997). Ayrıca bazı herbivor siliyatlar için beslenmede seçiciliğin, av büyüklüğü ve yüzey özellikleri ile temel oluşturduğu rapor edilmiştir (Jonsson, 1986). Çeşitli çalışmalar bakteri (Hollibaugh ve ark., 1980), diyatome ve dinoflagellatlar (Heinbokel and Beers, 1979; Stoecker ve ark., 1981, 1983, 1984) ve diğer ufak protozooların, tintinnidlerin besinini oluşturduğunu göstermektedir. Hatta bu besinler arasında zararlı-zehirli aşırı üreme gösteren türler de (*Alexandrium tamarense*, *Gymnodinium mikimotoi*) bulunmaktadır (Watras ve ark., 1985; Nakamura ve ark., 1996) ve bunların toksitelerinden dolayı siliyat populasyonunda büyük kayıplara neden olduğu daha önceki çalışmalarda verilmiştir (Nielsen ve ark., 1990; Buskey and Hyatt, 1995). Ancak zararlı alglerle beslenen siliyatların beslenme aktiviteleri laboratuvar çalışmaları ile sınırlı kalmıştır (Jeong ve ark., 1999). Stoecker ve ark., (1984) tarafından yapılan bir çalışmada özellikle *Favella* cinsine ait bazı türlerin, aşırı üreme gösteren dinoflagellatlar üzerinde predatör olarak özelleştiği rapor edilmiştir.

Ege Denizi'nde Ciliata sınıfı üzerine yapılan taksonomik çalışmalar ilk olarak İzmir Körfezi'nde (Ergen, 1967) başlamış olup, bunu daha sonra diğer çalışmalar izlemiştir (Koray ve Özel, 1983; Koray, 1987; Koray ve ark., 2000; Çolak Sabancı ve Koray, 2001). Bu çalışmada, İzmir Körfezi'nde dağılım gösteren siliyat tür komposizyonlarının belirlenmesi, aşırı üreme gösteren türlerin istasyonlara ve mevsimlere göre dağılımlarının çıkartılması amaçlanmıştır.

Materyal ve Metot

Türkiye'nin en büyük doğal körfezi olan İzmir Körfezi (enlem 38º 20' N, boylam 26º 30' E ve enlem 38º 40' N boylam 27º 10' E) Ege Denizi'ne açılan kapalı bir körfezdir ve körfezin yüzey alanı 500 km^2, su kapasitesi 11.5 milyon m^3 ve toplam 64 km uzunluğa sahiptir (**Şekil 1**). İzmir Körfezi topografik olarak 3 kısımda incelenir; iç körfez, orta körfez ve dış körfezdir. Karaburun Yarımadası ile Gediz Deltası arasında kuzeybatı-güneydoğu doğrultusunda uzanan daha geniş ve daha derin kesimi dış körfez olarak adlandırılır ve derinliği 45 ile 70 m arasında değişir. İç ve orta körfezde derinlik doğudan batıya doğru giderek artar. İç körfezin en derin yeri orta kesimlerde yer alır ve 21 m civarındadır (Kontaş ve ark., 2004).

Bu araştırmada İzmir Körfezi'nin Ciliata sınıfı topluluk yapısı seçilen 9 istasyonda (İst. 1, İst. 4, İst. 8, İst. 11, İst. 17, İst. 20, İst. 22, İst. 24 ve İst. 26) 0.5 m, 5.0 m, 10.0 m ve 15.0 m derinliklerden olmak üzere 2008-2010 yılları arasında (Kasım 2008, Şubat 2009, Nisan 2009, Temmuz 2009, Kasım 2009, Şubat 2010, Mart 2010 ve Temmuz 2010) mevsimsel olarak incelenmiştir (**Şekil 1**). Siliyat örneklemesi için her bir istasyonda belirlenen derinliklerden 2 litrelik nansen şişesi ile 5 litrelik su örneği alınmış ve bu materyal lugol ile fikse edilmiştir. Laboratuvara getirilen örnekler organizmaların çökmesi için 1 hafta süresince bekletilmiş ve üsteki sıvı kısmın sifonlanmasıyla örnekler 250 cc'lik mezürlere aktarılmıştır. Bunu takiben mezürlerde çökelen örnekler 10 cc'lik cam tüplere alınmıştır ve bu materyalin üzerine sonuç konsantrasyon %4 olacak şekilde formaldehit eklenmiştir. Tüpler örneklerin yoğunluğuna göre 1-5 cc'ye kadar tekrar konsantre edilmiş ve homojenizasyon sağlandıktan sonra sayıma başlanmıştır. Sayım işleminde tek damla yöntemi (=single drop technique) kullanılmış olup, sayım işlemi tamamlandıktan sonra başlangıç hacimleri bilinen örneklerden elde edilen siliyat sayım sonuçları geri hesaplama yoluyla hücre lt^{-1} şekline dönüştürülmüştür (Venrick, 1978; Semina, 1978). Siliyat türleri Nikon Labophot-2 araştırma mikroskoplarında yapılan incelemelerle tayin edilmiş ve tür tayinlerinde Tregouboff ve Rose (1957), Koray ve Özel (1983), Balkıs ve Toklu Alıçlı (2009), Lee ve Kim (2010)'dan yararlanılmıştır.

Elde edilen verilerin istatistiksel olarak değerlendirilmesinde, Shannon- Wiener çeşitlilik indeksi (H′), Pielou'nun düzenlilik indeksi (J′) ve Bray-Curtis'in benzerlik indeksi kullanılmıştır. Ayrıca benzerlik indeksi kullanılarak oluşturulan matriks yardımıyla parametrik olmayan MDS analizi yapılmıştır. İstatistiksel analizler Primer 5.0 ve Statgraphics Plus 5.1 kullanılarak yapılmıştır.

Bulgular ve Tartışma

2008-2010 yıllarında İzmir Körfezi'nde yürütülen bu çalışmada, 15 cinse ait toplam 17 taksa saptanmıştır **(Tablo 1)**. *Stenosemella nivalis* (Meunier) Kofoid et Campbell, *Tintinnopsis cylindrica* Daday ve *Undella hyalina* Daday hemen hemen tüm istasyonlarda gözlenen en baskın türlerdir. *Codonellopsis schabi* (Brandt) Kofoid et Campbell, *Salpingella decurtata* Jörgensen ve *Steenstrupiella steenstrupii* (Claparéde et Lachmann) Kofoid et Campbell ise diğer baskın türlerdir.

Ciliata tür sayısının istasyonlara göre dağılımları incelendiğinde, minimum tür sayısı 6 tür ile istasyon 4 ve 8'de, maksimum tür sayısı ise 11 tür ile istasyon 1'de saptanmıştır. Bununla birlikte tür sayısının mevsimlere göre dağılımları incelendiğinde minimum tür sayısının 3 tür ile Nisan 2009 döneminde, maksimum tür sayısı ise 12 tür ile Mart 2010 döneminde saptanmıştır **(Şekil 2)**.

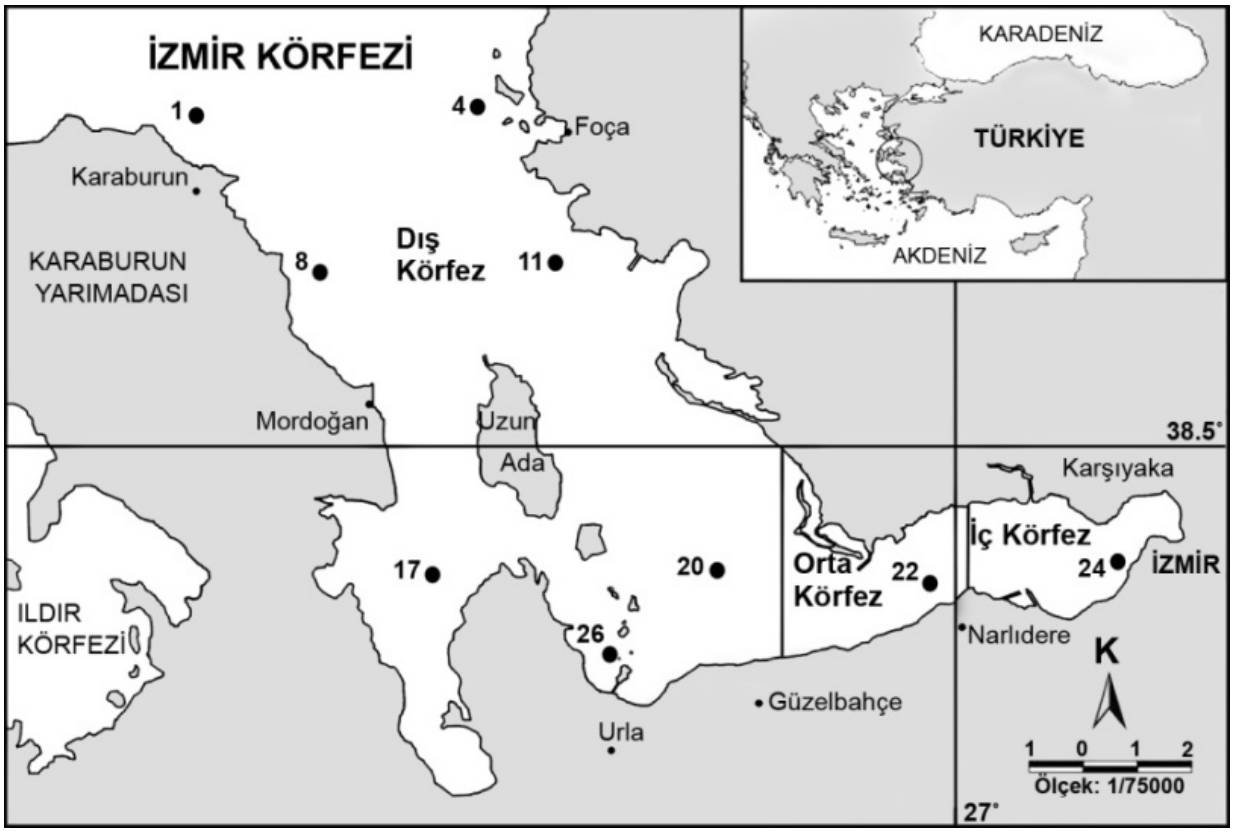
Ciliata sınıfının istasyonlara göre birey sayıları incelendiğinde, özellikle iç körfezde bulunan istasyonlarda yüksek hücre yoğunlukları gözlenmiş ve en yüksek hücre yoğunluğu istasyon 22 ve istasyon 24'de saptanmıştır. Ciliata sınıfındaki en yüksek hücre yoğunluğu Temmuz 2010 döneminde gözlenmiştir (**Şekil 3**). Bu dönemdeki artış, *H. subulata*, *S. decurtata* ve *S. steenstrupii* türlerinin yüksek hücre konsantrasyonlarına ulaşması ile açıklanabilir. *H. subulata* istasyon 22 tüm derinliklerinde, istasyon 24'ün ise 0.5 ve 5.0 m'sinde aşırı üreme göstermiştir. En yüksek hücre yoğunluğuna istasyon 22'nin 5.0 m'sinde ulaşmış ($28.5x10^3$ hücre lt^{-1}) ve diğer derinliklerde de benzer dağılım göstermiştir. *S. decurtata* istasyon 24'ün tüm derinliklerinde saptanmış ve en yüksek hücre yoğunluğuna 5.0 m'de ulaşmıştır ($0.59x10^3$ hücre lt^{-1}). *S. steenstrupii* ise istasyon 24'ün tüm derinliklerinde ve istasyon 22'in ise sadece 0.5 m'sinde aşırı üreme göstermiştir, en yüksek hücre yoğunluğuna istasyon 24'ün 10.0 m'sinde ulaşmıştır ($0.3x10^3$ hücre lt^{-1}).

Tablo 1. İzmir Körfezi'nde Kasım 2008-Temmuz 2010 döneminde saptanan Ciliata türlerinin istasyonlara göre dağılımları

Table 1. Distribution of Ciliata species observed in Izmir Bay in stations between November 2008 and July 2010.

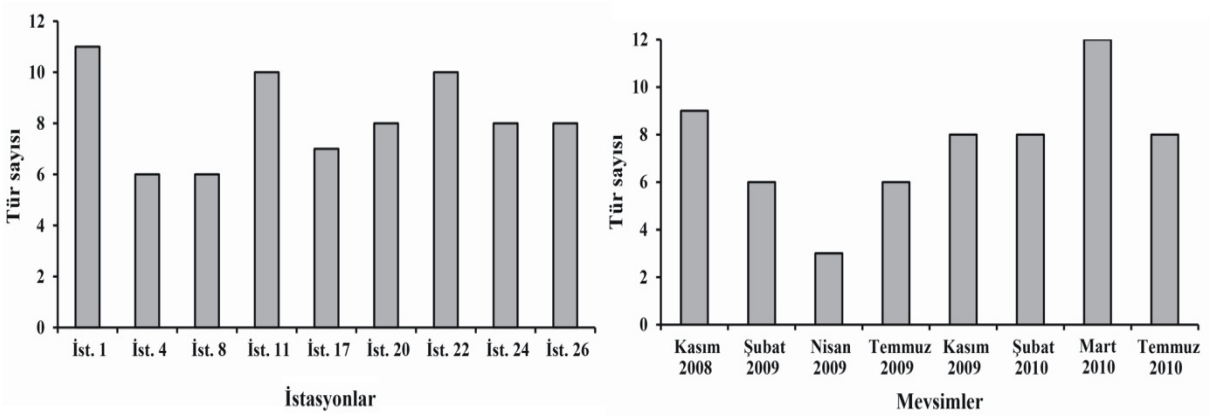
TÜRLER	İst.1	İst.4	İst.8	İst.11	İst.17	İst.20	İst.22	İst.24	İst.26
Amphorides quadrilineata (Claparede et Lachmann) Strand					*	*	*		*
Codonellopsis schabi (Brandt) Kofoid et Campbell		*		*	*	*	*	*	*
Dadayiella ganymedes (Entz sen.) Kofoid et Campbell	*	*	*	*					
Eutintinnus fraknoi (Daday) Kofoid et Campbell	*								
Favella azorica (Cleve) Jörgensen	*			*					*
Favella ehrenbergi (Claparede et Lachmann) Jörgensen						*	*	*	
Helicostomella subulata (Ehrenberg) Jörgensen	*			*		*	*	*	
Metacylis joergensenii (Cleve)	*		*						*
Rhabdonella spiralis (Fol) Brandt	*								
Salpingella decurtata Jörgensen		*	*	*	*		*	*	*
Steenstrupiella steenstrupii (Claparéde et Lachmann) Kofoid et Campbell	*		*	*	*	*	*	*	
Stenosemella nivalis (Meunier) Kofoid et Campbell		*	*	*	*	*	*	*	*
Tintinnopsis campanula (Ehrenberg) Daday				*			*	*	
Tintinnopsis cylindrica Daday	*	*		*	*	*	*	*	*
Undella claparedei	*								
Undella hyalina Daday	*	*	*	*	*	*	*		*
Xystonella longicauda (Brandt) Laackmann	*								

Bu araştırmanın sonucuna göre Shannon- Wiener çeşitlilik indeks değeri 0.032-2.165 bits arasında değişmekte, en yüksek çeşitlilik indeks değeri 20 nolu istasyonun 0.5 m'sinde, en düşük çeşitlilik indeks değeri ise 22 nolu istasyonun 10.0 m'sinde saptanmıştır **(Şekil 4)**. Düzenlilik indeks değişimleri incelendiğinde en yüksek ve en düşük indeks değerleri 0.013-1.000 arasında değişmekte, en yüksek düzenlilik indeks değeri 4 nolu istasyonun 15.0 m'sinde, en düşük düzenlilik indeks değeri ise 22 nolu istasyonun 10.0 m'sinde saptanmıştır.



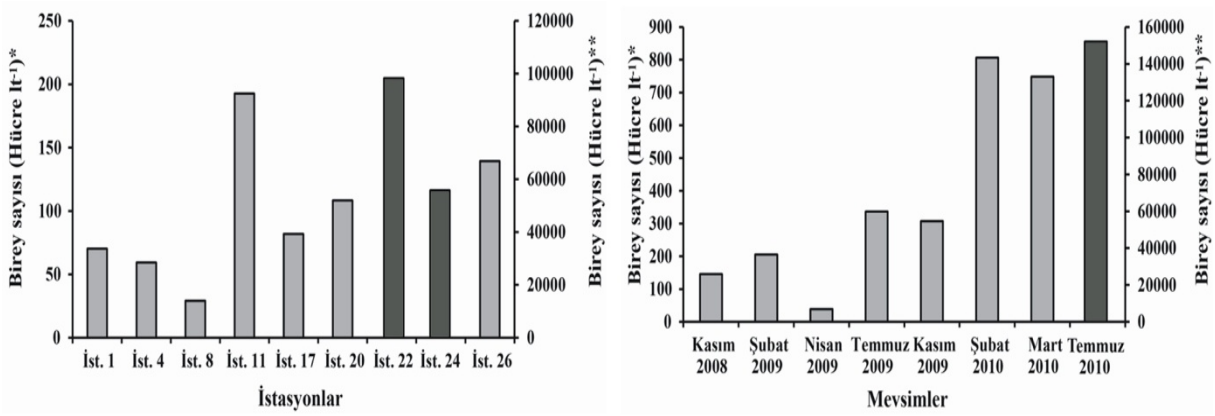
Şekil 1. İzmir Körfezi'nde çalışılan istasyonlar

Figure 1. Sampling stations in Izmir Bay.

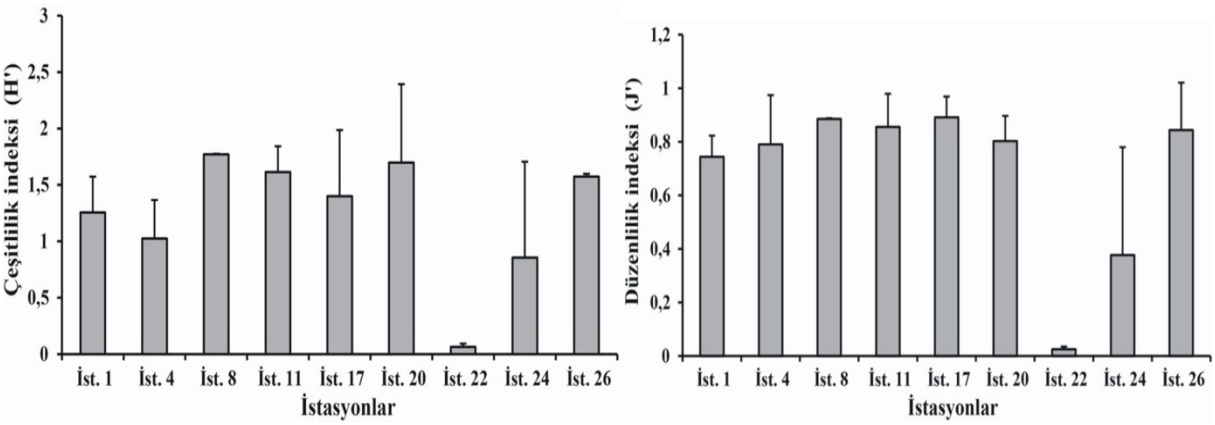


Şekil 2. 2008-2010 yılları arasında Ciliata tür sayısının istasyonlara ve mevsimlere göre dağılımları

Figure 2. Distribution of Ciliata species number in stations and seasons between 2008 and 2010.



Şekil 3. 2008-2010 yılları arasında Ciliata birey sayısının istasyonlara ve mevsimlere göre dağılımları
Figure 3. Distribution of Ciliata individual number in stations and seasons between 2008 and 2010.



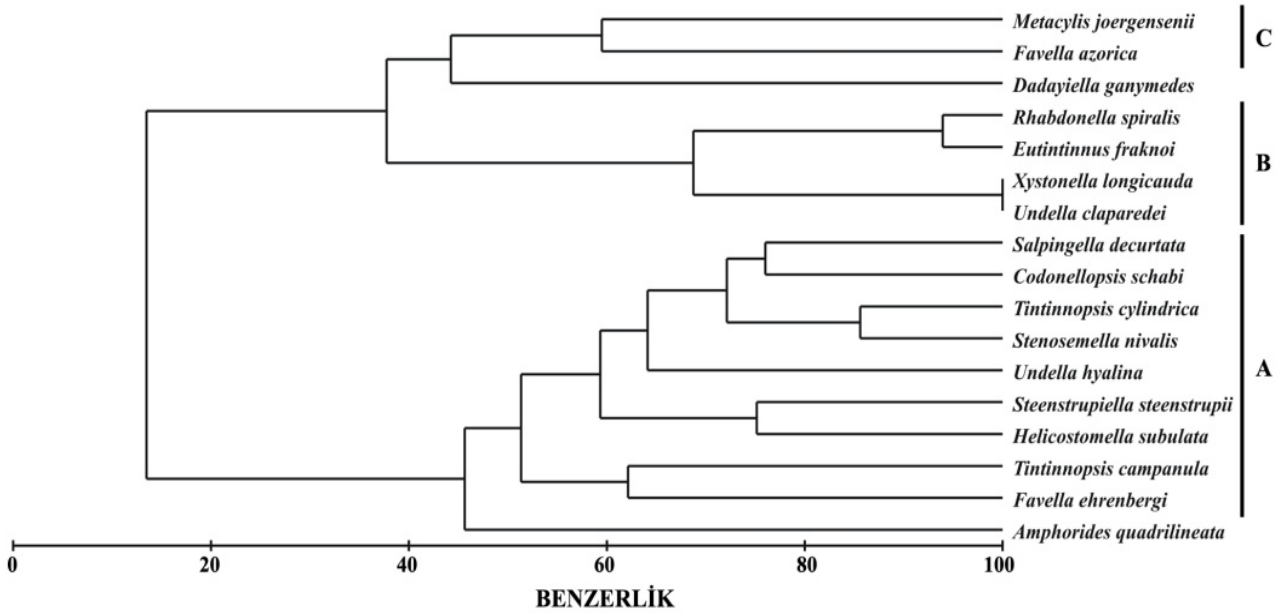
Şekil 4. 2008-2010 yılları arasında istasyonlara göre çeşitlilik ve düzenlilik indeks değişimleri (mean ±standart sapma)

Figure 4. The variations of species diversity and evenness indexes in stations between 2008 and 2010 (mean ±standard deviation)

Ciliata sınıfı kümelenme analizi sonuçlarına göre 3 grup saptanmıştır. A grubunda *C. schabi*, *Favella ehrenbergi* (Claparede et Lachmann) Jörgensen, *H. subulata*, *S. decurtata*, *S. steenstrupii*, *S. nivalis*, *Tintinnopsis campanula* (Ehrenberg) Daday, *T. cylindrica* ve *U. hyalina* kendi aralarında küme oluşturmuştur. B grubunda *Eutintinnus fraknoi* (Daday) Kofoid et Campbell, *Rhabdonella spiralis* (Fol) Brandt, *Undella claparedei* ve *Xystonella longicauda* (Brandt) Laackmann kendi aralarında küme oluşturmuş, C grubunda ise *Favella azorica* (Cleve) Jörgensen ve *Metacylis joergensenii* (Cleve) kendi içinde küme oluşturmuştur. *Amphorides quadrilineata* (Claparede et Lachmann) Strand ile *Dadayiella ganymedes* (Entz sen.) Kofoid et Campbell bu grupların dışında kalmıştır **(Şekil 5)**.

Yapılan araştırmada Ciliata sınıfına ait toplam 17 tür saptanmış olup, maksimum tür zenginliği 11 tür ile istasyon 1'de, minimum tür sayısı ise 6 tür ile istasyon 4 ve 8'de saptanmıştır. Yapılan kantitatif değerlendirmeler sonucunda istasyonlara bağlı olarak farklar açıkça belirlenmiş, en düşük hücre yoğunluğu Nisan 2009 döneminde 0.039×10^3 hücre lt^{-1} olarak belirlenmiş, en yüksek hücre yoğunluğuna Temmuz 2010 döneminde 152×10^3 hücre lt^{-1} ile ulaşmıştır. *H. subulata*, *S. decurtata* ve *S. steenstrupii* yüksek hücre konsantrasyonları ile dikkati çeken türlerdir. Saptanan tintinnidlerden *Helicostomella* cinsi yaygın olarak neritik sularda bulunduğu rapor edilmiştir

(Pierce ve Turner, 1993) ve bu genusa ait *H. subulata* türü özellikle ilkbahardan sonbahara kadar bol olarak saptandığı ve baskın olduğu dönemde diğer tintinnidler üzerinde çoğunlukla baskın olduğu rapor edilmiştir (Bojanić ve ark., 2006; ve ark., 2008). *H. subulata* kış döneminde muhtemelen kist formuna dönüşüp sedimente çökmesinden dolayı, bu dönemde neredeyse tamamen su kolonundan uzaklaşır (Paranjape, 1980). Araştırma dönemi boyunca *H. subulata* istasyon 22 ve 24'de aşırı üreme göstermiş ve en yüksek hücre yoğunluğuna Temmuz 2010 döneminde rastlanılmıştır. Pierce ve Turner (1993) tarafından yapılan çalışmada türlerin biocoğrafik dağılımlarına göre *Amphorides*, *Codonellopsis*, *Eutintinnus*, *Salpingella* ve *Steenstrupiella* kozmopolitan; *Rhabdonella* sıcak su türü ve *Favella*, *Metacylis* ve *Tintinnopsis* genusuna ait türler ise neritik olarak değerlendirilmektedir. Lee ve Kim (2010) tarafından yapılan çalışmada *Salpingella* genusuna ait türler oseanik tür olarak rapor edilmiştir. Ancak bu çalışmada *S. decurtata* Temmuz 2010 döneminde evsel ve endüstriyel atıksuların etkisi altında bulunan kıyı istasyonunda en yüksek yoğunluğa ulaşmıştır. *S. steenstrupii*' de istasyon bazında *S. decurtata* ile benzer şekilde dağılım göstermiştir ve en yüksek hücre yoğunluğuna aynı istasyonda ulaşmıştır.



Şekil 5. 2008-2010 yılları arasında Ciliata sınıfı hiyerarşik kümelenme analizi sonuçları

Figure 5. The results of hierarchical cluster analysis in Ciliata class between 2008 and 2010.

Tintinidler ve fitoplankton arasında negatif bir ilişkinin olduğu daha önceki yapılan çalışmalarda birçok kez rapor edilmiştir (Balkıs, 2004; Balkıs ve Toklu Alıçlı, 2009; Lee ve Kim, 2010). Ancak Kimor ve Golandsky (1977) ile Sorokin (1977) tarafından yapılan çalışmada, fitoplankton ve tintinnid bolluğu arasında güçlü pozitif korelasyon olduğu rapor edilmiştir. Balkıs (2004) yaptığı çalışmada tintinidlerin tür ve birey sayısının özellikle Ekim ve Kasım ayında arttığını ve buna paralel olarak fitoplankton bolluğunun düştüğünü rapor etmiştir. Mart ayında ise diyatom bolluğunun arttığı sırada tintinid bolluğunun azaldığını ifade etmiştir. İzmir Körfezi'nde yapılan bu çalışmada, tintinidlerin özellikle Temmuz 2010 döneminde ve kıyısal istasyonlarda en yüksek birey sayısına ulaşması dikkat çekmektedir. Çolak Sabancı ve Koray (2012) tarafından yapılan çalışmada dinoflagellat bolluğunun Nisan 2009 ve Temmuz 2009 döneminde maksimuma ulaştığı saptanmıştır. Yapılan çalışmada *P. triestinum* hemen hemen tüm istasyonlarda gözlenmekle beraber en yüksek hücre yoğunluğuna istasyon 24'ün 0.5 m'sinde; *Gonyaulax polygramma* Stein, *Gonyaulax spinifera* (Claparede & Lachmann) Diesing ve *Lingulodinium polyedrum* (Stein) Dodge türleri istasyon 22'nin 0.5 ve 5.0 m'sinde aşırı üreme göstermiş, her üç türde en yüksek hücre yoğunluğuna 5.0 m'de ulaşmıştır. DSP ile karakteristik olan *Dinophysis* ve *Prorocentrum* türleri tüm araştırma dönemi boyunca saptanmış, özellikle iç ve orta körfez istasyonlarında en yüksek hücre konsantrasyonlarına ulaş-

mışlardır. İzmir Körfezi'nde meydana gelen aşırı üremelerden sorumlu olan *Prorocentrum* türleri daha önceki çalışmalarda birçok kez rapor edilmiştir (Çolak Sabancı ve Koray 2001; 2005 ve 2011a). İzmir Körfezi'nde aşırı üremeler sırasında gözlemlenen diğer bir tür de *Noctiluca scintillans* (Macartney) Kofoid'dır. Ancak İzmir Körfesi'nde gerçekleştirilen çalışmalarda *N. scintillans* aşırı üremeleri artık dikkati çeker düzeyde oluşmamaktadır (Çolak Sabancı ve Koray 2005; 2011a). Bazı dinoflagelat türleri örneğin *Ceratium furca*, *Dinophysis caudata* Saville-Kent, *L. polyedrum*, *N. scintillans*, *Prorocentrum micans* Ehrenberg, *Prorocentrum lima* (Ehrenberg) Dodge, *Prorocentrum triestinium* Schiller ve *Scripsiella trochoidea* (Stein) Balech ex Loeblich III red-tide dan sorumlu olan türlerdir. Red-tide dünyanın pek çok tropik ve subtropik bölgelerinde olduğu gibi İzmir Körfezi'nde de izlenmektedir. Temmuz 2009 döneminde, Temmuz 2010 dönemine paralel olarak siliyat bolluğunun artması beklenirken, bu dönemde dinoflagellat bolluğunun artması, özellikle zehirli-zararlı mikroalglerin ortamda aşırı çoğalma göstermesi siliyat bolluğunu baskıladığını düşündürmektedir.

Aynı şekilde tintinnid bolluğu ile diyatom bolluğu arasında da negatif yönlü bir ilişki saptanmıştır. Çolak Sabancı ve Koray (2011b) tarafından yapılan çalışmada, en yüksek hücre yoğunluğu Şubat 2009 ve Şubat 2010 döneminde gözlenmiştir. 2009 döneminde; *Rhizosolenia setigera* Brightwell ve *Pseudo-nitzschia pungens* (Grunow ex. P.T. Cleve) Hasle, 2010 döneminde; *Skeletonema costatum* (Greville) Cleve baskınlığı nedeniyle sorumlu türlerdir. En yüksek hücre yoğunluğu istasyon 26'da saptanmış ve bunu istasyon 22 ve 24'ün izlediği rapor edilmiştir. Dinoflagellatlar kadar olmasa da diyatom bolluğunun da siliyat bolluğu ile negatif bir ilişkide olduğu görülmektedir.

Nanoflagellatların, Ciliata'ların başlıca besinini oluşturduğu çeşitli çalışmalarda çoğu kez rapor edilmiştir (Burkill ve ark., 1987; Dolan ve Coats, 1990; Paranjape, 1990; Sherr ve Sherr, 1994). Diyatomlar ve dinoflagellatların ortamda bulunmadığı zamanlarda nanoflagellatların ortamda bol bulunması, tintinidler ve fitoplankton arasındaki negatif korelasyonu açıklayabilir. Ancak bu çalışmada nanoflagellatlar ile ilgili elimizde herhangi bir data bulunmadığı için tintinid ile ilişkisi yorumlanamamıştır. Ayrıca denizel planktonda bol olarak bulunan miksotrofik ve hetetrofik dinoflagellatlar, fitoplankton ve bakteriler (Hansen, 1991; Bockstahler ve Coats, 1993a) üzerinde önemli tüketiciler olduğu bilinmekle beraber, aynı zamanda siliyatların da (Bockstahler ve Coats, 1993b) tüketicileridir. Miksotrofik dinoflagellatlardan *Ceratim* ve *Dinophysis* cinsleri; hetetrofiik dinoflagellatlardan *Noctiluca scintillans* ve *Protoperidinium* (*Protoperidinium depressum*, *P. divergens* ve *P. steinii*) cinsine ait türler tüm istasyonlarda ve mevsimlerde gözlenmekle beraber yüksek hücre konsantrasyonlarına ulaşmamışlardır (Çolak Sabancı ve Koray, 2012).

Bu araştırmanın sonucuna göre, en yüksek çeşitlilik indeks değeri Kasım 2008 döneminde 2.715 bits, en düşük çeşitlilik indeks değeri ise Nisan 2009 (0.594 bits) ve Temmuz 2010 döneminde (0.950 bits) olarak saptanmıştır. Kasım döneminde tür çeşitliliğinin fazla olması, türlerin düzgün dağılış sergilemesi ve düşük birey sayısı çeşitlilik indeks değerinin yükselmesine neden olmuştur. Nisan 2009 dönemi tür çeşitliliği bakımından en az tür ile temsil edilmekte (*H. subulata*, *S. decurtata* ve *S. nivalis*); Temmuz 2010 dönemi ise aşırı üremelerin gözlendiği dönem olarak saptanmıştır. Düşük çeşitlilik indeksi, genellikle tür zenginliğinin az olduğu yada baskın türlerin aşırı üreme gösterdiği sırada rapor edilmektedir (Coelho ve ark., 2007).

A. quadrilineata ile *D. ganymedes* türleri oseanik tür olarak rapor edilmiş (Lee ve Kim, 2010), MDS analizi sonuçlarına göre bu iki tür diğerlerinden farklı bir yapı sergilemiş ve tüm grupların dışında kalmıştır. *Salpingella* cinsine ait türler oseanik tür olarak (Lee ve Kim, 2010); *H. subulata* hem neritik (Pierce ve Turner, 1993) hem de soğuk su türü (Lee ve Kim, 2010) olarak rapor edilmiştir. Ancak yapılan çalışmada her iki türde (*S. decurtata* ve *H. subulata*) neritik bölgede, özellikle evsel ve endüstriyel atıksuların etkisi altında bulunan istasyonlarda saptanmış ve Temmuz 2010 döneminde en yüksek hücre yoğunluğuna ulaşmıştır.

SONUÇ

Yapılan çalışmada fitoplankton bolluğu ile tintinid bolluğu arasında negatif yönlü bir ilişkinin olduğu açıktır. İstasyonlarda fitoplankton bolluğunun arttığı dönemde tintinid bolluğunun daha düşük yada tam tersinin olduğu saptanmıştır. Bu da tintinid bolluğunun av ve avcı ilişkisi bakımından fitoplankton bolluğunu etkilemiş olabileceğini göstermektedir.

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FULL PAPER TAM MAKALE

ZOOPLANKTON COMPOSITION OF TOHMA STREAM (MALATYA - TURKEY)

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Abstract:

This study was completed with periodical surveys in Tohma Stream between April 2013- May 2014 period seasonally. During the study, a total of 32 species (22 belong to genus Rotifera, 8 to Cladocera and 2 Copepoda) were identified in Tohma Stream. During the study period, *Keratella cochlearis* (Rotifera), was found in every station in all seasons. Also, it was found that the most common family in the study was Brachionidae (8 species) from Rotifera. All of the zooplanktonic species have been detected for the first time in Tohma Stream.

Keywords: Rotifera, Cladocera, Copepoda, Tohma Stream, Turkey

Introduction

Zooplanktonic organisms are a very important step in the construction of modern aquatic food weebs. Zooplankton provides an important food source for larval fish and shrimps in natural waters and in aquaculture ponds. Zooplankton play a crucial role in aquatic food webs both in terms of biamass and energy fluxes by exploiting and recycling microscopic phytoplankton (Vannier et al., 2003). They produce massive quantities of nutrient-rich particles that constitute a permanent and exploitable resource for benthic communities. It is therefore important to include the state of these communities in any investigation on a river system, whether in ecological studies or risk assessment of pollutants (Butterfield, 2002).

In freshwater ecosystems, three groups of zooplankton, namely Rotifera, Cladocera, and Copepoda, have been reported (Berzins and Pejler, 1987). Some species have been reported as characteristic indicators of water quality and trophic level of lakes (Sladecek, 1983; Herzig, 1987; Saksena, 1987).

Many studies were carried out on zooplanktonic organisms in Turkey. Özdemir and Şen (1994), Göksu et al. (1997, 2005), Saler and Şen (2002), Ustaoğlu (2004), İpek and Saler (2008), Saler and İpek (2009), Bozkurt and Güven (2010), Saler et al. (2011a, b), İpek and Saler (2012) , Bozkurt and Akın (2012) were some of them.

Tohma Stream is an important water source, because it supplies the major portion of irrigation and fisheries needs in its province. Therefore, we carried out this study to explain the zooplankton fauna of Tohma Stream as no previous relevant data were available.

Materials and Methods

Tohma Stream is an important tributaries of Eupharate River and 107 km far away from Malatya city center (URL, 2014). Sampling was made seasonally between April 2013- May 2014 period from three stations which were defined to characterize whole Tohma Stream The coordinates of the stations were given in Table 1. Zooplankton samples were collected with a standart plankton net (Hydrobios Kiel, 25 cm diameter 55 µm mesh size) vertical and horizontal hauls and the specimens were preserved in 4% formaldehyde solution in plastic bottles. Zooplankton species were examined under Leitz inverted microscope. Relevant literatures as Edmondson (1959), Scourfield and Hardig (1966), Dussart (1969), Flössner (1972), Harding and Smith (1974), Kiefer (1978), Koste (1978 a, b), Dumont and De Ridder (1987), Reedy (1994) were used for the identification and classification of the species. Water temperature and dissolved oxygen were measured with Oxi 315i/SET oxygen meter and pH with Lamotte (pH 5-WC) pH meter in situ.

Table 1. Coordinates of the stations in Tohma

Stations	Locations
1	$38^0 33' 57.97'' N\ 37^0 29' 37.77'' E$
2	$38^0 33' 59.69'' N\ 37^0 29' 36.72'' E$
3	$38^0 34' 02.68'' N\ 37^0 29' 31.16'' E$

Results and Discussion

In Tohma Stream, 32 zooplankton species were identified, including 22 Rotifera, 8 Cladocera and 2 Copepoda groups. Based on the number of individual's rotifers were the dominant group in the stream (69.69%) followed by Cladocera (24.24%) and Copepoda (6.06%). Dominant Rotifera species was *Keratella cochlearis* followed by *Polyarthra dolichoptera* and *Filinia longiseta*. *Ceriodaphnia reticulata* was the dominant Cladocera species. *Cyclops vicinus* was the dominant Copepoda species. The seasonal distributions of species are given in Table 2.

There was a decrease in total zooplankton species richness in winter (21 species) (Table 2). The most taxa were observed in autumn (31 species) In spring and summer 30 species were recorded. According to the stations, the most number of species were recorded in the third station in spring with 25 species (18 belonging to Rotifera, 5 to Cladocera and 2 to Copepoda) and which the least were in the third station in winter with 6 species (4 belonging to Rotifera, 1 to Cladocera and 1 to Copepoda).

Temperature, dissolved oxygen and pH values of the Tohma Stream were recorded in the field and shown in the Table 3.

Zooplankton species are important indicators for aquatic habitats since most of them are used to determine the quality, the trophic level and level of population in lakes and streams. For example, species from Rotifera as *Keratella cochlearis* and *Polyarthra dolichoptera* are indicators of productive habitats, while *Notholca acuminata*

and *Notholca squamula* are indicators of cold waters (Kolisko, 1974). All of these species were detected in Tohma Stream. *K. cochlearis* and *P. dolichoptera* were observed in every seasons. *N. acuminata* and *N. squamula* were observed in cold seasons (autumn and winter). In lotic habitats, true plankters often predominate and fast growing rotifers are often dominant (Hynes, 1970). One of the fast growing rotifers, *K. cochlearis* was observed in every sampling period. Species richness of Rotifera was found quite high when compared to Cladocera and Copepoda in Turkish inland waters (Saler and İpek, 2009; Saler et al. 2011,a,b; Bozkurt and Güven 2010, Gaygusuz and Dorak, 2013). In this study 22 species were found to belong to Rotifera among 32 zooplankton species .

According to Stember and Gannon (1978), Rotifera forms an important part of biomass in eutrophic water systems. In Tohma Stream this data was supported with Rotifera species dominance in every seasons.

Table 2. Seasonal distribution of zooplankton in the stations of Tohma Stream

Seasons	Autumn			Winter			Spring			Summer		
Stations	1	2	3	1	2	3	1	2	3	1	2	3
SPECIES												
Rotifera												
Ascomorpha saltans Bartsch,1870	-	+	-	-	-	-	-	+	+	-	-	+
Asplanchna priodonta Gosse,1850	-	+	+	-	+	-	-	+	+	-	+	+
Brachionus angularis Gosse,1851	-	-	+	-	+	-	+	+	+	+	-	+
Brachionus quadridentatus Hermann, 1783	-	+	+	-	-	-	-	+	+	+	-	-
Cephalodella forficula (Ehrenberg, 1830)	+	+	-	-	-	-	+	+	-	-	+	-
Cephalodella gibba (Ehrenberg, 1830)	+	-	+	-	-	-	+	-	+	-	+	-
Colurella uncinata (Müller, 1773)	-	+	-	-	-	-	-	+	+	+	-	-
Euclanis dilatata Ehrenberg,1832	-	+	-	+	-	-	+	-	+	+	-	+
Epiphanes senta (Müller, 1773)	+	+	-	+	-	-	-	+	+	+	-	+
Filinia longiseta (Ehrenberg,1834)	+	+	+	+	-	-	+	+	+	+	+	+
Kellicottia longispina (Kellicott,1879)	+	-	-	+	-	-	+	+	+	+	+	+
Keratella cochlearis (Gosse,1851)	+	+	+	+	+	+	+	+	+	+	+	+
Keratella quadrata (Muller,1786)	+	-	-	-	-	-	+	-	+	+	-	-
Keratella valga (Ehrenberg, 1834)	+	-	+	-	-	+	+	+	+	-	+	+
Lepadella acuminata (Ehrenberg, 1834)	+	-	+	-	-	-	-	+	+	+	-	-
Lepadella patella (Müller, 1773)	-	+	+	-	+	-	+	+	+	-	-	+
Notholca acuminata (Ehrenberg, 1832)	+	-	+	+	+	+	-	-	-	-	-	-
Notholca squamula (Müller,1786)	+	-	-	-	+	+	-	-	-	-	-	-
Philodina roseola Ehrenberg,1832	-	+	+	-	-	-	+	+	+	-	+	+
Polyarthra dolichoptera Idelson, 1925	+	+	+	+	-	-	+	+	+	+	+	+
Pompholyx sulcata Hudson, 1885	-	+	+	+	-	-	+	-	+	-	+	+
Rotaria rotatoria (Pallas, 1766)	+	+	-	-	+	-	+	+	-	+	+	+
Cladocera												
Bosmina longirostris (Müller,1785)	-	+	+	-	-	-	+	+	-	+	-	+
Ceriodaphnia reticulata (Jurine,1820)	+	+	-	-	+	-	+	+	+	+	+	-
Coronatella rectangulata Sars,1861	-	+	+	-	+	-	+	-	+	-	-	+
Daphnia cucullata Sars,1862	-	-	-	+	-	-	-	+	-	-	+	-
Daphnia magna (Straus, 1820)	+	+	-	-	+	-	-	+	+	-	+	-
Disparalona rostrata (Koch,1841)	-	+	-	-	-	-	+	-	+	+	-	-
Leptodora kindtii (Focke, 1844)	+	-	+	+	-	+	-	-	-	-	+	+
Leydigia leydigi (Schoedler,1863)	-	-	+	-	-	-	+	-	+	+	-	-
Copepoda												
Acanthodiaptomus denticornis (Wierzejski, 1887)	+	-	+	-	+	-	+	+	+	+	-	+
Cyclops vicinus Uljanin, 1875	+	+	+	+	-	+	+	+	+	+	+	+

Table 3. Seasonal values of temperature, dissolved oxygen and pH recorded in Tohma Stream

Seasons	Autumn			Winter			Spring			Summer		
Stations	1	2	3	1	2	3	1	2	3	1	2	3
Parameters												
Temperature (ºC)	11.0	9.6	8.9	6.4	5.9	6.1	14.1	15.3	14.9	21.0	19.9	21.2
Dis. Oxygen(mg/L)	8.1	8.7	8.2	10.3	9.6	9.3	8.6	8.5	7.9	7.6	7.5	7.9
pH	7.6	7.4	7.2	7.9	8.1	7.9	8.3	8.5	8.1	7.9	8.0	7.7

All the recorded zooplankton species in the present study are widely distributed around the world. Also many of the recorded species are common in Turkey (Gündüz 1997, Ustaoğlu, 2004, Ustaoğlu et al, 2012).

Only 8 species of Cladocera were observed in stream. Among the identified species *Leydigia leydigi, Daphnia cucullata* and *Disparalona rostrata* were rarely found in the stream. *Ceriodaphnia reticulata*, *Coronatella rectangulata* and *Daphnia magna* were observed throughout all seasons. *Cyclops vicinus* and *Acanthodiaptomus denticornis* were the representatives of Copepods. Both species were recorded in all seasons.

The ecological features of the recorded species show that most of them are cosmopolitan and littoral inhabiting (Kolisko, 1974). Additionally, among the recorded species, *Bosmina longirostris* and *Cyclops vicinus, Polyarthra dolichoptera, Keratella cochlearis* are well known indicators of eutrophy (Ryding and Rast, 1989). Brachionus and Keratella species are inhabitants of moderately mesotrophic waters (Saksena 1987). In Tohma Stream *Keratella cochlearis* was observed in all seasons in every station. Studies in the literature revealed the fact that *Cyclops vicinus* is the indicator of eutrophic state, *Bosmina longirostris* and *Ceriodaphnia reticulata* are the indicators of oligotrophic-eutrophic waters (Makarewicz, 1993). *C. vicinus* and *C. reticulata* were recorded in the stream in all seasons.

Acharya, et al. (2005), were observed that with smaller body cladoceran like *Bosmina* were highly abundant in the rivers generally. In Tohma Stream *Bosmina longirostris* was recorded in every seasons except winter.

According to the results of this study, the frequency of occurrence of zooplanktonic species was showed an increase in autumn. The number of species in spring and summer, showed near values with the number of taxa in autumn. The zooplanktonic species seasonal diversities of some lotic systems as Haringet Stream, Seli Stream, Pülümür Stream, Asi River, Kürk Stream, Peri Stream and Görgüşan Stream were showed similarities with our findings (Özdemir and Şen, 1994; İpek and Saler, 2008; Saler et al., 2010; Bozkurt and Güven 2010, Saler et al., 2011a, b; İpek and Saler, 2012). In all of these streams number of zooplankton taxa were increased in spring and summer months and decreased in winter months.

Akbulut and Yıldız (2005), were observed 40 rotifera species in the 5 different localities from Euphrates River Basin, and *Brachionus* (6 species) *Lecane* (5 species) were the abundant genera and many of these species were same with Tohma stream zooplankton species. In Tohma Stream species from Brachionidae were recorded with 9 species.

Water temperature were changed between 5.9-21.2ºC, dissolved oxygen 7.5-10.3 mg/L, pH 7.2-8.5 (Table 3). These values were convenient for zooplankton life in aquatic habitats (Kolisko, 1974)

Conclusion

Zooplankton of Tohma Stream consist of Cladocera, Copepoda and Rotifera groups. Rotifers were dominant zooplanktonic group in Tohma Stream and represented with 22 species.

Rotifera has also showed higher diversity in all stations when compared to the other groups. No previous study was previously carried out on the zooplankton fauna of Tohma Stream. Present study, will be a base for further studies and acquirements of Turkey's lotic habitats biodiversity.

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SHORT COMMUNICATION **KISA MAKALE**

ASSESSMENT OF HEAVY METALS IN DIFFERENT BODY PARTS OF *Sarotherodon galillaeus* FROM ILO-IDIMU RIVER, OTA OGUN STATE, NIGERIA

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Abstract:

Ilo-Idimu River is a tropical zone lying between 60.47ºN of the equator and 20.33ºE, and 30.18ºE of the Greenwich meridian. The aim of this research is to determine the concentration of heavy metals in *Sarotherodon galilaeus*; a predominant fish species in Ilo-Idimu River, and its public health significance. Water samples were collected from the River at different locations and depth. Samples were also taken with the use of dissecting instruments from the scale, skin, flesh, gill, and gut of *S. galilaeus*. Atomic Absorption Spectrophotometer was used to determine the concentration of heavy metals in the water samples and various body parts of the fish. From the result obtained, the levels of heavy metals concentrations ranged between 0.00-3.14, 0.00-2.18, 0.52-3.08, 0.00-0.68 and 0.00-1.48 mg/kg in the gill, flesh, gut, skin and scale respectively. The highest level of heavy metals was recorded in the gill while the lowest was recorded in the skin. The concentration of each of the heavy metals was significantly different across body parts ($P<0.05$) except lead. Concentration of most of these heavy metals exceeded the maximum permissible limit. Our results indicated that there is inherent danger in consuming fishes from Ilo-Idimu river.

Keywords: *Sarotherodon galilaeus, assessment,* heavy metals, Ilo-Idimu River, Atomic Absorption Spectrophotometer

Introduction

Pollution of the aquatic environment is a serious and growing problem throughout the world. Increasing number and amount of industrial, agricultural and commercial chemicals discharged into the aquatic environment have led to various deleterious effects on the aquatic organisms, including fish. Heavy metals contamination of aquatic ecosystem has attracted the attention of several investigators in both the developed and developing countries of the world. The fact that heavy metals cannot be destroyed through biological degradation; their ability to accumulate in the environment make them deleterious to the aquatic environment and consequently, to man. Rivers represent the most complex aquatic systems in terms of transport and interactions of heavy metals with geochemical and biological processes. It was also observed that freshwater fish represent an important source of protein to human. Nevertheless, indiscriminate discharge of domestic, agricultural and industrial effluent into the water body limits its effective natural production and availability (Ogbuagu *et al,* 2005).

In a polluted environment, especially industrial area where effluent is being discharged regularly into the streams, from where it flows down to the river, there is a high possibility of heavy metal accumulation. Most of these metals are very poisonous and can have lethal effects on fish, other aquatic living resources and man when they find their way into the food chain. Some of these metals get into the river through metal scrapes, dissolved metals and their salts, loose enamel, glasses etc (Okonkwo and Eboatu, 1999). Examples of these heavy metals include mercury, cadmium (Cd), chromium (Cr), cobalt (Co), lead (Pb), zinc (Zn) etc. These metals can cause specific health problems. For instance, Cd causes kidney malfunctioning leading to hypertension (Okonkwo and Eboatu, 1999). Furthermore, exposure to Pb may result in human breast lesion (Siqddiqui *et al.,* 2006). Accumulation of higher concentration of heavy metals could predispose animals to illness (Harper *et al*., 1999). Therefore, there is a global call for research to determine the pollutant level, especially heavy metals in aquatic and terrestrial animals since people depend mainly on these animals as source of protein.

There have been previous works on investigation of heavy metals concentration in adjourning water bodies such as Badagry and Epe lagoons in Lagos, where Olowu *et al* (2010) had carried out several researches on determination of heavy metals in fish tissues, water, and sediments. But to the best of our knowledge, there has been no reported work in literature on investigation of heavy metal in Ilo-Idimu River.

This river is located in a low land, and by gravity effluent from the neighbouring industries and domestic sewage run down into it. The health hazard which the people in this community are exposed to, especially those who depend on the living aquatic resources from this river prompted this investigation on assessment of heavy metal concentration in *S. galilaeus*; a predominant fish species in Ilo-Idimu River, and its public health significance.

Materials and Methods

Study area

The study area is Ilo-Idimu river, Sango-Ota, Ogun State. The river is located in Ado-Odo/Ota Local Government Area. The area is a tropical zone lying between 60.47^{o}N of the equator and 20.33^{o}E, and 30.18^{o}E of the Greenwich meridian. The river is also at the boundary between Lagos and Ogun State, Nigeria.

Sampling

Samples of *S. galilaeus* were obtained from various locations at Ilo-Idimu river, Ota which covers different environmental conditions. The sampling locations include the upper region of the river, the middle and the lower region. However, this sampling was not intended to differentiate or compare fishes in each of these locations as regard heavy metals, rather this regional sampling was only done for the purpose of sampling only, because fish is a migratory animal. The weight of the fish samples ranged from 30.98-56.23 g, the standard length from 9.78-15.00 cm and the head length from 2.86-3.55 cm.

Determination of heavy metals

Fe, Zn, Cu and Pb were determined using AOAC (1990) method. Two grams (2 g) of each of the samples were heated in a muffle furnace at 600^{0}C until it changed to ash. Thirty millilitres (30ml) of 0.1M H_2SO_4 was used to digests the ash, and

the solution was made up to 100ml with de-ionized water and then filtered. The concentrations of these heavy metals in the scale, skin, flesh, gill and gut of *S. galilaeus* were measured by AAS; model 210 VGP at the Central Teaching and Research Laboratory of Bells University of Technology, Ota. The instrument setting and operational conditions were done in accordance with the manufacturers' specifications. Results were expressed in mg/kg dry weight for the body parts and mg/litre for the water samples.

Statistical analysis

The values of heavy metal concentration in water and fish samples were subject to a one-way analysis of variance (ANOVA) using SPSS 18.0 statistics for significance evaluation.

Results and Discussion

Table 1. shows the levels of heavy metals in the water and body parts (scale, skin, flesh, gill and gut) of *S. galilaeus* from Ilo-Idimu River. Heavy metals were found at various level of accumulation in the studied fish. The concentrations of heavy metal in water were measured in milligrams per litre while their concentrations in the fish samples were measured in milligram per kilogram.

Table 1. Mean concentration of heavy metals in the water and in different body parts of *S. galileaus* from Ilo-Idimu river, Ota

Heavy metals	Water (mg/L)	Gill (mg/kg)	Flesh (mg/kg)	Gut (mg/kg)	Skin (mg/kg)	Scale (mg/kg)
Zinc	0.24±0.01^{a}	0.35±0.02^{b}	0.53±0.02^{b}	0.52±0.01^{b}	0.57±0.01^{b}	0.94±0.02^{b}
Iron	1.05±0.57^{a}	3.14±0.01^{b}	0.64±0.01^{a}	3.07±0.02^{b}	0.64±0.03^{a}	0.94±0.02^{a}
Lead	1.08±0.32^{a}	0.00±0.00^{b}	0.00±0.00^{b}	0.68±0.01^{a}	0.00±0.00^{b}	0.00±0.00^{b}
Copper	0.25±0.04^{a}	1.71±0.03^{b}	2.28±0.01^{b}	1.22±0.01^{b}	0.64±0.02^{b}	1.69±0.01^{b}

Foot note:

- for water and each body part separately, mean ± S.D with superscript of the same alphabet shows no significant difference (P>0.05)
- for water and each body part separately, mean ± S.D. with superscript of different alphabet shows that there was significant difference (P<0.05)

Table 2. Recommended limit by National and International organisations on safety standard

	Water (mg/L)		Fish (mg/g)	
Metals	FDA	WHO	EPA	WHO
Pb	0.005	0.01	0.05	1.5
Zn	-	3.0	5.0	150
Cu	1.0	1-2	1.0	-
Fe	-	0.3	0.1	-

Source: WHO (1986); EPA and FDA (1976) as reported by Opanuwa *et al* (2012)

The level of heavy metal pollution in the water and their uptake by *S. galilaeus*; a predominant fish species in Ilo-Idimu river was determined in this study. According to the result obtained, the levels of heavy metals ranged between 0.00-3.14, 0.00-2.18, 0.52-3.08, 0.00-0.68 and 0.00-1.48 mg/kg in the gill, flesh, gut, skin and scale respectively. This result shows that the highest level of heavy metals was recorded in the gill (0.00-3.14 mg/kg) while the lowest was recorded in the skin (0.00-0.68 mg/kg) (Table 1.). All the body parts revealed varied levels of significance difference for each of the heavy metals concentration at $P<0.05$ except lead. There is a marked ($P<0.05$) difference in the concentration of all heavy metals between water and gut samples except lead ($P>0.05$). Similar result was observed in the scale and flesh ($P<0.05$) except for iron which does not reveal any significant difference in each case. The concentration of heavy metal in the gill also revealed a high significance ($P<0.05$) difference when compared with water. In the skin sample of the studied fish, the difference is highly significant ($P<0.05$) when compared with water sample except iron ($P>0.05$).

The concentration of most of the heavy metals that were analysed in the fish body parts were beyond the maximum permissible limit recommended by international organization on safety standard (Table 2.) except in the skin where Cu was within the recommended dose by Environmental Protection Agency (EPA). Also, the concentration of Zn in the fish body parts was below the maximum limit by EPA and World Health Organization (WHO). Lead was present only in the gut and is beyond the maximum permissible limit by EPA whereas it is within the recommended limit by WHO. The water sample also depicts a high concentration beyond the permissible limit for Fe and Pb as recommended by WHO. The corresponding concentrations of Cu and that of Zn in the water were within the acceptable limit by Food and Drug Administration (FDA) and WHO.

However, the high accumulation of Cu and Fe in the gill and gut may be due to the fact that gills serve as the respiratory organ in fishes through which metal ions were absorbed. This result corroborates the previous report by Bebianno *et al* (2004). Gill is in direct contact with the contaminated medium (water) and due to its very thin epithelium, it can easily receive heavy metals during filtration of water (Etuk and Mbonu, 1999). The high concentrations of Fe, Cu, and Pb in the gut may also be due to the fact that gut is the primary channel through which food substances get into the body of the fish. This result is similar to what Khaled (2004) observed in different fish species from El Max Bay Alexandria. Furthermore, high concentrations of some of the metals were found in the intestine because intestine is part of the viscera muscles which concentrates toxic metals (Kemdrin, 1979). The high accumulation of Fe in the gill of the studied fish is similar to what Mohammad (2008), Robinson and Avenant-Oldewage (2006) and Uysal *et al* (2008) obtained in *Oreochromis niloticus*, *Oreochromis mossambicus* and *Liza aurata* respectively. In a study reported by Christopher *et al* (2009) on the distribution of Pb, Zn, Cd, As and Hg in bones, gills, livers and muscles (flesh) of Tilapia (*O. niloticus*) from Henshaw town beach market in Calabar, his results showed that the muscle and gill of Tilapia harbour the least concentrations of heavy metals, Zn and Pb inclusive.

Olowu *et al* (2010) also recorded a low concentration of Zn in Tilapia and Catfish from two fish stations in Lagos and concluded that both fish species may be considered safe for consumption, but the need for continuous monitoring to prevent bioaccumulation is necessary.

Conclusion

This study shows that fish takes up and bio-accumulates heavy metals in various quantities depending on their concentrations in the water and the route they pass in to the body such as the gill and gastro intestinal tract. This agrees with the results of Oluyemi *et al* (2008) and Kemdrin (1979) who reported on the level of heavy metals in aquatic organism from different water bodies. Their results showed that aquatic animals (fish inclusive) bio-accumulate heavy metals in a considerable amount, and because these metals are not bio-degradable, they tend to stay in the fish tissues for a very long time which upon consumption of these fishes, the heavy metals get transferred to man, leading to heavy metal poisoning especially if present in higher concentrations.

Finally, since the concentration of most of these heavy metals in the studied fish and water are more than the recommended limit most especially Cu, Fe and Pb, the people in this area

should be discouraged from consuming this fish species until its safety is ascertained.

Based on the findings during this study, the following recommendations are suggested.

- The Government, through Ministry of Environment, should enforce a regulation that will ensure that effluent or sewage were properly treated before being discharge into the river, and this must be strictly adhered to by all industries and establishment concerned.
- The government should undertake effective and regular monitoring of this aquatic environment. This will helps to improve the quality of water and fishes in this river.
- Further research should be carried out on Heavy metal concentration in the body parts of other fish species in this river.

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