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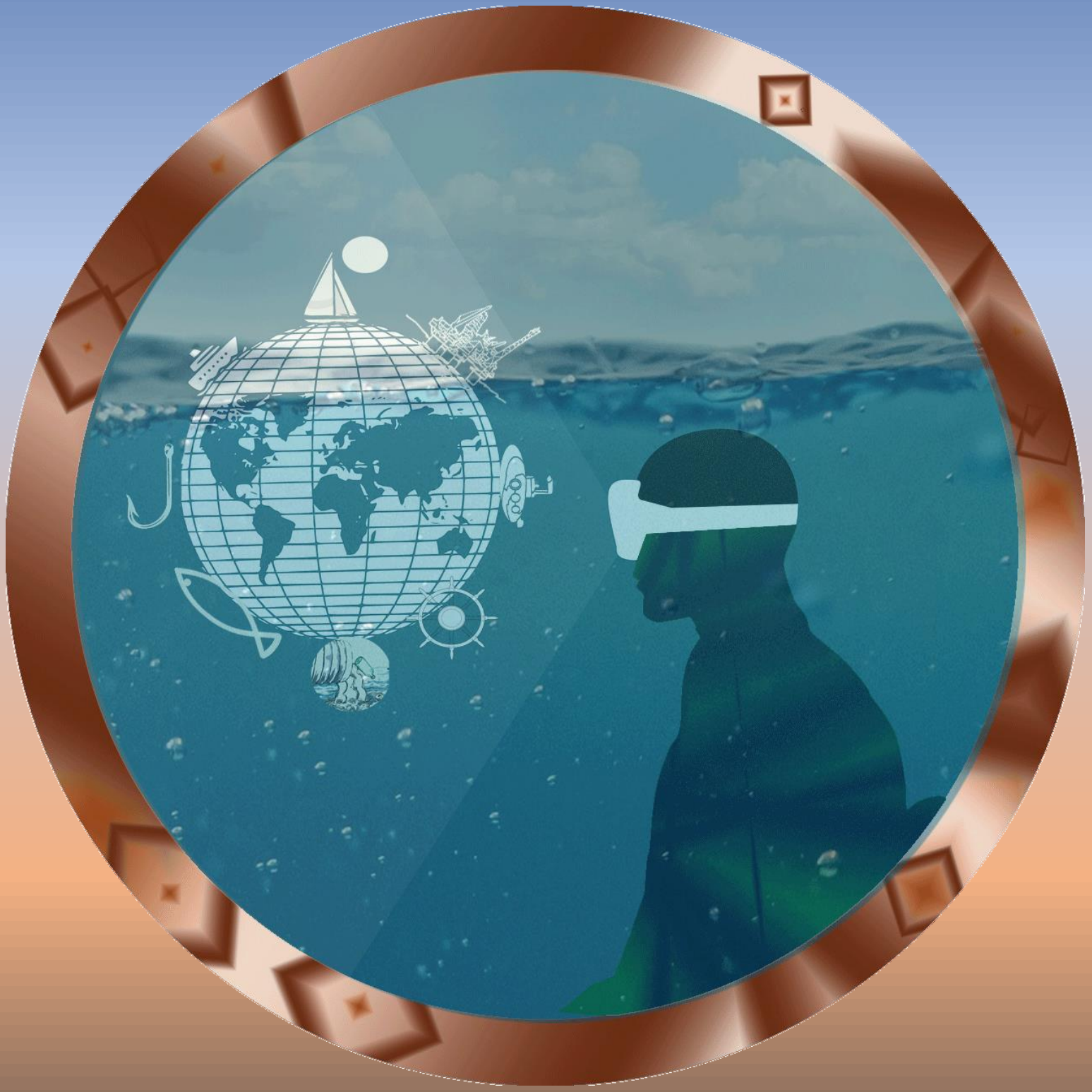
# Marine and Life Sciences



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## AIM & SCOPE

Marine and Life Sciences (Mar. Life Sci.), published twice a year (June and December), is a refereed English and Turkish journal. Mar. Life Sci. is a double peer-reviewed (blind) Open Access Journal. The Journal publishes original research, review articles, short communications, technical notes, reports, and letters to the Editor in the fields of marine and life sciences. The main purpose of the journal is to share the results of scientific research in the fields of science, engineering, and social sciences such as marine sciences, maritime, aquatic life, aquaculture, fisheries management, and environmental sciences. Mar. Life Sci. does not charge for any article.

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    - Statement of Human Rights
    - Data Availability
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Şimşek, E., & Kale, S. (2022). Length-weight relationship and condition factor of prussian carp (*Carassius gibelio*, Bloch, 1782) from Asi River. *Journal of Agricultural Production*, 3(2), 69-77. https://doi.org/10.56430/japro.1179095

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Hampton, S., Rabagliati, H., Sorace, A., & Fletcher-Watson, S. (2017). *Autism and bilingualism: A qualitative interview study of parents' perspectives and experiences*. PsyArXiv, *Preprint*. https://doi.org/10.31234/osf.io/76xfs

Hetland, B., McAndrew, N., Perazzo, J., & Hickman, R. (2018). *A qualitative study of factors that influence active family involvement with patient care in the ICU: Survey of critical care nurses*. PubMed Central, *Preprint*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5736422/?report=classic

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Chapter:

Langston, W. J. (1990). Toxic effects of metals and the incidence of marine ecosystems. In Furness, R. W. (Ed.), *Rainbow Heavy Metals in the Marine Environment* (pp. 102-l22). CRC Press.

Vassallo, A. I., & Mora, M. S. (2007). Interspecific scaling and ontogenetic growth patterns of the skull in living and fossil ctenomyid and octodontid rodents (Caviomorpha: Octodontoidea). In Kelt, D. A., Lessa, E., Salazar-Bravo, J. A., & Patton, J. L. (Eds.), *The Quintessential Naturalist: Honoring the Life and Legacy of Oliver P. Pearson* (pp. 945-968). 1st ed. University of California Press.

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Şimşek, E. (2018). Analysis of the factors affecting the discard fate for trawl fishery [Ph. D. Thesis, Iskenderun Technical University] (in Turkish).

Conference Proceedings:

Demirci, A., Şimşek, E., Demirci, S., Akar, Ö., & Bayraktar, O. (2018). Recreational fishing competitions in Turkey. *Proceedings Book of the International Ecology 2018 Symposium*, Kastamonu, Türkiye, pp. 505-506.

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FAO. (2016). *The State of World Fisheries and Aquaculture: Contributing to food security and nutrition for all*. Rome. 200 pp.

Report:

FAO. (2018). *Report of the ninth session of the Sub-Committee on Aquaculture*. FAO Fisheries and Aquaculture Report No. 1188. Rome, Italy.

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TurkStat. (2019). Fishery Statistics. Retrieved on December 28, 2019 from http://www.turkstat.gov.tr/

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**Original Budapest Open Access Initiative Declaration**

An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the worldwide electronic distribution of peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and the quest for knowledge.

The literature that should be freely accessible online is that which scholars give to the world without expectation of payment. Primarily, this category encompasses their peer-reviewed journal articles, but it also includes any unreviewed preprints that they might wish to put online for comment or to alert colleagues to important research findings. There are many degrees and kinds of wider and easier access to this literature. By "open access" to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.

While the peer-reviewed journal literature should be accessible online without cost to readers, it is not costless to produce. However, experiments show that the overall costs of providing open access to this literature are far lower than the costs of traditional forms of dissemination. With such an opportunity to save money and expand the scope of dissemination at the same time, there is today a strong incentive for professional associations, universities, libraries, foundations, and others to embrace open access as a means of advancing their missions. Achieving open access will require new cost recovery models and financing mechanisms, but the significantly lower overall cost of dissemination is a reason to be confident that the goal is attainable and not merely preferable or utopian.

To achieve open access to scholarly journal literature, we recommend two complementary strategies.

**I. Self-Archiving:** First, scholars need the tools and assistance to deposit their refereed journal articles in open electronic archives, a practice commonly called, self-archiving. When these archives conform to standards created by the Open Archives Initiative, then search engines and other tools can treat the separate archives as one. Users then need not know which archives exist or where they are located in order to find and make use of their contents.

**II. Open-access Journals:** Second, scholars need the means to launch a new generation of journals committed to open access, and to help existing journals that elect to make the transition to open access. Because journal articles should be disseminated as widely as possible, these new journals will no longer invoke copyright to restrict access to and use of the material they publish. Instead, they will use copyright and other tools to ensure permanent open access to all the articles they publish. Because the price is a barrier to access, these new journals will not charge subscription or access fees and will turn to other methods for covering their expenses. There are many alternative sources of funds for this purpose, including the foundations and governments that fund research, the universities and laboratories that employ researchers,

endowments set up by discipline or institution, friends of the cause of open access, profits from the sale of add-ons to the basic texts, funds freed up by the demise or cancellation of journals charging traditional subscription or access fees, or even contributions from the researchers themselves. There is no need to favor one of these solutions over the others for all disciplines or nations, and no need to stop looking for other, creative alternatives.

Open access to peer-reviewed journal literature is the goal. Self-archiving (I.) and a new generation of open-access journals (II.) are the ways to attain this goal. They are not only direct and effective means to this end, but they are also within the reach of scholars themselves, immediately, and need not wait on changes brought about by markets or legislation. While we endorse the two strategies just outlined, we also encourage experimentation with further ways to make the transition from the present methods of dissemination to open access. Flexibility, experimentation, and adaptation to local circumstances are the best ways to assure that progress in diverse settings will be rapid, secure, and long-lived.

The Open Society Institute, the foundation network founded by philanthropist George Soros, is committed to providing initial help and funding to realize this goal. It will use its resources and influence to extend and promote institutional self-archiving, to launch new open-access journals, and to help an open-access journal system become economically self-sustaining. While the Open Society Institute's commitment and resources are substantial, this initiative is very much in need of other organizations to lend their effort and resources.

We invite governments, universities, libraries, journal editors, publishers, foundations, learned societies, professional associations, and individual scholars who share our vision to join us in the task of removing the barriers to open access and building a future in which research and education in every part of the world are that much more free to flourish.

For various reasons, this kind of free and unrestricted online availability, which we will call open access, has so far been limited to small portions of the journal literature. But even in these limited collections, many different initiatives have shown that open access is economically feasible, that it gives readers extraordinary power to find and make use of relevant literature, and that it gives authors and their works vast and measurable new visibility, readership, and impact. To secure these benefits for all, we call on all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way. The more who join the effort to advance this cause, the sooner we will all enjoy the benefits of open access.

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## REVIEW PROCESS

### Double-Blind Review and Evaluation Process

Double-Blind Review is a method applied for publishing scientific publications with the highest quality. This method forms the basis of an objective evaluation of scientific studies and is preferred by many scientific journals.

The views of referees have a decisive place in the publication quality of ***Marine and Life Sciences*** uses the double-blind review method, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process, in the evaluation process of all studies. For this reason, the authors are asked to erase their names while uploading the articles to the system.

All the studies submitted to ***Marine and Life Sciences*** are evaluated by double-blind review method according to the following steps.

#### *1. Initial Evaluation Process*

The studies submitted to ***Marine and Life Sciences*** are first evaluated by the editor. At this stage, studies that are not in line with the aim and scope of the journal, are weak in terms of language and narrative rules in English contain scientifically critical mistakes, are not original worthy and cannot meet publication policies are rejected. Authors of rejected studies will be notified within one month at the latest from the date of submission. Eligible studies are sent to the field editor to which the study is relevant for pre-evaluation.

#### *2. Pre-Evaluation Process*

In the pre-evaluation process, the field editors examine the studies, introduction and literature, methods, findings, results, evaluation and discussion sections in detail in terms of journal publication policies, scope and authenticity of study. Study which is not suitable as a result of this examination is returned to the author with the field editor's evaluation report within four weeks at the latest. The studies which are suitable for the journal are passed to the referee process.

#### *3. Referee Process*

The studies are sent to the referees according to their content and the expertise of the referees. The field editor examining the study may propose at least two referees from the pool of ***Marine and Life Sciences*** Advisory Board or referee pool according to their field of expertise or may propose a new referee appropriate to the field of study.

The editors evaluate the referee's suggestions coming from the field editor and the studies are submitted to the referees. Referees are obliged to guarantee that they will not share any process or document about the study they are evaluating.

#### *4. Referee Evaluation Process*

The period given to the referee for the evaluation process is 15 days. Proposals for corrections from referees or editors must be completed by the authors within 1 month according to the "correction instruction".

Referees can decide on the suitability of the study by reviewing the corrections and may also request multiple corrections if necessary.

### Referee Reports

Referee evaluations are based in general on the originality of the studies, the method used, and the conformity with the ethical rules,

the consistent presentation of the findings and results, and the examination of the literature.

This review is based on the following elements:

*1. Introduction and Literature:* The evaluation report contains the presentation and purpose of the problem addressed in the study, the importance of the topic, the scope of the relevant literature, the timeliness and the originality of the study.

*2. Methodology:* The evaluation report includes information on the suitability of the method used, the choice and characteristics of the research group, validity and reliability, as well as on the data collection and analysis process.

*3. Findings:* The evaluation report includes opinions on the presentation of the findings obtained in the frame of the method, the correctness of the analysis methods, the aims of the research and the consistency of the findings, the presentation of the required tables, figures and images and the conceptual evaluation of the tests used.

*4. Evaluation and discussion:* The evaluation report includes the opinion on the subject based on findings, relevance to research questions and hypotheses, generalizability and applicability.

*5. Conclusion and suggestions:* The evaluation report contains the opinion on the contributions to the literature, future studies and recommendations for the applications in the area.

*6. Style and narration:* The evaluation report includes compatibility of the headline with the content, appropriate use of English in the study, and references in accordance with the language of the study and APA (7th) rules.

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# Donanımlı dalışlarda eğitmen ve dalıcı profili: İzmir ili örneği

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**Araştırma Makalesi**

*Makale Tarihçesi*
Geliş Tarihi: 19.12.2023
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*Anahtar Kelimeler:*
Donanımlı dalış
Dalış eğitimi
Eğitmen profili
Dalıcı profili
İzmir

## Ö Z E T

Donanımlı dalış, her geçen gün daha da yaygınlaşan bir aktivite olmasına rağmen, gerekli tedbirler alınmadığı takdirde yaralanma veya ölüme neden olabilecek potansiyel riskleri içermektedir. Bu çalışmada İzmir İl'inde donanımlı dalış faaliyetlerinde bulunan eğitmen ve dalgıç profilinin belirlenmesi amaçlanmıştır. Eğitmenlerin ve dalgıçların ortalama dalış süreleri, dalış sırasında karşılaştıkları sorunlar ve tehlikeler, seminer ve kurslara katılımları ve dalış merkezlerinin yeterliliği araştırılmıştır. Saha çalışması 2017 yılında İzmir ilinde 30 eğitmen ve 30 dalıcı ile yüz yüze anket ve derinlemesine görüşme yoluyla gerçekleştirilmiştir. Araştırmada elde veriler öncelikle tanımlayıcı istatistiki değerlendirmeye tabi tutulmuştur. Eğitmenler ve dalıcıların sosyo-demografik özellikleri değerlendirildiğinde eğitmenlerin yaş ortalamalarının (±SE/SH?) 42,1±1,32, dalıcıların ise 23,5±0,6 olduğu belirlenmiştir. Eğitmenlerin %93,7 erkek, %6,7'si kadınlardan oluşurken dalıcıların %86,7 erkek, %13,3'ü kadındır. Dalış güvenliği açısından herhangi bir sorunla karşılaşılmadığı, mevcut yasa yönetmelik ve talimatlara uyulduğu fakat federasyon ve ilgili kolluk kuvvetlerince yapılan denetimlerin yetersiz olduğu bildirilmiştir. Anket çalışmalarının sübjektif olabileceği göz önünde bulundurularak bu tür çalışmalar ileride yapılacak saha çalışmaları ile desteklenmesi gerekmektedir.

**Instructor and diver profile in SCUBA diving: An example of İzmir province**

*Keywords:*
SCUBA diving
Diving training
Instructor profile
Diver profile
Izmir

## A B S T R A C T

Scuba diving, despite becoming an increasingly prevalent activity, entails potential risks of injury or death if necessary precautions are not taken. In this study, the aim is to determine the profile of instructors and divers engaged in scuba diving activities in the İzmir Province. The average dive durations of instructors and divers, the problems and hazards encountered during dives, their participation in seminars and courses, and the adequacy of diving centers have been investigated. The fieldwork was conducted in 2017 in İzmir with 30 instructors and 30 divers through face-to-face surveys and in-depth interviews. The collected data were primarily subjected to descriptive statistical analysis. When evaluating the socio-demographic characteristics of instructors and divers, the average ages of instructors were determined to be 42.1±1.32, and divers were 23.5±0.6. While 93.7% of instructors were male, 6.7% were female, and 86.7% of divers were male, with 13.3% being female. It was reported that there were no issues related to dive safety, and compliance with existing laws, regulations, and instructions was observed. However, inspections conducted by federations and relevant law enforcement were reported as insufficient. Considering the subjective nature of survey studies, it is essential to support such research with future fieldwork.

## GİRİŞ

Dalışın tarihi çok eski zamanlara dayanmaktadır (Edmonds ve ark., 1975). Başlangıçta hiçbir alet kullanmadan yapılan dalışlarda teknolojik gelişmelerle birlikte süreç içerisinde daha derin sularda ve uzun süreli dalışlar gerçekleştirilmiştir. Bu buluşların miladı sayılabilecek gelişme ise 1943 yılında Cousteau ve Cagnan'ın su ciğeri (Aqualung) ismini verdikleri regülatörü bulmaları olmuştur (Düzbastılar & Düzbastılar, 2007). Bu buluşla birlikte dalış teknolojisi hızla gelişmiş profesyonel ve sportif sualtı dünyası popüler bir aktivite halini almıştır. Donanımlı dalış, yaygın adıyla Self-Contained Underwater Breathing Apparatus (yaygın adıyla SCUBA), dünyada ve ülkemizde en hızlı büyüyen rekreasyonel amaçlı faaliyetlerden biridir. Professional Association of Diving Instructors (PADI), 1967'den 2020 yılına kadar 28 milyon dalgıcın sertifikalandırıldığını bildirmiştir (PADI, 2021). Dünya genelinde 2020 yılında aktif olarak donanımlı dalış yapan kişi sayısı 6 milyondur (Mellen, 2021) ve bu sayıya yılda ortalama 900.000'den fazla kişi eklenmektedir (PADI, 2021). Dalgıç sayısının artması dalışın doğasında bulunan yüksek riskler nedeniyle ölümlü kazaları da arttırmıştır. Dalış kazaları ile ilgili raporlar National Oceanic and Atmospheric Administration (NOAA), British Sub-Aqua Club (BSAC) ve Divers Alert Network (DAN) gibi çeşitli kuruluşlar tarafından periyodik olarak yayınlanmaktadır. DAN raporunda dünya genelinde 2015 yılında 146, 2018 yılında 189 ölümle sonuçlanan dalış kazası bildirilmiştir. (Tillmans, 2020). Ülkemizde ise dalış kazaları ile ilgili araştırmalar son derece sınırlıdır (Koca, 2015; Alkan & Karadurmuş, 2023). Dalış kazalarının ve buna bağlı ölümlerin önlenebilmesi için eğitimlerin tam ve eksiksiz bir şekilde yetkili dalış merkezlerinden alınması oldukça önemlidir.

Dünya genelinde rekreasyonel amaçlı dalış eğitimleri; Dünya Sualtı Sporları Konfederasyonu (CMAS), PADI, Uluslararası SCUBA Okulu (SSI), Ulusal Sualtı Eğitmenler Birliği (NAUI) ve benzeri dalış kuruluşları verdikleri eğitim sonucu dalıcıları sertifikalandırmaktadır. Bu kuruluşlar dalıştan kaynaklanan olumsuz etkileri en aza indirmek üzere kendi standartlarını geliştirmektedir. Bunun yanı sıra dalış eğitim standartlarını hazırlayan Uluslararası Standartlar Teşkilatı (ISO) ve Dünya Rekreasyonel SCUBA Eğitim Konseyi (WRSTC) standartları da bulunmaktadır. Türkiye'de rekreasyonel dalış TSSF bünyesinde "Donanımlı Dalış Yönetmeliği" çerçevesinde yürütülmektedir (Anonim, 2008). Bu yönetmelik "deniz, iç sular ile havuzlarda yapılacak tüm sportif amaçlı donanımlı dalış ve dalışta uzmanlık eğitimlerinde uyulacak kuralların düzenlenmesi, dalış etkinlikleri ve eğitimleri düzenleyen dalış merkezleri ve sualtı spor kulüplerinin uyacakları standartları ve dalış ile ilgili tüm usul ve esasları içermektedir". Yönetmelik kapsamında 24.02.2017 tarihli "Donanımlı Dalış Talimatı" oluşturulmuştur. Bu talimatta tüm sportif amaçlı donanımlı dalışlarda ve dalışta uzmanlık eğitimlerinde uyulacak kuralların düzenlenmesini, dalış etkinlikleri ve eğitimleri düzenleyen dalış merkezleri ve sualtı spor kulüplerinin uyacakları standartları ve dalgıçlıkla ilgili tüm esas ve usulleri belirtilmiştir.

Dalış sistemleri genelde serbest dalış, SCUBA, satıhtan ikmalli dalış ve çeşitli sualtı araçlarıyla olmak üzere 4 kategoride sınıflandırılabilmektedir. Bütün dalış tiplerinde basınç, kullanılan gazlar (Acott, 1999), görme (Adolfson & Berghage., 1974), duyma (TSSF, 2007), ısı enerjisi (Düzbastılar & Düzbastılar, 2007) ve dekompresyon teorisi (Vann ve ark., 2011; Koca, 2015) gibi temel bilgi ve beceriler dalış güvenliği için son derece önemlidir. Dalışlarda karşılaşılan en sık sağlık sorunları barotravmalar (kulak, diş, akciğer, elbise, maske vb.) (Aktaş, 2005; Koca, 2015), dekompresyon hastalığı (Lynch & Bove, 2009), nitrojen narkozu (Koca, 2015), karbonmonoksit ve karbondioksit zehirlenmeleri (Millar & Mouldey, 2008; Karadurmuş & Aydın, 2023) ve disbarik osteonekroz'dur (Aktaş, 2019).

Bu çalışmada İzmir ili, dalış eğitmenlerinin ve dalıcıların profilleri başta olmak üzere, ortalama dalış süreleri, dalışlarda karşılaştıkları sorun ve tehlikeler, yeni seminer ve kurslara katılım durumu ve gibi bilgilerin sınanması ve ayrıca dalış merkezlerinin yeterliliklerinin araştırılması amaçlanmıştır. Bu çalışmada ele alınan bazı değerlendirmeler üzerinde bugüne kadar yapılmış herhangi çalışma bulunmamaktadır. Dolayısıyla verilen sonuçlar ilk bulgu niteliğini taşımaktadır.

## MATERYAL VE YÖNTEM

Türkiye'deki yönetmelikler ve standartlar doğrultusunda eğitmenler ve dalıcılara sorulmak üzere iki farklı anket formu oluşturulmuştur. Saha çalışması 2017 yılında Mayıs ve Haziran aylarında İzmir ilinde gerçekleştirilmiştir. Eğiticiler TSSF'den yetki belgesi almış dalış merkezlerinde çalışan eğitmenlerden, dalıcılar ise turizm amaçlı veya herhangi bir dalış merkezinden eğitim almış veya keşif dalışı yapanlar sportif dalgıçlardan seçilmiştir. Anket çalışması her iki gruptan 30'ar kişi ile yüz yüze derinlemesine görüşme yöntemiyle yapılmıştır.

Eğitmenlerle gerçekleştirilen anket; yaş, cinsiyet ve eğitim durumu gibi demografik özellikler, sertifika düzeyleri, mesleki ve dalış tecrübeleri, dalış esnasında karşılaşılan sorunlar ve tehlikeler, dalış yönetmeliğince dalıştan önce doldurulması gereken formlar, dalış merkezlerinde bulundurulması gereken ekipmanlar ve bu ekipmanların periyodik test ve bakımları hakkında genel

bilgileri federasyonca veya kolluk kuvvetlerince yapılan denetimlerin yeterliliği, federasyonun düzenlemiş olduğu seminerleri ne sıklıkla takip ettiklerini içermektedir.

Dalıcılarla gerçekleştirilen çalışmada aranan temel nitelik, İzmir bölgesindeki herhangi bir dalış merkezinde en az bir kez dalış gerçekleştirmiş olmalarıdır. Anket çalışması olarak; kaç kez donanımlı dalış yaptıkları hakkında düşünceleri sorgulanmıştır.

Bu çalışmada adı geçen dalıcı, eğitmen, rehber dalıcı tanımlamaları TSSF "Donanımlı Dalış Yönetmeliği" esas alınmıştır (Anonim, 2008).

Araştırmanın örneklemi eğitmenler için tam sayım, dalıcılar için ise amaçlı örnekleme yöntemlerinden kartopu örnekleme ile belirlenmiştir. 2017 yılında federasyona bağlı İzmir İl'inde faaliyet gösteren dalış merkezinde 30 eğitmenin tümü ile anket çalışması yapılmış, herhangi bir ana kitlenin belirlenemediği dalıcılarda ise kartopu örneklemi çerçevesinde 30 kişi ile anket yapılmıştır. Araştırmada elde verilerinin öncelikle tanımlayıcı istatistiki değerlendirmeye tabi tutulmuş, kategorik değişkenler sayı ve yüzde olarak, sürekli değişkenler ise minimum, maksimum ve ortalama (± standart hata) değer olarak tablo ve şekiller çerçevesinde sunulmuştur. Verilerin normal dağılım içerisinde yer alıp almadığının belirlenmesinde Shapiro-Wilk testi kullanılmıştır. Normal dağılım gösteren verilerin birebir karşılaştırılmasında t-test, göstermeyenlerde ise Wilcoxon testi kullanılmıştır. Kategorik değişkenlerin birbirleri ile karşılaştırılmalarında Ki-kare ve Fisher's-exact testi (gözlem sayısının yetersiz olması durumunda) kullanılmıştır. Tüm istatistiksel değerlerledirler $p$<0,05 önem düzeyinde, rstatix (v 0.7.1.) paket yardımı ile RStudio (v 2022.12.0) programında analiz edilmiştir (Kassambara, 2021).

## BULGULAR

### Eğitmenlere İlişkin Değerlendirmeler

#### *Eğitmenlerin sosyo-demografik özellikler*

Araştırmaya dahil olan eğitmenlerin yaşlarının 28 – 56 aralığında değişim gösterdiği, ortalama eğitmen yaşının 42,1±1,3 olduğu belirlenmiştir. Eğitmenlerin %93,3'ü erkek sadece %6,7'si kadın bireylerden oluşmuştur. Yaş ve cinsiyete göre ortalama eğitmen yaşı erkeklerde 42,1±1,4, kadınlarda ise 42,5±2,5 olarak bulunmuştur (Tablo 1).

Oldukça yüksek bir eğitim düzeyine sahip olduğu belirlenen eğitmenlerin yaklaşık olarak %70'i yüksek öğrenim düzeyinde eğitim almış olup kalan %30'luk kısım ise lise mezunudur. Cinsiyet ve eğitim durumu arasında istatistiksel farklılık bulunmamıştır ($p$>0,05). (Şekil 1). Eğitmenlerin eğitim durumlarına göre yaş dağılımları Şekil 1'de verilmiş olup, eğitim durumunda en büyük pay lisans iken onu sırasıyla lise, yüksek lisans ve yüksek okul takip etmiştir.

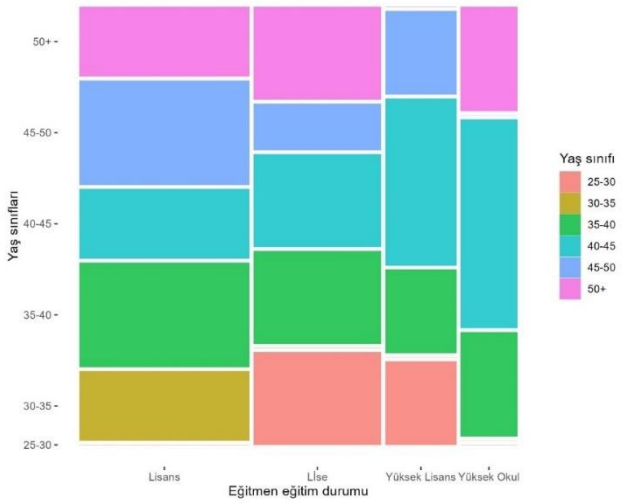
**Tablo 1.** Eğitmenlerin cinsiyete göre yaş dağılımları

***Table 1.*** *Age distribution of instructor by gender*

| Cinsiyet | N | N (%) | Min.-Mak. | Ort.±(SE) |
|---|---|---|---|---|
| Erkek | 28 | 93,3 | 28-56 | 42,1±1,4 |
| Kadın | 2 | 6,7 | 40-45 | 42,5±2,5 |
| Genel | 30 | 100,0 | 28-56 | 42,1±1,3 |

***Not:*** N: birey sayısı; Min: minimum; Mak: maksimum; SE: standart hata

***Note:*** *N: number; Min: minimum; Mak. Maximum; SE: standard error*




**Şekil 1.** Eğitmenlerin eğitim durumlarına göre yaş dağılımları

***Figure 1.*** *Age distribution of instructor by education levels*

#### *Mesleki yeterlilik*

Eğitmenlerin önemli bir bölümünün (%56,7) 1 yıldız eğitmen olduğu, 2 ve 3 yıldız eğitmenlerin oranı ise sırasıyla %36,7 ve %6,7 olarak belirlenmiştir (Tablo 2). Dalış eğitmenlerinin sertifika düzeyleri ile eğitim durumları arasında istatistiksel farklılık bulamamışken ($p$>0,05), yaş sınıfları ile sertifika düzeyleri arasındaki fark istatistiksel olarak farklılık ($p$<0,05) göstermiştir.

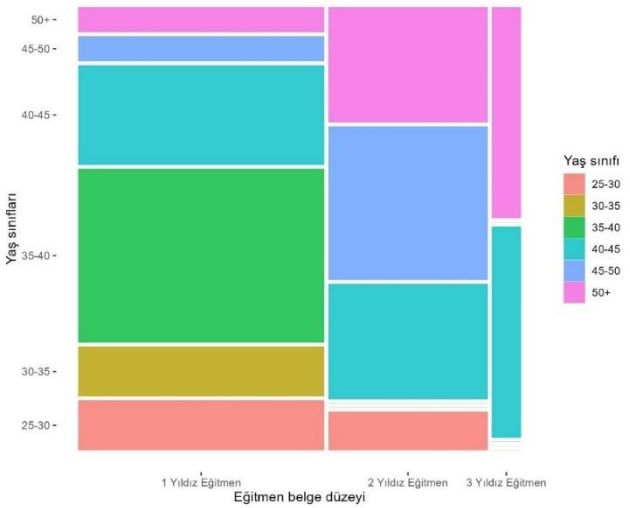
Genel olarak 1 yıldız eğitmen sertifikasına sahip olan eğitmenlerin orta yaş sınıfında olduğu, ilerleyen yaş gruplarına doğru sertifika düzeyinin 3. kategoriye (3 yıldız eğitmen) kaydığı belirlenmiştir (Şekil 2).

Dalış eğitmenlerinin %56,7'si rehber dalıcı olduklarını beyan etmiştir. Dalış eğitmenlerinin önemli bir kısmında (%76,7) CMAS harici eğitim sistemlerinden (PADI, SSI vd.) almış olduğu sertifikası bulunmaktadır. Hem eğitim durumu hem de yaş gruplarına göre başka eğitim sistemlerinden dalıcı sertifikası bulunma durumu arasında istatistiksel farklılık bulunamamıştır (p>0,05).

**Tablo 2.** Eğitmenlere ait sonuçlar
***Table 2.*** *Results for instructors*

| | N | N (%)±SE | CI (%95) |
|---|---|---|---|
| **Sertifika Düzeyi** | | | |
| 1 yıldız eğitmen | 17 | 56,7±9,2 | 37,8-73,8 |
| 2 yıldız eğitmen | 11 | 36,7±9,0 | 20,8-56,0 |
| 3 yıldız eğitmen | 2 | 6,7±4,6 | 1,5-24,7 |
| **Çalışılan Dalış Merkezi Sayıları** | | | |
| 1-3 | 21 | 70,0±8,6 | 50,5-84,2 |
| 4-6 | 7 | 23,3±7,9 | 11,0-42,8 |
| 7-9 | 1 | 3,3±3,3 | 0,4-22,2 |
| 10+ | 1 | 3,3±3,3 | 0,4-22,2 |
| **Aktif Dalış Süreleri (Yıl)** | | | |
| 1-3 | 9 | 30,0 | 15,8-49,5 |
| 4-6 | 4 | 13,3 | 4,8-32,0 |
| 7-9 | 3 | 10,0 | 3,0-28,3 |
| 10+ | 14 | 46,7 | 29,0-65,2 |
| **Ortalama Günlük Dalış Sayısı (Gün)** | | | |
| 1-3 | 19 | 63,3±9,0 | 44,0-79,1 |
| 4-6 | 5 | 16,7±7,0 | 6,7-35,7 |
| 7-9 | 6 | 20,0±7,4 | 8,8-39,2 |
| **Seminerlere Katılım** | | | |
| Ara sıra | 15 | 50,0±9,2 | 31,9-68,1 |
| Her zaman | 9 | 30,0±8,5 | 15,8-49,5 |
| Hiçbir zaman | 2 | 6,7±4,6 | 1,5-24,7 |
| Sıklıkla | 4 | 13,3±6,3 | 4,8-32,0 |

***Not:*** N: birey sayısı; SE: standart hata; CI: güven aralığı
***Note:*** *N: number; SE: standard error; CI: confidence interval*




**Şekil 2.** Eğitmenlerin sertifika düzeylerine göre yaş dağılımları
***Figure 2.*** *Age distribution of instructor by document levels*

Dalış eğitmenleri, çalışma hayatları süresince, %70,0 oranında 1-3 farklı dalış merkezinde çalıştıklarını beyan etmişlerdir (Tablo 2).

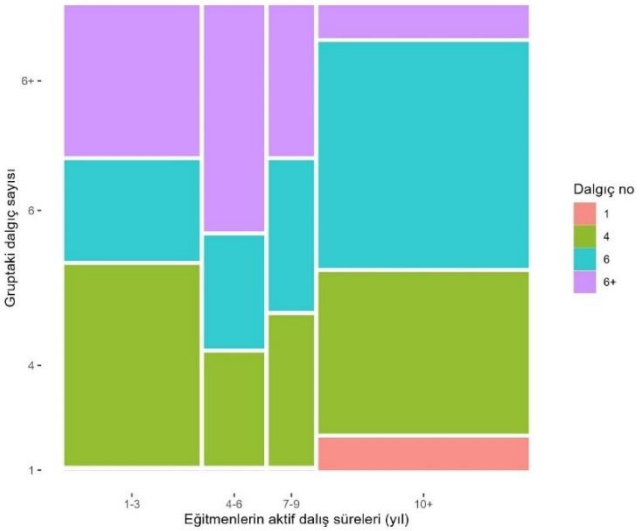
Çalışmaya dahil olan eğitmenlerin %46,7'sinin 10 yıl ve daha fazla bir dalış tecrübesine sahip olduğu belirlenmiştir (Tablo 2). İstatistiksel olarak anlamlı olmamakla birlikte 10 yıldan fazla dalış deneyimine sahip olan eğitmenlerin önemli bir bölümünün 40 yaş ve üzerindeki grupta yer aldıkları görülmektedir.

Anket sonuçlarına göre eğitmenlerin yarısı (%50,0) hayatlarını idame ettirebilmek için başka sektörlerde (su ürünleri, balıkçılık, sanayi dalgıçlığı vd.) de çalışmaktadırlar.

### *Eğitim tekniği*

Günlük ortalama dalış sayısı 1 – 9 arasında değişim göstermiştir. Ancak eğitmenlerin önemli bir bölümü (%63,3) günde ortalama 1 – 3 dalış yaptıklarını ifade etmiştir (Tablo 2).

Eğitmenler nezaretlerinde gerçekleştirilen dalışların ağırlıklı olarak 4 – 6 kişilik gruplardan oluştuğunu beyan etmişlerdir. 10 yıldan fazla dalış süresine sahip eğitmenlerin dahil oldukları gruptaki dalgıç sayısının 4 – 6 ve 7 – 9 yıl olanlara nazaran daha fazla olduğu belirmiş (Şekil 3), ancak bu durum istatistiksel olarak önemsiz bulunmuştur ($p$>0,05).




**Şekil 3.** Eğitmenlerin aktif dalış sürelerine (yıl) göre gruptaki dalgıç sayısı
***Figure 3.*** *Diver number in group by instructor active diving time (year)*

Eğitmenlerin %63,3'ü 15 dakika, %36,7'si de 30 dakikalık bir süre boyunca dalış öncesi dalıcılara brifing verdiklerini ifade etmişlerdir. Eğiticiler brifinglerini sözlü (%16,7), hem görsel hem sözlü anlatım (%83,3) şeklinde gerçekleştirmektedir.

Dalış kayıtlarınınım düzenli olarak tutulup tutulmadığının belirlenmesine yönelik olarak yöneltilen soruya eğitmenlerin %60,0'ının düzenli olarak kayıt tuttuklarını ifade etmiştir.

Eğitmenlerin %83,3'ü dalışlarında acil durumlara müdahale etmek üzere hazır stand-by dalgıç bulundurduğunu, %16,7'si de acil durumlar için önlem amaçlı stand-by dalgıç bulundurmadığını; tümü beklenmedik gelişmeler ve acil durumlar için bir acil durum planı olduğunu beyan etmiştir.

### *Dalış güvenliği*

Eğitmenler maksimum dalış derinliğinin 30 m olduğunu ve çoğunlukla (%56,7) 10 – 20 m derinliğe dalış yapıldığını ifade etmişlerdir. Ankete katılan eğitmenler dalış esnasında tehlikeli herhangi bir durumla karşılaşma durumunun en sık keşif dalışlarında (%76,7), daha sonra deneme dalışlarında (%16,7) ve son olarak %6,67'lik oranla eğitim dalışlarında gözlemlendiğini ifade etmişlerdir. Dalış eğitmenlerinin tümü dalış öncesinde dalıcılara TSSF tarafından hazırlanan donanımlı dalış sağlık bildirim formunun doldurtulup imzalatıldığını beyan etmiştir. Dalış eğitmenlerinin tümü dalış öncesinde dalıcıların risk kabul formlarını eksiksiz bir şekilde doldurduklarını bildirmiştir. Dalış eğitmenlerinin tümü dalış kuruluşlarının bulundurması gereken zorunlu malzemeleri eksiksiz bir şekilde bulundurduklarını ifade etmişlerdir. Dalış eğitmenlerinin tümü dalış kuruluşlarının bulundurması gereken zorunlu ilkyardım malzemelerini eksiksiz bir şekilde bulundurduklarını beyan etmiştir. Dalış eğitmenlerinin tümü kompresörlerin periyodik test ve bakımları düzenli olarak yapıldığını beyan etmiştir. Dalış eğitmenlerinin tümü dalış tüplerinin genel bakımlarının ve hidrostatik testlerinin periyodik (5 yılda bir) olarak yapıldığını beyan etmiştir. Ankete katılan eğitmenlerin %46,7'si federasyon yetkilileri ve kolluk kuvvetlerince yapılan denetimleri yeterli bulurken, %53,3'ü yetersiz bulmuştur. Dalış eğitmenlerin önemli bir bölümünün farklı düzeylerde federasyon tarafından düzenlenen donanımlı dalış gelişim seminerlerine katılım gösterdiği belirlenmiştir (Tablo 2).

## Dalıcılara İlişkin Değerlendirmeler

### *Dalıcıların sosyo-demografik özellikler*

Araştırmaya dahil olan dalıcıların yaş aralığının 19 – 31 aralığında değişim gösterdiği, ortalama dalıcı yaşının 23,5±0,7 olduğu belirlenmiştir. Dalıcıların önemli bir bölümü (%86,7) erkek sadece %13,3'si kadın bireylerden oluşmaktadır. Yaş ve cinsiyete göre ortalama dalıcı yaşı erkeklerde 23,4±0,8 kadınlarda ise 24,0±1,8 olarak bulunmuştur (Tablo 3). Kadın ve erkek dalıcıları ortalama yaşları arasında istatistiksel farklılık bulunamamıştır ($p$>0,05).

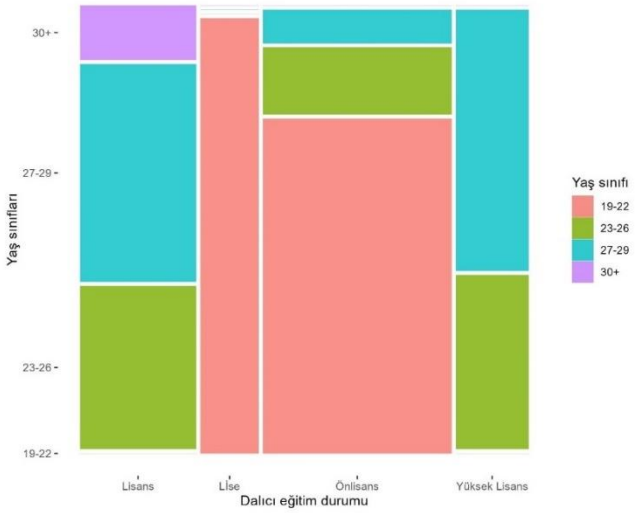
**Tablo 4.** Dalıcılara ait sonuçlar
***Table 4.*** *Results for divers*

Oldukça yüksek bir eğitim düzeyine sahip olduğu belirlenen dalıcıların %86,7'si yükseköğrenim düzeyinde eğitim almış olup kalan %13,3'lük kısım ise lise mezunudur. Cinsiyet ve eğim durumu arasında istatistiksel farklılık bulunmamıştır ($p$>0,05). Dalıcıların eğitim durumlarına göre yaş dağılımları şekil 4'te verilmiş olup, eğitim durumunda en büyük pay ön lisans iken bunu lisans, yüksek lisans ve lise takip etmiştir.

**Tablo 3.** Dalıcıların cinsiyete göre yaş değerleri
***Table 3.*** *Age value of diver by sex*

| Cinsiyet | N | N (%) | Min.-Mak. | Ort.±(SE) |
|---|---|---|---|---|
| Erkek | 26 | 86,7 | 19-31 | 23,4-0,8 |
| Kadın | 4 | 13,3 | 19-27 | 24,0-1,8 |
| Genel | 30 | 100 | 19-31 | 23,5-0,7 |

***Not:*** N: birey sayısı; Min: minimum; Mak: maksimum; SE: standart hata
***Note:*** *N: number; Min: minimum; Mak. Maximum; SE: standard error*



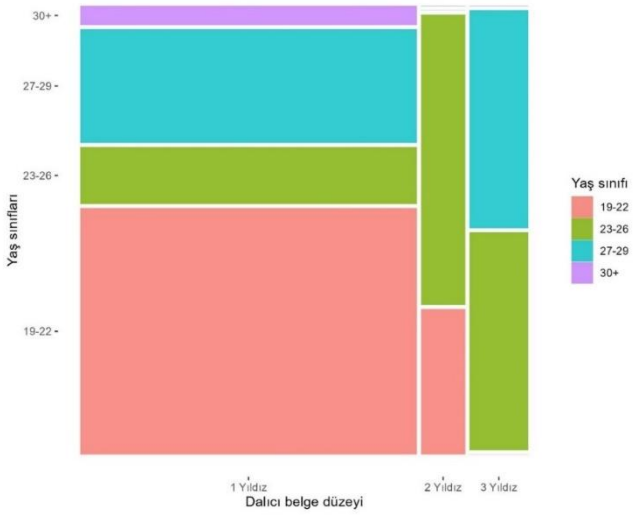

**Şekil 4.** Dalıcıların eğitim durumlarına göre yaş dağılımları
***Figure 4****. Age distributions of instructor by education status*

### *Dalıcıların dalış yeterlilikleri*

Ankete dahil olan dalıcıların önemli bir bölümünün (%76,7) 1 yıldız dalıcı sertifikasına sahip olduğu belirlenmiş olup 2 ve 3 yıldız dalıcı oranı sırasıyla %10,0 ve %13,3 olarak bulunmuştur (Tablo 4). Dalıcıların sertifika düzeyleri ile hem eğitim durumları hem de yaş sınıfları arasında istatistiksel farklılık ($p$>0,05) bulunamamıştır. Genel olarak 1 yıldız dalış sertifikasına sahip olan dalıcıların genç yaş sınıfında olduğu, ilerleyen yaş gruplarına doğru sertifika düzeyinin üst sınıflara kayma eğiliminde olduğu söylenebilmektedir (Şekil 5).

| | N | N (%) ±SE | CI (%95) |
|---|---|---|---|
| **Sertifika Düzeyi** | | | |
| 1 yıldız dalıcı | 23 | 76,7±7,9 | 57,2-89,0 |
| 2 yıldız dalıcı | 3 | 10,0±5,6 | 3,0-28,3 |
| 3 yıldız dalıcı | 4 | 13,3±6,3 | 4,8-32,0 |
| **Dalıcıların Donanımlı Dalış Sayıları** | | | |
| Toplam dalış sayıları | | | |
| 1-5 | 6 | 20,0±7,4 | 8,8-39,2 |
| 5-20 | 6 | 20,0±7,4 | 8,8-39,2 |
| 20-50 | 11 | 36,7±9,0 | 20,8-56,0 |
| 50+ | 7 | 23,3±7,9 | 11,0-42,8 |
| **Dalışlarda Sorunların Kaynağı** | | | |
| Ekipman | 19 | 63,3±9,0 | 44,0-79,2 |
| Doğal koşullar | 2 | 6,7±4,6 | 15,8-49,5 |
| Hiçbirisi | 9 | 30,0±8,5 | 1,53-24,7 |
| **Mevzuat Farkındalığı** | | | |
| Az | 5 | 16,7±6,9 | 6,7-35,7 |
| Çok | 13 | 43,3±9,2 | 26,2-62,2 |
| Kısmen | 12 | 40,0±9,1 | 23,5-59,1 |

***Not:*** N: birey sayısı; SE: standart hata; CI: güven aralığı
***Note:*** *N: number; SE: standard error; CI: confidence interval*




**Şekil 5.** Dalıcıların sertifika düzeylerine göre yaş dağılımları
***Figure 5.*** *Age distributions of divers by document levels*

### *Dalış güvenliği*

Çalışmaya dahil olan dalıcıların %36,7'si 5-10 kez dalış yaptıklarını beyan etmişlerdir (Tablo 4). Hem eğitim durumu hem de yaş gruplarına göre eğitmenlerin aktif dalış süreleri arasında istatistiksel farklılık bulunamamıştır ($p$>0,05).

Anket sonuçlarına göre dalıcıların çok büyük bir bölümü (%96,7) dalış yaptığı merkezde veya merkezlerde donanımlı dalış sağlık bildirim formunu eksiksiz olarak doldurduğunu beyan etmiştir. Kalan %3,3'lük kısım ise konu ile ilgili olarak bilgi sahibi olmadığını ifade etmiştir. Çalışmaya katılan dalıcıların %93,3'ü dalış yaptığı merkezde veya risk kabul belgesini tanzim ettiğini, kalan %6,7'lik kısım ise böyle bir belge düzenlenmediğini ifade etmiştir. Dalıcıların tamamı dalış öncesi brifing aldığını beyan etmiştir. Bunların %83,3'ü dalış yapmış olduğu merkez (veya merkezlerde) dalış öncesi her zaman, kalan %16,7'lik kısım ise sıklıkla brifing almışlardır. Herhangi bir dalış organizasyonuna katılan dalıcıların dahil olukları ekipte çoğunlukla (%83,3) 4-6 dalıcının bulundu ifade edilmiştir. İki kişilik gruplar %3,3 ve altı kişiden fazla sayıda dalıcıdan oluşan grupların oranı da %13,3 olarak bulunmuştur. Ankete dahil olan dalıcıların tümü dalış bölgesine ulaşmak amacıyla kullanılan deniz aracının (bot, tekne) mevcut dalıcıların toplam sayısına uygun kapasitede olduğunu ifade etmişlerdir. Dalış güvenliği açısından dalış esnasında tekne/botta kaptanın veya gemicinin bulunması gerekmektedir. Buradan elde edilen sonuca göre %93,3 oranında dalış yaptıran eğitmenle tekne kullananın farklı kişiler olduğu bulunmuştur.

Çalışma sonuçlarına göre, dalıcıların %80'i dalışlarda kullandıkları ekipmanların sürekli olarak eksiksiz ve dalışa uygun bir durumda bulunduğunu, kalan %20 ise sıklıkla uygun bir durumda bulunduğunu ifade etmiştir. Dalıcıların %96,7'si kendilerine eşlik eden rehber/eğitmenlerin sualtı ve su üstündeki teorik ve uygulamalı eğitimler doğrultusundaki bilgi birikimine ve tecrübelerine güvendiklerini ifade etmişlerdir.

Dalış sırasında karşılaşılan problemlerin en önemli nedeninin kullanılan dalış ekipmanlarından kaynaklandığı ifade etmişlerdir (Tablo 4).

Dalıcılar herhangi bir acil bir duruma müdahale etmek üzere tam ekipmanlı bir şekilde hazır bulundurulmaları

gereken iki dalıcının dalışları sırasında hazır bulundurulma oranın %50 olduğunu ifade etmişlerdir.

Çalışmaya dahil olan dalıcılar, dalış kuruluşunun dalış faaliyeti sürecinde ekibin yanlarında bulundurmaları gereken ilkyardım ekipmanlarının önemli oranda (%96,7) yanlarında bulundurulduğunu, kalan %3,3'lük kısım ise acil durum ekipmanlarının önemi hakkında bilgisinin olmadığı beyan etmiştir. Ankete katılan dalıcıların çok büyük bölümü (%96,7) daha önceleri herhangi bir dalış merkezinde dekompresyon gerektiren dalış yapmadığını ifade etmiştir. Dalıcıların büyük bölümü (%90,0) teorik ve uygulamalı eğitimleri eksiksiz bir şekilde aldığını belirtmiştir.

Çalışmamızda dalıcıların önemli bir bölümü orta ve ileri düzeyde donanımlı dalış yönetmelik ve talimatları hakkında bilgisinin olduğunu beyan etmiştir (Tablo 4). Dalıcının eğitim düzeyi ile mevzuat farkındalığı hakkında istatistiksel bir farklılık belirlenmemiştir ($p$>0,05).

Anket çalışmasına dahil olan dalıcıların büyük bölümü (%86,7) gerçekleştirmiş olduğu donanımlı dalışlar için gerekli olan güvenlik önlemlerinin tamamının alındığını düşünüyorken kalan %13,3'lük kısım gerekli tüm güvenlik önlemlerinin alındığını düşünmemektedir

## TARTIŞMA VE SONUÇ

İzmir ili dalış eğitmenleri ve dalıcı profilleri üzerine yapılan bu çalışmada eğitmenlerin ve dalıcıların sosyo-demografik özellikleri karşılaştırıldığında araştırmaya katılan eğitmenlerin yaş aralığı dalıcılardan daha yüksektir. Yaş grupları arasında %80'lik fark eğitmen olabilmek için belli gerekli yeterliliklerin alınabilmesi için bir süreye ihtiyaç olmasından kaynaklanmaktadır. Cinsiyet bakımından karşılaştırıldığında eğitmenler ve dalıcıların çoğunluğu erkek bireylerden oluşturmaktadır. Donanımlı dalış faaliyetinde erkek birey sayısının kadın sayısına oranla daha fazla olduğu diğer yapılan çalışmalarla da belirtilmiştir (Ivanova, 2004; Ranapurwala ve ark., 2017; PADI, 2021). Ayrıca. Komdeur ve ark. (2021) Hollandalı tüplü dalış eğitmenlerinin sağlık durumu üzerine yaptıkları araştırmada çalışmaya katılan 497 eğitmenin %87'sini erkek %13'nün kadın olduğunu bildirmiştir. Çulha & Gönül (2019) su altı dalış motivasyonu isimli çalışmasında erkek ve kadın dalıcı arasındaki sayısal farkın erkek dalgıçlar lehine olduğunu bildirmiştir. Erkek dalıcı sayısındaki üstünlüğün erkeklerin "tehlike-risk" unsurlarının sıra dışı motivasyon araçları olması erkeklerin sınırlarını zorlayarak yeni aktivitelere veya maceraya daha istekli olmaları şeklinde açıklanmıştır (Musa ve ark., 2011). Eren ve ark. (2020) dalış turizmine katılanların destinasyon imajı algılarının belirlenmesine yönelik araştırmalarında dalış turizmine katılan sertifikalı dalgıçlara ilişkin bulgularında %78'lik oranla erkek dalıcı sayısının kadın dalıcı sayısına oranla önemli ölçüde fazla olduğunu bildirmiştir.

Çulha & Gönül (2019) eğitim düzeylerine ilişkin dalıcıların %78,7'lik oranla yükseköğrenim düzeyinde eğitime sahip olduklarını bildirmiştir. Bu çalışmada da eğitmenlerin ve dalıcıların eğitim düzeyleri açısından yükseköğretim düzeyinde eğitim aldığı bulunmuştur.

Donanımlı dalış yönetmeliği (Anonim, 2008) gereği dalış merkezlerinde en az bir rehber dalıcının bulundurulması zorunludur. Bu nedenle çalışmaya katılan dalış eğitmenlerinin çoğu aynı zamanda rehber dalıcı sertifikasına sahiptir. Ayrıca personel maliyetleri göz önünde bulundurulduğunda dalış eğitmenlerinin rehber dalıcı olmaları dalış merkezleri tarafından tercih edilmektedir.

Dünya genelinde her biri kendi özelinde sertifika programına sahip CMAS, PADI, NAUI, SDI, SSI gibi birçok dalış organizasyonu bulunmaktadır. TSSF, CMAS eğitim standartlarını temel almaktadır (TSSF, 2007; Eren ve ark., 2020). Ancak diğer sertifika programlarına da denklik verilebilmektedir. Bu çalışmada eğitmenlerin tümünde CMAS eğitmenliği ile birlikte %76,7'lık bir oranla başka eğitim sistemlerinden (PADI, SSI, NAUI) alınmış dalış eğitmeni sertifikaları bulunmaktadır. Farklı programlarda sertifikaya sahip olmalarının olası nedenleri; mesleki gelişim isteği, prestij kazanma, uluslararası dolaşım, iş kaygısı gibi faktörlerden kaynaklanmaktadır.

Çalışmada dalış eğitmenlerinin çalıştıkları merkez sayısı genel olarak sınırlı bulunmuş, büyük bir çoğunluğu sadece 1-3 farklı merkezde çalıştıklarını beyan etmişlerdir. Dalış eğitmenlerinin farklı okullarda çalışmaları sebepleri arasında geniş kitlelere ulaşma, çeşitli deneyimler kazanma, iş güvencesi sağlama, profesyonel ağ oluşturma ve kişisel-mesleki gelişim fırsatları bulunmaktadır. Bu çok yönlü çalışma pratiği, eğitmenlere sektördeki esnekliği artırarak zengin bir kariyer deneyimi sunabilir.

Dekompresyon hastalığı riski donanımlı dalıcılarda genellikle derinlik ve bu derinlikte geçirilen süreye bağlı olarak tekrarlayan dalışlar sırasında görülebildiği bildirilmiştir. (Paulev, 1965). Çalışmada özellikle günde 7-9 arası dalış gerçekleştiren eğitmenler (%20) dekompresyon hastalığı riski altındadır. Çalışmaya katılan eğitmenler her ne kadar dalış tablolarına uyduklarını ve dekompresyon hastalığı geçirmediklerini ifade etseler de tekrarlayan dalışlardan kaçınmaları gerektiği önerilmektedir.

Dalış gruplarının özellikle yaz döneminde 6 ve üzeri kişiden oluşması dalış güvenliği açısından riskli görülmüştür. Gruptaki kişi sayısındaki artış su altında oluşabilecek karmaşayı da arttırabilmektedir. Ayrıca bu durumun sınırlı kapasiteye sahip şişme botlarda güvenlik

zafiyetine neden olabilmektedir. Dalışın daha güvenli yapılabilmesi için gruptaki kişi sayılarının az olması önerilmektedir.

Dalış faaliyeti sırasında meydana gelebilecek kazaları önlemek açısından dalışın tüm safhalarının planlanması ve dalıcılara eğitmenler tarafından dalış öncesi kapsamlı brifing verilmesi son derece önemlidir (Olgaç, 2022). Bu çalışmada dalış öncesi brifing faaliyetlerinin en az 15 dakika olmak üzere tüm dalış öncesinde verildiği belirlenmiştir. Brifing süresinin uzaması dalıcıların konsantrasyonlarının azalmasına neden olduğu eğitmenler tarafından belirtilmiştir. Brifinglerin hem sözlü hem görsel anlatım metodu ile gerçekleştirilmesi öğrenmenin daha rahat ve kalıcı olması açısından oldukça faydalıdır.

Donanımlı dalışlarda en önemli konuların başında acil durumlarda dalgıca müdahale edebilmek için en az bir stand-by dalgıç olmasıdır. Çalışma kapsamında dalış eğitmenleri herhangi bir olumsuz durumla karşılaşmasalar da stand-by dalgıcın yüksek oranda hazır bulundurulduğu belirlenmiştir. Stand-by dalgıç bulundurmayan eğitmenlerin sebebi sorgulandığında dalış noktasına ulaşım sağlanan botun sınırlı kişi kapasitesinden kaynaklandığını ifade etmişlerdir. Dalış merkezlerinin donanımlı dalış yönetmelik ve talimatlarında belirlenen kurallara uygun olarak ilkyardım ekipmanlarını bulundurdukları, dekompresyonlu dalış yapmadıkları, teorik ve uygulama eğitimlerini eksiksiz bir şekilde verdikleri dalış merkezlerinin mevzuata uygun şekilde güvenli dalış yaptığını ortaya koymaktadır.

Dalış kazaları dalış güvenliği açısından son derece önemlidir. BSAC tarafından 2018'de yayınlanan raporda en sık karşılaşılan dalış kazası oranı ileri seviye dalıcılarda görüldüğü bildirilmiştir (Buzzacott & Denoble, 2019; Doğru ve ark., 2019). Bu çalışmada eğitmenlerin büyük çoğunluğu (%76,7)'si ileri seviyeli dalıcılarda tehlikeli durumların gerçekleştiği bildirmişlerdir. Bunun başlıca sebepleri dalıcıların almış oldukları eğitimi yeterli görmeleri sonucu aşırı özgüvenli olmaları, dalış bölgesinde ilk kez dalış gerçekleştirmeleri ve bölgedeki koşullara yabancı olmalarından kaynaklandığı düşünülmektedir.

Sonuç olarak, İzmir bölgesinde dalış merkezlerinde eğitmen ve dalıcı profillerinin üzerine yapılan bu çalışmada eğitim düzeylerinin yüksek olması, güvenlik önlemlerine iyi uyum olumlu bir tabloyu ortaya koymaktadır. Ancak, eğitmenlerin daha düzenli olarak güncel eğitimlere katılmaları ve denetimlerin daha sıkı bir şekilde yapılması önerilir. Bu durum, dalış aktivitelerinin daha güvenli ve sorunsuz bir şekilde gerçekleştirilmesini sağlayacaktır. Bu tür anket çalışmalarının daha objektif sonuçlara ulaşabilmesi için dalış kayıtları ve dalış jurnallerine yönelik raporların değerlendirilmesi ve dalış merkezlerine yönelik yerinde incelemeye dayanan saha çalışmalarıyla desteklenmesi önerilmektedir.

## TEŞEKKÜR

Bu çalışma Oğuzhan TAKICAK'ın yüksek lisans tezinin bir kısmı kullanılarak hazırlanmıştır.

## ETİK STANDARTLARA UYGUNLUK

### Yazarların Katkısı

OT: Kavramsallaştırma, Metodoloji

OÖ: Danışmanlık, Yazma – Orijinal taslak hazırlama

HT: Yazma – Orijinal taslak hazırlama

CA: Yazma – Gözden geçirme

MC: Veri küratörlüğü, Veri Analizi

Yazarlar makalenin son halini okumuş ve onaylamıştır.

### Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını deklare etmektedir.

### Etik Onay

Yazarlar çalışmanın 2017 yılında yapılmış olmasından dolayı resmi etik kurul onayının gerekli olmadığını bildirmektedir.

### Maddi Destek

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### Veri Kullanılabilirliği Bildirimi

Yazarlar, bu çalışmanın bulgularını destekleyen verilerin makale içinde mevcut olduğunu onaylamaktadır.

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# Predictive model for the nematode (*Hysterothylacium aduncum*) in horse mackerel, *Trachurus trachurus* from the Black Sea

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**A B S T R A C T**

*Hysterothylacium aduncum* is a parasitic nematode that infects mainly marine fish. The information on the heterogeneity in the aggregation of macroparasites in fish species is still limited, particularly for the Raphidascarid nematode *H. aduncum* that infects exploitable marine fish species including horse mackerel (*Trachurus trachurus*). This study aimed to investigate the heterogeneity of the distribution of *H. aduncum* to **better** understand macroparasite aggregation in marine fish. Weibull tests comprising Maximum likelihood were used to analyze the frequency distribution of parasites within a fish host population over the three years period. The parasite, *H. aduncum* (third larval stage) prevalence was found to be 88% and the condition factor was 1.30∓0.029 in un-infected fish and 1.12∓0.022 in infected fish. The clustered pattern was observed in *H. aduncum* in horse mackerel. The relation between parasite load and the fish condition factor was found to be significant and conformity of length and weight was affected by parasite load. It is the first time that aggregation has been observed in *H. aduncum* distribution and forecasts of nematode intensity in horse mackerel. The findings related to the large individual variations suggest that this pattern is significant and should be considered for host-parasite dynamics.

## INTRODUCTION

Parasites impact biodiversity, the food web, competition between various organisms, and host structure, so parasites are significant in ecology. Due to the close relationships between parasites and their hosts, infections are anticipated to affect hosts across various organizational levels, spanning from gene expression to population dynamics (Barber & Wright, 2005).

*Hysterothylacium aduncum* (Nematoda: Raphidascarididae), a macroparasite, has a broad host range and has been identified in approximately 30 marine teleost fish species, categorizing it as a generalist nematode (Rohde, 2002; Özer et al., 2016). *H. aduncum* has previously been reported in horse mackerel (*Trachurus trachurus*) from Spain coasts in the Mediterranean Sea (Adroher et al., 1996) and in *Trachurus mediterraneus* from North African coasts (Amor et al., 2011). In terms of the Black Sea's geographical location, the nematode *H. aduncum* has been documented in horse mackerel (Pekmezci et al., 2013) and in whiting (Ismen & Bingel, 1999; Özer et al., 2016; Yavuzcan et al., 2022)

In fish, *H. aduncum* infects during the third larval stage, whereas previous stages are found in one or more crustacean intermediate hosts (Navone et al., 1998). Investigations into *H. aduncum* in whiting have demonstrated its continual presence throughout the entire year although higher

incidences of infection were observed in older and larger fish (Ismen & Bingel, 1999; Özer et al., 2016).

The aggregation of macro-parasites in their host populations has been described previously (Gaba et al., 2005; Grear & Hudson, 2011; McVinish & Lester, 2020). Aggregation denotes the uneven distribution of parasites among hosts.

In the case of natural fish populations, macroparasites are often aggregated, meaning that the majority of hosts have no parasites while a minority harbor a large number of them. Poulin (2011) describes aggregation as "a defining feature of metazoan parasite populations". Aquatic ecology emphasizes the importance of aggregation, which can reduce parasite population size and fecundity and decrease fish mortality resulting from excessive parasite loads (Wilson et al., 1996; McVinish & Lester, 2020). Parasites may exhibit an uneven distribution within their host populations with certain fish harboring a high number of parasites, while others have only a few.

This aggregation pattern is a fundamental law of parasite ecology (Poulin, 2011) and can influence the equilibrium between host and parasite (Wilson et al., 1996; Rabajante et al., 2020). The mean number of parasites per fish is often inadequate to measure parasitic infection levels due to the heterogeneity of parasite counts per host (Rózsa et al., 2000). The log-normal distribution is unsuitable for parasite data due to the tendency of parasites to exhibit aggregation and classical linear regression analysis may not be appropriate. Although there is no universal method or mathematical model to measure aggregation, The Weibull distribution provides a practical choice for modelling different levels of aggregation (Gaba et al., 2005; Balard et al., 2020). The Weibull distribution is a versatile method used in reliability analysis and life data analysis due to its ability to model a variety of life behaviors (Vijayalakshmi and Pushpanjali, 2022). Weibull analysis has been applied in various fields including nematode distribution in sheep (Gaba et al., 2005). Weibull analysis is used to analyze data sets containing values greater than zero (Vijayalakshmi and Pushpanjali, 2022) thus, the Weibull analyses may provide an appropriate approximation of the extensive data set of nematode numbers in fish. The Weibull distribution is advantageous because it can fit the heavily infected host while remaining flexible and less sensitive to small sample sizes (Gaba et al., 2005). The study aimed to examine the distribution of the macroparasite *H. aduncum* in horse mackerel (*T. trachurus*) and assess whether aggregation predominated. It also presents initial findings on parasite intensity and aggregation patterns, contributing to our understanding of macroparasite ecology.

## MATERIALS AND METHODS

### Parasite Identification

The visceral cavity and digestive system of the fish were examined for the existence of L3 of *H. aduncum*. The identification of the parasite was carried out by Adroher-Auroux & Benítez-Rodríguez (2021) using the morphological criteria of the parasite.

### Data Collection

The horse mackerel ($N_{total}$=358; $N_{infected}$=168; $N_{non\text{-}infected}$=190) was obtained from a fish market for three consecutive years from 2019 to 2021 in Ankara (Turkey) from a fish market. The fish originated from the central Black Sea, Turkey. Subsequently, they underwent examination, and the quantification of their parasites took place at the Laboratory of Fish Health at Ankara University.

The condition factor (K) of fish was calculated by using the fish weight and length in the equation below.

$$K = \frac{W}{L^3}$$

where, $W$ is body weight (g), $L$ is total length (cm).

The number of parasites (3rd larval stage) in the digestive system of horse mackerel was examined and recorded. The prevalence of the parasites was calculated the method suggested by Bush et al. (1997).

### Statistical Analysis

The correlation between the fish's condition factor and parasite counts and between the length and weight in infected and un-infected individuals was tested using regression analysis. Gaba et al. (2005) state that the Weibull analyses is adequate for macroparasite distributions. The Weibull distribution is suitable for assessing random effects between individual variations for macroparasites. Thus, for the aggregation assessment, Weibull analyses were employed to analyze parasite counts through SigmaExcel. The Weibull distribution is defined by its shape and scale parameters, which were estimated using the maximum likelihood method (Yang et al., 2019).

## RESULTS

The variance in parasite numbers exceeded the mean count of *H. aduncum*. Therefore, likelihood maximization was utilized to fit the model, as shown in Table 1.

**Table 1.** Weibull distribution (Maximum likelihood estimates with the following goodness-of-fit metrics: confidence level 95%, log-likelihood -155.210, and an Anderson-Darling *P*-value < 0.01).

| **Parameter** | **Estimate** | **SE of Estimate** | **Lower (95% CI)** | **Upper (95% CI)** |
|---|---|---|---|---|
| **Shape** | 1.465 | 0.154348 | 1.192 | 1.801 |
| **Scale** | 10.990 | 1.124 | 8.993 | 13.429 |
| **Mean (MTTF)** | 9.951 | 0.980560 | 8.203 | 12.071 |
| **Standard Deviation** | 6.905 | 0.855236 | 5.417 | 8.802 |
| **Variance** | 270.35 | | | |
| **Variance/mean** | 13.16 | | | |
| **Percentage** | **Time (Percentile)** | **SE (Percentile)** | **Lower (95% CI)** | **Upper (95% CI)** |
| 0.1 | 0.098479031 | 0.053104515 | 0.034224408 | 0.283369 |
| 0.135 | 0.120882 | 0.06261861 | 0.043795115 | 0.333654 |
| 0.5 | 0.295837 | 0.125948 | 0.128430 | 0.681458 |
| 1 | 0.475641 | 0.179402 | 0.227103 | 0.996175 |
| 5 | 1.447 | 0.384277 | 0.859859 | 2.435 |
| 10 | 2.365 | 0.515968 | 1.542 | 3.627 |
| 25 | 4.695 | 0.735554 | 3.454 | 6.383 |
| 50 | 8.557 | 0.973295 | 6.847 | 10.694 |
| 75 | 13.734 | 1.333 | 11.355 | 16.613 |
| 90 | 19.419 | 1.942 | 15.962 | 23.625 |
| 95 | 23.240 | 2.476 | 18.860 | 28.638 |
| 99 | 31.168 | 3.830 | 24.497 | 39.656 |
| 99.5 | 34.299 | 4.437 | 26.617 | 44.197 |
| 99.865 | 39.879 | 5.601 | 30.283 | 52.515 |
| 99.9 | 41.106 | 5.869 | 31.073 | 54.381 |

***Note:*** SE: Standard error; CI: Confidence interval.

**Table 2.** Linear regression statistics for condition factor (K) of horse mackerel and nematode, *H. aduncum* numbers

| **Regression Statistics** | | **ANOVA** | | | | | |
|---|---|---|---|---|---|---|---|
| Multiple R | 0.30363632 | | ***df*** | ***SS*** | ***MS*** | ***F*** | ***Significance F (p)*** |
| R Square | 0.09219501 | Regression | 1 | 0.00452908 | 0.00452908 | 16.8586564 | 6.3057E-05 |
| Adjusted R Square | 0.08672631 | Residual | 166 | 0.04459594 | 0.00026865 | | |
| Standard Error | 0.01639055 | Total | 167 | 0.04912502 | | | |
| Observations | 168 | | | | | | |

The parasite intensity of *H. aduncum* was predicted based on the actual parasite distribution using Weibull Ln probability test (Figure 1). The black line represents the best-fitting model or curve to the data and the most likely scenario, while the red lines indicate the range of variation that is statistically plausible at a 95% confidence level. The confidence interval is illustrated by the red lines. The interval is constructed such that there is a 95% probability that the true values of the parameters lie within this range.

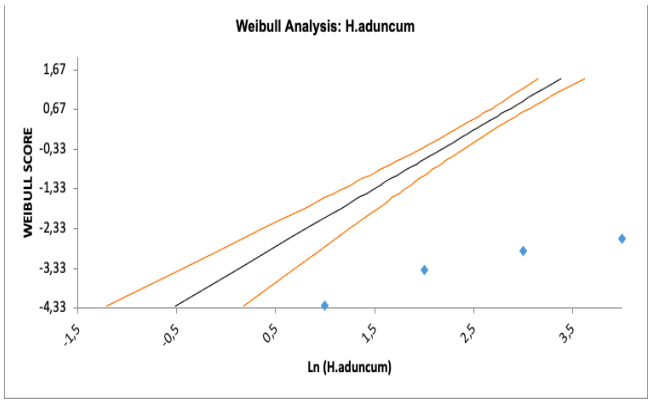


**Figure 1.** Weibull probability plots depicting *H. aduncum* intensity, accompanied by 95% two-sided confidence bounds. The optimized fit is represented by a black line, while the 95% confidence interval (CI) of the fit, accounting for all parameters varying within their 95% CI, is illustrated by the red lines.

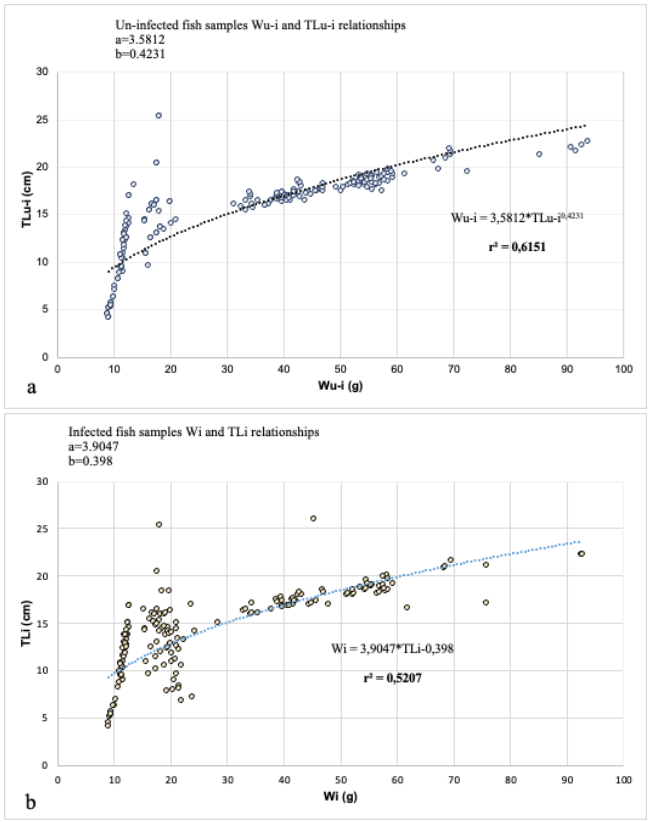


**Figure 2.** Relationship between fish length and fish weight in uninfected (a) and infected fish (b).

The parasite prevalence was 88% (168/190). The condition factor was 1.30∓0.029 in un-infected fish and 1.12∓0.022 in infected fish. The difference in the condition factor between infected and uninfected individuals was significant ($p<0.01$).

Linear regression analysis indicated a significant relationship ($p<0.01$) between the number of parasites and the condition factor of fish (Table 2). In addition, the multiple R value of 0.30 provided evidence of a significant linear correlation between parasite counts and the condition factor.

There were significant differences between infected and uninfected horse mackerel in their total lengths and body weight ($p<0.05$). The regression degree of relation between fish weight and length was 0.61 in uninfected horse mackerel and 0.52 in infected fish (Figure 2a, b). In un-infected fish $r^2=0.61$ showed that there was a significant and positive association between fish weight and length. In infected fish, $r^2=0.52$ indicated a moderate, positive linear correlation between the two variables (fish length and weight).

## DISCUSSION

The aggregation of *H. aduncum* nematodes in horse mackerel was evident from the Weibull distribution. Aggregation manifests when the variance of parasite count surpasses the mean number of parasites, a phenomenon noted in marine fish, as documented by Lester (2012). Parasite aggregation is influenced by various fish characteristics, including host size, host specificity, feeding behavior, sex, age, resistance and schooling behavior (Amarante et al., 2015; Timi & Poulin, 2020). Therefore, aggregation provides a more accurate representation of parasite distribution than the mean parasite load. The present study found that the distribution of the nematode *H. aduncum* in horse mackerel exhibited an aggregated pattern that varied among individual fish. Our primary finding indicates that variations in parasite distribution among fish contribute to the aggregated distribution of nematodes in horse mackerel.

This study utilized the Weibull distribution to determine the aggregation pattern of nematodes in fish, allowing us to predict the probability of higher parasite intensity. Maximum likelihood models, such as the Weibull distribution, effectively capture the heterogeneity of parasite loads (Wilson et al., 1996; Gaba et al., 2005). The observed variance of parasite counts (270.35) was more significant than the mean (13.16), indicating an aggregated distribution of nematodes in horse mackerel. In Weibull analyses, parameters associated with aggregation are the scale and shape (Balard et al., 2020). Our findings are consistent with previous research suggesting that the shape parameter of the Weibull distribution exhibits an inverse relationship with

aggregation, with a low shape parameter of 1.208 indicating an aggregated distribution of nematodes (Gaba et al., 2005). Additionally, we found that the scale parameter, which is correlated with aggregation, was more significant than 1, suggesting that the mean number of *H. aduncum* modulates the level of aggregation. The flexibility of the Weibull distribution made it an appropriate fit for heavily infected fish with *H. aduncum*, with parasite frequencies ranging from 1 to 76 in these fish. According to our results, the key factor influencing aggregation is the quantity of infected intermediate hosts consumed by fish. Supportively, Amarante et al. (2015) reported that the degree of parasite aggregation, especially for endoparasites typically transmitted at a trophic level, may be linked to the feeding habits of hosts.

In addition, the life cycle strategy of the nematode may also be crucial, as evidenced by Klimpel & Rückert's (2005) study, which showed that Hyperiids (a type of crustacean) served as the obligatory intermediate host for *H. aduncum* and carried large numbers of nematode larvae in their hemocoel. While we lack data on fish immunity, Lester (2012) suggests that fish resistance may also be linked to nematode aggregation in fish. Future studies should be conducted to reveal the relationship between parasitized and non-parasitic fish, blood, and liver enzymes, and immunity-related gene expressions and parasite aggregation/presence from other perspectives.

In this study, overall fish of 88% were infected with third-stage larvae (L3s), higher than the reported prevalence (31.1%) for horse mackerel on the Mediterranean coasts of South and Southeast Spain (Adroher et al., 1996). Increasing parasite aggregation has been associated with the host's age or body size, and larger fish are generally expected to have a higher parasitism rate (Wilber et al., 2017). The anticipated correlation between the extent of aggregation and body length arises from the expectation that hosts with larger lengths would be capable of harboring a greater number of parasites. This expectation is based on the premise that body size serves as an effective indicator of the total nutrients or energy available in a host to sustain a specific parasite species (Luque et al., 2004). Hence, previous research has documented an increased nematode (*H. aduncum*) burden in larger or lengthier whiting, as indicated by studies conducted by Ismen & Bingel (1999) and Özer et al. (2016).

Similarly, in our study, the relationship between the condition factor and mean parasite load was significant. On the contrary, a recent investigation by Yavuzcan et al. (2022) demonstrated that the distribution of *H. aduncum* exhibited aggregation, and the parasite load did not show a positive correlation with the fish condition factor. However, it should be noted that, according to the $r^2$ of the length-weight relationship in infected fish is lower compared to the non-infected ones. This indicates that the presence of parasites has an effect on the length-weight relationship of the fish.

Hence, it can be concluded that aggregation is related to the number of infected intermediate hosts consumed by fish (host). The condition factor of fish may change due to the parasite load, whether or not it is dependent on aggregation. Incorporating the varying levels of infected intermediate hosts throughout the different seasons, researchers have elucidated the seasonal infection pattern of *H. aduncum* in whiting populations in the Black Sea (Özer et al., 2016).

Furthermore, the aggregation of parasites may be linked to the heterogeneity of fish-infected intermediate host encounters, leading to varying degrees of aggregation among individual fish. In this regard, infected intermediate hosts (consumed by fish) may play a crucial role in understanding the relationship between aggregation and *H. aduncum* infections. Another important point is related to the drawbacks linked to excessive aggregation: as the number of parasites per host rises, factors like heightened host immune response, increased virulence, and intraspecific competition for energy or space will work to decrease intensity per host by raising the parasite death rate, as stated by Grear & Hudson (2011). Thus, excessive aggregation of the macroparasites in fish populations necessitates further research.

To summarize, parasite aggregation in marine fish is a complex phenomenon influenced by several factors, including host specificity, life cycle, and spatial distribution.

## CONCLUSION

A typical aggregation pattern was observed among individuals of horse mackerel infected with the nematode *H. aduncum*. The degree of aggregation varied among individual fish. The Weibull distribution provided an appropriate match for the probability of *H. aduncum* and reasonable forecasts. The Weibull distribution can be applied in the field of fish parasitology to model the distribution of macroparasites. The results pertaining to aggregation and projected parasite intensity could indicate the likelihood of ecological ramifications such as alterations in the population size of either the nematode or the fish. For the first time, this research characterizes the aggregated model of *H. aduncum* in horse mackerel, furthering our comprehension of the dynamics between marine fish and nematodes within host-parasite systems. Understanding the heterogeneity in macroparasite aggregation can be important for studying parasite transmission dynamics, disease ecology, and host-parasite interactions.

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## COMPLIANCE WITH ETHICAL STANDARDS

### Authors' Contributions

HYY: Conceptualization, Writing – review & editing

EG: Supervision, Writing – review & editing

DK: Investigation, Writing – review & editing

BY: Methodology, Investigation

All authors read and approved the final manuscript.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

As the fish used in the study were already dead and obtained from a fish market, animal ethical permission was not required.

### Funding

Not applicable.

### Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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# Alizarin red S marking in otoliths: A study on the growth dynamics of *Diplodus vulgaris* juveniles

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**A B S T R A C T**

This study investigates the age and growth rates of juvenile *Diplodus vulgaris* in the Çanakkale Strait, utilizing Alizarin Red S (ARS) marking to analyze otoliths for daily growth increments. The research aimed to validate the daily deposition of growth rings in otoliths as a reliable method for age determination in young fish. A total of 65 specimens were subjected to ARS immersion at varying concentrations to identify the optimal marking conditions that would not adversely affect the survival rates of the juveniles. Post-treatment, the fish were released into controlled environments and monitored over a period to assess the incorporation and visibility of ARS marks in the otoliths. The results demonstrated a clear correlation between fish size and age, with a consistent daily growth rate that supports the hypothesis of daily increment formation in otoliths. The mortality rate associated with ARS treatment was within acceptable limits, confirming the method's viability for non-lethal age and growth studies. This research not only underscores the effectiveness of ARS marking in studying juvenile fish growth patterns but also contributes to a better understanding of the life history of *D. vulgaris* in the Çanakkale Strait, offering valuable insights for fisheries management and conservation efforts.

## INTRODUCTION

The Mediterranean Sea, with its rich biodiversity and complex ecosystems, serves as a crucial habitat for a wide range of marine species. Among these, the two-banded sea bream (*Diplodus vulgaris*) stands out due to its ecological significance and widespread presence, particularly in the shallow waters of the Çanakkale Strait. This strait, acting as a natural bridge between the Aegean Sea and the Sea of Marmara, presents unique environmental conditions that are conducive to the study of marine life, especially during its early developmental stages. The early life history of marine species, including their growth rates and patterns of survival, is fundamental to understanding their overall ecology and the dynamics of their populations (Morales-Nin, 2000).

In recent years, the analysis of otolith microstructure has emerged as a key technique in ichthyology for investigating these aspects. Otoliths, the calcified structures in the inner ears of fish, contain growth increments that can be interpreted similarly to the rings of a tree, providing a detailed chronology of an individual's age and growth history (Campana & Neilson, 1985). For species like *D. vulgaris*, understanding the formation and significance of these growth increments is essential for accurate age

determination, which in turn, is crucial for assessing population dynamics, growth patterns, and survival strategies. However, despite the acknowledged importance of otolith analysis, there remain gaps in our knowledge regarding the validation of daily growth rings in the otoliths of young *D. vulgaris* within the Çanakkale Strait. This lack of information hampers our ability to accurately determine the age and growth rates of these fish, which is vital for their conservation and management (Wilson et al., 1999).

The application of fluorescent dyes, such as alizarin complexone, to mark otolith growth increments has been recognized as a powerful tool for validating age determination methods (Wilson et al., 1999). The incorporation of these chemicals into the otoliths at known time intervals allows researchers to accurately count the growth increments, thereby providing a direct validation of the age of the fish. This technique has proven to be invaluable in enhancing the accuracy of age determination in marine species, offering a more precise understanding of their growth patterns and life history traits.

Therefore, the primary objective of this study is to validate the formation of daily growth rings in the sagittal otoliths of juvenile *D. vulgaris* inhabiting the shallow waters of the Çanakkale Strait.

## MATERIALS AND METHODS

### Study Area and Specimen Collection

The research was carried out in the Çanakkale Strait, a vital ecological corridor linking the Aegean Sea with the Sea of Marmara. This area is recognized for its rich biodiversity and serves as an essential habitat for a variety of marine life, including the species *D. vulgaris*. Throughout the year, juvenile *D. vulgaris* specimens were systematically collected on a monthly basis. The collection utilized a beach seine net, specifically targeting shallow waters (less than 2 meters deep), where juvenile congregations are predominantly found. Upon capture, specimens were promptly placed in aerated containers and transported to the laboratory for further processing.

### Acclimatization and Maintenance

Upon arrival at the laboratory, young of the year (YOY) *D. vulgaris* were acclimated to a 4500-liter closed recirculating seawater system, equipped with a biofilter and aeration system. The fish were fed granular feed suited to their size and mouth opening. The system maintained a natural photoperiod, with water temperature held steady at 20°C±1.0°C, and salinity around 37 ppm, mirroring the natural conditions of their capture site. Water quality parameters, including temperature, salinity, and pH, were monitored daily. The temperature has been kept constant with the help of air conditioning. There has been no change in salinity levels.

### Experimental Setup and Alizarin Red S (ARS) Marking

Following acclimatization, YOY *D. vulgaris* were transferred to 80-liter ventilated tanks for a 14-day period before the commencement of the experiments. The fish were exposed to six different concentrations of Alizarin Red S: 0 (control), 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, and 300 mg/L. During the marking period, no food was provided, and tanks were heavily aerated to maintain a pH of approximately 7. Post-dyeing, fish were held in separate aquariums for 20 days. In the control group, there are 10 samples, while in the other group, there are 11 samples. Fish that perished prior to the experiment of the study were excluded from the analysis.

### Otolith Extraction and Analysis

Sagittal otoliths were carefully extracted from the sacrificed fish, embedded on a glass slide, and prepared for analysis. The preparation process involved grinding the proximal side of the otolith with abrasive papers (gradually from 12, 9 to 3 mm) and polishing with 0.3 mm paper until daily growth rings were visible from the center to the edge, following established protocols (Secor et al., 1991; Jones, 1992). The detection of ARS marks was conducted under a fluorescent microscope (Carl Zeiss Axio Scope A1), and images were captured using a digital camera (Carl Zeiss Axiocam 305).

### Data Analysis

The counting of daily growth increments between the fluorescent mark and to the otolith edge was performed independently by two readers to ensure accuracy. The correlation between the number of daily growth increments within the ARS mark and the days post-treatment was assessed through linear regression analysis. Chi-square test was employed to evaluate the congruence of daily growth increment counts against the elapsed time. Statistical significance was determined at an alpha level of 0.05 (Agresti, 2002; Peck et al., 2012). All statistical analyses were performed using the PAST (version 4) program (Hammer et al., 2001).

## RESULTS

In the present study, a cohort of 65 young of the year (YOY) *D. vulgaris* specimens, with total lengths ranging from 2.5 cm to 6.5 cm, were subjected to experimental conditions.

These juvenile fish were marked using an ARS solution, which resulted in visible ring under fluorescent light in the sagittal otoliths of the specimens (Figure 1). It was observed that immersion in ARS solutions, with concentrations varying between 50 mg/L to 300 mg/L for a duration of 24 hours, led to a mortality rate peaking at 7.69% during and immediately following the treatment period.

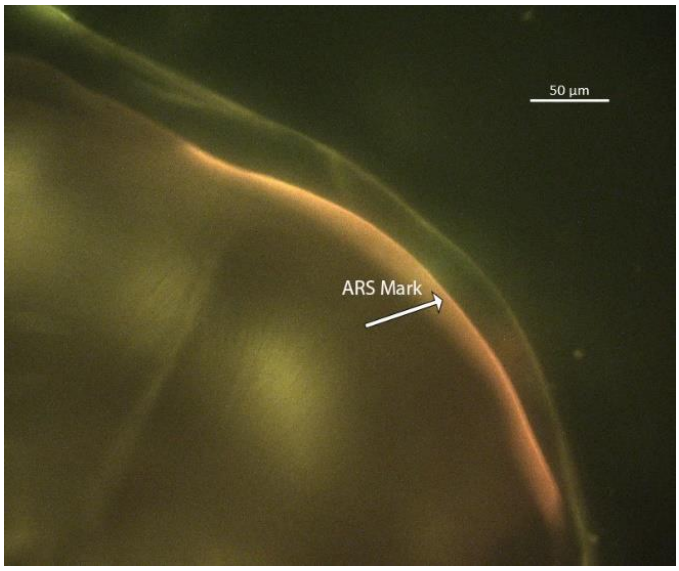


**Figure 1.** Appearance of ARS mark on *D. vulgaris* sagittal otolith.

Out of the initial 65 specimens, 60 successfully completed the experimental protocol, including those in the control group. The ARS marking was clearly discernible in the sagittal otoliths of 45 YOY *D. vulgaris* under a fluorescent microscope. Notably, mark was observed in five specimens from the group treated with 50 mg/L ARS solution.

The analysis of daily growth increments, between the fluorescent mark and extending to the edge of the otoliths, was conducted. This analysis was performed on 45 specimens, which ranged in total length from 2.5 cm to 6.5 cm. The age determination based on daily growth increments revealed the youngest individual to be 89 days old, while the oldest was found to be 168 days old.

A length-age regression analysis was employed to ascertain the average daily growth rates of the YOY *D. vulgaris* individuals. The calculated daily growth rate stood at 0.031 cm per day. The linear relationship between total length (TL) and age (days) was established as follows:

$$TL = 0.248 + 0.031\,(days), \qquad N = 45\; R^2 = 0.81$$

Chi-square tests conducted to assess the linear regressions of the number of daily growth increments against elapsed time yielded a result that was not statistically significant (Chi-square = 0.297, df = 45, P = 0.91). This outcome indicates that the formation of daily growth increments in YOY *D. vulgaris* specimens, collected from the shallow waters of Çanakkale, occurs on a daily basis, corroborating the hypothesis that daily increment formation is a consistent process in these juvenile fish.

## DISCUSSION

The successful marking of YOY *D. vulgaris* with Alizarin Red S (ARS) and the subsequent analysis of daily growth increments in this study contribute valuable insights into the age and growth patterns of this species in the Çanakkale Strait. Our findings align with the broader understanding of otolith marking techniques as reliable tools for studying fish growth and age determination, a concept well supported in the literature (Campana & Thorrold, 2001; Morales-Nin, 2000).

The mortality rate observed during and after the ARS treatment, peaking at 7.69%, falls within the acceptable range reported in previous studies that employed similar marking techniques (Secor et al., 1991; Jones, 1992). This suggests that the concentrations of ARS used (50 mg/L to 300 mg/L) are not unduly harmful to YOY *D. vulgaris*, corroborating findings from studies on other species where similar or higher concentrations were deemed safe (Amos et al., 1998; Green & McCormick, 2001).

The absence of ARS mark in a small portion of the 50 mg/L treatment group underscores the importance of concentration in the marking process. This observation is consistent with the dose-dependent nature of chemical marking techniques described by Tsukamoto et al. (1989), who emphasized that sufficient concentration and exposure time are critical for successful mark deposition in otoliths.

The linear relationship between total length and age established in this study provides a clear indication of the growth rate of YOY *D. vulgaris* in the Çanakkale Strait. The daily growth rate of 0.031 cm/day is slightly higher than rates reported for other *Diplodus* species in different environments (Fowler, 1990; Morales-Nin & Aldebert, 1997), suggesting that local conditions in the Çanakkale Strait may be particularly conducive to the growth of *D. vulgaris* juveniles. The relatively high ($R^2$) value (0.81) indicates a strong correlation between age and total length, reinforcing the reliability of otolith analysis for growth studies.

According to the results of the Chi-square test, the hypothesis that daily growth increase in YOY *D. vulgaris* is a consistent process is supported. This finding is crucial for validating the use of otolith increment analysis as a method for age determination in fish, as suggested by Fowler (1995) and Secor et al. (1991).

## CONCLUSION

In conclusion, this study not only demonstrates the efficacy of ARS marking for studying the growth and daily age of *D. vulgaris* but also highlights the potential environmental and biological factors influencing growth rates in the Çanakkale Strait. Further research is needed to explore the impact of these factors in more detail and to verify the applicability of these findings to other marine species. Additionally, expanding the scope of research to include different seasons and a broader size range of specimens could provide a more comprehensive understanding of the growth dynamics of *D. vulgaris* in this ecologically significant region.

## COMPLIANCE WITH ETHICAL STANDARDS

### Authors' Contributions

HA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

EK: Data curation, Investigation, Resources, Validation

PÇ: Investigation, Visualization

AA: Data curation, Investigation, Writing – review & editing

All authors read and approved the final manuscript.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

The care and use of experimental animals complied with Çanakkale Onsekiz Mart University, Animal Experiments Local Ethics Committee animal welfare laws, guidelines and policies as approved by 2018/02-10.

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### Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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# Morphological examination of the larval development in Tigris kingfish, *Cyprinion macrostomus* Heckel, 1843

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**A B S T R A C T**

This study presents a comprehensive morphological examination of the larval development stages and growth rates of *Cyprinion macrostomus*. *C. macrostomus* broodstock have been collected from their natural habitats in Kangal, Sivas, Türkiye, and taken into cultivation under laboratory conditions. The research meticulously observed the early developmental stages, feeding behaviors, and growth rates of the larvae. Findings indicate significant morphological changes during the transformation of larvae into juvenile fish, with morphological metamorphosis completed by day 25. The average length of the larvae reached 14.78 mm by the end of day 25. This study provides fundamental information for the cultivation and conservation of *C. macrostomus*, identifying necessary conditions for optimizing larval growth and development processes. Moreover, this research contributes to the development of strategies for the sustainable management and conservation of *C. macrostomus*, offering a foundation for future studies to build upon for the species' conservation and successful aquaculture cultivation.

## INTRODUCTION

*Cyprinion macrostomus* is a fish species belonging to the Cyprinidae family, commonly found in the basins of the Euphrates and Tigris rivers. This species typically has a grey back color and whitish sides, with some individuals displaying a large orange-reddish spot on the operculum. *C. macrostomus* has been utilized in health tourism in Türkiye, especially by the Kangal community, due to its healing properties discovered by chance (Özçelik & Akyol, 2008).

This species coexists with *Garra rufa* in natural spring waters and is used for therapeutic purposes in health service establishments at spas (Wildgoose, 2012). While *C. macrostomus* nibbles at the skin with its firm mouth movements, *C. macrostomus* consumes the softened skin, removing it from the environment (Wildgoose, 2012). This cooperation plays a significant role in the therapeutic process for both species.

Achieving success in the aquaculture of Tigris kingfish, *C. macrostomus* Heckel, 1843 necessitates a comprehensive morphological analysis of the species' larval development. The morphological progression observed during the larval phase of this species provides critical insights into the optimization of aquaculture conditions and environmental parameters. Specifically, the analysis of larval growth rates, morphological transitions, and developmental stages constitutes a foundational framework for the effective planning and management of aquaculture operations (Alwan et al., 2009).

The detailed examination of larval development from a morphological perspective aids in addressing challenges encountered in the aquaculture of *C. macrostomus*. These

investigations facilitate the identification of optimal nutritional requirements, growth trajectories, and the requisite water quality parameters for healthy larval development (Faris et al., 2014). Armed with this knowledge, the design and management of aquaculture systems can be aligned with the biological requisites of the species, thereby ensuring the robust growth and development of larvae.

Moreover, the morphological examination of *C. macrostomus* larval development holds significant implications for the conservation and sustainable management of the species. Such scientific inquiries enhance our understanding of the species' ecological needs and contribute to the formulation of strategies essential for the support of natural populations (Khalaf, 2008). Consequently, a meticulous morphological analysis of *C. macrostomus* larval development is imperative not only for augmenting aquaculture success but also for bolstering the conservation of the species within its natural habitats.

Therefore, it is imperative that research endeavors related to the aquaculture and conservation of *C. macrostomus* accord special emphasis to the analysis of morphological development during the larval stage. This approach furnishes the requisite scientific foundation for the sustainable management and conservation of the species, thereby facilitating the attainment of positive outcomes from both an economic and ecological perspective.

## MATERIALS AND METHODS

### Study Area and Fish Collection

Approximately 200 *C. macrostomus* specimens were collected from the natural habitats in Kangal, Sivas, Türkiye. The collection was carried out using nets, and the specimens were immediately transported to the laboratory within 24 hours post-capture. Upon arrival, the fish were placed in specially prepared aquariums for acclimatization and further study.

### Aquarium Conditions and Maintenance

The specimens were housed under controlled conditions in the laboratory. Each aquarium was designed to accommodate a maximum of 50 fish, ensuring ample space and optimal living conditions for the specimens. The fish were maintained in these conditions for a period of 12 months. The diet provided was a commercial fish feed composed of 42% protein, 17% fat, 3% fiber, 12% ash, and 8.5% moisture, administered two to three times daily to meet the nutritional requirements of the fish.

### Water Quality Monitoring

Water quality parameters, including temperature, pH, and dissolved oxygen (DO) were closely monitored throughout the broodstock culture period. The water temperature was maintained at 28±1°C, pH levels ranged from 8.0 to 8.4, and DO levels were kept between 6.0 to 6.2 mg $l^{-1}$. These conditions were consistently maintained to ensure an optimal environment for the growth and development of the fish.

### Breeding and Incubation

After a period of 12 months, sexually mature males and females were identified based on morphological characteristics and segregated. The breeding ratio was set at 2 females to 2 males per tank. The breeding tanks were equipped with sponge filters and aeration systems to maintain water quality. The tanks were filled with coarse gravel and small stones to mimic natural breeding environments.

Post-spawning, eggs were carefully collected from the breeding tanks, and the total count of eggs and hatchlings was recorded. The eggs were then transferred to 30-liter glass incubation tanks, which contained water from the breeding tanks and were supplemented with aeration through air stones. The incubation tanks were maintained at a constant temperature of 28±1°C.

### Larval Rearing

Newly hatched larvae were reared in the incubation tanks from hatching to 30 days after hatching (DAH). From 4 DAH to 30 DAH, 10% of the water in the tanks was changed daily to maintain water quality. The larvae were fed with brine shrimp (Artemia) from 3 DAH to 15 DAH, after which they were gradually transitioned to artificial diets until the end of the experiment.

### Sampling and Observation

Random sampling of larvae (n=2) was conducted daily from the day of hatching until the end of the study period. The sampled larvae were observed under a stereo microscope for detailed morphological analysis. Additionally, general observations on morphology were conducted to monitor developmental changes throughout the larval stage.

This methodology provided a comprehensive approach to studying the growth, development, and morphological changes in *C. macrostomus* larvae under controlled laboratory conditions.

## RESULTS

This study aims to determine the early developmental stages and larval growth rates of *C. macrostomus*. Throughout the research, the morphological developments, feeding behaviors, and growth rates of the larvae have been meticulously observed.

### Early Developmental Stages

**1 DAH (Days After Hatching):** Newly hatched larvae had an average total length of 4.5 mm, with the yolk sac constituting more than 50% of the total length.

**2 DAH:** The mouth and anus remained closed, and the yolk sac size reduced.

**3 DAH:** Larvae exhibited limited swimming activity. The yolk sac continued to diminish, with increased pigmentation over the eyes and body.

**4 DAH:** The mouth and anus opened, larvae developed a one-chambered swim bladder, and swimming activity increased. The notochord's end was slightly flexed, marking the beginning of exogenous feeding.

**5 DAH:** Anal and dorsal fins started to develop, and the yolk sac was completely absorbed.

**8 DAH:** The postflexion stage was observed, with the dorsal and caudal fins beginning to separate from the continuous fin.

**9 DAH:** The dorsal and pelvic-fin spines started to elongate, with most larvae homogeneously distributed in the water column.

**10 DAH:** A second inflation of the swim bladder occurred between 9 and 10 DAH. Pigmentation increased on the head and lateral parts of the body.

**18 DAH:** All fins were well-developed, indicating significant progress in the larvae's morphological development.

**25 DAH:** The body shape and pigmentation pattern resembled those of adult fish, with the body completely covered in pigment. This marked the completion of morphological metamorphosis.

These findings highlight the rapid growth and significant morphological changes *C. macrostomus* larvae undergo in their early life stages. The transition from yolk sac dependence to active feeding and swimming, followed by the development of key anatomical features, reflects the larvae's adaptation to their aquatic environment. The completion of morphological metamorphosis by 25 DAH demonstrates the species' efficient early development, providing valuable insights for aquaculture practices and conservation strategies aimed at supporting the *C. macrostomus* population.

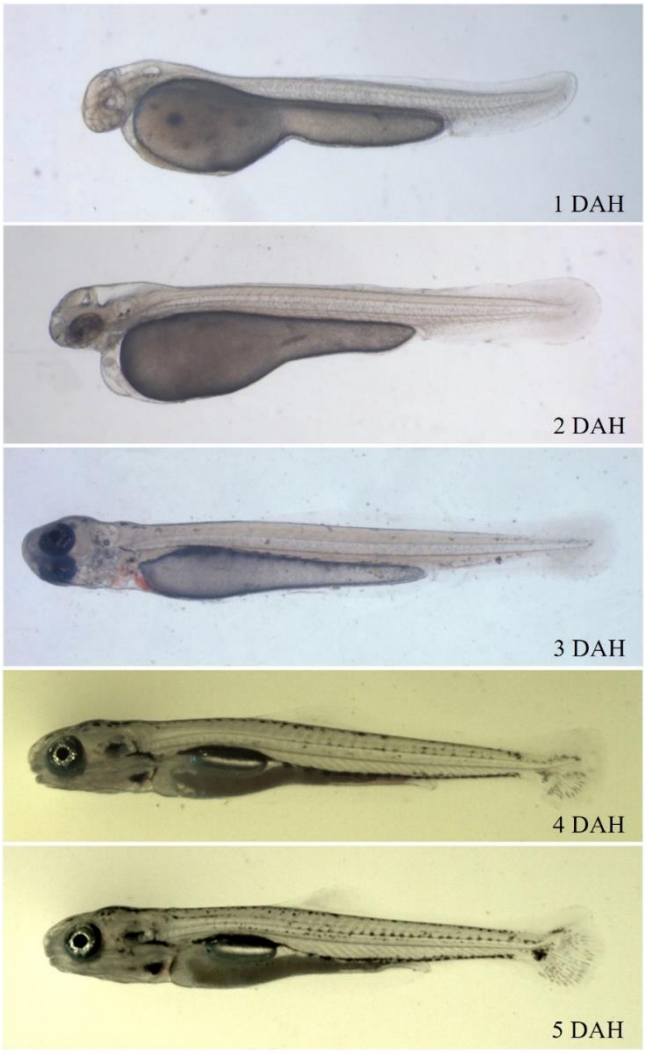


**Figure 1.** Morphological development of *C. macrostomus* larvae during the first 5 days post-hatching.

### Larval Growth Rates

By the sixth day, the average length of the larvae was recorded at 7.42 mm. By the end of the eighth day, the larvae reached a length of 8.00 mm, and by the tenth day, a more pronounced increase in length was observed, averaging 9.48 mm. From the eleventh day onwards, the larvae's length rapidly increased, reaching 10.84 mm by the sixteenth day, 11.54 mm by the eighteenth day, and 14.78 mm by the twenty-fifth day.

These findings indicate that *C. macrostomus* larvae exhibit a rapid growth rate during their early developmental stages. The initiation of active swimming and feeding behaviors following the consumption of the yolk sac plays a significant role in the increase in larval growth rates. Furthermore, the development of pigmentation and the maturation of the

mouth structure during the larval period reflect critical morphological changes in the early life stages of the species.

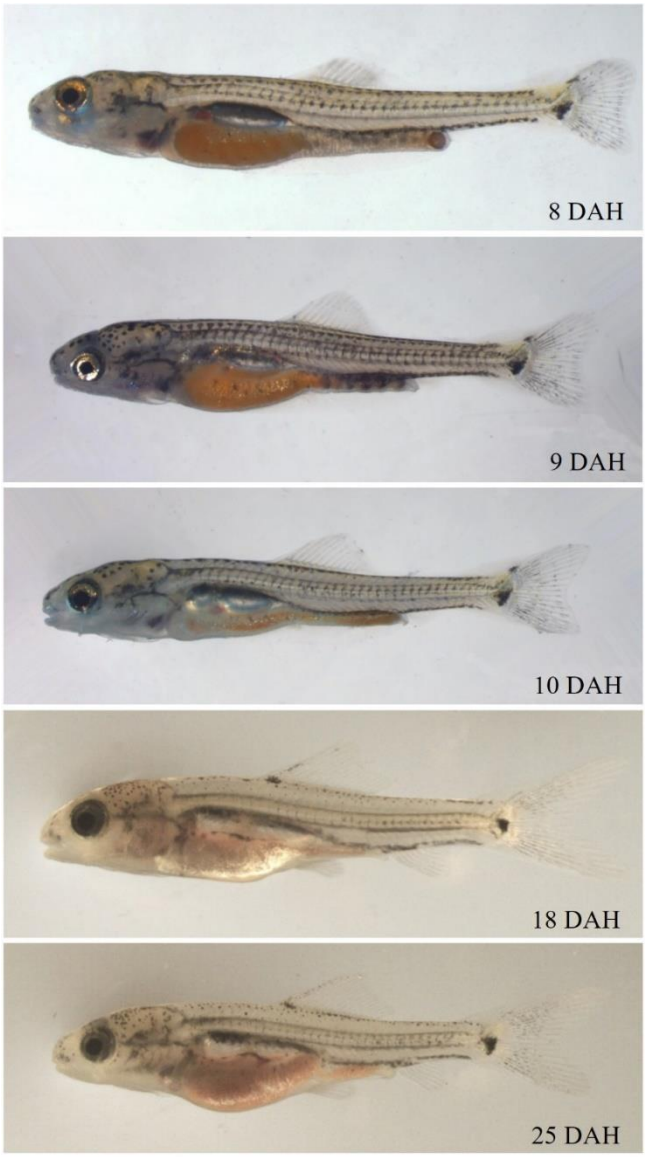


**Figure 2.** Morphological development of *C. macrostomus* larvae from day 8 to day 25 post-hatching

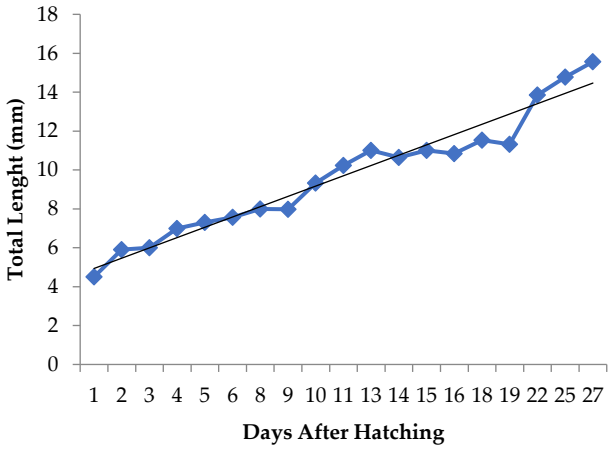


**Figure 3.** Growth chart of *C. macrostomus* larvae from hatching to the juvenile stage during the first month (mm)

This study provides essential insights into the larval development and growth dynamics of *C. macrostomus*, contributing to the development of strategies for the species' cultivation and conservation. This study has also meticulously examined the larval development stages and growth rates of *C. macrostomus*, shedding light on the morphological changes and growth dynamics of the species during its early life stages.

## DISCUSSION

The study has demonstrated that *C. macrostomus* larvae undergo rapid morphological transformations within the first 25 days, developing critical anatomical structures such as the swim bladder, anal and dorsal fins. These findings underscore the importance of rapid growth and development during the early stages for effective aquaculture management and enhancement of larval survival rates.

This study presents a comprehensive morphological examination focused on the larval development stages and growth rates of *C. macrostomus*, aiming to fill gaps in this area. The research documents significant morphological changes during the transformation process from larvae to juvenile fish, based on detailed observations of the early development stages, feeding behaviors, and growth rates of this species. It has been determined that morphological metamorphosis is completed by the twenty-fifth day, with the larvae reaching an average length of 14.78 mm by the end of this period. This study provides critical information for the cultivation and conservation of *C. macrostomus*, identifying the necessary conditions to optimize larval growth and development processes. Additionally, the research contributes to developing strategies for the sustainable management of this species while establishing a solid foundation for future studies.

The results of the research highlight the rapid growth and significant morphological changes observed in the early development stages of *C. macrostomus* larvae. The transition from dependence on the yolk sac to active feeding and swimming behaviors, followed by the development of main anatomical features, indicates the successful adaptation of the larvae to the aquatic environment. The completion of morphological metamorphosis on the twenty-fifth day demonstrates the efficiency of the species' early development and offers valuable insights for aquaculture practices and conservation strategies aimed at supporting *C. macrostomus* population.

This study provides significant insights into the larval development and growth dynamics of *C. macrostomus*, contributing to the development of strategies for its cultivation and conservation. The research enriches the

existing literature in this field by offering detailed information on the morphological changes and growth dynamics during the early life stages of the species. In the discussion and conclusion sections, the main findings of the study are interpreted, comparisons are made with the existing literature, the limitations of the research are addressed, and suggestions for future studies are provided.

Previous studies by Alwan et al. (2009) have documented the morphological variations of *C. macrostomus*, but this study contributes significantly to the literature by detailing the larval development stages and growth rates. Research by Faris et al. (2014) explored the effects of water temperature on the growth performance and survival rate of *C. macrostomus* larvae. The findings of this study support the critical role of water quality parameters and feeding regimes on larval growth.

Scientific studies on the cultivation and production of *C. macrostomus* have evaluated the growth performance of this species under different water temperatures. One such study found that the best growth performance of *C. macrostomus* juveniles was achieved between the temperatures of 28-30°C when reared in temperatures ranging from 24°C to 34°C (Çelik & Güzel, 2017). These findings represent an essential step in determining the optimal temperature range for the cultivation of *C. macrostomus* juveniles.

The larval development process of *C. macrostomus* is characterized by a morphological metamorphosis that is completed by the twenty-fifth day. During this period, it has been observed that the larvae develop critical anatomical structures such as the swim bladder, anal, and dorsal fins, facilitating their adaptation to the aquatic environment (Çelik & Güzel, 2017). Rapid growth and development in the early stages are of critical importance for effective aquaculture management and increasing larval survival rates to support the *C. macrostomus* population (Özçelik & Akyol, 2008). Research contributes to the development of strategies for the sustainable management of *C. macrostomus* by identifying the necessary conditions for its cultivation and conservation (Wildgoose, 2012).

One limitation of this study is its confinement to laboratory conditions. Future research could explore the development of *C. macrostomus* larvae under different environmental conditions. Additionally, the effects of genetic factors on larval development could be investigated in more detail.

In addition to marine fish species, the larval development of freshwater fish also exhibits interesting differences and similarities. For instance, *Cyprinus carpio* (common carp) larvae hatch with a larger yolk sac and can survive longer on this endogenous nutrition compared to *C. macrostomus* (El-Sayed, 2006). In contrast, *Oncorhynchus mykiss* (rainbow trout) larvae begin exogenous feeding early in their development, similar to marine fish (Kendall et al., 1984).

Morphological development of freshwater fish larvae also varies among species. *Oreochromis niloticus* (Nile tilapia) larvae develop certain anatomical features more rapidly compared to *C. macrostomus* (Fujimura & Okada, 2007). On the other hand, the morphological development of *Salmo salar* (Atlantic salmon) larvae follows a more similar trajectory to that of marine fish (Gorodilov, 1996).

Larvae of different freshwater fish species may exhibit variable adaptations to environmental factors and threats. For example, *Clarias gariepinus* (African sharptooth catfish) larvae are tolerant to low oxygen levels and high temperatures (Hecht & Appelbaum, 1988). Similarly, *Ictalurus punctatus* (channel catfish) larvae show good development in turbid and nutrient-rich waters (Tucker & Robinson, 1990).

## CONCLUSION

In conclusion, this study reveals that *C. macrostomus* larvae undergo rapid morphological transformations within the first twenty-five days, including the development of critical anatomical structures such as the swim bladder, anal, and dorsal fins. These findings highlight the critical importance of rapid growth and development in the early stages for effective aquaculture management and increasing larval survival rates. This research serves as a valuable reference source for the conservation and culture of *C. macrostomus* while laying a solid foundation for future studies.

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## COMPLIANCE WITH ETHICAL STANDARDS

### Authors' Contributions

İÇ: Conceptualization, Data curation, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing

PÇ: Investigation, Visualization, Writing – original draft, Writing – review & editing

All authors read and approved the final version of the article.

### Conflict of Interest

The authors declare that there is no conflict of interest.

## Ethical Approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. Both authors have a Certificate for the Use of Experimental Animals.

## Funding

Not applicable.

## Data Availability

The data supporting the findings of this study are available from the corresponding author upon request.

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