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Aşağı Sakarya nehri balıkçılarının sosyo-ekonomik analizi

İsmail Reis, Hasan Cerim, Celal Ateş

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ÖZ

Bu araştırmada, Aşağı Sakarya Nehri balıkçılarının sosyo-ekonomik yapısı incelenmiştir. Bu çalışma, Haziran 2017 - Mayıs 2018 tarihleri arasında yürütülmüştür. Elde edilen sonuçlara göre avcılıkta kullanılan teknelerin boyları 3.0-5.0 metre arasında değişiklik göstermekte ve %71.0'lik oran ile de 3.6-4.0 metre boy uzunluğundaki tekneler çoğunluğu oluşturmaktadır. Balıkçı teknelerinin %91,3'lük kısmı ahşap malzemeden yapılmıştır. Balıkçı yaşlarının 36-64 arasında değiştiği, %42'sinin 50-59 yaşları arasında olduğu tespit edilmiştir. Aşağı Sakarya Nehri'ndeki balıkçıların eğitim durumları incelendiğinde %91.3'ünün ilköğretim ve %8.7'sinin lise mezunu olduğu tespit edilmiştir. Aşağı Sakarya Nehri'ndeki balıkçıların %65.2'si çiftçilikle uğraşmakta iken %21.7'sinin emekli olduğu belirlenmiştir. Balıkçıların mesleği seçme nedenleri arasında ilk sırada %59.4'lük oranla aile bütçesine katkı gelmektedir. Sonuç olarak Türkiye nehirleri balıkçılığı araştırılarak bir yönetim modeli oluşturulmalıdır.

Anahtar Kelimeler: Sakarya Nehri, Sosyo-ekonomik yapı, Balıkçı profili

ABSTRACT

Socio-economic analysis of fishermen in the lower Sakarya River

In this study, it was investigated that the socio-economic structure of fishermen in the Lower Sakarya River. This study was conducted between June 2017 - May 2018. According to the results, the length of the boats used in fishing varies between 3.0-5.0 meters and the majority (with a ratio of 71.0%) of the boats with a length of 3.6-4.0 meters. 91.3% of the fishing boats are made of wooden. The age of fishermen ranged between 36-64 and 42% of fisherman were between 50-59. When the educational status of the fishermen in the Lower Sakarya River is examined, it was found that 91.3% of them are primary and 8.7% are high school graduates. In the Lower Sakarya River, 65.2% of the fishermen are engaged in farming, while 21.7% are retired. "Contribution to the family budget" was the first reason with a ratio of 59.4% of the fishermen why they choose the profession. As a result, Turkish rivers fishing should be investigated and a management model should be established.

Keywords: Sakarya River, Sosyo-economic structure, Fisherman profile

Giriş

Nehirler ve doğal göller dünyamızın önemli ekosistemleridir ve dünya yüzeyinin yaklaşık olarak % 2.5'luk kısmını kapsamaktadır (Shiklomanov, 1999). Türkiye dünya üzerindeki jeopolitik konumu itibariyle önemli su kaynaklarına sahiptir. Bu su kaynaklarından bir tanesi de Karadeniz'e dökülen Türkiye'nin en uzun üçüncü akarsuyu olan Sakarya Nehri'dir. Sakarya Nehri Eskişehir'in Çifteler ilçesinden doğar Sakarya'nın Karasu ilçesinden Karadeniz'e dökülür. Nehrin uzunluğu 824 km genişliği ise 60–150 m arasında değişmektedir. Sakarya Nehri havzası (58 bin km^2) Türkiye'nin yüzey alanının (783 bin km^2) yaklaşık % 7'sini kaplamaktadır. Sakarya Nehri'nin önemli yan kolları başta Porsuk ve Ankara Çayı olmak üzere Seydisuyu, Çarksuyu, Karasu Deresi, Kirmir Çayı, Göynük Çayı, Mudurnu Çayı ve Göksu'dur (Şengörür ve İsa, 2001). Sakarya Nehri *Siluris glanis*, *Esox lucius*, *Perca fluviatilis* ve *Cyprinus carpio* gibi ekonomik ve ekolojik öneme sahip bir çok balık türüne ev sahipliği yapmaktadır (Ölmez, 1992; Kahraman ve diğ., 2014; Reis ve diğ., 2019).

1980'lerden itibaren tüm dünyada deniz balıklarının stoklarında azalmalar gözlemlenmektedir (WWF, 2013). Bu durum su ürünleri sektörünü balık yetiştiriciliği ve iç su balıklarının avcılığına yöneltmiştir. Buna bağlı olarak da iç su balıklarının avcılığında kullanılan av araçlarının özellikleri, kullanılan teknelerin yapısı, balıkçıların sayısı ve avlanan balıkların ekonomik değerinin belirlenmesi önem arz etmektedir.

Ülkemizde içsularda göl balıkçıları ile ilgili yapılan bir çok sosyo-ekonomik çalışma mevcuttur (Soylu ve Uzmanoğlu, 2004; Ergüden ve diğ., 2007; Dartay ve diğ., 2009; Doğan, 2009; Yiğit ve diğ., 2009; Özer ve diğ., 2010; Uzmanoğlu ve Soylu, 2012; Mete ve Yüksel, 2014; Cesur ve diğ., 2014; Yılmaz ve Pulatsü, 2019). Sosyo-ekonomik önemine rağmen Türkiye nehir havzalarının neredeyse tamamında balıkçılık üzerine araştırma olmaması balıkçılık yönetimini zorlaştırmaktadır. Bu çalışma Sakarya Nehri balıkçılarının sosyo-ekonomik analizi ile ilgili yapılan ilk araştırmadır.

Yapılan bu araştırma ile Aşağı Sakarya Nehri balıkçıları ile ilgili sosyo-ekonomik konularda veri eksikliğini gidermek, çalışma yapılmayan diğer nehirler için örnek teşkil etmek ve karşılaştırma materyali oluşturarak literatüre katkı sağlamak amaçlanmıştır. Ayrıca, elde edilen veriler doğrultusunda bölge balıkçılarının gelirlerinin, av araç-gereçlerinin ve mevcut durumlarının iyileştirilmesine olumlu yönde katkı sağlayacağı düşünülmektedir.

Materyal ve Metot

Bu çalışma, Haziran 2017 - Mayıs 2018 tarihleri arasında Sakarya Nehri'nin Sakarya ili sınırları içerisinde kalan 159.5 km'lik bölümünde (Pamukova'nın güneyinde Mekece ve Karadeniz'e bırakıldığı Karasu Yenimahalle) yapılmıştır (Şekil 1). Araştırma bölgesine 9 kez gidilerek devamlı olarak avcılık yapan 69 adet balıkçıya 18 soruluk bir anket uygulanmıştır. Balıkçılarla yüz yüze görüşülerek, hazırlanan anket soruları sorulmuş ve cevapları kaydedilmiştir. Balıkçılara sorulan anket soruları; balıkçıların yaşı, öğrenim düzeyi, sosyal güvenlik durumları, meslek tecrübeleri, mesleği seçme nedenleri, kullandıkları av araçlarının özellikleri ve çalışma koşulları ile ilgilidir. Yapılan anket sonucunda elde edilen veriler analiz edilerek tablolar halinde verilmiştir.

Şekil 1. Çalışma sahası

Bulgular ve Tartışma

Bulgular çalışmanın amacı doğrultusunda av araçlarının fiziksel ve teknik özellikleri, balıkçıların sosyo-ekonomik yapıları ve balıkçılık faaliyetinin ekonomik yapısı gibi üç ayrı aşamada değerlendirilmiştir.

Av Araçlarının Teknik ve Fiziksel Özellikleri ile Av Süreleri

Balıkçıların kullandıkları av araçlarının teknik ve fiziksel özellikleri balıkçıların verdiği bilgiler doğrultusunda incelenmiştir. Balıkçıların av esnasında kullandıkları av araçlarının fiziksel özellikleri ve miktarları ile avlanma süreleri (Tablo 1)'de verilmiştir. Avcılıkta kullanılan teknelerin boyları 3.0-5.0 metre arasında değişiklik göstermekte ve % 71.0'lik oran ile de 3.6-4.0 metre boy uzunluğundaki tekneler çoğunluğu oluşturmaktadır. Teknelerin %91,3'lük kısmı ahşap malzemeden yapılmıştır.

Yeni Karpuzlu Baraj Gölü'nde yapılan bir çalışmada balıkçıların kullandıkları teknelerin %54.55'inin 5.0-5.99 m boyundaki teknelerden oluştuğu bildirilmiştir (Uzmanoğlu ve Soylu, 2012). Avan, 2007 yılında Manyas Gölü'nde yapmış olduğu bir çalışmada balıkçı teknelerinin boylarının genellikle 4.0 m ile 8.5 m arasında değiştiğini ve 8 m boyunda olan teknelerin % 38 oranı ile ilk sırayı aldığını bildirmiştir. Sakarya ili göllerinden Poyrazlar Gölü'nde kullanılan teknelerin boylarının 3.0-4.0 m arasında değiştiği ve Büyük Akgöl Gölü'nde 4,0 m boyunda olduğu bildirilmiştir (Yiğit ve diğ., 2009). Araştırmamızın sonuçlarına göre Sakarya ili göllerinde kullanılan teknelerin boyları çalışmamızda tespit edilen teknelerin boyları ile benzerlik gösterirken diğer göllerde kullanılanlar ile farklılık göstermektedir. Bu durumu bölgesel avcılık yöntemlerinden kaynaklanan farklılıklar olarak açıklayabileceğimiz gibi nehirde manevra kabiliyetini arttırmak için daha küçük boylu teknelerin tercih edilmesi olarak da açıklayabiliriz.

Aşağı Sakarya Nehri'nde balıkçılık pinter ağı ve uzatma ağları ile yapılmaktadır. Aşağı Sakarya Nehri'nde avcılık meteorolojik şartlara bağlı olarak yıl boyunca devam etmektedir. Balıkçılıkta av sürelerinin 150 ile 270 gün arasında değiştiği ve % 36.2 ile en yüksek oranda 240 gün üzeri olduğu saptanmıştır.

Yiğit ve diğ., 2009 yılında Sakarya ili göllerinde yapmış oldukları çalışmada balıkçıların pinter ağı, uzatma ağı ve olta ile av sezonu boyunca balık avladıklarını bildirmiştirler. Kenya nehirlerinde yapılan bir araştırmada balık avcılığında dalyan, sepet ve ağlar ile avcılık yapıldığı bildirilmiştir (Whitehead, 1958). Bölgede ve diğer bölgelerde yapılan çalışmalar nehir ve göllerdeki balık avcılığı metotlarının benzer olduğunu göstermektedir.

Balıkçıların Sosyo-Ekonomik Özellikleri

Yapılan araştırma sonucunda Aşağı Sakarya Nehri'nde balıkçılık faaliyeti ile uğraşan 250-300 kişi olduğu tespit edilmiş ancak sorulara olumlu yanıt veren 69 balıkçı değerlendirmeye alınıp analiz edilmiştir. Balıkçıların demografik ve sosyo-ekonomik özellikleri Tablo 2'de verilmiştir. Balıkçı yaşlarının 36-64 arasında değiştiği, %42'sinin 50-59 yaşları arasında olduğu tespit edilmiştir.

Soylu ve Uzmanoğlu, 2003 yılında Terkos Gölü'nde yapmış oldukları çalışmada toplam 22 balıkçının olduğunu bildirmiştir. 2007 yılında Seyhan Baraj Gölü'nde yapılan diğer bir çalışmada bölgede 33 balıkçının gölden avlandığı belirtilmiştir (Ergüden ve diğ., 2007). Yeni Karpuzlu Baraj Gölündeki balıkçıların yaşlarının 20 ile 59 (Uzmanoğlu ve Soylu, 2012), Manyas Gölü'nde 26 ile 72 (Avan, 2007), Keban Baraj Gölünde % 64.52'si 30-50 (Dartay ve diğ., 2009), Sakarya ili göllerinden Taşkısığı Gölü'nde 49, Poyrazlar Gölü'nde 38 ile 68 ve Büyük Akgöl Gölü'nde 29 ile 75 (Yiğit ve diğ., 2009) yaşları arasında değiştiği bildirilmiştir. Yapılan başka bir araştırmada Eski Brahmaputra Nehri'nde profesyonel balıkçıların yaş ortalamasının 43 olduğu bildirilmiştir (Ahmed ve diğ., 2013).

Aşağı Sakarya Nehri'ndeki balıkçıların eğitim durumları incelendiğinde % 91.3'ünün ilköğretim ve % 8.7'sinin lise mezunu olduğu tespit edilmiştir. Aşağı Sakarya Nehri'ndeki balıkçıların %65.2'si çiftçilikle uğraşmakta iken %21.7'sinin emekli olduğu belirlenmiştir. Balıkçıların mesleği seçme nedenleri arasında ilk sırada %59.4'lük oranla aile bütçesine katkı gelmektedir.

Ahmed ve diğ., (2013), Eski Brahmaputra Nehri'nde yapmış oldukları araştırmada profesyonel balıkçıların yalnızca %10'unun okuryazar olduğunu, Usman ve Ifabiyi, (2012), yapmış oldukları çalışmada Niger nehri balıkçılarının %30'unun ilkokul mezunu olduğunu bildirmiştirler. Ülkemizde balıkçıların eğitim durumları ile ilgili yapılan birçok araştırma balıkçıların eğitim düzeylerinin oldukça düşük olduğunu göstermektedir (Uzmanoğlu ve Soylu, 2012; Dartay ve diğ., 2009; Yiğit ve diğ., 2009; Ergüden ve diğ., 2007; Avan, 2007). Yeni Karpuzlu Baraj Gölü balıkçılarının % 90,91 inin balıkçılığın yanı sıra çiftçilik de yaptığı (Uzmanoğlu ve Soylu, 2012), Manyas Gölü balıkçıları içerisinde hem balıkçılık hem de çiftçilik yapanların oranının % 36.44, hayvancılık yapıp balıkçılıkla uğraşanların oranının % 4.23, emekli olup aynı zamanda balıkçılıkla geçimini sağlayanların oranının % 1.69 olduğu (Avan, 2007) bildirilmiştir.

Tablo 1. Kullanılan av araçlarının fiziksel özellikleri ve miktarları

Tekne Özellikleri	Adet	Yüzde (%)
Boyu (Metre)		
3.0-3.5	14	20.3
3.6-4.0	49	71.0
4.1-5.0	6	8.7
Tekne Yapım Malzemesi		
Ahşap	63	91.3
Fiberglas	4	5.8
Şişme bot	2	2.9
Av Aracı Miktarı		
Pinter (Adet)		
1-5	3	4.3
6-10	16	23.2
11-15	34	49.3
16-20	7	10.1
≥ 20	9	13.0
Uzatma Ağı (Metre)		
50-100	27	39.1
101-200	33	47.8
201-300	7	10.1
≥ 300	2	2.9
Yıllık Av Süresi (Gün)		
150	9	13.0
180	14	20.3
210	21	30.4
≥ 240	25	36.2

Tablo 2. Balıkçıların demografik ve sosyo-ekonomik özellikleri

Yaş Grupları	Adet	Yüzde (%)
30-39	2	2.9
40-49	21	30.4
50-59	29	42.0
≥ 60	17	24.6
Statüsü		
Sigortalı işçi	2	2.9
Bağ-kur	7	10.1
Emekli	15	21.7
Çiftçi	45	65.2
Eğitim Durumları		
İlköğretim	63	91.3
Lise	6	8.7
Balıkçılığı Seçme Nedeni		
Aile bütçesine katkı	41	59.4
Baba mesleği	3	4.3
Hobi	13	18.8
Nehir kenarında ikamet	12	17.4
Meslek Tecrübeleri (Yıl)		
1-10	2	2.9
11-20	19	27.5
21-30	34	49.3
31-40	14	20.3

Balıkçılık Faaliyetinin Ekonomik Analizi

Balıkçıların av esnasında yakaladıkları günlük balık miktarları 3-25 kg arasında değişiklik göstermektedir. Bölgede avcılığı yapılan yayın (*Silurus glanis*) balığının kilosunun 15-20 TL, turna (*Esox lucius*) balığının kilosunun 10-15 TL, tatlı su levreğinin (*Perca fluviatilis*) kilosunun 10-15 TL ve sazan, kızılkanat, tahta balığı ve çapak gibi sazangillerin (Cyprinidae) kilosunun 5-10 TL arasında değişen fiyatlarda satıldığı tespit edilmiştir. Av araçlarından teknelerin sermayesi 1000-1500 TL, pinterlerin sermayesi 500-1500 TL, ağların da özelliklerine göre 300 TL ile 2500 TL arasında değiştiği tespit edilmiştir. Balıkçılık sezonu içerisinde balıkçıların giderlerinin tamamını av malzemesi ve tekne bakım giderleri oluşturmaktadır. İşçi çalıştırmadıkları için işçi masrafı yoktur. Kumanyalarını kendileri sağlamaktadırlar. Bölgede kullanılan tüm tekneler insan gücü (kürek) ile hareket ettirildiğinden yakıt gideri yoktur.

Sonuç

4/1 Numaralı Ticari Amaçlı Su Ürünleri Avcılığının Düzenlenmesi Hakkında Tebliğ'de Türkiye akarsularında ticari amaçlı su ürünleri avcılığının yasak olduğu belirtilmesine rağmen Aşağı Sakarya Nehri'nde azımsanmayacak miktarlarda balık avcılığı yapıldığı tespit edilmiştir. Bu veriler ışığında ülkemizde bulunan diğer akarsu ve nehirlerde de bu faaliyetlerin yapıldığı düşünülmekte ve bölge balıkçıları tarafından da ifade edilmektedir. Bu durum Türkiye nehirleri balıkçılığının araştırılıp gerekli düzenlemelerin yapılması ihtiyacını ortaya çıkarmıştır.

Sonuç olarak, Aşağı Sakarya Nehri ekolojik ve ekonomik açıdan Türkiye'nin en önemli nehir havzalarından bir tanesidir. Balıkçılık baskısı, çevresel kirlenmeler gibi faaliyetlerin yoğun olarak yaşandığı Aşağı Sakarya Nehri'nden elde edilen faydanın devamlılık arz etmesi için sürdürülebilir balıkçılık yönetimi politikaları geliştirilerek ivedilikle uygulanması gerekmektedir.

Etik Standart ile Uyumluluk

Çıkar çatışması: Yazarlar herhangi bir çıkar çatışmasının olmadığını beyan eder.

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Kaynaklar

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Length-weight relationships and condition factors of Mochokidae (Pisces: Teleostei: Siluriformes) from Niger River, Northern Benin

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ABSTRACT

In the Niger River in Benin, the fishes of Mochokidae family are of high commercial and economic importance. The current study investigated size structures, length-weight relationships and condition factors of these catfishes in order to evaluate their plumpness. Mochokids were sampled monthly from February 2015 to July 2016 with traps, seine and gillnet. Overall, the fish species showed unimodal, bimodal and tri-modal standard-length distributions. Length-weight models displayed allometric coefficients (b) varying between 2.236 and 3.380, indicating positive and negative allometric growth with correlation coefficients (r) ranging between 0.87 and 0.99. Condition factors were moderate to low and varied from K= 0.409 for *Synodontis frontosus* to K= 7.276 for *Synodontis sorex* that showed a higher value K= 31.13 in aquatic vegetation. Major threats were the use of chemical fertilizers and pesticides for adjacent agriculture, the retrieval of water for agriculture and domestic uses, the invasion of floating plants, the introduction of exotic fish species and overfishing. These data constitute valuable fisheries documentation that will contribute to conservation, valorization and sustainable exploitation of Mochokid fishes in Niger River in Benin.

Keywords: Allometric growth, Conservation, *Synodontis schall*, Sustainable exploitation

Introduction

Length-weight relationship (LWR) and condition factor (K) have been widely used by aquatic biologists and fisheries managers to assess fisheries ecology, population dynamics and fish stocks in natural aquatic ecosystems and in semi-controlled aquatic mediums (Ricker, 1968). In addition, the « ecological health » and productivity level of aquatic ecosystems can be evaluated through length-weight models and condition factors (Deekae and Abowei, 2010) that are also powerful tools to assess growth patterns and the wellbeing of fishes (Muchlisin *et al*., 2010; Ndiaye *et al.,* 2015). In general, the growth of fishes could be negative allometric, positive allometric or isometric. Negative allometric growth with slopes $b<3$ implies that the fish becomes more slender as it increases in weight while positive allometric with slopes $b>3$ indicates that the fish become more rotund as length increases (Deekae and Abowei, 2010). In isometric growth ($b=3$), there is no change in body shape as the fish grows (Deekae and Abowei, 2010; Khristenko *et al.,* 2017).

The condition factors indicate the degree of plumpness of fish in their habitat and stand as a measure of various ecological and biological factors such as season, water quality parameters, food availabilities, stress, toxicity and gonadal development (Mac Gregoer, 1959). Condition factor is a useful index to assess the status of the fishes and can be used to monitor aquatic ecosystems (Oni *et al.,* 1983). In general, the fish shows a better condition or wellbeing when a higher value of the condition indices is recorded (Khallaf *et al.,* 2003).

In the Niger River in Northern Benin, recent fisheries surveys by Arame *et al.* (2019) revealed fourteen demersal Mochokid fish species that accounted for about 10.80% of the artisanal catches (Koba, 2005). In the fish community of Niger River, Mochokids are considered as one of the most abundant fish of high economic and commercial importance and thus, these fishes are intensively exploited by sedentary and migrant fishermen for sales and subsistence. However, in Benin, this regional running water is under strong anthropogenic pressures that caused severe threats to fish biodiversity. These degradation factors included the use of chemical fertilizers and pesticides in adjacent agricultures, the discharges of household wastes, the introduction of exotic species, the use of detrimental fishing gears and the lack of regulatory texts and management schemes. In the region, these ecosystem disturbances have caused habitat fragmentations and losses, spawning ground destructions, changes in fish community structure, and depletion of fish stocks (Hauber, 2011; Arame *et al.,* 2019).

Notwithstanding their high fisheries importance and the multiple habitat disturbances and threats to the fish fauna, nothing is known about the growth structure and the wellbeing of Mochokids in this regional riverine water. In particular, length-weight relationships and condition factors of this these fishes have not been investigated.

The current study was aimed at evaluating length-weight relationship (LWR) and condition factor (K*)* of dominant Mochokid fishes living in the Niger River in Northern Benin in order to provide a broader understanding of their plumpness and wellbeing.

Material and Methods

Study Area

The study region is the Benin part of the Niger River around Malanville municipality (North-Benin) that covered about 3.016 km². Malanville is located between 11°52'05″ North latitude and 3°22′59″ East longitude with a mean altitude reaching 200 m. The Niger River serves as a frontier between Benin and Niger Republic, a neighbor country. Malanville and surroundings exhibit a Sudano-Sahelian climate characterized by a dry season (November-April) and a rainy season (May-October). A dominant wind called Harmattan blows in all directions from November to January with temperatures ranging between 16 and 25°C (Adjovi, 2006). In Benin, the Niger River shows three tributaries, Mékrou, Sota and Alibori that caused severe inundations which at peak flood extended on about 275 km^2 (Adjovi, 2006), thus, creating a wetland that served as reproduction grounds for the fish community (Welcomme, 1985; Moritz *et al.,* 2006; Adite *et al.,* 2017). Malanville showed gneissic and gravelly soils whereas the Niger River valley and its tributaries exhibited sandy-clayish and ferruginous soils. Plant communities were dominated by grassy savanna. The river comprised floating and submerged plants that degraded the water quality. Artisanal fisheries involving many ethnic groups were highly developed on Niger River and constituted traditional activities that occurred on the river channel as well as on floodplains, pools and marshes (Hauber, 2011 ; Arame *et al.,* 2019; Adjibade *et al.,* 2019).

Mochokid Fish Collections

Sampling stations: For this study, four stations (Figure 1) were selected on the Niger River for the fish samplings (Arame *et al.,* 2019). Site 1 (Tounga village) is located at 11°52'216"N, 3°23'907"E. This site is highly degraded because of anthropogenic disturbances. Site 2 is located behind the "Dry Port" at 11°52'216"N, 3°23'907"E and is also degraded due to the construction of the dry port. Site 3 (Money village) is situated at 11°52'987"N, 3°20'819"E and is less degraded. Also less degraded, Site 4 (Gaya village) is situated at Niger Country side at 11°52'675"N, 3°25'329"E. Unlike Site 1 and Site 2 were artisanal fisheries were moderate, fishing activities were very developed at Site 3 and Site 4.

Fish sampling: Fish samplings were performed monthly from February 2015 to July 2016. On each sampling site, two habitats (aquatic vegetation and open water) were chosen. Traps, seines and experimental gillnets were used for the samplings that follow Adite *et al.* (2013).

In addition, fish were sampled from fishermen captures based on fish abundances. One third of each fishermen capture was sampled and uncommon species were systematically included in the sample (Okpeicha, 2011). All individuals were retained for the sample when the catch amount is less than 50 for a given species (Kakpo, 2011; Okpeicha, 2011). Mochokids were then identified *in situ* using identification references such as Van Thielen *et al.* (1987), Levêque and Paugy (2006). After identification, lengths (total length, standard length) of individual were measured to the nearest 0.1 cm using a measuring board and the weight (W) was measured to the nearest 0.01g using an electronic scale (CAMRY) (Arame *et al.,* 2019). As recommended by Murphy and Willis (1996), identified fishes were preserved in 10% formalin and transported to “Laboratoire d’Ecologie et de Management des Ecosystèmes Aquatiques (LEMEA)” of the Faculty of Sciences and Technics, University of Abomey-Calavi. In the laboratory, fish individuals were transferred into ethanol to facilitate biological observations.

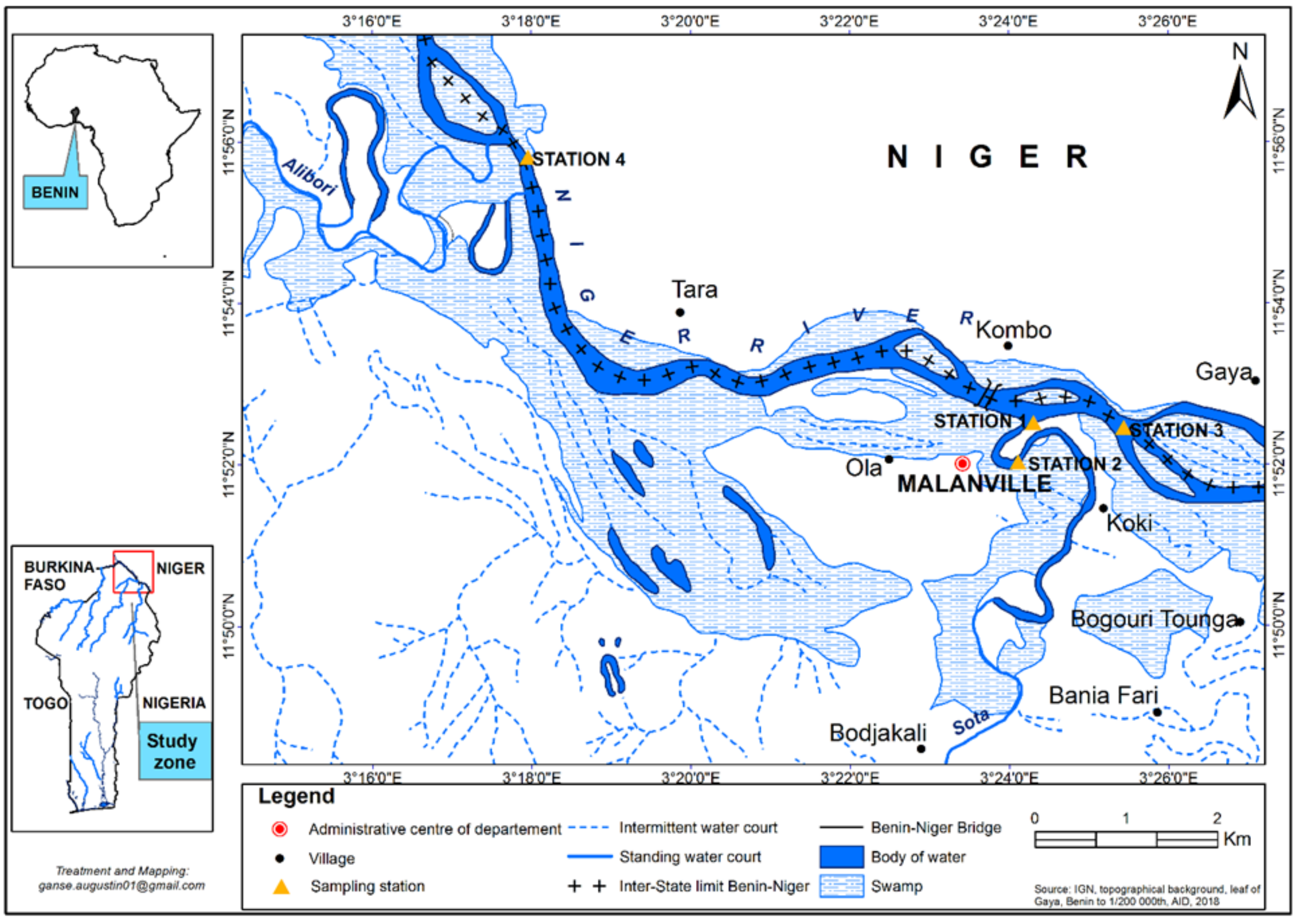


Figure 1. Study region (Malanville town and Niger River) and sampling stations**:** Station 1 = Tounga, Station 2 = Behind dry port, Station 3 = Gaya and Station 4 = Money

Data Analysis

Length-weight relationships of each Mochokid species were examined using the model below:

$W = a L^b$ (Le Cren, 1951) and its log-linear form is:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

where L = Fish total length, W = weight, *a* = intercept, *b* = slope (Le Cren, 1951). The allometry coefficient (slope) "*b*" was compared with *b* =3 using t-test (Sokal and Rohlf, 1995), which was performed using SPSS Software version 21 (Morgan *et al.,* 2001). Length-weight relationships and size structure were established for species with sample size ≥ 20 individuals. Size structures were established through frequency histograms of standard-length intervals of each species. The wellbeing of each Mochokid was evaluated using Bagenal and Tesch, 1978 condition factor:

$$K = \frac{W}{L^b} \times 100$$

where, K is the condition factor, W is the total weight (g) and L the total length (cm).

Results and Discussion

Size Structures

A total of 4240 individuals of Mochokids were sampled in the Benin part of the Niger River including individuals from Gaya. Mochokid numerical abundances varied with species and ranged between 23 individuals for *Synodontis frontosus* and *Synodontis courteti* and 3159 individuals for the dominant species, *Synodontis schall*. With regards to sizes, standard length (SL) of Mochokid assemblages ranged between 4.5 cm (*Synodontis schall*) and 25 cm (*Synodontis membranaceus*) (Table 1). Species with large size individuals were *Synodontis membranaceus* exhibiting SL varying between 5.0-25.0 cm, *Synodontis courteti* (SL: 12.0-21.0 cm), *Synodontis budjetti* (SL: 10.9-21.0 cm), *Synodontis schall* (SL: 4.5-20 cm), *Synodontis sorex* (SL: 7.0-20.0 cm), *Synodontis clarias* (SL: 8.5-19.5 cm), *Synodontis violaceus* (SL: 8.0-17.5 cm) and *Synodontis melanopterus* (SL: 6.0-18.5 cm). Medium-sized species included *Synodontis macrophthalmus* (7.5-15.0 cm), *Synodontis ocellifer* (7.5-14.5 cm), *Synodontis filamentosus* (SL: 6.5-14.0 cm) and *Synodontis frontosus* (10.0-13.0 cm) and small Mochokids were *Synodontis nigrita* a (6.0-10.5 cm) and *Synodontis nigrita* b (7.0-9.5 cm) (Table 1).

Seven species, *Synodontis schall*, *Synodontis membranaceus*, *Synodontis nigrita* a, *Synodontis clarias*, *Synodontis sorex*, *Synodontis melanopterus* and *Synodontis filamentosus*, showed unimodal distributions. In contrast, species such as *Synodontis violaceus* showed bimodal size distributions (Figure 2(a-h)). Dominant species, *Synodontis schall*, *Synodontis clarias* and *Synodontis membranaceus* from the three major habitats (open water, aquatic vegetation, traditional fishpond "Whedo") showed significant variations ($P < 0 .01$) of standard length across habitats. Indeed, calculated *F* values along with degrees of freedom and *p* values were $F_{2,\ 3156} = 19.64$ with $P = 0.001$ for *Synodontis schall*; $F_{2,\ 69} = 4.01$ with $P = 0.001$ for *Synodontis clarias* and $F_{2,709} = 4.64$ with $P = 0.001$ for *Synodontis membranaceus*.

Length-Weight Relationship (LWRs)

Allometric coefficients (*b*), intercept (*a*), correlation coefficients, growth trends and *p*-values of length-weight equations of the Mochokids inventoried are summarized in Table 1. Overall, allometric coefficients (*b*) were relatively high and ranged between 2.2588 and 3.0859 for *Synodontis sorex* and *Synodontis clarias*, respectively (Table 1 Figure 3: (a-h)). Seven species, *Synodontis schall*, *Synodontis membranaceus*, *Synodontis nigrita* a, *Synodontis sorex*, *Synodontis melanopterus*, *Synodontis violaceus* and *Synodontis filamentosus*, showed significant negative allometric growth ($b < 3$; $P < 0.05$). In contrast, one specie, *Synodontis clarias*, exhibited significant positive allometric growth ($b > 3$; $P < 0.05$) (Table 1).

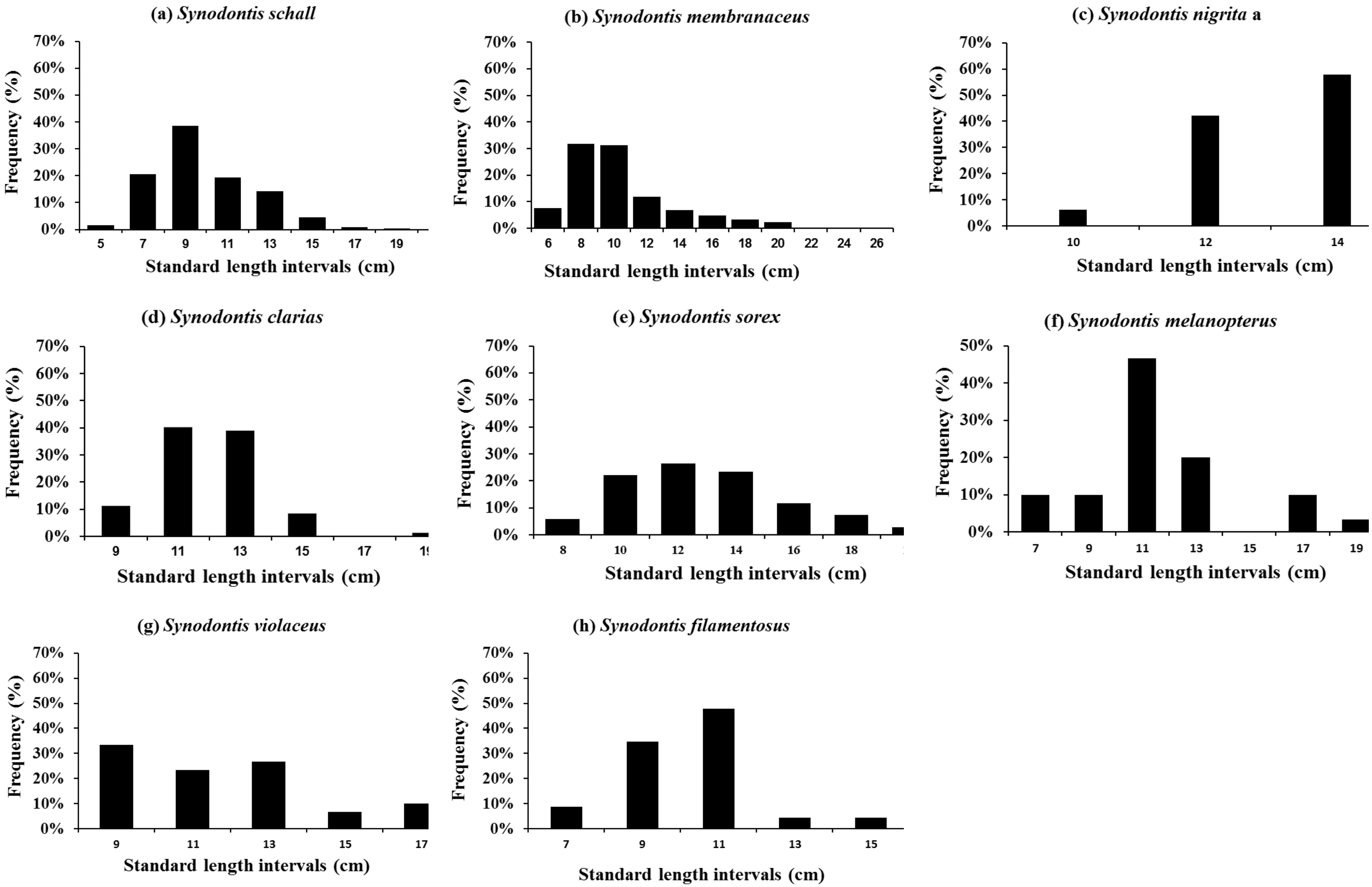
Seasonally, allometric coefficients (*b*) varied between 2.4843 (*Synodontis schall*) and 3.0261 (*Synodontis clarias*) for the dry season, and between 2.4842 (*Synodontis schall*) and 3.3907 (*Synodontis clarias*) during the wet season. Inversely, the flood period showed a slope (*b*) ranging between 2.3234 for *Synodontis membranaceus* and 2.6205 for *Synodontis schall* (Table 2).

Spatially, *b* value ranged from 2.2439 (*Synodontis sorex*) to 3.1458 (*Synodontis clarias*) in the open water habitat, but this value was reduced in the aquatic vegetation habitat where it ranged between 2.5047 (*Synodontis membranaceus*) and 2.6191 (*Synodontis schall*). In the traditional fish pond (''Whedo'') *b* varied between 2.7995 (*Synodontis membranaceus*) and 2.911 (*Synodontis schall*) (Table 3). Overall, the distribution of *b* values of Mochokids in the Niger River followed a normal distribution (Ryan-Joiner normality test: $P > 0.05$) (Figure 4).

Table 1. Length-weight regression equations* of Mochokid fishes collected from February 2015 to July 2016 in Niger River in Northern Benin. N: Species abundance; a: Regression equation intercept; b: Regression equation slope, r^2: Coefficient of determination.

Species	N	**Standard Length (cm)**		**Weight (g)**		**Length-Weight Relationships**				
		Min	Max	Min	Max	a	b	r^2	Growth	*P*-value (t-test)
Synodontis schall	3159	4.5	20.0	34.0	237.5	0.027	2.6327	0.929	A-	*P* = 0.001
Synodontis membranaceus	712	5.0	25.0	4.5	451.3	0.024	2.6974	0.947	A-	*P* = 0.001
Synodontis nigrita a	95	4.5	10.5	3.2	44.3	0.020	2.9033	0.854	A-	*P* = 0.001
Synodontis clarias	72	8.5	19.5	15.3	178.3	0.008	3.0859	0.927	A+	*P* = 0.001
Synodontis sorex	68	7.0	10.0	7.5	176.5	0.062	2.2588	0.847	A-	*P* = 0.001
Synodontis melanopterus	30	6.0	18.5	6.5	108.0	0.0423	2.4805	0.961	A-	*P* = 0.001
Synodontis violaceus	30	8.0	17.5	11.1	22.5	0.016	2.8306	0.937	A-	*P* = 0.001
Synodontis filamentosus	23	6.5	14.0	5.2	48.4	0.014	2.7966	0.954	A-	*P* = 0.001
Synodontis ocellifer	15	7.5	14.5	11.2	83.7	-	-	-	-	-
Synodontis macrophthalmus	14	7.5	15.0	11.2	105.3	-	-	-	-	-
Synodontis budjetti	10	10.9	21.0	32.5	237.6	-	-	-	-	-
Synodontis nigrita b	6	7.0	9.5	10.0	27.0	-	-	-	-	-
Synodontis courteti	3	12.0	21.0	29.8	221.3	-	-	-	-	-
Synodontis frontosus	3	10.0	13.0	23.3	74.3	-	-	-	-	-

* Length-weight regression equations were performed only for species with sample size ≥ 20
A-: Negative allometric growth
A+: Positive allometric growth



* Size structure were performed only for species with sample size ≥ 20

Figure 2(a-h). Size structures of Mochokidae fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

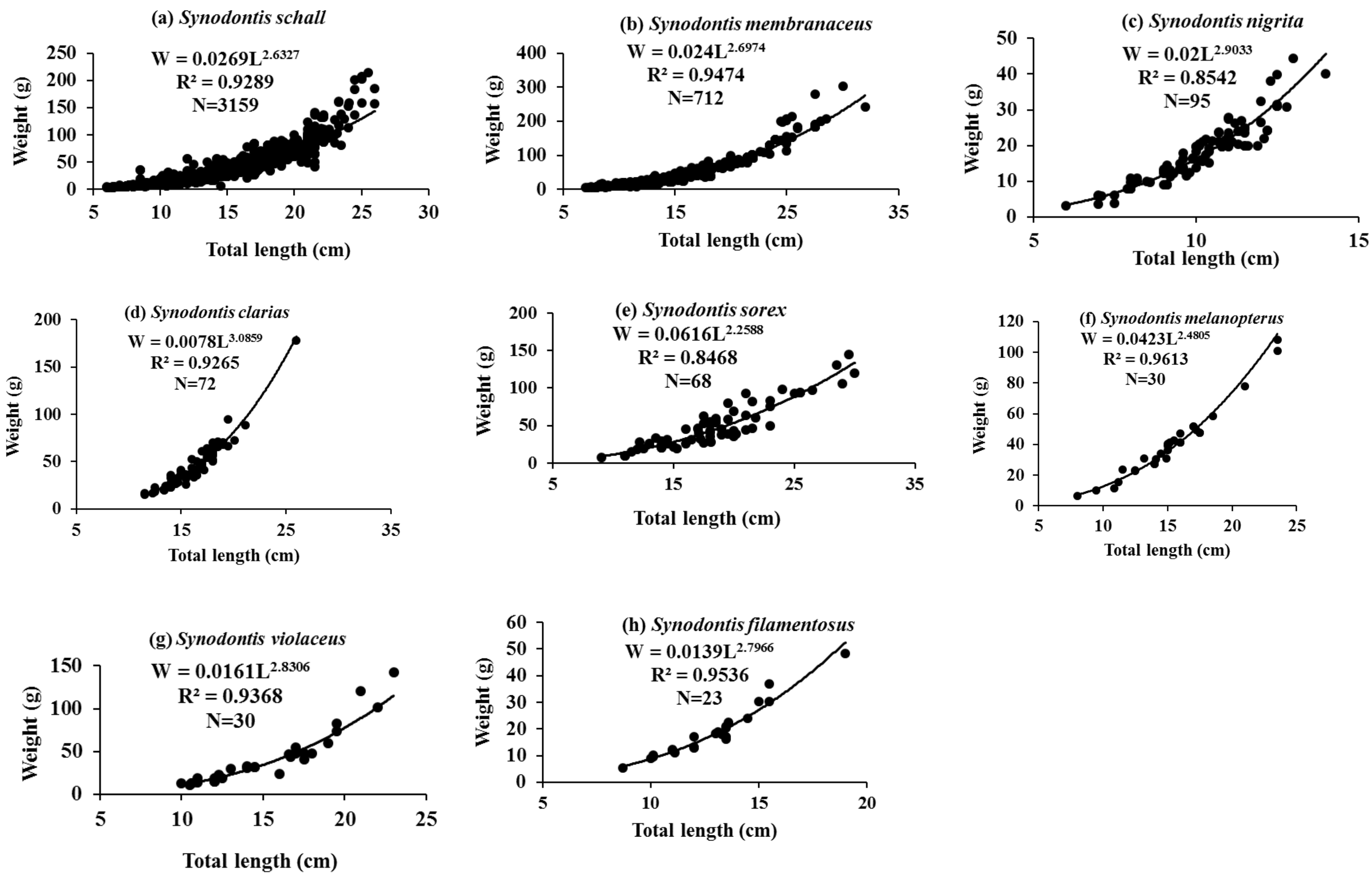


Figure 3(**a-h**). Curvilinear relationships between total length (L) and body weight (W) of Mochokidae fishes collected in Niger River in Northern Benin from February 2015 to July 2016

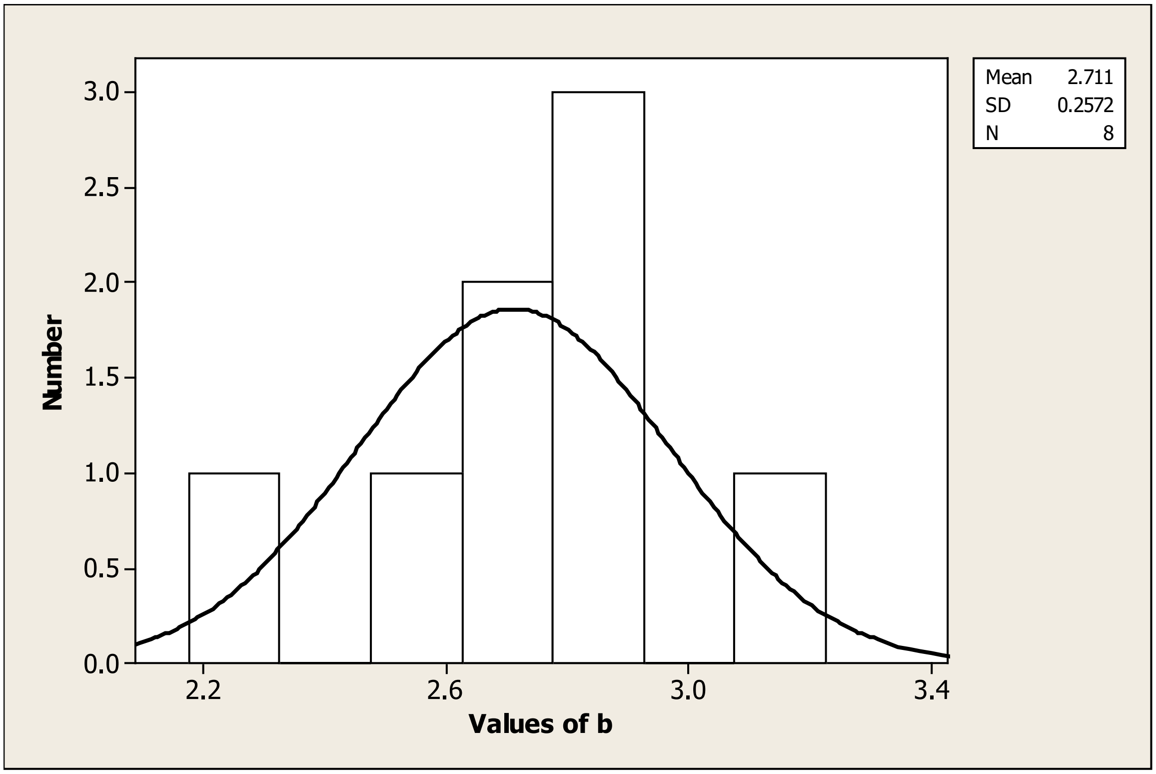


Figure 4. Distribution of slope (b) value of Mochokid fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

Condition Factors

In this study, the condition factors of Mochokidae fishes significantly (P<0.05) varied with species. *Synodontis sorex* exhibited the highest condition value (K = 7.276) whereas the lowest condition value (K = 0.790) was recorded for *Synodontis clarias* (Table 4). Except *Synodontis melanopterus,* all the species showed significant (P<0.05) seasonal variations of the condition factors (Table 5). Overall, during the dry season, *Synodontis sorex* showed the highest mean K = 8.25 ±3.36 whereas the lowest mean K= 0.94 ±0.12 was recorded in *Synodontis clarias*. In contrast, *Synodontis clarias* exhibited the highest K = 5.52 ±1.22 during the wet season with *Synodontis membranaceus* showing the lowest condition factor K= 1.98 ±0.26. In the flood season, K were relatively reduced and ranged between 3.05 ±0.61 for *Synodontis schall* and 5.94 ±0.97 for *Synodontis membranaceus.* Spatially, condition factors significantly (P < 0.05) varied with the different habitats and the highest value (K = 7.18 ±2.98) recorded in the open water for *Synodontis sorex*, whereas the lowest value (K = 0.67 ± 0.08) was recorded in the open water for *Synodontis clarias* (Table 6).

Overall, the results showed high length size variabilities within species assemblages and between populations (Figure 2, Table1). In this study, the maximum standard length (SL = 20 cm) recorded for the dominant species (*Synodontis schall*) is similar to that reported by Sidi Imorou *et al*. (2019) in Okpara Stream (SL = 20.3 cm) in Northern-Benin. However, the current findings for *Synodontis schall* were lower than the value reported by Konan *et al.* (2007) in the Coastal Rivers (SL = 22.5 cm) in South-Eastern of Ivory Coast and by Hazoume *et al.* (2017) in the Sô River (SL = 24.3 cm) in Southern Benin. In contrast, the maximum standard length for *Synodontis melanopterus* (SL = 18.5 cm) and *Synodontis macrophtalmus* (SL = 15.0 cm) were higher than the values reported by Sidi Imorou *et al.* (2019) in Okpara Stream (SL = 14.2 cm, SL = 12.4 cm, respectively).

However, the current records for *Synodontis nigrita* a (SL = 10.5 cm) and *Synodontis budjetti* (SL = 21.0 cm) were lower than the values reported by Sidi Imorou *et al.* (2019) in Okpara Stream, SL= 14.5 cm and SL = 23.0 cm, respectively. Likewise, the maximum SL of *Synodontis filamentosus* (SL = 14.0 cm), *Synodontis ocellifer* (SL = 14.5 cm) and *Synodontis sorex* (SL = 10 cm) recorded in the Niger River in Benin were lower than the values reported by Entsua-Mensah *et al.* (1995), SL = 19.0 cm, SL = 16.2 cm, SL = 21.6 cm, respectively in the Volta River in Ghana. These differences in Mochokid sizes were the results of different habitat conditions, mainly water quality, food availability, high fishing pressure, and levels of environmental degradations (king, 1991, 1996; Hart, 2007; Sidi Imorou *et al.,* 2019).

With regards to length-weight patterns, the current research indicated that allometric coefficients (*b*) varied between 2.2588 for *Synodontis sorex* and 3.0859 for *Synodontis clarias* along with significant ($P<0.05$) correlation coefficients (*r*) ranging between 0.84 and 0.92. These results agreed with those recorded ($2<b<4$) by Hazoume *et al.* (2017) and Sidi Imorou *et al.* (2019) respectively in the Sô river and in Okpara stream from Benin freshwater fishes. In general, the results revealed that most Mochokids (7/8) exhibited negative allometric growth with slopes (*b*) less than 3, indicating that the fish becomes less rotund as they increase in weight (Deekae and Abowei, 2010). These negative growth trends could be attributed to the multiple degradation factors such as the proliferation of invasive floating plants, dumping of domestic wastes, overfishing, introduction of invasive exotic fishes, uses of chemical fertilizers and pesticides in agriculture occurring in Niger River. Also, several other factors such as season, habitat, gonad maturity, sex and diet could have contributed to this negative growth patterns. For the dominant species, *Synodontis schall*, similar negative growth trends were reported by Laleye (2006) in the Oueme River and by Sidi Imorou *et al.,* (2019) in Okpara stream. Likewise, negative allometric growth were reported by Lawson (2013) in the Ugudu creek for *Synodontis ocellifer*, by Laleye (2006) in the Oueme River and by Hazoume (2017) in the Sô River for *Synodontis nigrita*. In contrast with our findings, *Synodontis schall* showed positive allometric growth in the Coastal Rivers of Ivory Coast (Konan, 2007) and both Mochokids, *Synodontis sorex* and *Synodontis ocellifer* exhibited an isometric growth in the Volta River in Ghana (Entsua-Mensah,1995).

Table 2. Length-weight regression equations by seasons of Mochokid fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

	DRY				WET				FLOOD			
Species	a	b	r	Growth	a	b	r	Growth	a	b	r	Growth
Synodontis schall	0.0399	2.4843	0.9405	A^{**}-	0.0399	2.4842	0.9405	A^{**}-	0.086	2.6205	0.9542	A^{**}-
Synodontis membranaceus	0.0162	2.8466	0.9380	A^{**}-	0.0197	2.7673	0.9803	A^{**}-	0.0588	2.3234	0.9441	A^{**}-
Synodontis nigrita a	0.0294	2.7245	0.9277	A^{**}-	-	-	-	-	0.0547	2.4922	0.8310	A^{**}-
Synodontis clarias	0.0093	3.0261	0.9599	A^{**}+	0.0032	3.3907	0.9747	A^{**}+	-	-	-	-
Synodontis sorex	0.0777	2.1924	0.8680	A^{**}-	-	-	-	-	-	-	-	-
Synodontis melanopterus	0.0474	2.4378	0.9715	A^{**}-	-	-	-	-	-	-	-	-

** $P < 0.001$
A-: Negative allometric growth
A+: Positive allometric growth

Table 3. Length-weight regression equations by habitat of Mochokid fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

	Open water				Aquatic vegetation				'Whedo"			
Species	a	b	r	Growth	a	b	r	Growth	a	b	r	Growth
Synodontis schall	0.0267	2.6324	0.9612	A^{**}-	0.0291	2.6191	0.9747	A^{**}-	0.0153	2.911	0.9851	A^{**}-
Synodontis membranaceus	0.0245	2.6887	0.9754	A^{**}-	0.0412	2.5047	0.8293	A^{**}-	0.0226	2.7995	0.9139	A^{**}-
Synodontis nigrita a	0.0190	2.9158	0.9281	A^{**}-	0.0464	2.5769	0.9051	A^{**}-	-	-	-	-
Synodontis clarias	0.0066	3.1458	0.9646	A^{**}+	-	-	-	-	-	-	-	-
Synodontis sorex	0.0673	2.2439	0.8708	A^{**}-	-	-	-	-	-	-	-	-
Synodontis melanopterus	0.0423	2.4805	0.9805	A^{**}-	-	-	-	-	-	-	-	-
Synodontis violaceus	0.0161	2.8306	0.9679	A^{**}-	-	-	-	-	-	-	-	-
Synodontis filamentosus	0.0139	2.7966	0.9765	A^{**}-	-	-	-	-	-	-	-	-

** $P < 0.001$
A-: Negative allometric growth
A+: Positive allometric growth

Table 4. Condition factors (K) of Mochokid fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

Species	Abundances	Condition factors (K)
Synodontis schall	3159	2.732
Synodontis membranaceus	712	2.438
Synodontis nigrita a	95	2.099
Synodontis clarias	72	0.790
Synodontis sorex	68	7.276
Synodontis melanopterus	30	4.267
Synodontis violaceus	30	1.633
Synodontis filamentosus	23	1.402

Table 5. Seasonal variations of condition factors (K±SD) of Mochokid fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

	Dry	Wet	Flood	*P*-value
Species	K±SD			
Synodontis schall	4.09 ±1.10^{c}	4.00 ±0.37^{b}	3.05 ±0.61^{a}	*P* = 0.001
Synodontis membranaceus	1.65 ±0.30^{a}	1.98 ±0.26^{b}	5.94 ±0.97^{c}	*P* = 0.001
Synodontis nigrita a	3.00 ±0.57^{b}	-	5.54 ±0.88^{c}	*P* = 0.001
Synodontis clarias	0.94 ±0.12^{a}	5.52 ±1.22^{b}	-	*P* = 0.001
Synodontis sorex	8.25 ±3.36^{b}	-	-	*P* = 0.001
Synodontis melanopterus	4.77 ±0.51	-	-	*P* = 0.059

Table 6. Spatial variation of condition factors (K±SD) of Mochokid fishes collected in Niger River in Northern Benin from February 2015 to July 2016 in open water, aquatic vegetation and "Whedo".

	Open water	Aquatic vegetation	''Whedo"	*P*-value
Species	K±SD			
Synodontis schall	2.72 ±0.56^{b}	2.96 ±0.56^{c}	1.54 ±0.10^{a}	*P* = 0.001
Synodontis membranaceus	2.48 ±0.44^{a}	4.18 ±0.63^{b}	2.27 ±0.17^{a}	*P* = 0.001
Synodontis nigrita a	1.93 ±0.34^{a}	4.7 ±0.71b	-	*P* = 0.001
Synodontis violaceus	1.48 ±0.26	-	-	*P* = 0.001
Synodontis filamentosus	1.40 ±0.15	-	-	*P* = 0.001
Synodontis sorex	7.18 ±2.98^{a}	-	-	*P* = 0.001
Synodontis clarias	0.67 ±0.08^{a}	-	-	*P* = 0.001

Nevertheless, in this survey, one (1) species, *Synodontis clarias,* showed positive allometric growth patterns along with slopes $b>3$, indicating that the fish became more rotund as total length increased (Deekae and Abowei, 2010). Probably, *Synodontis clarias*, showed high tolerance to habitat disturbances, and therefore, was indifferent to critical habitat conditions.

In the Niger River, condition factors (K) of Mochokids significantly ($P<0.05$) varied with species and ranged between 0.790 and 7.276. Species such as *Synodontis sorex*, *Synodontis melanopterus*, *Synodontis schall*, *Synodontis membranaceus* and *Synodontis nigrita* a showed high to moderate K between 2.1-7.3 probably because of their tolerance to ecosystem disturbances and changes in habitat conditions. Inversely, relatively reduced K varying between 0.790 and 1.633 were recorded for *Synodontis violaceus, Synodontis filamentosus* and *Synodontis clarias* that likely exhibited low tolerance to habitat degradation. In this survey, the condition factors recorded for the dominant species, *Synodontis schall*, were lower than those reported by Sidi Imorou *et al.* (2019) in the Okpara stream and by Akombo (2014) in the Benue River in Nigeria.

Seasonally, *Synodontis schall* showed a relatively good condition during dry, wet and flood periods, *Synodontis nigrita* a performed well during dry and flood periods and *Synodontis* *violaceus* displayed a good wellbeing during wet and flood seasons. *Synodontis sorex* performed well only during dry periods*, Synodontis clarias* showed a good condition only during the wet seasons and *Synodontis membranaceus* exhibited a high condition factor only during flooding. Differential tolerance to abiotic factors, stage of development, spawning cycle and habitat variability in relation with the species could act to affect the plumpness of each Mochokid in Niger River. For example, though *Synodontis sorex* performed well in open water habitat with mean K = 7.18 ±2.98, the highest value was recorded in aquatic vegetation where K peaked at 31.13 ±7.08. Finally, *Synodontis schall* and *Synodontis membranaceus*, two (2) indifferent Mochokids, performed well in both habitats.

Conclusion

The current fisheries research provides useful information for Mochokids management in the degrading Niger River. These catfishes showed a unimodal, bimodal and tri-modal size distributions in this riverine water. Among the eight dominant Mochokids discussed, seven (7) exhibited negative allometric growth while only one species, *Synodontis clarias,* showed positive allometric growth, indicating a weak wellbeing of the fishes. Condition factors were moderate and varied according to season and habitat types. These findings will serve both as reference data for follow-up and as documentation for a management scheme of Mochokidae fishes in Niger River.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: This study was conducted in accordance with ethics committee procedures of animal experiments.

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Marmara Denizi biyoçeşitliliği ve Derinsu pembe karidesi av miktarı

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ÖZ

Bu çalışmada Marmara Denizi'nin biyoçeşitliliği ve Derinsu Pembe Karidesi av miktarları belirlenmiştir. Örneklemeler Ekim 2011-Temmuz 2014 tarihleri arasında mevsimlik olarak gerçekleştirilmiştir. Marmara Denizi balıkçıların av sahaları dikkate alınarak 6 bölge değerlendirilmiştir: Erdek açıkları, Tekirdağ, Marmara Adası, Kapıdağ, Yalova ve Silivri. Toplamda 6 grup altında 90 farklı tür elde edilmiştir; kemikli balıklar (42) kıkırdaklı balıklar (7), kabuklular (12), çift kabuklu yumuşakçalar (8), kafadanbacaklılar (5), derisidikenliler (10) ve diğer omurgasızlar (6). Margalef tür zenginliği (d), Shannon çeşitlilik (H') ve Pielou'nun düzenlilik (J) indeksleri hesaplanmıştır. Benzerlik diyagramları mevsimlere, bölgelere ve derinliklere göre hazırlanmıştır. Mevsimlere göre ekolojik indeks değerleri kış periyodunda yüksek bulunmuştur. Bölgelere göre en yüksek tür çeşitliliği 1. (Erdek açıkları) ve 5. (Kağıdağ) bölgede, en düşük çeşitlilik 6. (Silivri) bölgede bulunmuştur. Benzerlik diyagramına göre bölgelerin %57 oranında benzer oldukları görülmektedir.

Anahtar Kelimeler: Algarna, Ekolojik indeksler, Marmara Denizi

ABSTRACT

Biodiversity of the Sea of Marmara and catch amount of the Deep-water rose shrimp

This study indicated that the catch amounth of the *P.longirostris* and the biodiversity of the Sea of Marmara. Sampling was carried out between October 2011 and February 2014 with beam trawler vessel operating in the Marmara Sea as seasonal. The Sea of Marmara was examined in 6 regions: Erdek, Tekirdağ, Marmara Island, Kapıdağ, Yalova, and Silivri. In total, the catch consisted of 90 species belonging to 6 groups of marine fauna, including Osteichthyes (42 species), Chondrichthyes (7), Crustacea (12) Bivalvia (8), Cephalopoda (5), Echinodermata (10) and other invertebrates (6). Margalef species richness index (d), Shannon diversity index (H'), Pielou's evenness index were calculated. Kruskal Wallis similarity dendrograms were drawn by seasonal, regional and depth. According to seasons maximum species richness, diversity and evenness index values were in the winter periods. According to the regions' maximum species richness, diversity and evenness index values were in the 1. (Erdek) and 4. (Kapıdağ) regions and minimum values of the indexes were in the 6. (Silivri) region. And the Kruskal Wallis similarity dendrogram shows 57 % similarity between the regions.

Keywords: Beam trawl, Ecologic indexes, Sea of Marmara

Giriş

Eklem bacaklı türler üzerine yapılan balıkçılık son yıllarda dünya çapında büyük önem kazanmıştır. Bunun yanında karides balıkçılığı yine büyük bir ekonomik değer oluşturmaktadır (Tully ve ark., 2003). Karides balıkçılığı içerisinde Derinsu pembe karidesi (*Parapenaeus longirostris* Lucas, 1846) Avrupa'da ticari olarak yüksek ekonomik değere sahip bir tür olup, Doğu Atlantik ve tüm Akdeniz'de İspanya, Fransa, İtalya, Yunanistan ve Tunus gibi ülkelerde en önemli omurgasız türü olduğu söylenebilir (Deval ve ark., 2006). Ülkemizde de Marmara, Ege ve Levant kıyıları boyunca balıkçılığın yoğun olarak yapıldığı bölgelerde, Derinsu pembe karidesinin yüksek ekonomik potansiyele sahip olduğu bilinmektedir (Baran ve Öztürk, 1990; Zengin ve ark., 2004; Bayhan ve ark., 2005).

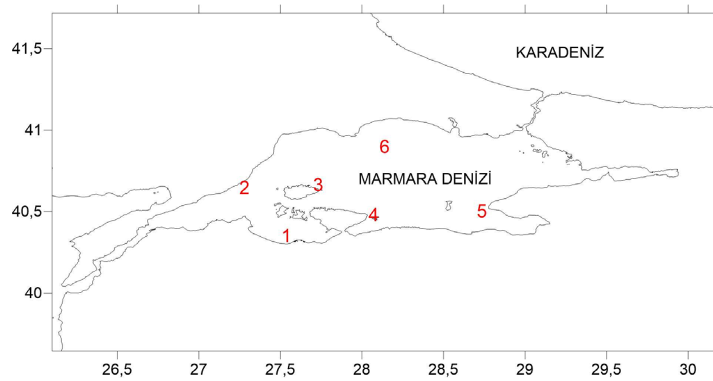
Karidesler, lüks besin maddesi sınıfında olmaları dolayısıyla ticari değerlerinin yüksek olması gibi nedenlerle yoğun olarak avlanmaktadır. Ülkemize önemli miktarda ekonomik girdi sağlamakta ve insanların hayvansal gıda gereksinimini karşılamaktadır. Aynı zamanda sağlıklı ve dengeli beslenmedeki önemi düşünüldüğünde, karides endüstrisinin geliştirilmesinin gerekli olduğu görülmektedir (Manaşırlı, 2008).

Marmara Denizi'nde karides algarnası ile yapılan çalışmalar sınırlı sayıdadır. Yazıcı ve ark. (2004) Erdek Körfezi'nde, Bayhan ve ark. (2006) Marmara Denizi'nin Güneydoğu'sunda; Öztürk (2009) Kuzey Marmara'da algarnanın av kompozisyonunu ve Derinsu pembe karidesini araştırmışlardır. Yapılan bu araştırmalar Marmara Denizi'nin tamamını kapsayan çalışmalar değildir. Yalnızca bir çalışmada Marmara Denizi'nin tamamında algarna ağının av kompozisyonu bildirilmiştir (Zengin ve ark., 2004). Diğer çalışmalar kısıtlı bölgelerde ve az sayıda örnekleme noktası içermektedir. Bu bağlamda yapılan bu araştırma Marmara Denizi'ndeki en kapsamlı çalışma niteliğindedir.

Bu araştırmada, Marmara Denizi'nde karides algarnasının av kompozisyonunu mevsimlere, bölgelere ve derinliğe göre belirlemek ve algarna av aracının avladığı tür çeşitliliğini ve dağılımlarını ortaya çıkarmak amaçlanmıştır. Bu araştırmanın sonuçları, sürdürülebilir karides balıkçılığının gelecekteki yönetim planları için politikalar geliştirilmesi, yapılacak yasal düzenlemelere katkı sağlaması ve gelecekteki çalışmalara kaynak oluşturması açısından önemlidir.

Materyal ve Metot

Çalışma materyalini, Marmara Denizi'nden Eylül 2011-Temmuz 2014 tarihleri arasında algarna ile aylık olarak elde edilen örnekler oluşturmaktadır. Algarna çekimleri Marmara Adası Limanına kayıtlı Şükriye Ana isimli balıkçı teknesi ile 2 mil/s hızda ve 30'ar dakikalık süreler ile yapılmıştır. Balıkçıların av sahaları dikkate alınarak Marmara Denizi altı bölgede değerlendirilmiştir (Şekil 1). Ekim 2011-Temmuz 2014 tarihleri arasında toplam 229 adet algarna çekimi yapılmıştır. Her bir bölgedeki çekim sayısı; 1.bölge: 43, 2.bölge: 31, 3. bölge: 49, 4.bölge:42, 5.bölge: 24, 6.bölge: 40 adet olarak değişmiştir.



Şekil 1. Marmara Denizi'nde algarna çekimi yapılan bölgeler (1: Erdek Açıkları , 2: Tekirdağ, 3: Marmara adası , 4: Kapıdağ yarımadası , 5: Yalova , 6: Silivri)

Figure 1. Sampling areas in the Sea of Marmara (1: Erdek , 2: Tekirdağ, 3: Marmara Island , 4: Kapıdağ peninsula, 5: Yalova, 6: Silivri)

Örnekleme işlemi Holden ve Raitt (1974)'e göre yapılmıştır. Teknede algarna ağından çıkan tüm karides, balıklar ve omurgasızlar türlerine ayrılarak, toplam ağırlıkları ölçülmüştür. Tür Çeşitliliği (Shannon – Wiener) İndeksi, Pielou'nun Düzenlilik (Homojenlik) İndeksi ve Tür Zenginliği (Margalef) İndeksi PRIMER 7.0 ekolojik istatistik paket programının DIVERSE fonksiyonu kullanılarak hesaplanmıştır (Clarke ve Warwick, 2001). Dendogramların çiziminde MINITAB 16 programı kullanılmıştır.

Tür zenginliği Margalef İndeksi kullanılarak $d = \frac{S-1}{\log N}$ formülü ile hesaplanmıştır.

S: Toplam tür sayısı, N: Toplam birey sayısı

Pielou'nun Düzenlilik indeksi $J' = \frac{H'}{\log S}$ formülü ile hesaplanmıştır

S: Tür sayısı [J ' değeri 0 (düşük homojenite) ile 1 (yüksek homojenite) sınırları arasında değişebilir] .

Tür çeşitliliği Shannon–Wiener İndeksi (H') kullanılarak $\log_2$ tabanında hesaplanmıştır. $H' = -\Sigma\, p_i \log_2 (p_i)$

H': Tür çeşitliliği, p_i: Bir türün birey sayısının toplam birey sayısına oranıdır.

Bu indeks ekolojik kalitenin en iyi göstergelerinden biridir, çoğunlukla 1.5 (düşük çeşitlilik) ile 3.5 (yüksek çeşitlilik) arasında değişir. Seyrek olarak 0 ile 4.6 sınır değerlerine ulaşabilir.

Bulgular ve Tartışma

Av Kompozisyonu

Marmara Denizi'nde Ekim 2011-Temmuz 2014 tarihleri arasında toplam av miktarı 4.2 ton olarak bulunmuştur. Toplam biyokütlenin %25'ini Derinsu pembe karidesi, %13'ünü kemikli balıklar, %2'sini kıkırdaklı balıklar ve %60'ını diğer omurgasız türler oluşturmuştur. Kemikli balıklar grubunu çoğunlukla bentik ortamla ilişkili bento-pelajik türler oluşturmuştur. Algarna çekimlerinde toplam 90 tür avlanmıştır. Bunların 42'sini kemikli balık, 7'sini kıkırdaklı balık, 41'ini omurgasız türler oluşturmuştur (Tablo 1).

Tablo 1. Marmara Denizi'nde algarna ile avlanan türler

Table 1. The species caught with beam trawl in the Sea of Marmara

Kemikli balıklar	
Barbun	*Mullus barbatus* Linnaeus, 1758
Benekli pisi balığı	*Lepidorhombus boscii* (Risso, 1810)
Berlam	*Merluccius merluccius* (Linnaeus, 1758)
Çizgili hani	*Serranus hepatus* (Linnaeus, 1758)
Dil balığı	*Solea solea* (Linnaeus, 1758)
Dülger balığı	*Zeus faber* Linnaeus, 1758
Fener balığı	*Lophius budegassa* Spinola, 1807
Hamsi	*Engraulis encrasicolus* (Linnaeus, 1758)
Horozbina	*Blennius ocellaris* Linnaeus, 1758
Isparoz	*Diplodus annularis* (Linnaeus, 1758)
İskorpit	*Scorpaena porcus* Linnaeus, 1758
İstavrit	*Trachurus trachurus* (Linnaeus, 1758)
İzmarit	*Spicara maena* (Linnaeus, 1758)
Kancaağız pisi balığı	*Citharus linguatula* (Linnaeus, 1758)
Kayabalığı	*Lesuerigobius friesii* (Malm, 1874)
Kırlangıç	*Chelidonichthys lucerna* (Linnaeus, 1758)
Kırlangıç	*Lepidotrigla cavillone* (Lacepède, 1801)
Kömürcü kayabalığı	*Gobius niger* (Linnaeus, 1758)
Kurdela balığı	*Cepola macrophthalma* (Linnaeus, 1758)
Küçük gelincik	*Gaidropsarus biscayensis* (Collett, 1890)
Lekeli dil balığı	*Microchirus variegatus* (Donovan, 1808)
Mazak	*Trigloporus lastoviza* (Bonnaterre, 1788)
Mezgit	*Merlangius merlangus* (Linnaeus, 1758)
Mığrı	*Conger conger* (Linnaeus, 1758)
Öksüz	*Trigla lyra (*Linnaeus, 1758)
Sardalya	*Sardina pilchardus* (Walbaum, 1792)
Sarıkuyruk İstavrit	*Trachurus mediterraneus* (Steindachner, 1868)
Şeffaf dil balığı	*Arnoglossus kessleri* (Schmidt, 1915)
Tekir	*Mullus surmuletus* (Linnaeus, 1758)
Tiryaki	*Uranoscopus scaber* (Linnaeus, 1758)
Trakonya	*Trachinus draco* (Linnaeus, 1758)
Üzgün	*Callionymus lyra* (Linnaeus, 1758)
Üzgün	*Callionymus fasciatus* (Valenciennes, 1837)
Kıkırdaklı balıklar	
Domuz balığı	*Oxynotus centrina* (Linnaeus, 1758)
Kedi balığı	*Scylorhinus canicula* (Linnaeus, 1758)
Sivriburun vatoz	*Dipturus oxyrincus* (Linnaeus, 1758)
Torpedo	*Torpedo marmorata* (Risso, 1810)
Vatoz	*Raja clavata* (Linnaeus, 1758)
Vatoz	*Raja miraletus* (Linnaeus, 1758)
Vatoz	*Dasyatis pastinaca* (Linnaeus, 1758)
Omurgasızlar	
Ahtapot	*Octopus vulgaris* (Cuvier, 1797)
Akdeniz midyesi	*Mytilus galloprovincialis* (Lamarck, 1819)
Beyaz kum midyesi	*Chamelea gallina* (Linnaeus, 1758)
Çalı karidesi	*Plesionika heterocarpus* (A. Costa, 1871)
Deniz hıyarı	*Holathuria tubulosa* (Gmelin, 1791)
Deniz kestanesi	*Spatangus purpureus* (O.F. Müller, 1776)
Deniz kestanesi	*Brissopsis lyrifera* (Forbes, 1841)
Deniz kestanesi	*Echinus acutus* (Lamarck, 1816)
Deniz minaresi	*Turritella communis* (Risso, 1826)
Deniz kalemi	*Pennatula sp.*
Deniz örümcekleri	*Pycnogonida sp.*
Deniz pabucu	*Parastichopus regalis* (Cuvier, 1817)
Deniz salyangozu	*Galeodea echinophora* (Linnaeus, 1758)
Deniz salyangozu	*Murex brandaris* (Linnaeus, 1758)
Deniz salyangozu	*Aporrhais serresianus* (Locard, 1891)
Deniz tavşanı	*Aplysia sp.*
Deniz yıldızı	*Marthasterias glacialis* (Linnaeus, 1758)
Deniz yıldızı	*Asterias rubens* (Linnaeus, 1758)
Deniz yıldızı	*Astropecten irregularis* (Pennant, 1777*)*
Deniz yıldızı	*Hacelia attenuata* (Gray, 1840)
Deniz yıldızı	*Anseropoda placenta* (Pennant, 1777*)*
Deniz yıldızı	*Antedon mediterranea* (Lamarck, 1816)
Deniz yılan yıldızı	*Ophiura texturata* (Lamarck, 1816)
Derinsu pembe karidesi	*Parapenaeus longirostris* (Lucas, 1846)
Jumbo karides	*Penaeus japonicus* (Spence Bate, 1888)
Karides	*Pontocaris lacazei* (Gpurret, 1887)
Kalamar	*Loligo vulgaris* (Lamarck, 1798)
Karavida	*Squilla mantis* (Linnaeus, 1758)
Keşiş yengeci	*Paguristes syrtensis* (Saint Laurent, 1971)
Kırmızı karides	*Aristeus antennatus* (Risso,1816)
Kerevit	*Nephrops norvegicus* (Linnaeus, 1758)
Midye	*Aequipecten opercularis* (Linnaeus, 1758)
Mis ahtapot	*Eledone moschata* (Lamarck, 1798)
Mürekkep balığı	*Sepia officinalis* (Linnaeus, 1758)
Örümcek yengeç	*Macropodia rostrata* (Linnaeus, 1761)
Pina	*Pinna sp.*
Süngerler	*Spongiidae*
Yengeç	*Liocarcinus depurator* (Linnaeus, 1758)
Yengeç	*Goneplax rhomboides* (Linnaeus, 1758)
	Alcyonium sp.

Mevsimsel Av Kompozisyonu ve Tür Çeşitliliği

Sonbahar 2011-Yaz 2014 tarihleri arasında yapılan toplam 12 mevsimlik örneklemede sırasıyla; Sonbahar 2011'de 334 kg, Kış 2012'de 110 kg, İlkbahar 2012'de 533 kg, Yaz 2012'de 379 kg, Sonbahar 2012'de 393 kg, Kış 2013'de 383 kg, İlkbahar 2013'de 195 kg, Yaz 2013'de 518 kg, Sonbahar 2013'de 79,5 kg, Kış 2014'de 145 kg, İlkbahar 2014'de 521 kg, Yaz 2014'de 450 kg toplam av elde edilmiştir. Toplam av içerisinde *P. longirostris'*in ve diğer türlerin mevsimsel dağılımları belirlenmiştir (Şekil 2). *P. longirostris*'in mevsimlere göre av miktarları ve oranlarına bakıldığında en yüksek av ve oranları sonbahar mevsiminde elde edilmiştir. En düşük av ve oranları ise kış mevsiminde bulunmuştur. Derinsu pembe karidesin mevsimsel av ve oranları sırasıyla; Sonbaharda 2011'de 120.9 kg (%37), Kış 2012'de 30.6 kg (%28), İlkbahar 2012'de 83.2 kg (%16), Yaz 2012'de 87.8kg (%23), Sonbahar 2012'de 134 kg (%34), Kış 2013'de 80.5 kg (%21), İlkbahar 2013 'de 104.3 kg (%53), Yaz 2013'de 115.2 kg (%22), Sonbahar 2013'de 43.4 (%54); Kış 2014'de 51.8 kg (%35,7), İlkbahar 2014'de 45.6 kg (%9) ve Yaz 2014'de 84.3 kg (%19) olarak tespit edilmiştir (Şekil 3).

Mevsimlere göre tür çeşitliliği benzerlik diyagramına göre mevsimler arasında %53 oranında benzerlik bulunmuştur (Şekil 4). Pieulou'nun düzenlilik (J'), Shannon-Wiener çeşitlilik (H') ve Margalef tür zenginliği (d) indekslerine göre kış mevsimlerinde tür çeşitliliği ve tür zenginliğinin daha yüksek, yaz mevsimlerinde ise en düşük olduğu görülmüştür. En yüksek tür zenginliği indeksine (d) 5.757, en yüksek düzenlilik indeksine (J') 0.4567, en yüksek çeşitlilik indeksine (H') 1.854 değerleri ile kış mevsimlerinde rastlanmıştır (Tablo 2).

P. longirostris'in mevsimlere göre av miktarları ve oranlarına bakıldığında en yüksek av oranları sonbahar mevsiminde elde edilmiştir. En düşük av ve oranları ise kış mevsiminde bulunmuştur. Biyokütle oranları sonbaharda yüksek, ilkbaharda düşük bulunmuştur. Bu sonuçlar türün en başta avcılık olmak üzere üreme, yeni birey katılımı ve mevsimsel derinliğe bağlı göç davranışından kaynaklandığı düşünülmektedir.

Bölgelere Göre Av Kompozisyonu ve Tür Çeşitliliği

Marmara Denizi'nde 6 av bölgesinde yapılan örneklemede sırasıyla; 1. bölgede 614.7 kg, 2. bölgede 828.8 kg, 3. bölgede 565 kg, 4. bölgede 629 kg, 5. bölgede 426.7 kg, 6. bölgede 1028 kg toplam av elde edilmiştir. Bölgelere göre toplam av içerisinde *P. longirostris*'in ve diğer türlerin oranı ve dağılımları belirlenmiştir. *P. longirostris*'in bölgelere göre av miktarları ve oranları sırasıyla 1. Bölgede 137.5 kg (%22), 2. Bölgede 176.2 kg (%21), 3. Bölgede 197 kg (%35), 4. Bölgede 180.8 kg (%29), 5. Bölgede 45.8 kg (%11), 6. Bölgede 253 kg (%25) olarak tespit edilmiştir (Şekil 5). Bölgelere göre av kompozisyonu dağılımları incelendiğinde en fazla karides yüzde olarak 3. ve 4. bölgeden elde edilmiştir (Şekil 5).

Bölgelere göre belirlenen tür çeşitliliği benzerlik diyagramına göre bölgeler arasında %57 oranında benzerlik bulunmuştur. Bölgelerin kendi aralarında 3 grup oluşturdukları görülmüştür. 1-3, 2-6, ve 4-5 bölgeler kendi içlerinde daha benzer olarak belirlenmiştir (Şekil 6).

Pieulou'nun düzenlilik (J'), Shannon-Wiener çeşitlilik (H') ve Margalef tür zenginliği (d) indekslerine göre 1. ve 4. bölgede tür zenginliği yüksek, 6. bölgede en düşük bulunmuştur (Şekil 11). En yüksek tür zenginliği indeksine (d) 6.232 ile, en yüksek düzenlilik indeksine (J') 0.4447, en yüksek çeşitlilik indeksine (H') 1.87 ile 1.bölgede rastlanmıştır (Tablo 3).

Marmara Denizi'nde av sahalarına göre *P. longirostris*'in av oranları bölgelere göre değişim göstermiştir. Bölgelere göre av oranları incelendiğinde en fazla karides Güney Marmara Bölgesi olan 3. Bölge (Marmara Adası) ve 4. bölgeden (Kapıdağ Yarımadası) elde edilmiştir.

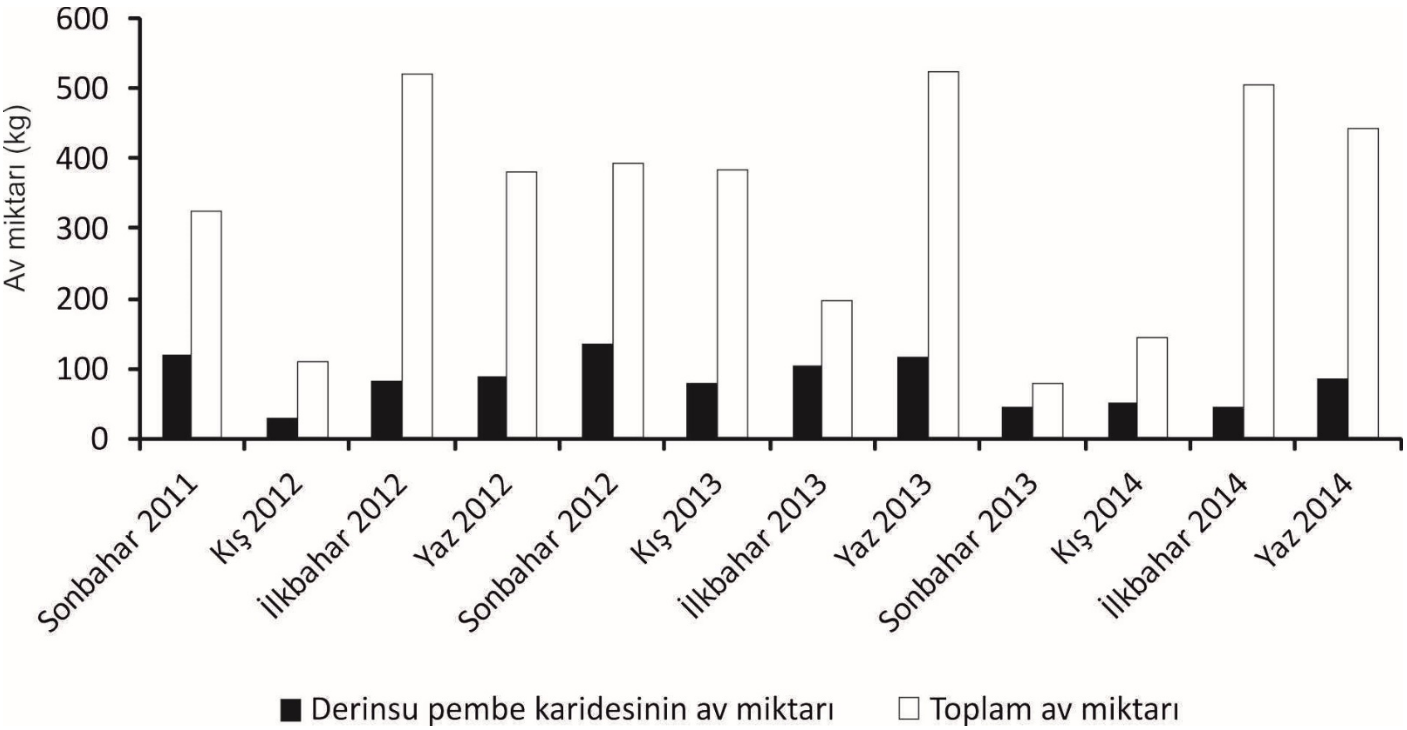
Derinliğe Göre Av Kompozisyonu ve Tür Çeşitliliği

Araştırma bölgesi 50-100 m ve ≥100 m olmak üzere iki farklı derinlik konturunda değerlendirilmiştir. Derinsu pembe karidesin ve diğer canlı gruplarının av oranının derinlik konturlarına göre değiştiği tespit edilmiştir. 50-100 m derinlikler ile karşılaştırıldığında 100 m ve daha derin sularda avlanan Derinsu pembe karidesin oranı daha düşük bulunmuştur. Diğer omurgasızların av oranı ise derinlikle artmıştır (Şekil 7).

Derinliğe göre tür çeşitliliği benzerliğinin düşük olduğu belirlenmiştir. Pieulou'nun düzenlilik (J'), Shannon-Wiener çeşitlilik (H') ve Margalef tür zenginliği (d) indeksleri değerlerine göre derinlik arttıkça tür zenginliğinin azaldığı belirlenmiştir. En yüksek tür zenginliği indeksine (d) 9.123, en yüksek düzenlilik indeksine (J') 0.295, en yüksek çeşitlilik indeksine (H') 1.375 değerleri ile 50-100 m derinlik aralığında rastlanmıştır (Tablo 4).

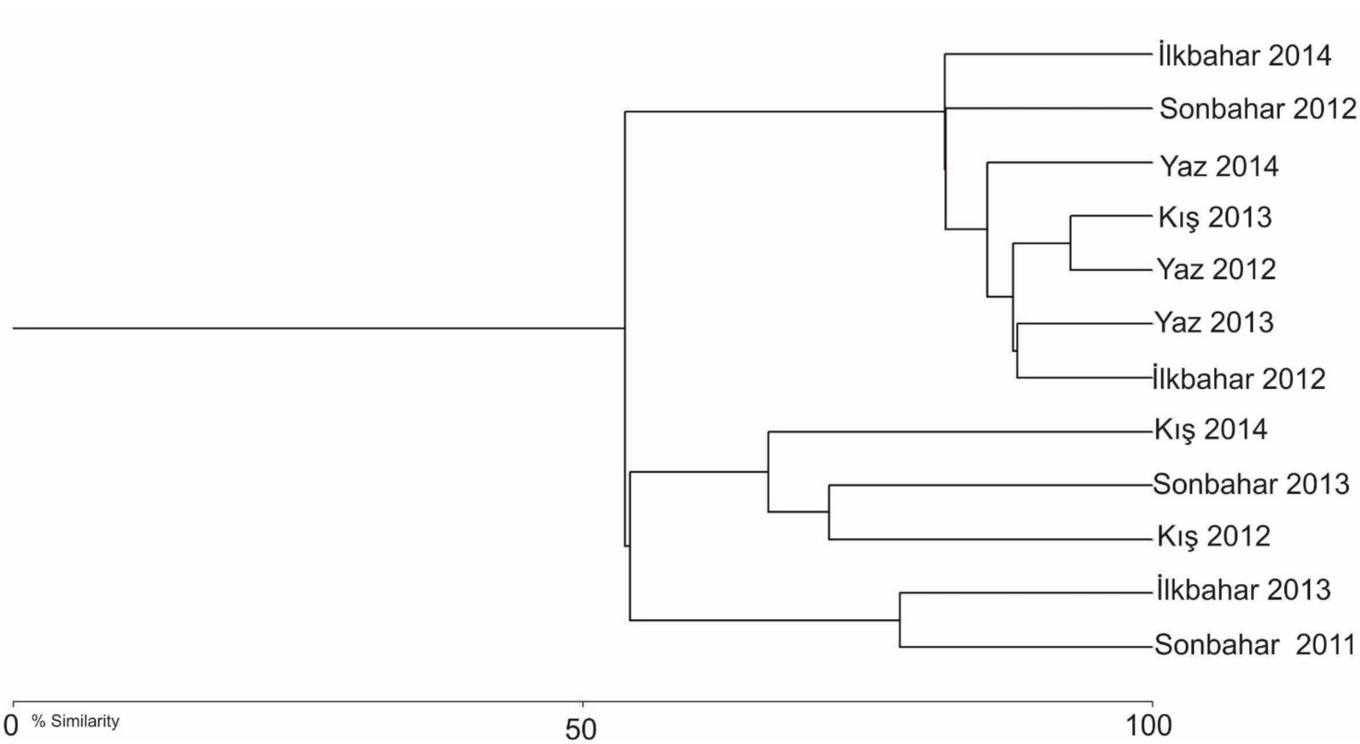
Şekil 2. Mevsimlere göre av kompozisyonu dağılımları

Figure 2. Distribution of the catch composition according to the seasons



Şekil 3. Mevsimlere göre toplam av ve Derinsu pembe karides av miktarları

Figure 3. The total catch and Deep water rose shrimp amounth according to the seasons



Şekil 4. Mevsimlere göre tür çeşitliliği benzerlik diyagramı

Figure 4. Kruskal Wallis similarity dendrogram according to the seasons.

Tablo 2. Mevsimlere göre ekolojik indeks değerleri

Table 2. Ecological index values according to the seasons.

Mevsimler	Birey sayısı (n)	Margalef (d)	Pieulou (J')	Shannon-Wiener (H')
Sonbahar 2011	38310	5.307	0.3795	1.534
Kış 2012	14867	5.622	0.4465	1.789
İlkbahar 2012	71230	4.654	0.3106	1.269
Yaz 2012	67459	3.957	0.2573	0.9796
Sonbahar 2012	63022	4.525	0.2538	0.998
Kış 2013	61264	5.262	0.2331	0.9503
İlkbahar 2013	25121	4.936	0.1879	0.7388
Yaz 2013	86700	4.573	0.3189	1.266
Sonbahar 2013	10772	4.954	0.3731	1.437
Kış 2014	19948	5.757	0.4567	1.854
İlkbahar 2014	48542	4.912	0.2925	1.167
Yaz 2014	79935	4.252	0.2515	0.9786

Tablo 3. Bölgelere göre ekolojik indeks değerleri

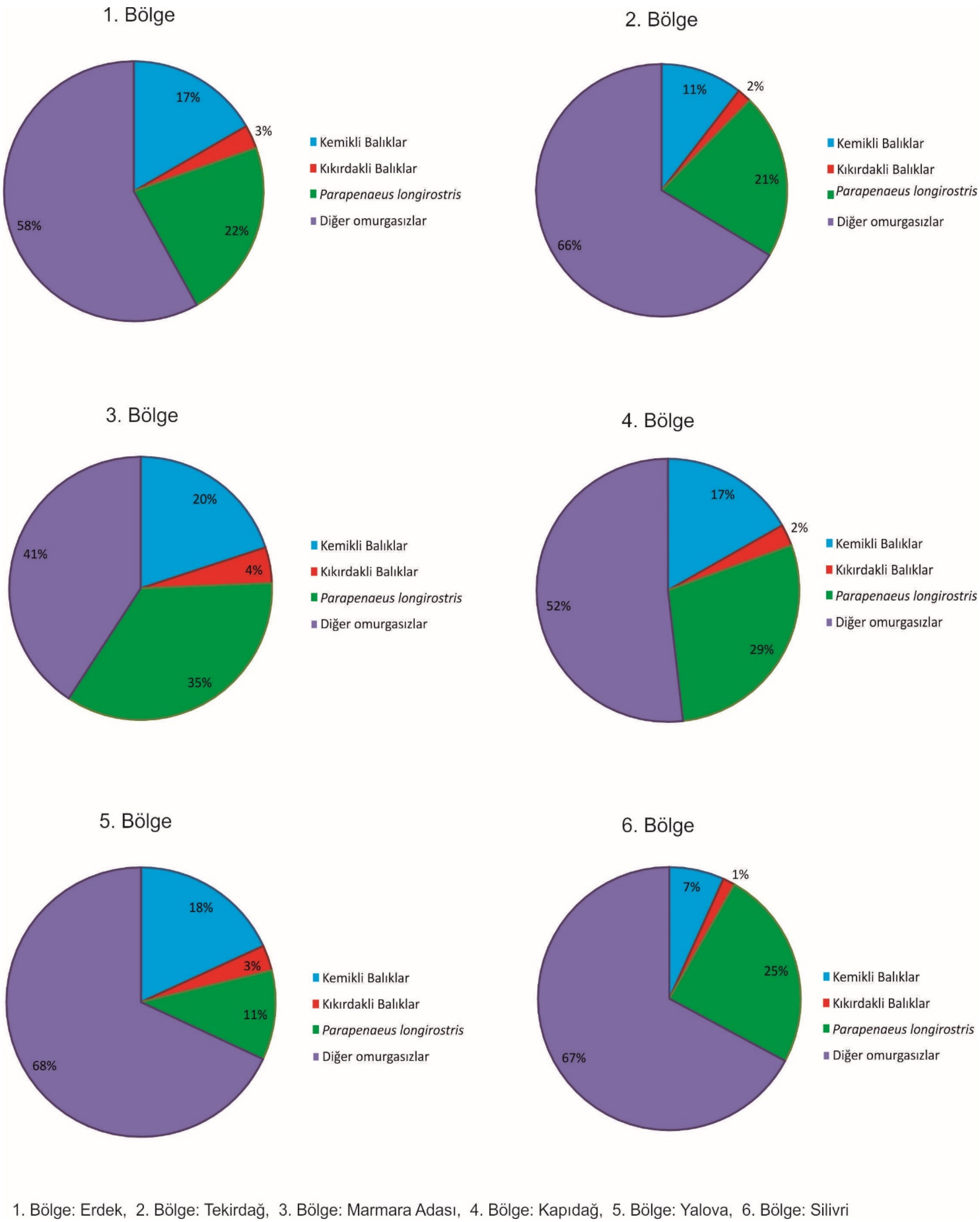
Table 3. Ecological index values according to the regions

Bölgeler	Birey sayısı (n)	Margalef (d)	Pieulou (J')	Shannon-Wiener (H')
1. Bölge	39761	6.232	0.4447	1.87
2. Bölge	150097	4.782	0.2987	1.213
3. Bölge	55578	5.766	0.3173	1.32
4. Bölge	75017	6.147	0.3114	1.323
5. Bölge	67532	5.396	0.3678	1.512

Tablo 4. Derinliğe göre ekolojik indeks değerleri

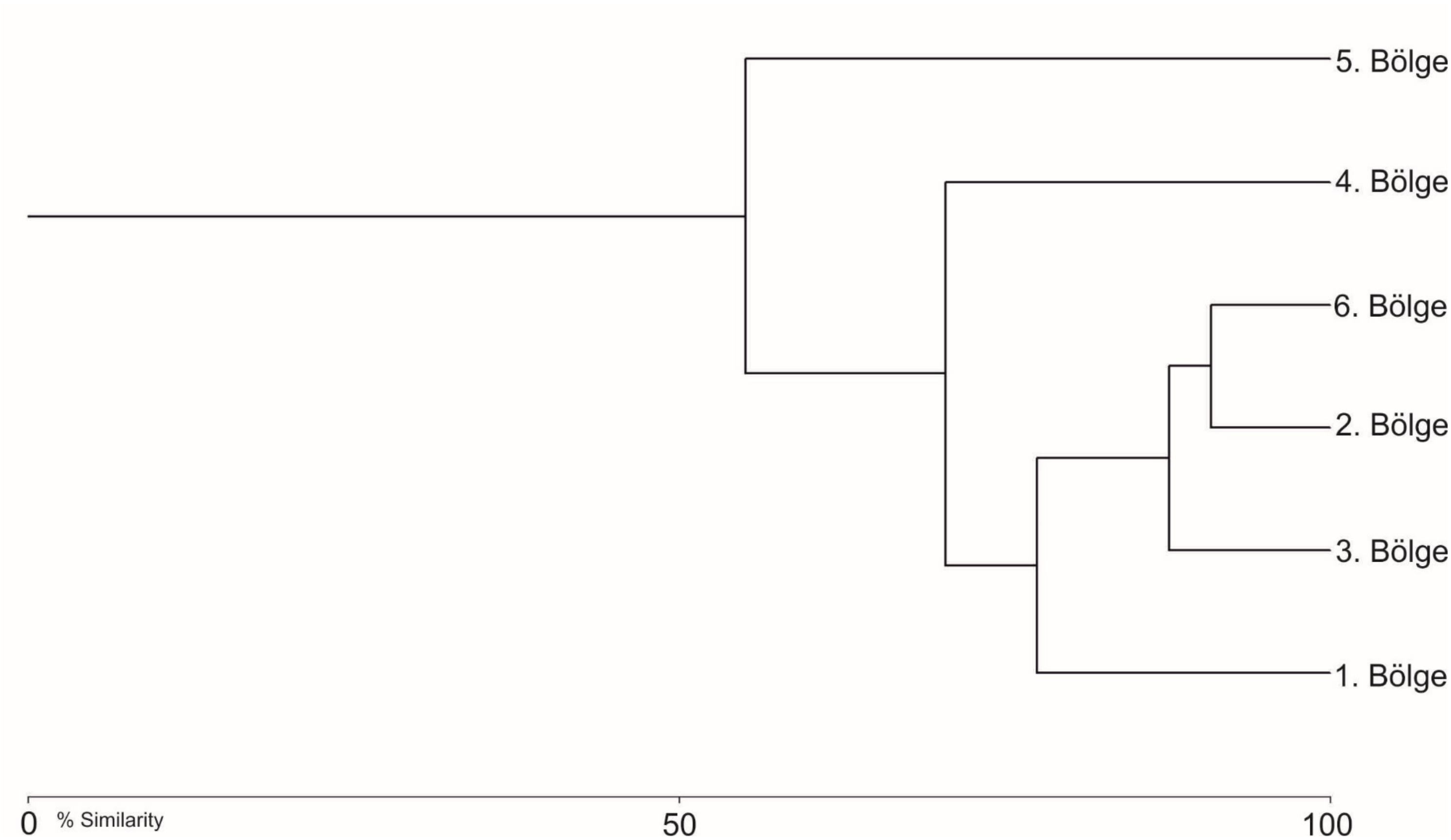
Table 4. Ecological index values according to the depth

Derinlikler	Birey sayısı (n)	Margalef (d)	Pieulou (J')	Shannon-Wiener (H')
50-100 m	192467	9.123	1.375	1.375
>100 m	8360	5.758	0.7387	0.2243



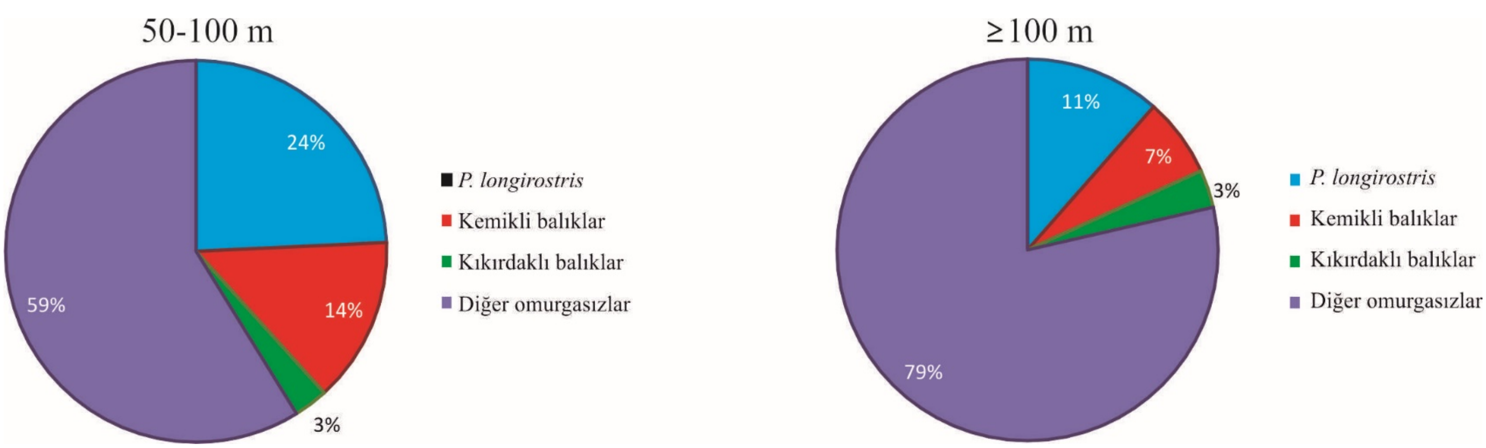
Şekil 5. Bölgelere göre av kompozisyonu dağılımları

Figure 5. Distribution of the catch composition according to the regions



Şekil 6. Bölgelere göre tür çeşitliliği benzerlik diyagramı

Figure 6. Kruskal Wallis similarity dendrogram according to the regions



Şekil 7. *P. longirostris*'in derinliklere göre av kompozisyonu dağılımları

Figure 7. Distribution of the catch composition of *P.longirotsris* according to the depth

Bu çalışmada algarna ile yakalanan türlerin sayısı ve kompozisyonu önceki çalışmalara benzerlik göstermektedir. Marmara Denizi'nde algarna avcılığı konusunda Erden ve ark. (1971) tarafından 1970 yılında Şarköy-Eriklice-Kalamış-Mürefte önlerinde, 15 istasyonda yapılan çalışma sonrasında 46 tür yakalanmıştır. Kınacıgil ve ark. (2003) Kapıdağ yarımadasının kuzey ve kuzey-doğusunda geleneksel ve model algarnalar ile 17 istasyonda yaptıkları çalışmada 19 tür avlandığını, Yazıcı (2004); güney-batı Marmara'da algarna ile yaptığı araştırma sonrasında 37 türün yakalandığını ve *P. longirostris*'in toplam avın ağırlık olarak % 50.8'ini oluşturduğunu bildirmiştir. Bunun dışında DEÜ/DBF-JICA (1993) tarafından hazırlanan Marmara Denizi'nde demarsal kaynaklar sörveyinde balık tür sayısı 62 ve omurgasız tür sayısı 14 olarak bildirilmiştir. Zengin ve ark. (2004) Marmara Denizi'nde dip trolü, derin su manyatı ve algarna gibi geleneksel sürütme ağları ile 10 taksonomik gruba ait 118 adet farklı türün avlandığını, taksonomik grupların sırasıyla; Kemikli balıklar; 42, Yumuşakçalar;18, Kabuklular;17, Derisi dikenliler;13, Kıkırdaklı balıklar;8, Kurtçuklar;7, Kafadan bacaklılar;6, Koloniler;6, Süngerler;1 ve Ascidesler;1 tür içerdiğini saptamışlardır. Bayhan ve ark. (2006) Kasım 2000 - Ekim 2001 tarihleri arasında Güneydoğu Marmara'da algarna ile yapılan çekimler sonucunda, 7 taksonomik gruba ait toplam 51 tür yakalanmış, toplam avın sayısal olarak %64.5'ni hedef tür olan *Parapenaeus longirostris*, %35.5'ini hedef dışı av oluşturmuştur. Hedef dışı avın % 17.16'sını Kemikli balıklar (Osteichthyes), %8.58'ini Kabuklular (Crustacea-Decapoda), %4.94' ünü Derisi Dikenliler (Echinodermata), % 2.53'ünü Yumuşakçalar (Mollusca), %2.14' ünü Cnidaria ve %0.13' ünü kıkırdaklı balıklar (Chondrichthyes) oluşturmuştur. Araştırıcılar, Marmara Denizi'nde algarna ile avcılıkta yakalanan tür sayısının 88'e kadar çıkabildiğini, bunun yanında hedef dışı avın toplam av içerisindeki sayısal oranının %12.1-35.48, ağırlıkça oranın ise %24.4 - 49.2 arasında değişebildiğini belirtmişlerdir. Öztürk (2009) Kuzey Marmara Denizi'nde 1987-1988 yıllarında algarna ile yürütülen çalışmada karides dışında toplam 44 tür (24 balık türü, 20 omurgasız türü) elde edildiğini belirtmişlerdir. Çalışmamızda, Derinsu pembe karidesin ağırlıksal olarak mevsimsel av oranları sonbahar-yaz dönemlerinde yüksek, kış-ilkbahar dönemlerinde ise düşük bulunmuştur. Bunun nedeni, başta avcılık olmak üzere türün üreme, yeni birey katılımı ve mevsimsel derinliğe bağlı göç davranışından kaynaklandığı düşünülmektedir.

Türün ülkemiz sularında; Akdeniz ve Marmara Denizi'nde 50-700 m (Artüz, 2005), Marmara Denizi'nde 35-500 m (Kocataş ve ark., 1991), Ege Denizi'nde 80-350 m (Kara ve Gurbet, 1999) 200-400 m (Tosunoğlu ve ark., 2009) derinliklerde dağılım gösterdiği bildirilmiştir. Derin su pembe karidesi sayı ve ağırlık olarak en yüksek Ege Denizi için 150-400 m (Politou ve ark., 1998), Güney Ege için 200-500 m (Tserpes ve ark., 1999), Orta Ege'de 150-350 m (Kara ve Gurbet, 1999) derinliklerde avlandığı bildirilmiştir. Türün ülkemiz sularında; Marmara Denizi'nde 150-200 m (Zengin vd., 2004), 50-120 m (Artüz, 2006) ve 44-110 m (Zengin ve Akyol 2009) derinliklerde yoğun dağılım gösterdiği bildirilmiştir. Bu değerler çalışmamız ile benzerlik göstermiş ve derinlikler arasındaki anlamlı farklılıkların olması farklı bölgelerde türün belirli derinliklerde daha yoğun olduğunu desteklemektedir. Marmara Denizi'nde av sahalarına göre *P. longirostris*'in ağırlık olarak av oranları sırasıyla 1. bölge %22, 2. bölge %21, 3. bölge %35, 4. bölge %29, 5. bölge %11, 6. bölge %25 olarak tespit edilmiştir. Bölgelere göre av oranları incelendiğinde en fazla karides Güney Marmara Bölgesi olan 3. ve 4. bölgeden elde edilmiştir. Bu bölgelerdeki nüfus yoğunluğu ve kirletici etmenler daha azdır. Kocaçay ve Gönen Çayı'nın getirdiği nehir girdileri bölgenin besince zengin oluşunu sağlamaktadır. Marmara Adası ve Kapıdağ Yarımadası'nın besince ve oksijence daha zengin olduğu önceki çalışmalarda bildirilmiştir (Satılmış ve ark., 2017)

Bu araştırmada Derinsu pembe karidesinin dağılımı mevsimlere, bölgelere, derinliklere göre farklılık göstermiştir. Yapılan araştırmalarda türlerin dağılımına farklı faktörlerin etkisi olduğu belirtilmiştir. Ungaro ve ark. (2004), Güney Adriyatik Denizi'nde türün çoğunlukla kıta sahanlığı sınırlarında ve kıtasal eğimin üst parçalarında bulunduğunu, dağılımında su sirkülasyonu, sıcaklık ve jeomorfolojik farklılıkların etkili olduğunu tespit etmislerdir. Ungaro ve ark. (1999), Güney Adriyatik Denizi'nde oseanografik sartlarla Crustacean türlerinin dağılımı arasında güçlü iliskiler bulunduğunu ortaya koymuslardır. Benchoucha ve ark. (2008), Fas'ın Atlantik sularında türün yakalama miktarlarında sıcaklığın önemli olduğunu tespit etmislerdir. Tosunoğlu ve ark. (2009) Ege Denizi'nde su sıcaklığının 200 m derinlikten sonra 14-15°C'de sabitlendiğini ve türün bu sıcaklıkları tercih etmesi nedeniyle 200-400 m derinliklerde yoğun bulunduğunu bildirmiştir. Dall ve ark. (1990), türün Akdeniz ve Doğu Atlantik'te 13-17°C arasındaki sularda yayılım gösterdiğini, Ungaro ve Gramolini (2006), Güney Adriyatik Denizi'nde 14-15°C'deki suları tercih ettiğini, Yüksek ve ark. (2000) ve Artüz (2005) Marmara Denizi'nde, Akdeniz kökenli 14.2°C su sıcaklığını, özellikle de 40 m ile 110 m tabakayı tercih ettiklerini bildirmişlerdir. Guijarro ve ark. (2009), Akdeniz'de Balear Adaları'nda türün yoğunluğundaki alansal-zamansal farklılıkların deniz tabanı topografisi, sediment kompozisyonu, hidrografik özellikler ve besin miktarı ile ilişkili olduğunu belirtmislerdir.

Sonuç

Av kompozisyonu mevsimlere, bölgelere ve derinliğe göre değişim göstermiştir. Tür çeşitliliği yaz mevsiminde yüksek kış mevsiminde ise düşük bulunmuştur. Tür çeşitliliği çalışma bölgelerine göre farklılık göstermiştir. Marmara Denizi'nin güneyinde tür çeşitliliği Kuzeye göre daha yüksek bulunmuştur. Tüm veriler incelendiğinde Marmara Denizi tür çeşitliliği ve av kompozisyonu bakımından Kuzey Marmara ve Güney Marmara olarak farklı yapılarda olduğu sonucuna varılmıştır.

Marmara Denizi'nde hedef dışı av oranının yüksek olması nedeniyle, kullanılan ağlarla ilgili düzenlemeler yapılmalı, juvenil bireylerin avlanmaması için Avrupa Birliği'nde uygulanan minimum av boyu (20 mm CL) ve torbada ağ göz boyu ve şeklinin 40 mm kare ya da 50 mm baklava uygulaması getirilmelidir. Marmara Denizi'nde algarna seçiciliği ile ilgili yapılan önceki çalışmalarda da baklava ağ göz boyunun arttırılması gerektiği, bunun sonucunun küçük boylu bireylerinin kaçışına imkan sağlayacağı ve hedef dışı av oranını azaltacağı (Zengin ve Tosunoğlu, 2006), ayrıca kare gözlü ve baklava gözlü ağlar karşılaştırıldığında 40 mm kare gözlü ağların daha seçici olduğu ve eşeysel olgunluğa ulaşmamış bireylerin kaçmasına olanak sağlayacağı bildirilmiştir (Ateş ve ark., 2010).

Algarna ağlarına tür seçiciliğini artıran ızgara sistemleri uygulaması getirilmelidir. Marmara denizinde ticari karides avcılığında kullanılan manyat ağlarının kullanımına mutlaka sınırlama getirilmedir. Ayrıca, illegal trol avcılığının yasal denetimlerle önüne geçilmesi gerekmektedir.

Marmara Denizi'nde Derinsu pembe karides populasyonundaki değişimleri anlamak, avcılığının etkilerini gözlemlemek ve uygulanacak balıkçılık stratejilerini belirlemek amacıyla izleme programı kapsamında stok tahmin çalışmaları ile ekosisteme ait temel parametreleri ölçme çalışmalarının kesintisiz yürütülmesi gerekmektedir.

Marmara Denizi'nde Derinsu pembe karidesinin derinlik dağılımına ve mevsimsel göçlerine ait bilgilerin ortaya konulabilmesi için dağılım gösterdiği alanlarda ve derinlik konturlarında çalışmalar gerçekleştirilmelidir. Türün dağılımında etkili olan sediment yapısı, bulunduğu derinliklerdeki su sıcaklığı, tuzluluğu ile besin yoğunluğunun tespit edilmesi gerekmektedir.

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The evaluation of ecological status in Tunca (Tundzha) River (Turkish Thrace) based on environmental conditions and bacterial features

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ABSTRACT

It is inevitable that the running waters which are used for a lot of different activities like fishing, irrigation, domestic water usage are under threat because of the settlements, industrial or agricultural activities. To provide the sustainable usage of these ecosystems we have to know their current features and their balance under changing environmental conditions. In the present study, the ecological status of Tunca (Tundzha) River which is located on Turkish Thrace was evaluated based on environmental conditions and bacterial features of the river. For this aim, the research has been carried out at 5 different stations in the river between October 2010 and September 2011 at monthly intervals. Some environmental conditions (temperature, dissolved oxygen, pH, conductivity, salinity, chloride, turbidity, hydrogen sulfide, magnesium, calcium, total hardness, NO_3-N, NO_2-N, sulfate, orthophosphate, suspended solid substances, biological oxygen demand) and bacterial features (total coliform, fecal coliform, and *Escherichia coli* bacterial abundances) were examined performing at the same time samplings. Consequently, it was determined that the water quality of Tunca River has proper physicochemical conditions allowing surviving of living things, but bacteriological findings belonging to the river was not found proper for direct use of water by human. Also, the correlations were evaluated between the obtained environmental features and the bacteria by using Spearman's index. While positive correlations were found between TMAB density and some environmental parameters (water-air temperature, EC, magnesium, nitrate nitrogen, sulfate, o-phosphate, and suspended solids); negative correlations were found between TMAB density and the other parameters (pH, hydrogen sulfide, calcium, total hardness, and BOD_5).

Keywords: Tunca River, Water quality, Coliform bacteria, Environmental condition, Physicochemical features

Introduction

Rivers are recipient areas that can be easily contaminated from environmental pollutants. The negative conditions from both continental and atmospheric environments can instantly reflected by these ecosystems (Çolakoğlu & Çakır, 2004; Bernot & Dodds, 2005). Although the studies on composition and abundance of microorganisms in biosphere have a lot of significance, in recent years it was also the investigations of bacteria in aquatic ecosystems have got an increasing significance (Jamieson et al., 2003; Hunt & Sarıhan, 2004; Agbogu et al., 2006; Niemi & Raateland, 2007; Sabae & Rabeh, 2007; Mishra & Batt, 2008; Suneela et al., 2008; Mishra et al., 2009, 2010; Saha et al., 2009; Bulut et al., 2010; Kumar et al., 2010; Venkatesharaju et al., 2010; Nguyen et al., 2016; Islam et al., 2017; Alves et al., 2018; Loucif et al., 2020). A lot of study is also carried out in our country. Çolakoğlu & Çakır (2004) attempt to investigate physicochemical and bacteriological quality of water in the Sarıçay stream. They investigated total mesophilic aerobic bacteria, total coliform, *Pseudomonas, Enterobacteriaceae, Staphylococcus, Lactobacillus, Enterococcus* and yeast-mold abundance. Physical, chemical and microbiological aspects of the aquatic ecosystem were measured in Manyas Lake by Karafistan & Colakoglu-Arik (2005). They performed total and fecal coliform bacteria, *Escherichia coli, Enterococcus, Staphylococcus, Lactobasillus* and *Pseudomonas* analysis. Toroğlu et al. (2006) were carried out total mesophilic aerobic bacteria, total coliform and fecal coliform bacteria analyzes in Aksu Stream. The physicochemical and microbiological parameters were investigated in the Karanfillicay (Bulut et al., 2010) and Egirdir Lake (Bulut et al., 2016). In these studies water samples were taken for total mesophilic aerobic bacteria, total coliform, fecal coliform and *Escherichia coli* analyzes. Koloren et al. (2011) evaluated the total coliform, fecal coliform, *Escherichia coli* and *Clostridium perfringens* levels in Gaga Lake.

Tunca River (Tundzha in Bulgarian) which is born in Bulgaria has 384 km length and it enters Turkey from Edirne province. This running water joins Meric River (Maritsa in Bulgarian; Evros in Greek) which is one of the most important tributary of Meric-Ergene River Basin and it is a boundary river between Turkey and Greece. Although there are some studies at Bulgarian and Turkish segments of Tunca River (Uzunov, 1980; Russev et al., 1984; Janeva & Russev, 1985; Uzunov & Kapustina, 1993; Kavaz, 1997; Uluçam, 1997; Öterler, 2003; Kirgiz et al., 2005; Camur-Elipek et al., 2006; Sakcali et al., 2009; Georgieva et al., 2010; Vassilev et al., 2010; Aytas et al., 2014), there is no study on correlation between environmental conditions and bacteriological features in the river. In the present study, ecological status of Tunca River was evaluated using the environmental properties and bacterial features from autochthonic and allochthonic environments.

Material and Methods

The samplings were made at 5 different stations chosen from Tunca River (Figure 1) between October 2010 and September 2011 at monthly intervals. The water samples for bacterial investigation were taken from 30 cm beneath of the water surface and were put into 100 mL sterile sampling bottles under aseptic conditions and were brought to the laboratory under the condition of cold chain system. The total mesophilic aerobic bacteria (TMAB) numbers were determined by using spread plates method, while the others (total coliform, fecal coliform, and *E. coli* bacterial numbers) were determined by using Most Probable Number (MPN) method (Halkman, 2005). The culture media and incubation conditions were presented at Table 1. Nansen water sampler was used to take the water samples and the material was carried to the laboratory in lightproof bottles to analyze the physicochemical features (Egemen & Sunlu, 1999). Spearman's correlation index was used in order to determine the effects of physicochemical conditions on TMAB numbers (Krebs, 1999). Sediment and water samples were also taken at seasonally intervals to determine some heavy metal contents (iron, copper, zinc, lead, cadmium) and the concentrations were measured by using graphite-furnace atomic absorption spectroscopy (Erçal, 2007).

Results and Discussion

The data obtained from bacteriological analysis in Tunca River were presented at Table 2, and the data of physicochemical parameters were presented at Tables 3 and 4.

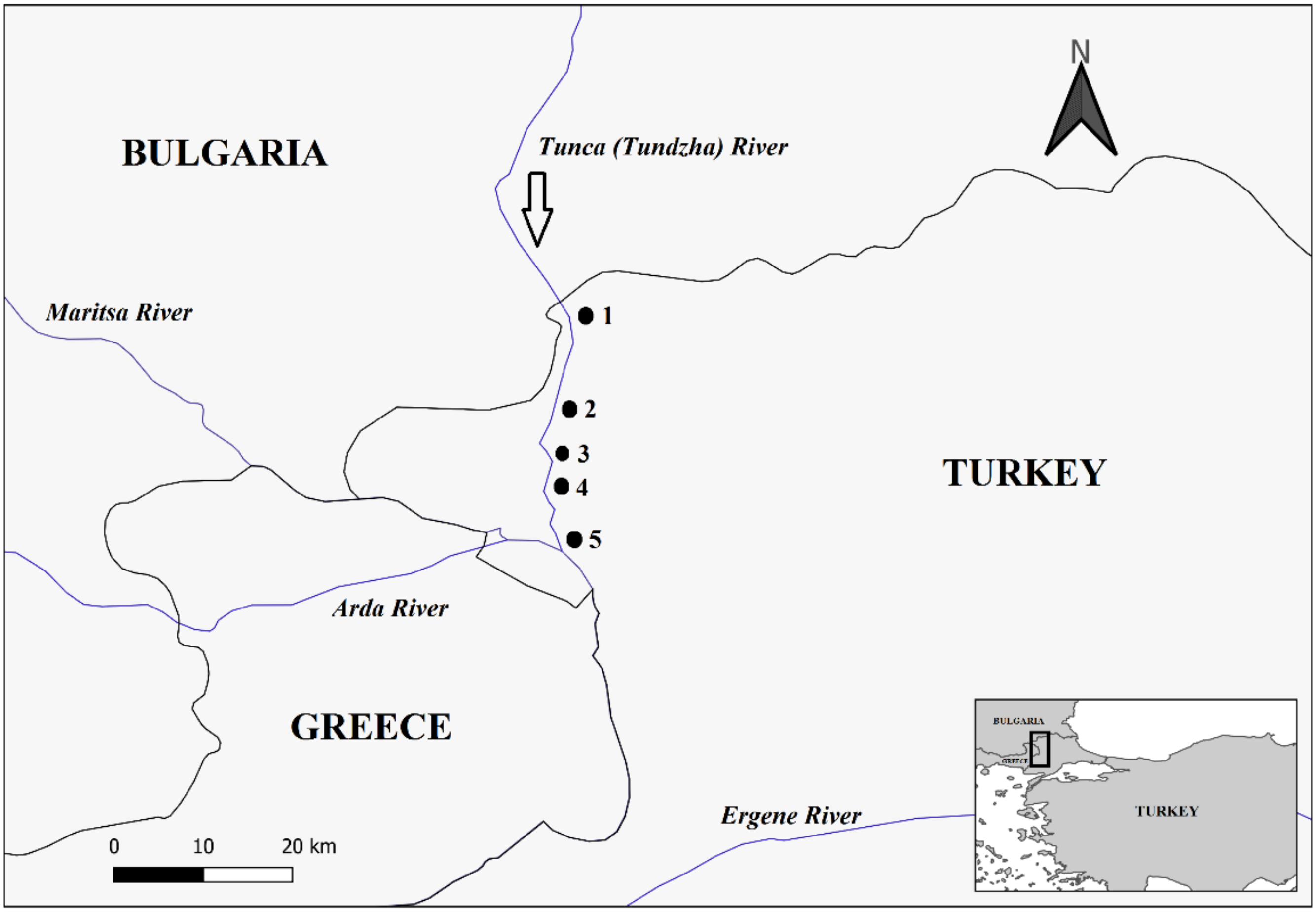


Figure 1. Location of Tunca River and the sampling stations

Table 1. Culture media and incubation conditions on growth of Microorganisms

Microorganisms	***Culture Media***	***Temperature***	***Times***
TMAB	PCA	35 ±0.5°C	24 ±2 hours
Total Coliforms	LST Broth	35 ±0.5°C	24 ±2 hours
Fecal Coliforms	LST Broth	35 ±0.5°C	24 ±2 hours
	EC Broth	44.5 ±0.2°C	24 ±2 hours
Esherichia coli	LST Broth	35 ±0.5°C	24 ±2 hours
	EC Broth	44.5 ±0.2°C	24 ±2 hours
	EMB Agar	35 ±0.5°C	24 ±2 hours
	Tryptone Broth	35 ±0.5°C	24 ±2 hours
	MR-VP Broth	35 ±0.5°C	24-48hours
	Simmon’s Citrate Agar	35 ±0.5°C	24 ±2 hours

Table 2. The numbers of bacteria determined from Tunca River

	ST. 1	**ST. 2**	**ST. 3**	**ST. 4**	**ST. 5**
Total Mesophilic Aerobic Becteria (cfu/100mL)					
October	$1.25x10^{5}$	$1.68x10^{5}$	$1.97x10^{5}$	$1.91x10^{5}$	$1.63x10^{5}$
November	$6.2x10^{4}$	$1.24x10^{5}$	$2.1x10^{5}$	$3.04x10^{5}$	$2.95x10^{5}$
December	$3.6x10^{4}$	$9.1x10^{4}$	$7.6x10^{4}$	$1.02x10^{5}$	$1.66x10^{5}$
January	$6.9x10^{4}$	$8.6x10^{4}$	$8.2x10^{4}$	$6.7x10^{4}$	$8.1x10^{4}$
February	$5.4x10^{4}$	$6.6x10^{4}$	$4.8x10^{4}$	$6.5x10^{4}$	$7.6x10^{4}$
March	$4.8x10^{4}$	$5.9x10^{4}$	$4.6x10^{4}$	$8.7x10^{4}$	$1.07x10^{5}$
April	$6.7x10^{4}$	$6.4x10^{4}$	$9.6x10^{4}$	$3.44x10^{5}$	$2.01x10^{5}$
May	$5.3x10^{4}$	$1.48x10^{5}$	$1.65x10^{5}$	$2.34x10^{5}$	$1.5x10^{5}$
June	$2.9x10^{5}$	$5.5x10^{5}$	$7.3x10^{5}$	$5.2x10^{5}$	$4.8x10^{5}$
July	$4.5x10^{5}$	$1.0x10^{6}$	$4.0x10^{5}$	$6.0x10^{5}$	$5.9x10^{5}$
August	$1.7x10^{5}$	$2.0x10^{5}$	$3.1x10^{5}$	$4.8x10^{5}$	$7.7x10^{5}$
September	$1.6x10^{5}$	$3.4x10^{5}$	$3.8x10^{5}$	$5.2x10^{5}$	$4.2x10^{5}$
Total Coliform (MNP/100mL)					
October	$2.1x10^{3}$	$2.3x10^{3}$	$1.5x10^{3}$	$9.2x10^{2}$	$9.3x10^{3}$
November	$<3.0x10^{2}$	$2.3x10^{3}$	$1.5x10^{3}$	$1.5x10^{4}$	$1.1x10^{5}$
December	$9.2x10^{2}$	$4.3x10^{3}$	$9.2x10^{2}$	$9.3x10^{3}$	$2.4x10^{4}$
January	$2.3x10^{3}$	$7.5x10^{3}$	$4.3x10^{3}$	$1.1x10^{5}$	$2.1x10^{4}$
February	$4.3x10^{3}$	$4.3x10^{3}$	$2.8x10^{3}$	$1.1x10^{5}$	$7.5x10^{3}$
March	$<3.0x10^{2}$	$9.3x10^{3}$	$9.2x10^{2}$	$4.6x10^{4}$	$2.3x10^{3}$
April	$3.6x10^{2}$	$2.3x10^{3}$	$3.6x10^{2}$	$9.3x10^{3}$	$1.1x10^{5}$
May	$<3.0x10^{2}$	$7.4x10^{2}$	$9.2x10^{2}$	$9.3x10^{3}$	$1.1x10^{5}$
June	$7.4x10^{2}$	$9.3x10^{3}$	$7.4x10^{2}$	$4.6x10^{4}$	$2.4x10^{4}$
July	$2.3x10^{3}$	$4.6x10^{4}$	$2.8x10^{3}$	$>1.1x10^{7}$	$4.6x10^{4}$
August	$<3.0x10^{2}$	$9.3x10^{3}$	$1.5x10^{3}$	$1.5x10^{4}$	$1.5x10^{4}$
September	$<3.0x10^{2}$	$9.2x10^{2}$	$4.6x10^{4}$	$2.4x10^{4}$	$7.5x10^{3}$
Fecal Coliform (MPN/100mL)					
October	$9.2x10^{2}$	$2.3x10^{3}$	$1.5x10^{3}$	$9.2x10^{2}$	$9.3x10^{3}$
November	$<3.0x10^{2}$	$2.3x10^{3}$	$9.2x10^{2}$	$1.5x10^{4}$	$1.1x10^{5}$
December	$9.2x10^{2}$	$4.3x10^{3}$	$3.6x10^{2}$	$9.3x10^{3}$	$2.4x10^{4}$
January	$2.3x10^{3}$	$4.3x10^{3}$	$4.3x10^{3}$	$4.6x10^{4}$	$2.1x10^{4}$
February	$1.5x10^{3}$	$4.3x10^{3}$	$2.1x10^{3}$	$1.1x10^{5}$	$7.5x10^{3}$
March	$<3.0x10^{2}$	$2.1x10^{3}$	$9.2x10^{2}$	$1.5x10^{4}$	$2.3x10^{3}$
April	$3.6x10^{2}$	$2.3x10^{3}$	$3.6x10^{2}$	$9.3x10^{3}$	$1.1x10^{5}$
May	$<3.0x10^{2}$	$7.4x10^{2}$	$9.2x10^{2}$	$9.3x10^{3}$	$1.1x10^{5}$
June	$7.4x10^{2}$	$9.3x10^{3}$	$3.6x10^{2}$	$4.6x10^{4}$	$2.4x10^{4}$
July	$2.3x10^{3}$	$9.3x10^{3}$	$2.0x10^{3}$	$1.5x10^{4}$	$1.5x10^{4}$
August	$<3.0x10^{2}$	$9.3x10^{3}$	$9.2x10^{2}$	$1.5x10^{4}$	$9.3x10^{3}$
September	$<3.0x10^{2}$	$9.2x10^{2}$	$2.4x10^{4}$	$2.4x10^{4}$	$7.5x10^{3}$
***E. coli* (MPN/100mL)**					
October	$9.2x10^{2}$	$2.3x10^{3}$	$7.4x10^{2}$	$9.2x10^{2}$	$9.3x10^{3}$
November	$<3.0x10^{2}$	$2.3x10^{3}$	$9.2x10^{2}$	$1.5x10^{4}$	$1.1x10^{5}$
December	$9.2x10^{2}$	$4.3x10^{3}$	$3.6x10^{2}$	$9.3x10^{3}$	$2.4x10^{4}$
January	$2.3x10^{3}$	$4.3x10^{3}$	$4.3x10^{3}$	$4.6x10^{4}$	$2.1x10^{4}$
February	$1.5x10^{3}$	$4.3x10^{3}$	$2.1x10^{3}$	$1.1x10^{5}$	$7.5x10^{3}$
March	$<3.0x10^{2}$	$2.1x10^{3}$	$9.2x10^{2}$	$1.5x10^{4}$	$2.3x10^{3}$
April	$3.6x10^{2}$	$2.3x10^{3}$	$3.6x10^{2}$	$9.3x10^{3}$	$1.1x10^{5}$
May	$<3.0x10^{2}$	$7.4x10^{2}$	$9.2x10^{2}$	$2.1x10^{3}$	$1.1x10^{5}$
June	$7.4x10^{2}$	$9.3x10^{3}$	$3.6x10^{2}$	$4.6x10^{4}$	$2.4x10^{4}$
July	$2.3x10^{3}$	$9.3x10^{3}$	$2.0x10^{3}$	$1.5x10^{4}$	$1.5x10^{4}$
August	$<3.0x10^{2}$	$9.3x10^{3}$	$9.2x10^{2}$	$7.5x10^{3}$	$4.3x10^{3}$
September	$<3.0x10^{2}$	$9.2x10^{2}$	$9.3x10^{3}$	$2.4x10^{4}$	$7.5x10^{3}$

(ST:station; cfu:colony forming unit; MPN:most probable number)

Table 3. Annual average values of physicochemical properties of the water samples in Tunca River

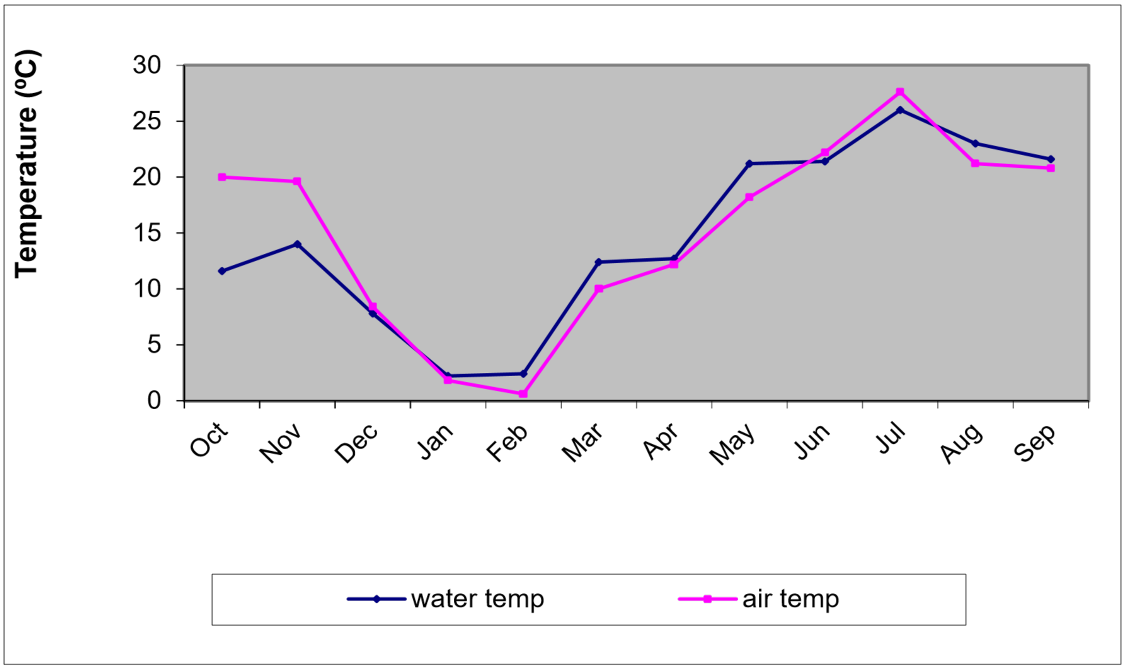
PARAMETERS	ST. 1	ST. 2	ST. 3	ST. 4	ST. 5	Mean
Water temp (ºC)	14.5	14.5	14.6	14.7	15.4	14.7
Air temp (ºC)	14.5	15	15.3	15.1	16.2	15.2
pH	8.92	8.52	8.41	8.41	8.31	8.51
EC (µS/cm)	549	556	568	574	574	564
DO (mg/L)	5.83	5.80	5.50	5.64	5.45	5.64
Turbidity (cm)	60	61	62	63	64	62
Salinity (‰)	0.088	0.086	0.081	0.087	0.088	0.086
Chlorides (mg/L)	37.82	40.23	40.90	41.32	41.65	40.38
H_2S (mg/L)	0.284	0.461	0.497	0.337	0.550	0.425
Ca^{+2} (mg/L)	61.05	62.65	60.78	58.55	56.51	59.90
Mg^{+2} (mg/L)	15.44	17.78	18.15	18.76	18.67	17.76
Total hardness (FSº)	17.0	18.3	17.6	17.1	17.1	17.4
NO_2-N (mg/L)	0.023	0.021	0.023	0.024	0.026	0.023
NO_3-N (mg/L)	5.648	5.859	5.389	6.708	6.621	6.045
Phosphate (mg/L)	0.056	0.055	0.057	0.060	0.057	0.057
Sulphate (mg/L)	2.013	2.104	2.212	2.204	2.203	2.147
SSS (mg/L)	302	295	320	345	394	331

(ST:station; EC:conductivity, DO:dissolved oxygen, SSS:suspended solid substances)

The highest average values for the TMAB numbers in Tunca River was recorded as $6.08x10^5$ cfu/100 mL at month July. Also, it was found that the increasing of TMAB numbers in the summer and the autumn was remarkable (Table 2). Çolakoğlu & Çakır (2004) reported that, in summer and autumn, most diversification of bacteria was observed. This situation can be explained by rising of water temperature in summer season and decreasing of flow, and increasing of organic substances which has been joined the water because of rain fall in autumn (Elmacı et al., 2008; Mishra et al., 2009; Saha et al., 2009; Bulut et al., 2010). Koloren et al. (2011) reported that the number of indicator bacteria and rain fall is directly proportional. Bulut et al. (2016) reported that TMAB ranged between with 0 to 172 cfu/100 mL in Egirdir Lake. TMAB in the Golbasi Lake was determined as $20x10^3$ cfu/mL (Toroglu & Toroglu, 2009). In our study, TMAB ranged between $3.6x10^4$-$1.0x10^6$ cfu/100 mL. When the total coliform, fecal coliform, and *E. coli* bacterial numbers were evaluated considering the sampling stations, the highest values were recorded in the 4th and 5th stations which are located near to city center of Edirne Province (Table 2), but the 1st station which is the most away from city center has been observed to be has the least bacteriological numbers. These high values can be explained by the sewages enter to the river from the 4th and 5th stations. Although, Karafistan & Colakoglu-Arik (2005) reported that Lake Manyas is threatened by anthropogenic pollution. Our findings demonstrated similar results. Bulut et al. (2016) reported that *E. coli* was not detected at all stations in Egirdir Lake. But our findings, *E. coli* were found at all times and stations in Tunca River.

The water and air temperature values of Tunca River were observed at seasonal expectancy that the values range between minimum 2°C and maximum 28°C (Figure 2). Also, Spearman's index showed that a positive correlation between the TMAB numbers and temperature values (for water temperature $r= 0.576$, $p<0.05$ in the autumn and $r= 0.571$, $p<0.05$ in the spring; for air temperature $r= 0.894$, $p<0.05$ in the April, $r= 0.975$, $p<0.01$ in the August and $r= 0.533$, $p<0.05$ in the autumn).

While the average values of dissolved oxygen (DO) in the river was observed as 5.64 mg/L, the lowest DO levels were measured at sampling stations which are the nearest to city center. Speraman's index showed that a negative correlation between the DO values and TMAB numbers in Tunca River ($r = -0.894$, $p<0.05$ in October; $r = -0.894$, $p<0.05$ in May; $r= -0.949$, $p<0.05$ in November). This situation can be explained by the organic materials found in water were decomposed by activities of aerobic microorganisms and thus oxygen consumed. Also, it was observed that the water temperature and DO have an inversely correlation in the study (Figure 2).


Temperature (ºC)
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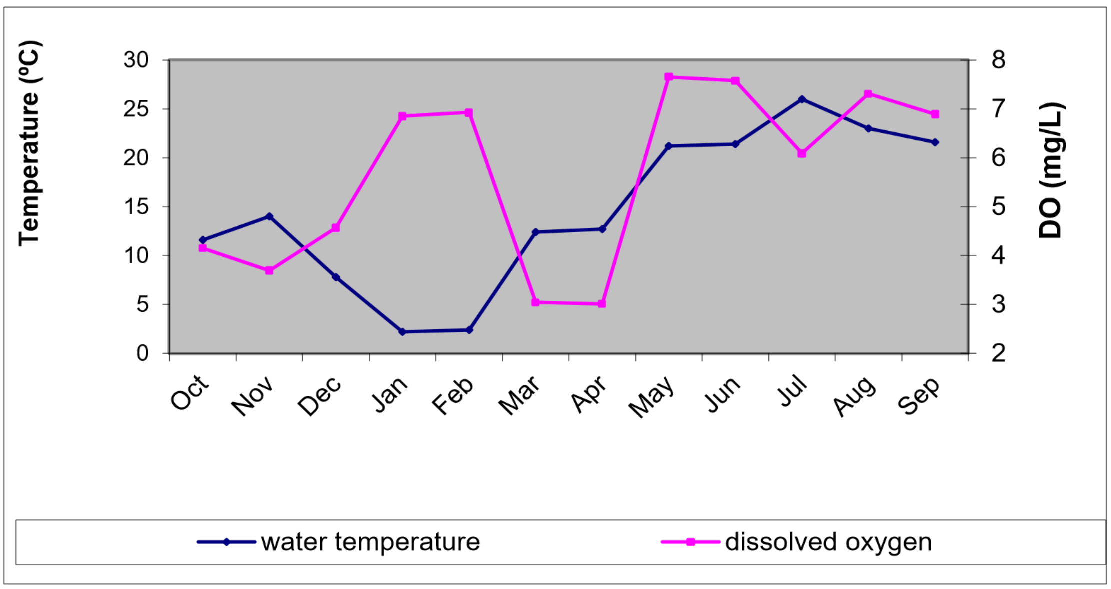
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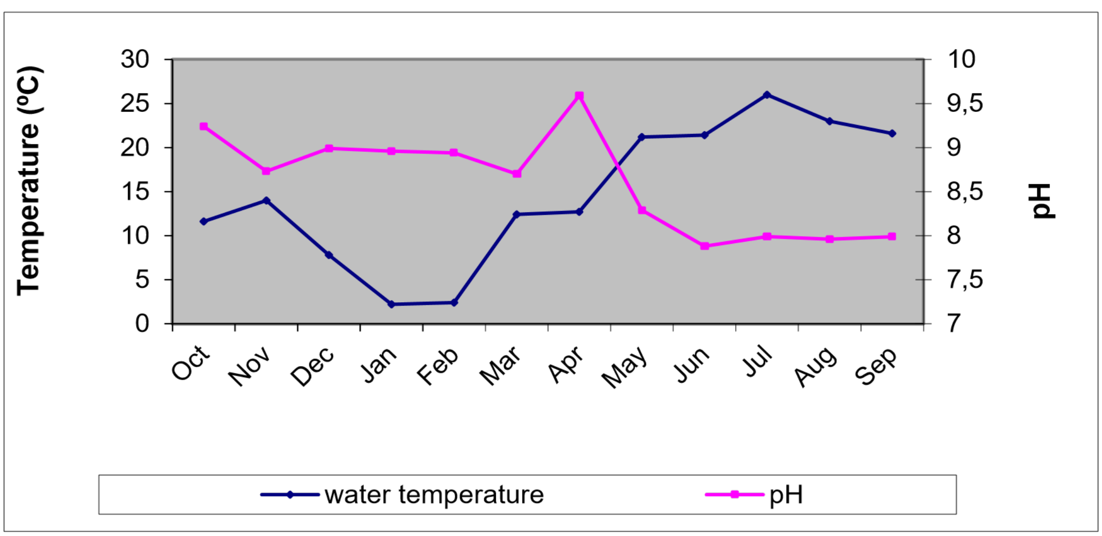
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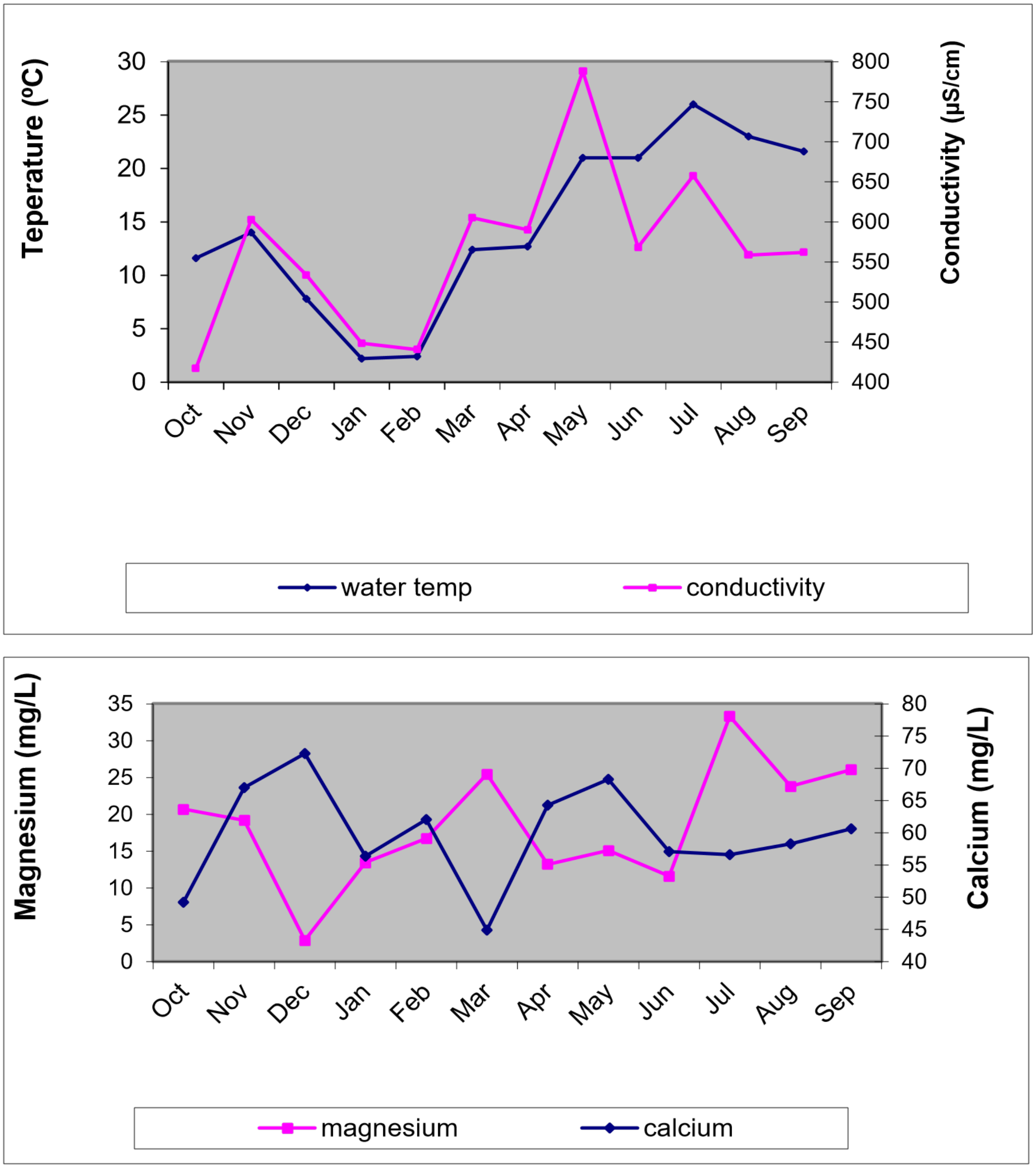

Figure 2. Monthly averages of some physicochemical parameters of Tunca River

The pH values were measured to have the lowest values in summer period and the highest in winter (Figure 2). The reason of the decrease in the summer might be the decomposition of organic materials by increasing activities of microorganisms. While the pH values change between 7.77 and 9.98, it was observed to have a negative correlation between the TMAB numbers and pH values (r = -0.900, p<0.05 in June; r = -1.000, p<0.01 in October; r = -0.699, p<0.01 in autumn; r = -0.651, p <0.01 in spring).

The decreasing of conductivity (EC) values of the river at winter season can be explained by decreasing of temperature in cold months (Figure 2). The average EC values were recorded as 564 µS/cm and it was observed to have a positive correlation between the EC and the TMAB numbers (r= 1.000, p<0.01 in August).

Although, the highest value was observed at month June, salinity levels in Tunca River did not change during the sampling periods. Excessive evaporation from surface of river and the lowest water level at month June can explain this situation.

The secchi disc depth was found to be very high in the summer because of the highest light permeability. But the secchi disc depth was measured very low at autumn season because of erosion towards to the river by the effect of rain.

The measured minimum H_2S rate was recorded in the winter season as 0.028 mg/L. Activities of microorganisms decrease in winter season because of falling of water temperature, and thus H_2S values decrease, too. Furthermore, a negative correlation was observed between H_2S values and TMAB numbers in the river (r = -0.975, p<0.01 in October).

While it was recorded that the calcium values at minimum 36.07 and maximum 76.95 mg/L; the magnesium values were observed minimum 0.48 and maximum 42.13 mg/L. Furthermore, an inverse correlation was determined between Ca^{+2} and Mg^{+2} levels in the river (Figure 2). Also, a negative correlation was observed between TMAB numbers and Ca^{+2} values (r = -1.000, p<0.01 in December); and a positive correlation between TMAB numbers and Mg^{+2} values (r = 0.533, p<0.05 in autumn).

Annual mean total hardness (TH) in Tunca River was measured as 17.4 FH°. A negative correlation was determined between TH value and TMAB numbers (in June r= -0.894, p<0.05; in winter r= -0.740, p<0.01; in spring r= -0.651, p<0.01).

The average nitrite nitrogen values were recorded as 0.023 mg/L in Tunca River. This value showed that the river has beta-mezosaprobic level towards to alfamezosaphrobic (Kazancı & Dugel, 2009). The maximum values belonging nitrite nitrogen were measured as 0.143 mg/L in November. The reason of this increase in November might be explained because of decrease bacterial activities transforming nitrite to nitrate by the intermediate product of nitrification with the temperature falling. In this study, the average nitrate nitrogen values were recorded as 13.969 mg/L with the highest ratio in May. This value showed that the river has beta-mezosaprobic level (Kazancı & Dugel, 2009). Furthermore, a positive correlation was found between NO_3-N values and TMAB numbers (r = 0.575, p<0.05 in winter). Our results on the increasing of nitrate levels in spring season are similar the results the study performed by Hunt & Sarıhan (2004) in Saricam Stream.

The average sulfide values were measured as 2.14 mg/L in the river. Also, a positive correlation was determined between SO_4^{-2} values and TMAB numbers (r = 0.975, p<0.01 in August; r = 0.900, p<0.05 in September; r = 0.515, p<0.05 in summer).

It was measured the o-PO_4^{-3} (ortho-phosphate) values between minimum 0.020 and maximum 0.146 mg/L, and a positive correlation was found between o-PO_4^{-3} and TMAB numbers (r= 0.975, p<0.01 in November; r= 0.900, p<0.05 in December; r= 0.975, p<0. 01 in July; r= 0.751, p<0.01 in winter). The values indicated that the river has beta-mesotrophic conditions according to the o-PO_4^{-3} levels.

The values of suspended solid substances (SSS) were measured at very high levels in November with 546 mg/L. Erosion material might have entered to the river by influence of rainfall, and thus the SSS values have reached to the high levels. It is seen that the data on SSS we obtained in the present study show similarity with the results of the study performed by Öterler (2003) in Tunca River. However, our findings on SSS were found to be higher than the findings from another study performed by Uluçam (1997) in the river. Furthermore, a positive correlation was determined between SSS values and TMAB numbers (r= 0.900, p<0.05 in April; in September r = 0.900, p<0.05).

As it was compared with studies carried out in Tunca River in previous, it was observed that biological oxygen demand (BOD_5) values increased at time. The entering of pollutant material to the river might lead to this situation. Also, a negative correlation was found between BOD_5 values and TMAB numbers (r = -0.975, p<0.01 in November; r= -0.900, p<0.05 in May; r = -0.900, p<0.05 in September).

Summarized, according to Spearman's Correlation Index, positive correlations were found between TMAB density and some environmental parameters (water-air temperature, EC, magnesium, nitrate nitrogen, sulphate, o-phosphate, and suspended solids); negative correlations were found between

TMAB density and the other parameters (pH, hydrogen sulphide, calcium, total hardness, and BOD_5).

The obtained data for heavy metals were shown at Table 4. According to the observed heavy metal values, the lead concentrations were found at high level.

When the obtained data on the physicochemical variables were evaluated according to Surface Water Quality Control Regulation of Turkey (Anonymous, 2016), the water quality of Tunca River was found at first quality level in terms of some parameters (temperature, pH, chloride, nitrate nitrogen, sulfate, phosphate, and cadmium). However, some observed parameter values (DO, nitrite nitrogen, iron, copper, and zinc) have signed that the river has second quality level. And the river was found at fourth quality level according to the findings of total coliform, fecalcoliform, BOD_5, and lead.

Conclusions

According to the some physicochemical findings observed in this study, it was determined that the water quality of Tunca River has proper conditions allowing surviving of living things. However, bacteriological findings belonging to the river was not found proper for direct use of water by human. Especially, the existence of *E.coli* in the river has shown that a serious contamination with fecal matter. Furthermore, the high levels belonging coliform, fecal coliform and *E. coli* indicate that the possibility the presence of other pathogenic microorganisms. Consequently, using the water of river will has been restricted by emergence of some resistant bacteria (Toroglu et al., 2006).

Consequently, it is suggested that pollution sources reaching to the river should be determined in order to remove present pollution of Tunca River or to prevent it to be more polluted. Therefore, it is also required to repeat similar analysis frequently and to follow the changes to appear in the water quality.

Table 4. Annual average values of heavy metals of the water and sediment samples in Tunca River

Station ↓	Heavy Metals →	**Fe (mg/L)**	**Cu (mg/L)**	**Zn (mg/L)**	**Pb (mg/L)**	**Cd (mg/L)**
ST. 1	**Water**	1.82	0.08	0.39	4.21	ND
	Sediment	78.25	1.01	1.19	57.43	ND
ST. 2	**Water**	1.36	0.11	0.31	4.91	ND
	Sediment	91.62	1.82	2.47	61.49	ND
ST. 3	**Water**	0.75	0.08	0.16	4.69	ND
	Sediment	348.20	1.51	9.23	74.05	ND
ST. 4	**Water**	1.19	0.03	2.69	5.42	ND
	Sediment	191.41	1.98	2.56	66.64	ND
ST. 5	**Water**	2.08	0.09	0.48	5.31	ND
	Sediment	266.96	1.85	3.56	66.64	ND

(ND:not determined)

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: All authors declare that this study does not include any experiments with human or animal subjects.

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Aspects of life history patterns of the cichlid fish *Hemichromis fasciatus* Peters, 1857 from Okpara Stream, Northern Benin, West Africa

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ABSTRACT

The piscivorous cichlid *Hemichromis fasciatus* dominated the Okpara Stream of Oueme River in Benin, and numerically made 29.49% of the fish community. Some aspects of the reproductive biology of this fresh/ brackish water cichlid were examined to evaluate the spawning patterns and establishment of the species in Okpara Stream. *Hemichromis fasciatus* individuals were sampled monthly during 18 months from December 2015 to May 2017 with seine, cast nets, gillnets, hooks and traps. Among the 2,818 individuals sampled, 55.43% were females and 37.33% were males with a sex-ratio of 1.49:1. The species showed low fecundities ranging between 113 and 1,716 oocytes. Length at first sexual maturity (L_{50}) in Okpara Stream were reduced, 9.22 cm-TL (females) and 10.95 cm-TL (males), indicating an early maturation. The ovarian structure give evidence of multiple spawning and the species reproduces all seasons. In Okpara Stream, *Hemichromis fasciatus* exhibited a life history strategy between "*r*" and "*K*" selection, yet, close to "*r*" selection. Because the length at first capture (Lc_{50} = 8.78 cm) is lower than sizes at first sexual maturity, stocks of spawners could be reduced and leading to low recruitment.

Keywords: Life-history, *Hemichromis fasciatus*, Okpara Stream, Multiple spawning, Recruitment, Early maturity

Introduction

Hemichromis fasciatus (Actinopterygii: Perciformes: Cichlidae) is a widespread African piscivorous cichlid dwelling most inland waters such as freshwater lakes, brackish waters, estuaries, rivers, streams floodplains etc. because of its high tolerance to environmental conditions (Leveque and Paugy, 2006, Kuela 2002, Paugy *et al.,* 2003, Kantoussan 2007, Montchowui *et al.,* 2007 Sidi Imorou *et al.,* 2019a). Like most African cichlids and despite its reduced abundance, the species showed great fisheries importance in the most water bodies. As colourful species, *Hemichromis fasciatus* is utilized as ornamental fish and raised in the aquarium. The species has a laterally cylindrical compressed body mainly covered with cycloid scales ranging from 28 to 30 scales in lateral line (Lévêque and Paugy, 2006). Juveniles lack the orange-red coloring of adults and show traces of intervening dark stripes. Subadult and adults in a state of stress also show dark interstices. The maximum size observed is 204 mm standard length (SL) (Lévêque and Paugy, 2006).

As feeding habit, *H. fasciatus* showed a moderate diet breadth and foraged mainly on fishes, aquatic insects, zooplankton and detritus. Unlike other cichlids, *H. fasciatus* is monogamous and protects eggs and fry but does not incubate orally (Albaret, 1982). The eggs are laid on a block of rock, and are fixed on a submerged support, in a clean place, sheltered from the current and at a depth of 10 to 20 cm (Daget, 1956). Parental custody is highly developed in this species; both parents protect and accompany their offspring until they reach a size of 2 to 3 cm.

In Benin, *H. fasciatus* is common and was recorded in almost all water bodies and running waters where this piscivorous cichlid showed reduced abundances varying between 0.37% and 6% of the fish community, but constituted an important fisheries resource (Jackson *et al.,* 2013; Montchowui *et al.,* 2007). However, recent fisheries survey by Sidi Imorou *et al.* (2019a) in the Okpara stream (North Benin), a tributary of the Oueme River indicated that *H. fasciatus* dominated this stream making numerically 29.49% of the fish assemblages. Consequently, in the Okpara Stream, the species is intensively exploited and thus, displayed high commercial and economic values in this northern running water.

Despite its high abundance and fisheries importance in the Okpara stream associated with ongoing environmental threats, nothing is known about the life history strategy and the reproductive ecology of this piscivorous species in this riverine water. This documentation is badly needed to characterize the species and to set up conservation, valorization and a rational exploitation scheme that assure the ecosystem balance.

The purpose of this fisheries study is to document some aspects of the reproductive biology of *Hemichromis fasciatus* from Okpara Stream in order to provide basic knowledge needed for management studies.

Material and Methods

Study Area and Sampling Sites

The study was performed in Okpara stream (200 Km), one of the longest tributary of the Oueme River (510 Km)**.** This river sourced in the Northeast of Benin country at 450 m of altitude. Oueme River is the longest river and the more important in term of fish species richness and fish production (Lalèyè *et al.,* 2004). Okpara stream is stretched between 8°14’-9°45’ North and 2°35’-3°25’ East and belongs to the northern hydrographic network. The Benin northern region, is characterized by a tropical climate with an alternation of dry season (November - April) and wet season (May - August) with a flood period from September to October. Annual ambient temperature averaged 26.6°C and lower temperatures (18°C) were recorded in December-January. Annual mean rainfall is about 1200 mm with a peak (2100 mm) recorded in July or August (Kora, 2006). Soils are ferruginous and alluvial and covered by a wooded savanna of *Parkia biglobosa*, *Khaya senegalensis*, *Vitellaria paradoxa,* marshy meadows, bamboo and fallow bushes (Dossou-Yovo, 2009). Commercial fisheries take place in Okpara Stream that was exploited by the surrounding populations. Also, this stream supplies the surrounding populations with drinking water from a dam built by SONEB, the Benin water company. Furthermore, Okpara Stream provides water for irrigated agriculture.

For this study, *H. fasciatus* individuals were collected in five (05) sampling sites (Figure 1). These sites were chosen according to localities, accessibility, fisheries importance and levels of sites degradation. Site 1 is situated in Perere Township at Okpara up stream and Site 2 is localized in Parakou Township at Gadela village (Okpara up stream), at about 2 km from SONEB dam. Site 3 is located at Kpassa village where a dam was built to serve as a source of drinking water for the populations of Tchaourou and Parakou Townships and surrounding villages. Site 4 is situated around Okpara downstream at Yarimarou village (Tchaourou Township) where the dam withdraws its water. Site 5 is also located around Okpara downstream at Sui village (Tchaourou Township). At the five collecting sites, samplings were done in the “aquatic vegetation habitat” at the edge of the stream and in the “open water habitat” exempt of vegetation, but characterized by a relatively high depth (Sidi Imorou *et al.,* 2019a).

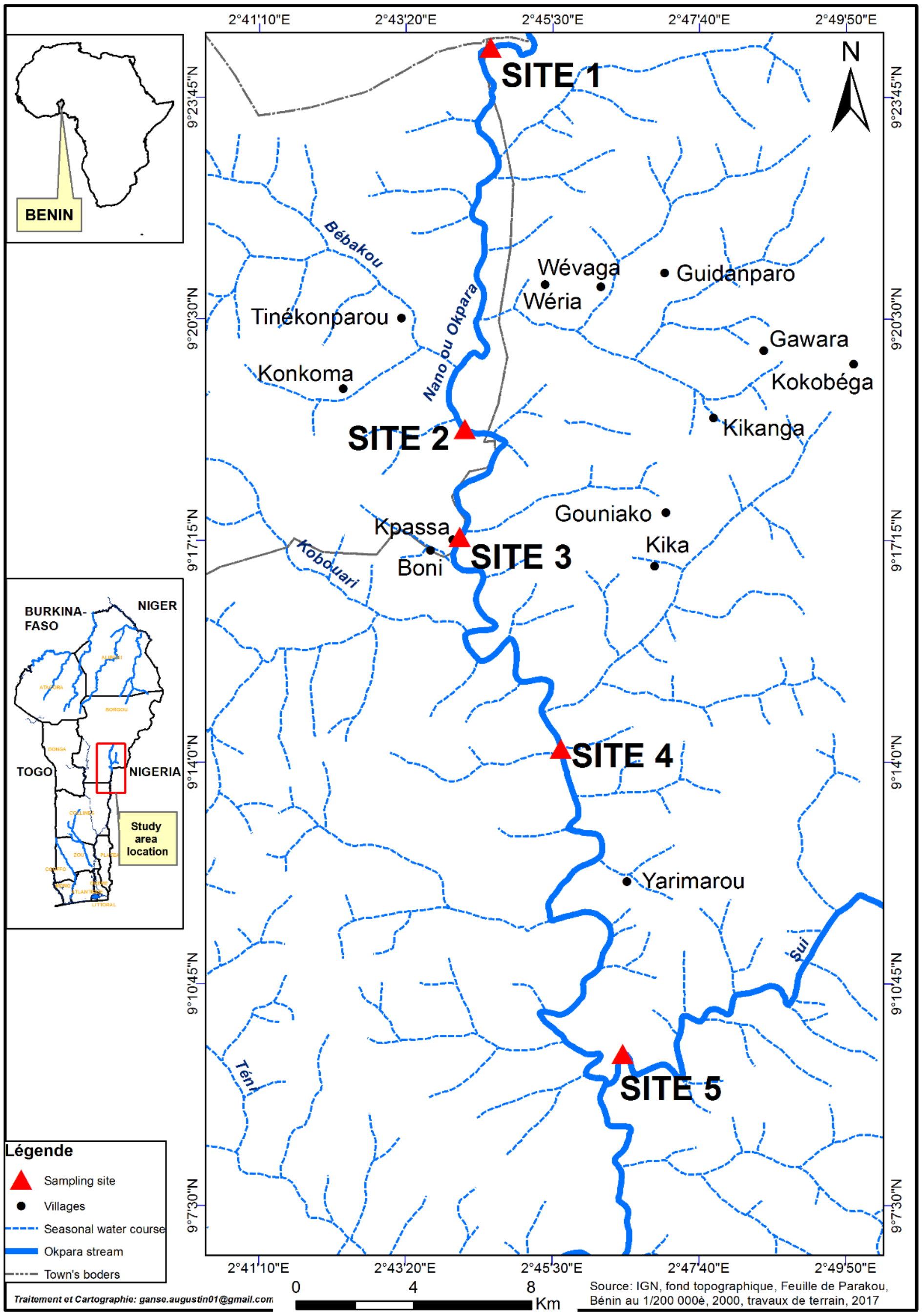

Figure 1. Okpara stream and sampling sites. Site 1= Perere Township, Site 2 = Gadela village (Parakou Township), Site 3= Kpassa village (Tchaourou Township), Site 4= Yarimarou village (Tchaourou Township), Site 5 = Sui village (Tchaourou Township).

Okpara Stream displayed a relatively adequate water quality with moderate temperatures ranging between 25 to 30.1°C, depths between 17 to 1080 cm and low transparencies varying between 10 and 78.1 cm. Dissolved oxygen concentrations ranged between 0.44 and 5.66 mg/l and the percentages of saturation were moderate to low and varied from 6.37 to 75.3%. The water was acid or alkaline with pHs ranging between 6.4 to 8.1 (Sidi Imorou *et al.,* 2019a). As results, and based on the physicochemical features recorded, the Okpara stream is relatively suitable for a high primary production and the prominence of the fish fauna.

Fish Sampling

Hemichromis fasciatus samplings were done once a month from December 2015 to May 2017 at all sites. Collections were done in open water with experimental gill net and in aquatic vegetation and with seines (Winemiller, 1992; Adite *et al.,* 2013; Gbaguidi and Adite, 2016, Sidi Imorou *et al.,* 2019a). Also, fish samplings were directly made in fishermen artisanal captures with gill net (50 m x 1.30 m, 2.5 mm-mesh; 50 m x 1.30 m, 30 mm-mesh; 50 m x 1.30 m, 35 mm-mesh). Fish species were identified using references such as Lévêque and Paugy (2006). After collection, fishes were preserved in 10% formalin and then transported to the Laboratory of Ecology and Management of Aquatic Ecosystem (LEMEA) where they were kept in 70% ethanol to make easier biological observations (Murphy and Willis, 1996).

Laboratory Procedure

In the laboratory, fishes were removed from the ethanol and measured for total length (TL) and standard length (SL) to a nearest 0.1mm with a digital caliper, and then weighed to the nearest 0.1g with an electronic scale. Before dissection, sexes were identified by examination of anal and genital opening (Gbaguidi and Adite, 2016): males possess a tinny sexual opening that also serves as anal orifice whereas females possess two (2) distinct orifices. After dissection, gonad weight, gonad length and width were recorded, and stage of maturity (I, II, III, IV, or V) in both males and females were evaluated using the gonad maturation scale described by King (1995) : (1) stage "immature" testis are simple translucent filaments and ovaries are not developed, they are small and translucent. Oocytes are not visible to the naked eye; (2) stage "Beginning of maturation" During development, testicles are yellow or ocher color and ovaries are opaque orange with opaque oocytes and visible to the naked eye; (3) "Advanced maturity" testis are large and opaque white, ovaries are mature and fills the ventral region of the abdominal cavity with translucent eggs large and round; (4) stage "Mature" corresponding to Ripe testis, fully developed and white milt was expelled by gentle pressure on the abdomen. For females, Ovaries are mature and oocytes are ready to be expelled; (5) expelled sperm, soft testes without milt, and expelled oocytes, narrowing of the ovaries with some residual eggs.

The ovaries and testicles are then preserved in 90% alcohol. Oocytes from mature ovaries were then separated using forceps and then enumerated. Oocytes diameters were recorded using a binocular loupe. Batch fecundity was estimated as the total number of oocytes in a ripe ovary. *H. fasciatus* oocytes showed an ovoid form comprising with two dimensions (d_1 and d_2), measured with a calibrated eyepiece micrometer mounted to a dissecting stereomicroscope. Therefore, the theoretical diameters (d) utilized to construct the frequency histograms of egg diameters were the geometric means (d) of d_1 and d_2, expressed as following:

$d = \sqrt{(d1 \times d2)}$ (Adite *et al.,* 2017)

Data Analysis

Data collected was recorded in Excel spreadsheet and analyzed with SPSS software version 21.0. The length of the smallest mature specimen was the basis of the categorization of the different life stages (Juveniles, subadults and adults) and the length at first sexual maturation (TL_{50}) for *H. fasciatus* (male and female) was estimated as the length at which 50% of the individual were mature as predicted by the formula of Ghorbel *et al.* (1996):

$$\boldsymbol{P = \frac{1}{1+e^{-(a+bTL)}}},$$

Where P is the pourcentage of individual mature, TL the total length, a and b are constants. The length at first sexual maturation were determined by: $TL_{50} = \frac{-a}{b}$

The sex ratio was computed as the ratio between the number of males and the number of females. In order to evaluate the spawning periodicity, the gonadosomatic indexes (GSI) were calculated on the monthly basis for males and females following the formula:

GSI = (gonad weight / body weight)*100.

The batch fecundity was estimated for ripe ovaries, and the relationship between fecundity (F) and Total length (TL) was determinate following the curvilinear formula:

$\mathbf{F = aTL^b}$**,** where a and b are the parameters of the regression

In addition, the linear relationship between fecundity (F) and body weight (W) was examined following linear regression:

F = bW + a, with *a* is the intercept, and *b* the slope.

For each season (flood, dry, wet), a mature gonad with a highest GSI was randomly chosen and frequency distributions of oocyte diameters were plotted to examine the trends of egg maturations and weather or not there was production of multiple cohorts per spawning season. The mean values of oocyte diameters and gonadosommatic index (IGS) were given with their standard deviation (mean ± standard deviation). Gender percentages (sex ratio) and length at first sexual maturity were compared using the χ^2 test. Multiple comparisons of IGS averages, and oocyte diameter were performed using a one-way ANOVA based on sex and seasons. The differences are considered significant at $p < 0.05$. All analyze were done by SPSS Software version 21.

Results and Discussion

Population Structure and Sex Ratio

In Okpara Stream, a total of 2,818 individuals of *Hemichromis fasciatus* were sampled from December 2015 to May 2017. This abundance represented 29.49% of the fish assemblages making this piscivorous cichlid, the dominant species of Okpara Stream fish community. In this stream, *H. fasciatus* exhibited a bimodal size distributions dominated by individuals of total length ranging between 9 -11 cm (Figure 2). Larger size (>11 cm) abundances were reduced.

Of the 2,818 *H. fasciatus* specimen, 55.43% (1562 individuals) were females, 37.33% (1052 individuals) were males and 7.24% (204 individuals) were unidentified. This corresponded to a sex-ratio of 1:1.49 that is in favor of females. This sex-ratio is significantly different to the theoretical sex ratio, 1:1 (χ^2= 99.503 p< 0.05) (Table 1). Also, the sex ratio varied significantly with seasons with females dominating the dry, wet and flood fish assemblages (Table 2).

Evolution of Gonadosomatic Index (GSI) and Spawning Time

Figure 3 showed the variation of the gonadosomatic index of *H. fasciatus* during the sampling period. Overall, the GSI ranged from 0.001 to 15.202 and averaged 3.186 ±2.64 for the females and there were significant difference ($F_{18,1544}$= 2.588; p< 0.05) monthly variations. In males, the GSI values were reduced and ranged between 0.01 and 1.70, with a mean of 0.6 ±0.007. Like the females, the GSI of males showed significant ($F_{18,1052}$ = 8.144; p< 0.05) monthly variations.

Mature individuals (Stage 2, 3 and 4) are present all months round with the highest proportions obtained in April (78.88%), May (84.54%), June (82.29%), July (80.32%) in males (Figure 4) and May (98.39%), June (91.56%), July (77.52%) and August (75.00%) among females (Figure 5). According to seasons, the wet and the flood were most favorable for the maturation of fishes with 96.52% and 95.82% respectively mature individuals.

Size at Sexual Maturity

Individuals of *H. fasciatus* with gonads at stages 2, 3 and 4 of the maturation scales were considered as mature and used to estimate the size at maturation (SSM). For the male, the smallest mature individual measured 8 cm-TL and weighted 8.2 g, and the smallest mature individual for females measured 6.4 cm-TL and weighted 4.68 g. Percentage of ripe gonads reached 100% at sizes 14-17 cm for females and 15-17 cm for males. Figures 6 and 7 illustrated the sigmoid curves generated by the plot of ripe gonad percentages against total length, respectively for males and females. The sigmoid model showed that the sizes at sexual maturity for male and female were 10.98 cm -TL and 9.22 cm-LT, respectively. The sizes at maturity are not significantly different (χ^2= 0.048475, p> 0.05) between males and females. The regression's equations were:

- $P_f = \frac{1}{1+e^{-(-4.9345+0.5351TL)}}$; r = 0.95 (for females)
- $P_m = \frac{1}{1+e^{-(-6.1074+0.5558TL)}}$; r = 0.91 (for males)

Ovarian Structure and Oocyte Sizes

Like in most cichlids, *Hemichromis fasciatus* possesses a pair gonads (Moyle, 1988; Gbaguidi and Adite, 2016). Eggs showed an ovoid shape and diameters varied from 0.800 mm to 1.5297 mm with a mean of 1.10±0.11mm. Overall, the oocytes exhibited seasonal variations of diameters that ranged between 0.8944 - 1.5297 (mean= 1.1280±0.1), 0.949 - 1.510 (mean= 1.192±0.12) and 0.80 - 1.342 (mean= 0.983±0.08) during wet, flood and dry. Egg diameter frequency distributions by seasons showed unimodal distributions (Figure 8).

Absolute and Relative Fecundity

Of the 2,818 individuals of *H. fasciatus* sampled, 821 mature females were recorded and were used to estimate batch fecundities. In this study, *H. fasciatus* showed batch fecundity ranging between 113 oocytes for an individual of TL = 8.9 cm (W = 14.4g, GSI = 2.08) to 1716 oocytes for an individual of TL = 9.7 cm (W = 19.5g, GSI = 5.64) with an average value of 857 ± 284.78 oocytes for the fish assemblages. Relative fecundity varied from 15.21 oocytes/g (15 <TL <17) to 71.015 oocytes/g (7 <TL <9) (Table 2). Power curve fitted to total length (TL) and fecundity (F) scatter plot showed that batch fecundity significantly increase with TL (r = 0.93, p<0.05) (Figure 8). Also linear regression fitted to body weight (W) and batch fecundity scatter plot showed that fecundity significantly (r = 0.89, p<0.05) increase with body weight (Figure 9). Regressions equations were as follows:

$F = 16.369TL^{1.8637}$ (r = 0.93, N = 821) (Figure 9) and

$F = 22.017W + 715.87$ (r = 0.89, N = 821) (Figure 10)

With: F= Fecundity (Number of oocytes); TL= Total length (cm); W= Body weight (g); N= Number of mature females; r= correlation coefficient

Table 1. Seasonal variations of the sex-ratio of *H. fasciatus* collected from December 2015 to May 2017 in Okpara Stream (North Benin)

Seasons	Males	Females	Sex ratio (M:F)	χ2
Dry	590	693	1:1.18	$\chi2 = 8.2689$, $p < 0.05$
Wet	422	766	1:1.82	$\chi2 = 99.609$, $p < 0.05$
Flood	40	103	1:2.58	$\chi2 = 27.755$, $p < 0.05$
Total	1052	1562	1:1.49	$\chi2 = 99.503$, $p < 0.05$

Table 2. Mean, range and relative fecundities by length classes of *H. fasciatus* collected from Okpara Stream (North Benin)

TL class (cm)	N	Mean body weigth (g)	Mean ovary weigth (g)	Mean fecundity	Fecundity range	Num of eggs/ovary gram	Relative fecundity	Mean GSI
7-9	141	11.42	0.58	811	168-1716	1398	71.015	5.05
9-11	666	16.60	0.68	854	113-1555	1256	51.45	4.14
11-13	58	30.18	0.72	897	397-1622	1246	29.72	2.46
13-15	14	49.34	0.86	951	540-1484	11.06	19.27	1.78
15-17	2	69.33	1	1055	945-1164	1055	15.21	1.24
Total	881	17.36	0.67	857	113-1716	1272	49.08	4.13

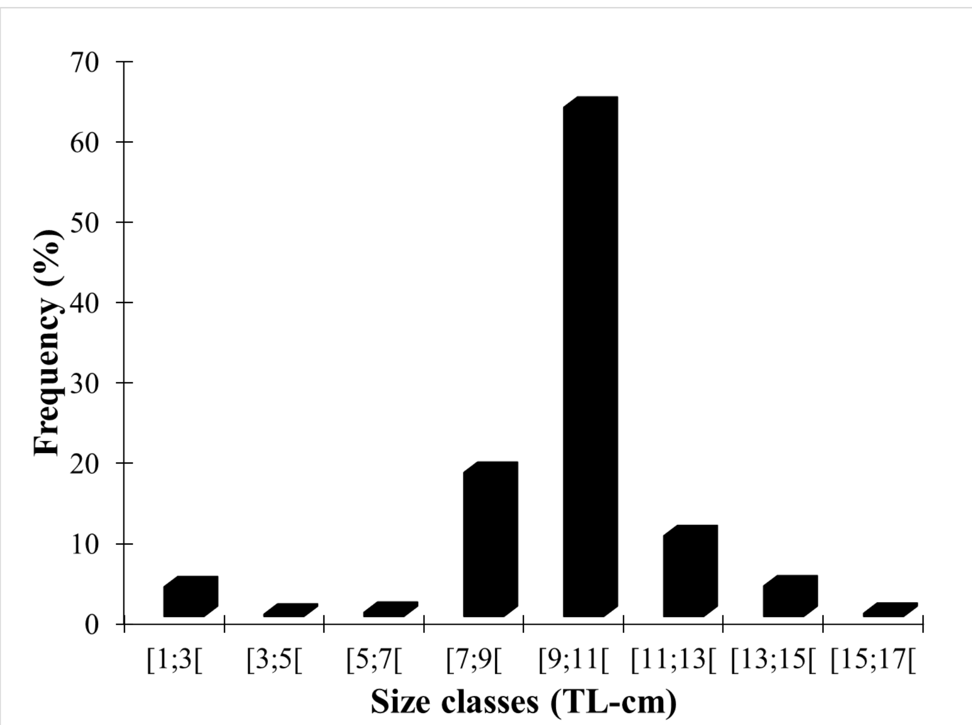

Figure 2. Size structure (TL) of *H. fasciatus* (n = 2,818) collected in Okpara Stream (North-Benin) from December 2015 to Mai 2017.

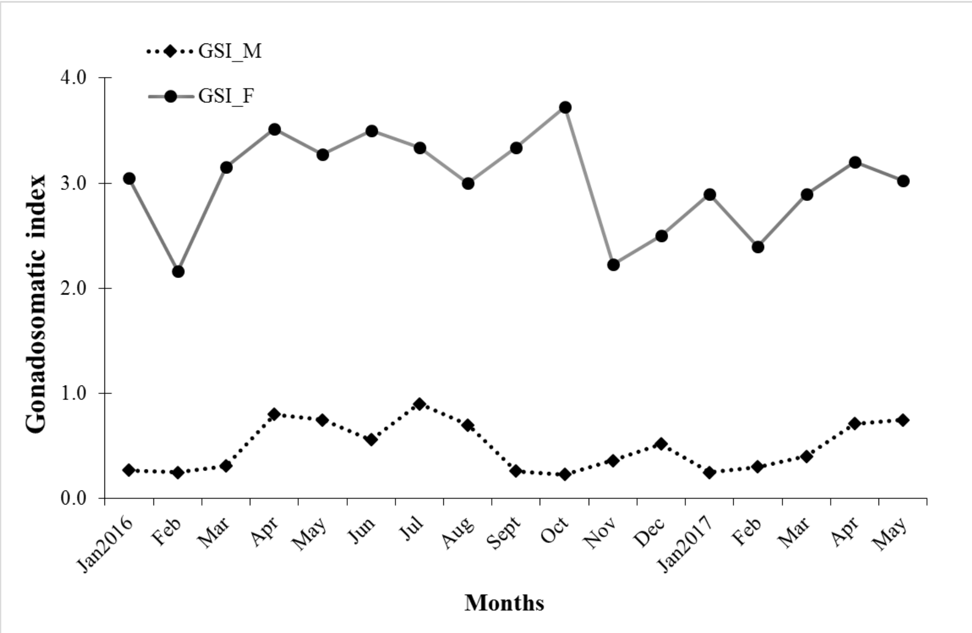

Figure 3. Variation of gonadosomatic index of *H. fasciatus* from December 2015 to May 2017 in Okpara stream (North Benin)

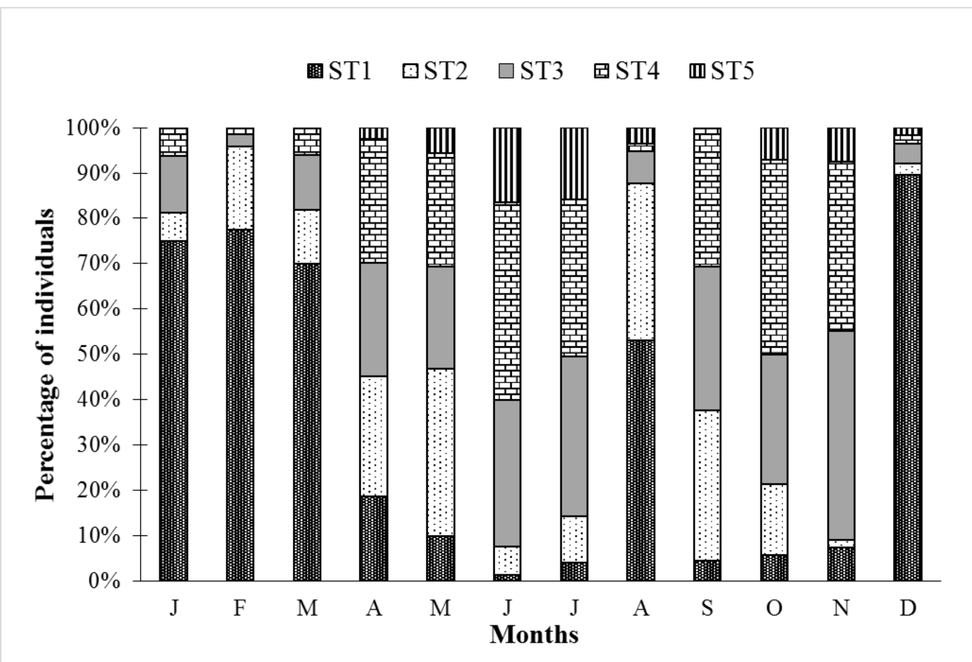

Figure 4. Percentage of gonads maturation stages in *H. fasciatus* males by months. ST1 = Immature stage; ST2 = Stage of beginning of maturation; ST3 = Advanced ripening stage; ST4 = Maturation stage and ST5 = Post-spawned

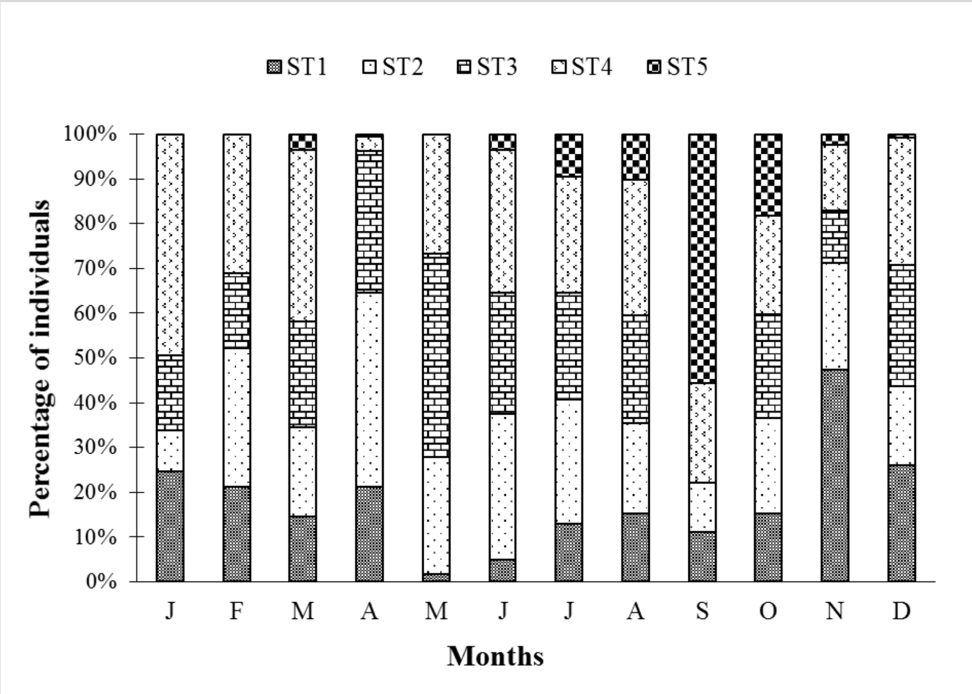

Figure 5. Percentage of gonads maturation stages in *H. fasciatus* females by months. ST1 = Immature stage; ST2 = Stage of beginning of maturation; ST3 = Advanced ripening stage; ST4 = Maturation stage and ST5 = Post-spawned

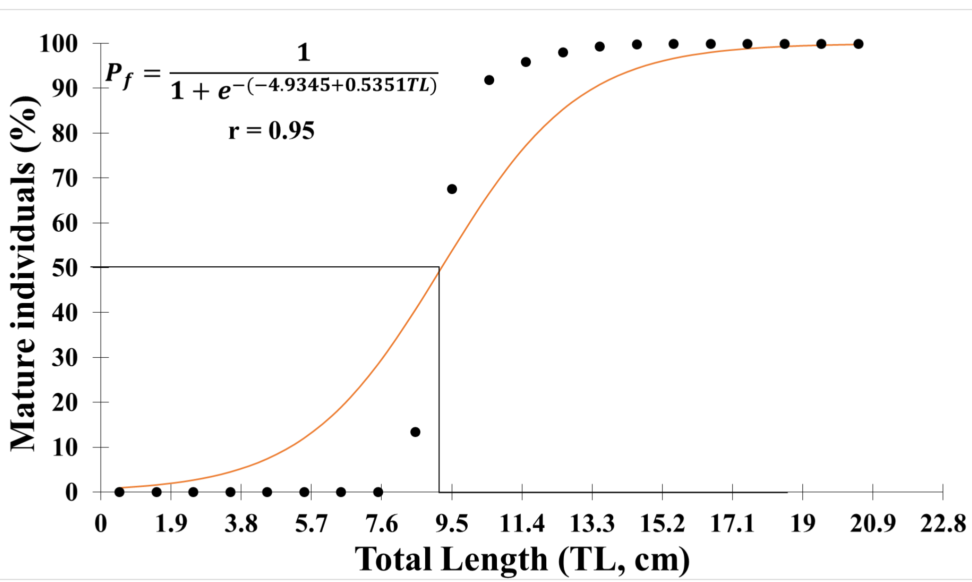

Figure 6. Lengths at first sexual maturity (L50) of *H. fasciatus* females (L50: 9.22cm, TL) from Okpara Stream, North Benin

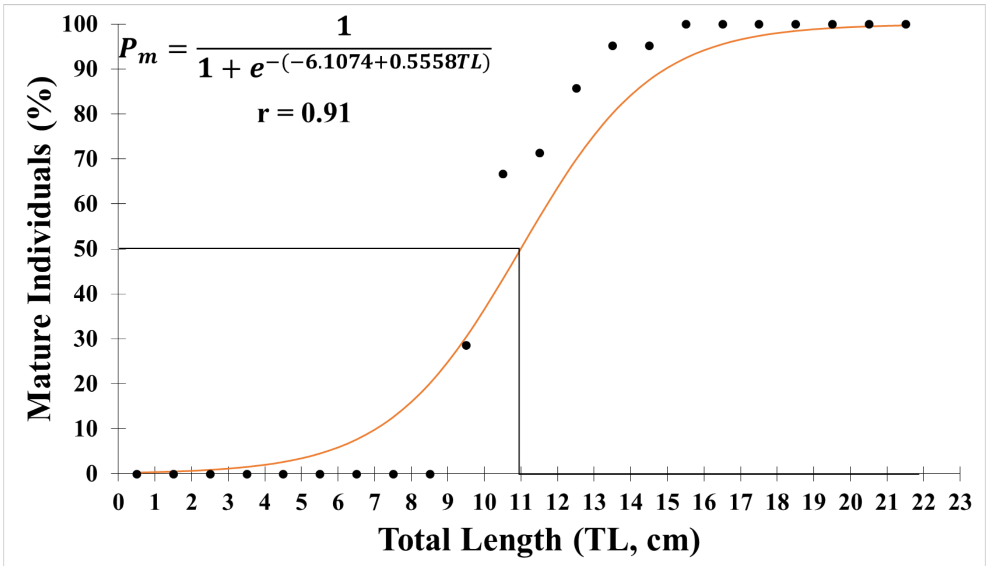

Figure 7. Lengths at first sexual maturity (L50) of *H. fasciatus* males (L50: 10.98 cm TL) from Okpara Stream, North Benin

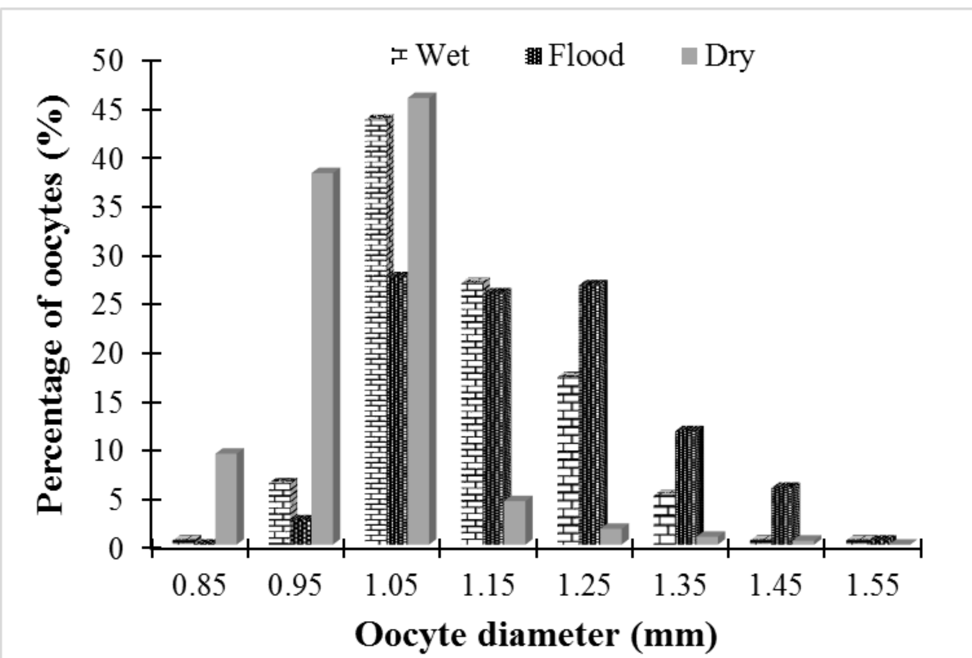

Figure 8. Seasonal Egg diameter frequency distribution of *H. fasciatus* from December 2015 to May 2017in Okpara stream, North Benin.

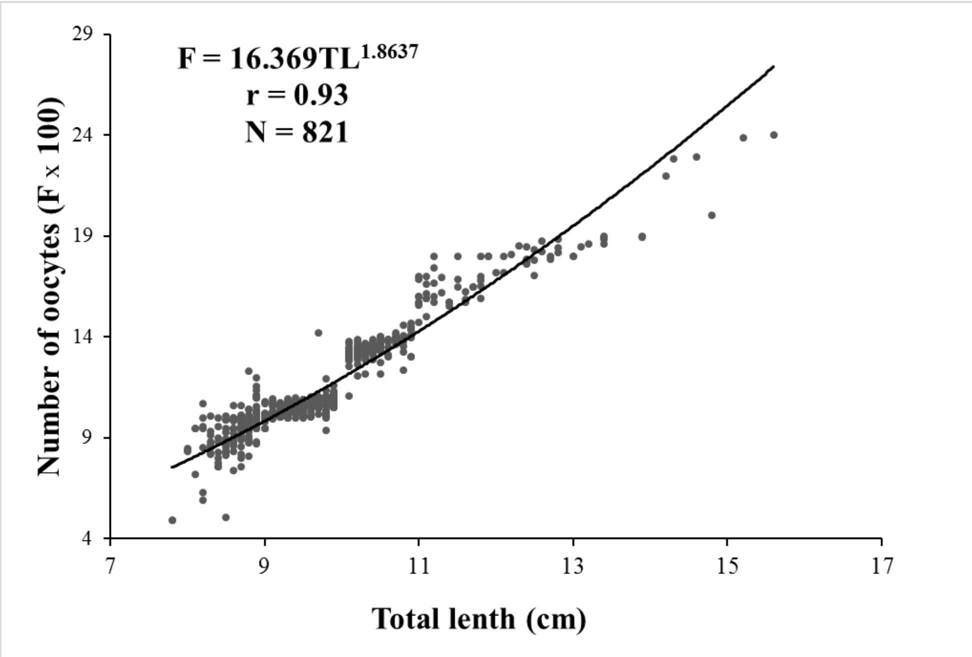

Figure 9. Relationship between Total length and fecundity of *H. fasciatus* in Okpara stream, North Benin

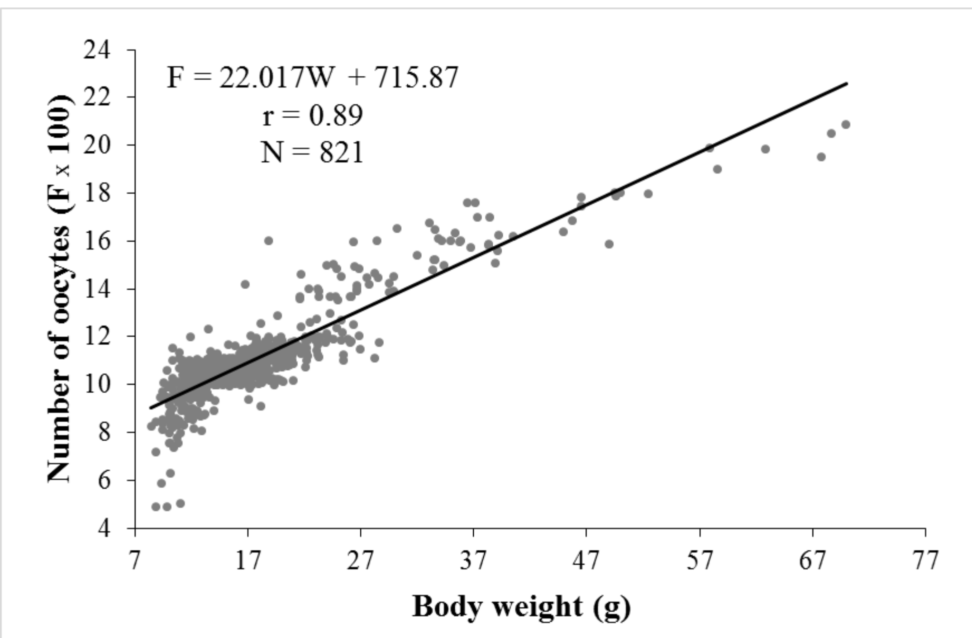

Figure 10. Relationship between Body weight and fecundity of *H. fasciatus* in Okpara stream, North Benin.

Sex-ratio, Maturation and Spawning Time

As reported by many authors such Poulet (2004) in teleost fishes, one sex predominates over the other. This general trend agreed with that recorded for the population of *H. fasciatus* in Okpara Stream where the sex-ratio (1:1.49) recorded was in favor of females with 1 male for 1.49 female. In Owa Stream in Nigeria Olurin and Odeyemi (2010) rather reported for *H. fasciatus* population, a sex ratio 1:0.36 in favor of males. The morphological traits, the growth rates and the behavioral characteristics of males/females as selective may play in favor of one sex. Also, in general, females are more sedentary and more vulnerable to fishing gears because of parental care behavior such as egg incubation and offspring protection at the spawning grounds (Atse *et al.,* 2009).

As reported by Sidi Imorou *et al.* (2019b), Okpara Stream showed favorable growth conditions for *H. fasciatus* that exhibited an isometric growth pattern (slope b: 3.0024) and a relatively high condition factor (K) reaching 8.02. Therefore, spawning was effective, successful and the species was perfectly established. Indeed, the current study revealed the presence of different life stages small juvenile, juvenile, sub-adult and adult in the population of *H. fasciatus* suggesting that the reproduction and the recruitment of fishes were successful (Gbaguidi and Adite, 2016). This result was also confirmed by the presence of all maturation stages in the gonads. Abundance of oocytes of big diameters (d > 1.05 mm) during the dry season (7.29%), the wet season (49.79%) and the flood period (70.12%) combined with the relative abundance of ripe gonads (stage 3 and 4) indicated that in Okpara Stream, *H. fasciatus* breeds all seasons. This finding agreed with that reported by Albaret (1982) in Ivory Coast and by Kwarfo-Apegyah and Ofori-Danson (2010) in Batonga Reservoir in Ghana where *H. fasciatus* spawned all year with a peak recorded in wet and flood seasons (Kwarfo-Apegyah and Ofori-Danson, 2010). As it is the case for many tropical fish species, the increase of water level during wet and flood seasons was the favorable condition that stimulates gonad maturation and led to spawning and recruitment (Albaret 1982; Wootton 1998; Lalèyè *et al.,* 1995; Dadebo *et al.*, 2003; Rutaisire and Booth 2005; Adité *et al.,* 2006).

Length at First Sexual Maturation (TL_{50})

In Okpara Stream, males of *H. fasciatus* reached their size at first maturity at a total length (L_{50} = 10.98 cm-TL) higher than that of females (L_{50} = 9.22 cm -TL). This sexual difference in L_{50}, mostly tardive in males was reported for several fish species such *Chrysichthys nigrodigitatus* and *Chrysichthys auratus* (Lalèyè *et al.,* 1995), *Clarias ebriensis* (Ezenwaji, 2002), *Labeo horie* (Dadebo *et al.,* 2003), *Labeo victorianus* (Rutaisire and Booth 2005); *Heterotis niloticus* (Adité *et al.,* 2006), *Clarias gariepinus*, *Clarias ebriensis*, *Schilbe intermedius*, *Schilbe mystus*, *Synodontis schall* (Chikou *et al.,* 2011), *Sarotherodon galileus* (Gbaguidi and Adite 2016) etc. Genetic factors including sexual dimorphism of growth and habitat conditions such as physicochemical variations and food resource availabilities could greatly affect the size at first sexual maturity (Wootton, 1998; Koné *et al.* 2011; Tembeni *et al.* 2014).

In this study, the size at first sexual maturity (L_{50} = 9.22 cm - TL) recorded for *H. fasciatus* females agreed with that reported by Olurin and Odeyemi (2010) in Owa Stream in Nigeria and that reported by Albaret (1982) in Ivory Coast. Also, in Batonga Reservoir in Ghana, Kwarfo-Apegyah and Ofori-Danson (2010) reported similar L_{50} for *H. fasciatus.* In contrast, in Ogun River in Nigeria, Adebissi (1987) found a higher L_{50}=10.4 cm-TL for *H. fasciatus* female. Though genetic traits could cause this differential L_{50} through breeding tactics and biological characteristics, habitat ecological status, fishery condition, population structure and environmental conditions and stockascity could together influence the length at first sexual maturity (Rutaisire and Booth, 2005). In Okpara stream, the length at first capture (Lc_{50}) for *H. fasciatus* is Lc_{50}=8.78cm (Sidi Imorou *et al.,* 2019c). This length is lower than the length at first maturity (L_{50}=10.98 cm for males and L_{50}=9.22 cm for females). This result suggested that in Okpara stream, specimen of *H. fasciatus* were caught before breeding for the first time. This situation could lead to a depletion of the stock of this species in the river.

Power curve fitted to total length (TL) and fecundity (F) scatter plot showed that batch fecundity significantly increase with TL ($r= 0.93$, $p<0.05$) (Figure 8). Also linear regression fitted to body weight (W) and batch fecundity scatter plot showed that fecundity significantly ($r = 0.89$, $p<0.05$) increase with body weight (Figure 9).

Fecundity and Breeding Strategy

In the current fishery survey, *H. fasciatus* showed batch fecundities ranging between 113 and 1716 oocytes (mean = 857 oocytes) with a relative fecundity of 49.08 oocytes / g of body weight in Ivory Coast, Albaret (1982) recorded a highest fecundity that reached 2509 oocyte along with a reduced relative fecundity of 30 oocytes / g of body weight. In contrast, in New Bussa kigera reservoir in Nigeria, Issa *et al.* (2005) reported a lowest fecundity of 520 oocytes. Probably, these spatial differences in fecundities were the results of differential environmental variabilities and differential availability in food resources (Fagade *et al.,* 1984; Issa *et al.,* 2005). In this study, batch fecundity exhibited significant ($r= 0.93$, $p< 0.05$) curvilinear relationship with total length and was positively correlated with body weight. Legendre and Ecoutin (1989) and Atse *et al.* (2009) reported similar trends in some other cichlids such as *Sarotherodon melanotheron*, *Tilapia guineensis* and *Tylochromis jentinki* from Ebrie Lagoon in Ivory Coast.

With regards to ovarian structure, *H. fasciatus* showed moderate oocyte diameter averaging 1.10 ± 0.11 mm and varying between 0.800 mm and 1.5297 mm. These diameter values were lower than those reported by Albaret (1982) in the water bodies of Ivory Coast and by Olurin and Odeyemi (2010) in Owa Stream in Nigeria where the oocyte diameters reached 1.65 mm and 1.94 mm, respectively. Also, the gonads comprised oocytes at all stages of maturity regardless of month (Figures 3 and 4), suggesting that *H. fasciatus* displayed multiple reproduction in the Okpara River with several offspring cohorts during the same spawning season. These breeding pattern is typical to most teleost fishes and cichlids in particular (Paugy *et al.,* 2006).

In this study, *H. fasciatus* exhibited a relative low sizes at sexual maturity 10.98 cm-TL (males) and 9.22 cm-LT (females), a low batch fecundity (F = 857 ± 284.78 oocytes), a relative low eggs diameters (d=1.10±0.11mm) and reproduce early. This piscivorious fish built nests in which eggs are laid and had multiple layers and practices parental care for the survival of its offspring (Stiassny *et al.,* 2007). These biological characteristics indicate that *H. fasciatus* has a demographic strategy between selections "r" and "K" but much closer to selection "r". This strategy optimizes the survival of eggs, larvae and juveniles through the practice of parental care with moderately early maturation associated with several spawnings throughout the year (Winemiller and Rose, 1992).

Conclusion

The current study on the reproductive biology of *H. fasciatus* gives valuable information on the spawning time, fecundity and spawning strategy of this fish species in Okpara stream. The favorable environmental conditions of Okpara stream coupled with the all seasons breeding and the spawning strategy characterized by the high offspring survivorship (parental care), the high accounted for the prominence in this ecosystem. However, values of size at first sexual maturity for both sexes superior to the length at first capture require special attention in the sustainable management plan for this ecosystem.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: This study was conducted in accordance with ethics committee procedures of animal experiments.

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Introduction

Material and Methods

Results and Discussion

Conclusion

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Acknowledgment: Acknowledgments allow you to thank people and institutions who assist in conducting the research.

References

Tables

Figures

Manuscript Types

Original Articles: This is the most important type of article since it provides new information based on original research. The main text should contain Introduction, "Materials and Methods", "Result and Discussion" and Conclusion sections.

Statistical analysis to support conclusions is usually necessary. Statistical analyses must be conducted in accordance with international statistical reporting standards. Information on statistical analyses should be provided with a separate subheading under the Materials and Methods section and the statistical software that was used during the process must be specified.

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Review Articles: Reviews prepared by authors who have extensive knowledge on a particular field and whose scientific background has been translated into a high volume of publications with a high citation potential are welcomed. These authors may even be invited by the journal. Reviews should describe, discuss, and evaluate the current level of knowledge of a topic in researches and should guide future studies. The main text should start with Introduction and end with Conclusion sections. Authors may choose to use any subheading in between those sections.

Short Communication: This type of manuscript discusses important parts, overlooked aspects, or lacking parts of a previously published article. Articles on subjects within the scope of the journal that might attract the readers' attention, particularly educative cases, may also be submitted in the form of a "Short Communication" Readers can also present their comments on the published manuscripts in the form of a "Short Communication". The main text should contain Introduction, "Materials and Methods", "Result and Discussion" and Conclusion sections.

Table 1. Limitations for each manuscript type

Type of manuscript	Page	Abstract word limit	Reference limit
Original Article	≤25	180	40
Review Article	no limits	180	60
Short Communication	≤5	150	20

Tables

Tables should be included in the main document, presented after the reference list, and they should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables. Abbreviations used in the tables should be defined below the tables by footnotes (even if they are defined within the main text). Tables should be created using the "insert table" command of the word processing software and they should be arranged clearly to provide easy reading. Data presented in the tables should not be a repetition of the data presented within the main text but should be supporting the main text.

Figures and Figure Legends

Figures, graphics, and photographs should be submitted as separate files (in TIFF or JPEG format) through the submission system. The files should not be embedded in a Word document or the main document. When there are figure subunits, the subunits should not be merged to form a single image. Each subunit should be submitted separately through the submission system. Images should not be labelled (a, b, c, etc.) to indicate figure subunits. Thick and thin arrows, arrowheads, stars, asterisks, and similar marks can be used on the images to support figure legends. Like the rest of the submission, the figures too should be blind. Any information within the images that may indicate an individual or institution should be blinded. The minimum resolution of each submitted figure should be 300 DPI. To prevent delays in the evaluation process, all submitted figures should be clear in resolution and large (minimum dimensions: 100 × 100 mm). Figure legends should be listed at the end of the main document.

All acronyms and abbreviations used in the manuscript should be defined at first use, both in the abstract and in the main text. The abbreviation should be provided in parentheses following the definition.

When a drug, product, hardware, or software program is mentioned within the main text, product information, including the name of the product, the producer of the product, and city and the country of the company (including the state if in USA), should be provided in parentheses in the following format:

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"Discovery St PET/CT scanner (General Electric, Milwaukee, WI, USA)"

All references, tables, and figures should be referred to within the main text, and they should be numbered consecutively in the order they are referred to within the main text.

Limitations, drawbacks, and the shortcomings of original articles should be mentioned in the Discussion section before the conclusion paragraph.

References

Reference System is APA 6th Edition

In-text Citation with APA

The APA style calls for three kinds of information to be included in in-text citations. The **author's last name** and the work's **date of publication** must always appear, and these items must match exactly the corresponding entry in the references list. The third kind of information, the page number, appears only in a citation to a direct quotation.

....(Crockatt, 1995).

Direct quote from the text

"The potentially contradictory nature of Moscow's priorities surfaced first in its policies towards East Germany and Yugoslavia," (Crockatt, 1995, p. 1).

Major Citations for a Reference List in Table 2.

Note: All second and third lines in the APA Bibliography should be indented.

REVISIONS

When submitting a revised version of a paper, the author must submit a detailed "Response to the reviewers" that states point by point how each issue raised by the reviewers has been covered and where it can be found (each reviewer's comment, followed by the author's reply and line numbers where the changes have been made) as well as an annotated copy of the main document. Revised manuscripts must be submitted within 30 days from the date of the decision letter. If the revised version of the manuscript is not submitted within the allocated time, the revision option may be cancelled. If the submitting author(s) believe that additional time is required, they should request this extension before the initial 30-day period is over.

Accepted manuscripts are copy-edited for grammar, punctuation, and format. Once the publication process of a manuscript is completed, it is published online on the journal's webpage as an ahead-of-print publication before it is included in its scheduled issue. A PDF proof of the accepted manuscript is sent to the corresponding author and their publication approval is requested within 2 days of their receipt of the proof.

Table 2.

Material Type	Reference List/Bibliography
A book in print	Baxter, C. (1997). *Race equality in health care and education.* Philadelphia: Ballière Tindall, p. 110-115, ISBN 4546465465
A book chapter, print version	Haybron, D.M. (2008). Philosophy and the science of subjective well-being. In M. Eid & R. J. Larsen (Eds.), *The science of subjective well-being* (p. 17-43). New York, NY: Guilford Press. ISBN 4546469999
An eBook	Millbower, L. (2003). *Show biz training: Fun and effective business training techniques from the worlds of stage, screen, and song*. p. 92-90. Retrieved from http://www.amacombooks.org/ (accessed 10.10.2015)
An article in a print journal	Carter, S. & Dunbar-Odom, D. (2009). The converging literacies center: An integrated model for writing programs. *Kairos: A Journal of Rhetoric, Technology, and Pedagogy,* 14(1), 38-48.
Preview article in a journal with DOI	Gaudio, J.L. & Snowdon, C.T. (2008). Spatial cues more salient than color cues in cotton-top tamarins (*Saguinus oedipus*) reversal learning. *Journal of Comparative Psychology,* https://doi.org/10.1037/0735-7036.122.4.441
Websites - professional or personal sites	*The World Famous Hot Dog Site.* (1999, July 7). Retrieved January 5, 2008, from http://www.xroads.com/~tcs/hotdog/hotdog.html (accessed 10.10.2015).
Websites - online government publications	U.S. Department of Justice. (2006, September 10). Trends in violent victimization by age, 1973-2005. Retrieved from http://www.ojp.usdoj.gov/bjs/glance/vage.htm (accessed 10.10.15).
Photograph (from book, magazine or webpage)	Close, C. (2002). *Ronald.* [photograph]. Museum of Modern Art, New York, NY. Retrieved from http://www.moma.org/collection/object.php?object_id=108890 (accessed 10.10.2015).
Artwork - from library database	Clark, L. (c.a. 1960's). *Man with Baby.* [photograph]. George Eastman House, Rochester, NY. Retrieved from ARTstor.
Artwork - from website	Close, C. (2002). *Ronald.* [photograph]. Museum of Modern Art, New York. Retrieved from http://www.moma.org/collection/browse_results.php?object_id=108890 (accessed 10.10.2015).