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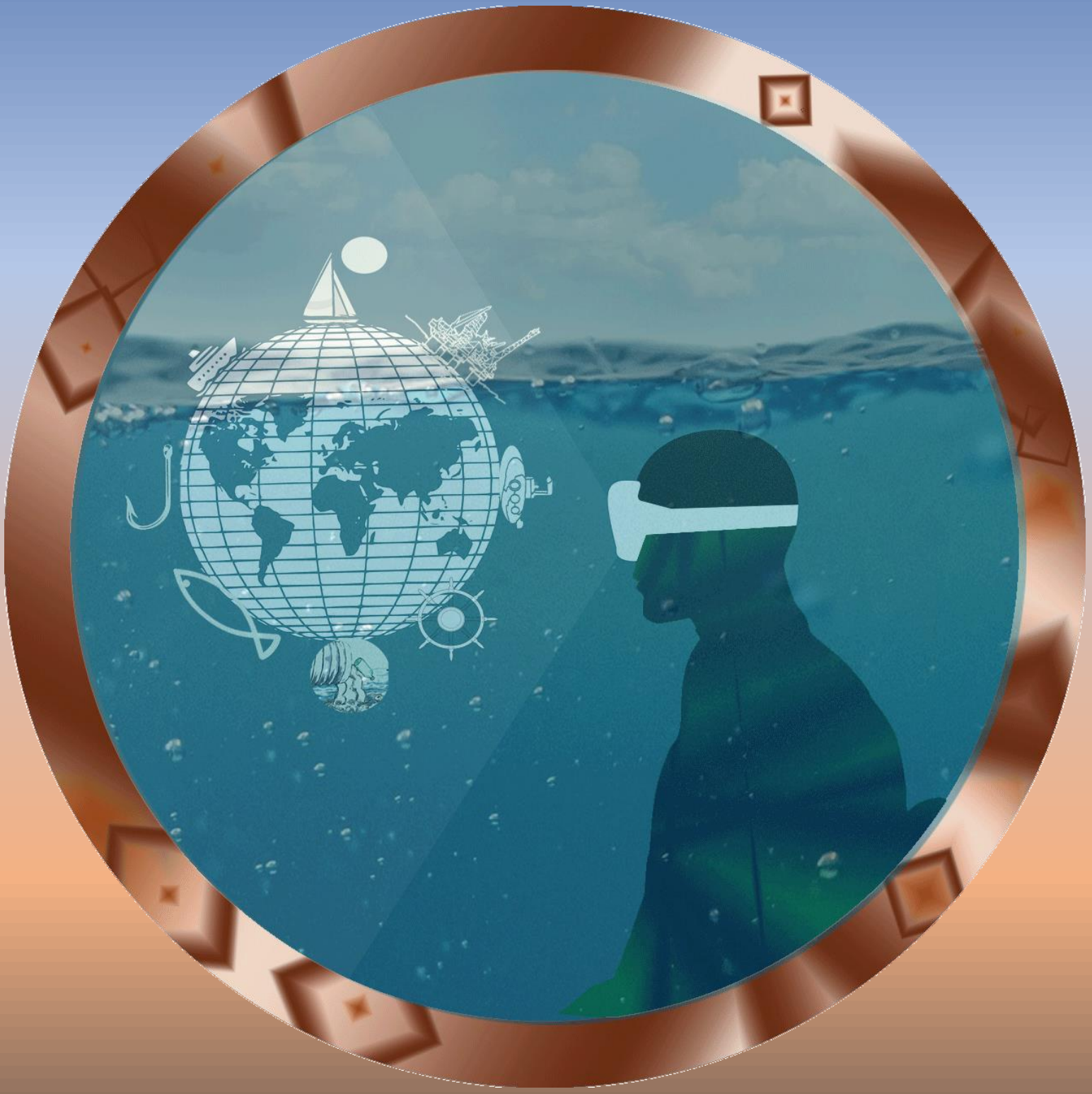
Marine and Life Sciences



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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

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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.

Thesis and Dissertation:

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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:

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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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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.

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TABLE OF CONTENTS

Marine and Life Sciences
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Analyzing the impact of container shipping service reliability on global supply chain pressure: An asymmetric approach

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A B S T R A C T

Delays in international trade negatively affect the global world economically, commercially, and politically. We aimed to empirically determine the asymmetrical effect of the delays experienced in the arrival of container shipping vessels to their destinations on the pressure on the global supply chain by using Global Schedule Reliability (GSR) and Global Supply Chain Pressure Index (GSCPI). The dataset covers the period between January 2017 and April 2023 and consists of 76 observations. The results show that the effect of delays on the supply chain is asymmetrical, while the increase in delays increases the pressure, the decrease in delays has no effect. This shows that the effects of delays on the supply chain are sticky and take a long time to clear from the system. In this direction, policies are recommended to minimize the effect of delays on international trade.

INTRODUCTION

Optimum functioning of the global supply chain is crucial for the global economy, as production and consumption activities are interconnected worldwide. A well-functioning supply chain ensures efficient transportation of goods. Thus, costs are reduced and delivery times are accelerated. In addition, production activities located in different parts of the world due to globalization are not interrupted due to a well-functioning supply chain. It also helps stabilize prices, reducing inflationary pressures. In addition, a predictable supply chain increases investor confidence and reduces risk from uncertainty. In this respect, there is a strong relationship between economic activities and the operational ability of the supply chain (Shahzad et al., 2023).

One of the most important actors in the global supply chain is maritime transport, because approximately 90% of the world's cargoes in quantity and 30% in value are transported by sea (Janic, 2022). In addition, maritime transport plays a triggering role in international trade due to the cost advantage arising from large volumes (Lun et al., 2023). Since ships are a very large means of transportation, the cost of transportation per unit is considerably lower and this makes trade with long distances possible (Tongzon, 2022). In addition, wide and almost unlimited waterways can be used as roads for sea transportation, allowing cargo to be transported without requiring huge infrastructure investments. When a country is strongly connected to the global maritime transport network, it gains competitive advantage in the international market. For these reasons, maritime transport is of great importance for international trade and economy, both globally and regionally (Durmuş, 2023).

Operational activities in maritime transport are generally carried out in three different ways: liner shipping, industrial shipping, and tramp shipping. Industrial shipping is about

the transportation of large industrial companies' own cargoes with their own ships. Liner and tramp shipping operators provide transportation services to shippers. While liner shipping is based on the execution of activities by calling at certain destinations on a certain route on certain dates, tramp shipping is based on the execution of point-to-point contract-based activities (Song, 2021). Therefore, the types of cargoes carried by both types of operational activities also differ. While products with high added value are generally transported with liner shipping, products with low added value are generally transported with tramp shipping (Koukaki and Tei, 2020). For this reason, it is of great importance for the supply chains that ships reach their destinations on time in liner shipping operations for several reasons. First, the on-time arrival of ships ensures minimizing inventory holding costs (Cariou et al., 2019). This increases satisfaction for both companies and customers. Second, when ships arrive on time, manufacturers and other businesses can make healthy production plans (Schuldt, 2011). Possible delays can cause inefficiency, cost increase, and job loss by disrupting production plans. Third, the timely arrival of ships minimizes disruptions in the global supply chain. Since many production stages are globally dependent on each other, disruption in any stage will spread to other stages ((Hoffer, 2015). Fourth, the timely arrival of ships generates a better and more trusting relationship between ship owners and customers (Plomaritou and Papadopoulos, 2018). This situation can have a positive impact on the whole society by reducing costs. Fifth, the timely arrival of the ship will facilitate the optimization of transport modes, as cargoes arriving by sea transport are transported inland by other modes (Verbraeck, 2016). In general, the timely arrival of ships has significant effects on the global supply chain.

As is known, the pressure on the global supply chain ultimately increases the costs and reduces the purchasing power of the people by triggering inflation due to the reasons mentioned above (e.g., Liu and Nguyen, 2023; Ye et al., 2023; Kim et al., 2023). In addition, as the transportation costs increase, the need for foreign exchange of the state increases as transport charges are generally paid in foreign currency (Branch and Robarts, 2014), while their competitive advantages decrease (Porter, 1990). For this reason, we aimed to empirically reveal the possible differences in the effect of timely arrival of container ships on the pressure of the supply chain for companies and policy makers. Thus, proactive strategies can be developed by following the global container schedule reliability as the causality analysis determines the direction of information flow. Since the variables were produced relatively recently, no empirical study with a similar approach could be found in the literature. As a result of the asymmetric causality test we applied by considering the distributions of the variables, schedule reliability affects global supply chain pressure significantly and asymmetrically. We found only significant causality from decreases in reliability to increases in supply chain pressure. This shows that the decrease in the timely arrival of the ships increased the pressure, but the increase did not have any decreasing effect on the pressure. When ships start to delay, this causes congestion and pressure in the supply chain. Even if the ships start to arrive on time, this negative effect continues for a long time. In other words, the decline in reliability has a sticky effect on supply chain pressure.

In the second part of the study, the relevant literature is evaluated and a conceptual framework is formed. In the third part, the dataset and method used in the study are introduced. The empirical findings are presented in the last part.

Literature Review

The narrative approach was preferred while reviewing the literature. The fact that there are many studies from various fields in our research topic makes it difficult to conduct an in-depth systematic review on a specific relationship between specific variables. The narrative approach is based on making a general assessment of a topic by conducting a reasonable comparison. Thus, the studies are summarized by referring to the theory related to the research area and a framework is drawn for our own research question (Clark et al., 2021). While reviewing the literature, the keywords "GSCPI", "container schedule reliability", and “freight rate determinants” were searched in web of science (WOS). In addition, the same keywords were searched in the google scholar, and it was aimed to reach other studies that were not listed in the WOS, because studies from every index are listed in the scholar.

When studies on GSCPI are reviewed in the literature, it is seen that they are generally associated with environmental, climatic, economic, and financial issues. Some of these studies have been compiled to draw a general theoretical framework for our study. There are several studies examining the GSCPI variable in environmental and regional terms in the literature. In the study by Qin et al. (2023a), GSCPI was used as a dependent variable and other variables affecting it were investigated. The southern oscillation (SOI), which represents changes in air pressure differences in a certain region, and the geopolitical risk index (GPR), which represents global geopolitical risks, are modeled as independent variables with the wavelet-based quantile regression approach. The results obtained showed that both variables affect the GSCPI variable in different time dimensions. Extreme climatic conditions and increasing geopolitical risks increase the pressure on supply chains. In addition, as the increased GSCPI value directly affects

transportation activities, it can also affect CO_2 emissions. This situation was investigated by Tiwari et al. (2023) and they found that disruptions in the supply chain significantly increase gas emissions in the short and long term.

GSCPI was also associated with several macroeconomic financial indicators as it is also representative of global risk and can affect the level of the risk appetite of investors. In a study examining the relationship between gold prices and GSCPI using the wavelet approach, Li et al. (2023) determined that the GSCPI variable affects gold prices in the short, medium, and long term, while the gold price affects the GSCPI variable in the short and medium term. In this case, they stated that gold both played a predictive role in the GSCPI index and remained a safe haven by maintaining its hedging feature against increasing pressures. The same issue was investigated by Qin et al. (2023b) with causality analysis. The results obtained showed that the GSCPI variable had both positive and negative effects on the gold price. They indicated that increasing supply chain pressures may increase the tendency to view gold as a safe haven. In a study using the GSCPI variable as a proxy variable for global supply chain uncertainty (GSCU), the relationship between GSCU and precious metals was investigated by Su et al. (2023). In the research conducted with wavelet-based quantile regression analysis, it was determined that the interactions differed in the short, medium and long term. In addition, the effect of the GSCPI variable on alternative investment instruments has also been the subject of research. The relationship between GSCPI and bitcoin markets was analyzed by Qin et al. (2023c), and they determined that the GSCPI variable affects bitcoin markets positively and negatively, although it changes over time.

In terms of the components GSCPI contains, there are also direct effects on the inflation of the countries, as the increased GSCPI variable also means increased transportation costs. In the research conducted by Liu and Nguyen (2023), the effect of the GSCPI variable on the United States's inflation was examined. The results show that increasing pressure raises input costs and triggers inflation by increasing society's higher price expectations. A similar study was conducted by Ye et al. (2023) for developed and developing countries using panel data. They found that an increase of 1 standard deviation in the GSCPI variable increased the inflation of developed countries more than that of emerging ones. In a similar study conducted for Sub-Saharan African countries and using panel data, it was revealed by Andriantomanga et al. (2023) that changes in the GSCPI variable significantly affected inflation in African countries. They suggested that central banks could implement proactive monetary policies to control the increase in inflation by following developments in the supply chain. The effect of the GSCPI variable on inflation is not limited to price increases, and it is also pass-through to other areas. It was revealed by Kim et al. (2023) that increases in the GSCPI variable not only increase inflation but also cause decreases in employment and production activities. Due to increasing risk and uncertainty, companies naturally reduce their production and demand for labor. In a microscale study by Hupka (2022), the effect of the global supply chain pressure index on the leverage ratios of firms was investigated. The author determined that the increase in pressures in the supply chain decreased total debt ratios and was decisive in company policies.

The movement of the GSCPI variable naturally occurs under the influence of some factors. However, we couldn't encounter a study in the literature that directly analyzes this and is suitable for scope of our work. Because of this situation, we aimed to compile some studies on the components that make up the GSCPI variable and to generate a framework about the factors that may affect it. While forming the GSCPI index, maritime and air transportation costs, and the Purchasing Managers' Index (PMI) surveys of the major economies in the world are used. Maritime transportation costs are represented by Baltic Dry Index (BDI), which measures the market in which dry bulk cargoes are transported, and Harpex Index, which measures the market in which container cargoes are transported (New York FED, 2023). The PMI survey, on the other hand, shows the health of the general economy and provides information about macroeconomic conditions such as GDP, inflation, exports and labor (S&P Global, 2023).

When we consider the issue in terms of freight rates that make up the GSCPI variable, freights are basically formed by the balance between supply and demand. Shift on either side causes the equilibrium freight point to be higher or lower (Karakitsos and Varnavides, 2014). Therefore, any factor that affects supply and demand in maritime transportation will also affect the GSCPI. When we look at the literature, there are numerous studies, and it is not possible to mention all of them. In addition, since this study is not a study focusing on freights, we only considered it appropriate to summarize the factors affecting the freights they determined in their findings. While scanning these studies, the word "freight" was used as a keyword in various combinations in the databases mentioned above.

Factors affecting freights are divided into microeconomic and macroeconomic. Since each ship can be considered as a separate business in terms of microeconomics, the costs may vary depending on the condition of the ship and the business. The microeconomic factors discovered in the literature can be listed as age of the ship (Alizadeh and Talley, 2011), size of the ship (Kavussanos, 2003), speed of the ship (Beenstock and Vergottis, 1989; Magirou et al., 2015), characteristics of buyers

and sellers (Adland et al., 2016), open registries (Wilmsmeier and Martinez-Zarzoso, 2010), and bunker price (Shen and Chou, 2015; Yin et al., 2017). On the other hand, the macroeconomic and some other factors discovered in the literature can be listed as oil price (Shi et al., 2022), fleet size (Xu et al., 2011), industrial production (Strandenes, 1984), connectivity to transportation network (Wilmsmeier and Hoffmann, 2008), exchange rates (Chi, 2016), commodity prices (Bandyopadhyay and Rajib, 2023), inflation (Michail et al., 2022), GDP (Başer and Açık, 2019), port efficiency (Lei and Bachmann, 2020), port closures (Lewis et al., 2006), market sentiment (Bai et al., 2021), weather conditions (Açık and Başer, 2018), and pandemics (Xu et al., 2022). Any factor that affects freight will naturally be reflected in the GSCPI value, but modeling all these factors is relatively difficult.

Possible increases in GSCPI indicate that disruptions in the supply chain have increased, transportation costs have increased, and expectations for the future have become negative. Disruptions in the supply chain can negatively affect national and international trade, as they generate problems in the supply of raw materials and the delivery of final products. In addition, increases in transportation costs may discourage more entrepreneurs from participating in business activities (Reyes and Sawyer, 2016), increase costs, cause inflation (Carrière-Swallow et al., 2023), and thus reduce the welfare of society (Sexton, 2016). Finally, negative expectations can lead to a sticky process and the formation of chronic inflationary markets. In this respect, it is important to identify and analyze the factors that cause such events, represented by the changes in the GSPCI, to take proactive measures. In the literature, the focus has been mostly on the factors that GSCPI affects rather than the factors that affect GSCPI. These factors consisted of issues such as gas emission, inflation, employment, gold price, investment instruments, and cryptocurrencies. However, in order to understand such interactions, it is necessary to go to the source and examine the main factors affecting GSCPI. Since maritime transportation accounts for approximately 80% of global trade by volume (Song, 2021), the impact of the performance of this transportation mode on the supply chain is inevitable. However, there is a lack of empirical studies on the seaside of GSCPI in the literature. Ship delays, which significantly affect the supply, especially in maritime transport, are likely to have an impact on freight and therefore on GSCPI. When the proportion of fleet available for maritime transport decreases due to the shortage of supply, freights and thus supply chain pressure increase. In this respect, we demonstrated our contribution by analyzing the effect of GSR on GSCPI asymmetrically, considering the distributions of the variables.

MATERIALS AND METHODS

Our dataset covers the period between January 2017 and April 2023 and consists of 76 observations. The Global Schedule Reliability (GSR) variable is a reliability index compiled from statistics on whether container ships arrive at their destination on time. It is simply obtained by the ratio of the number of on time voyages to the total number of voyages and corresponds to a percentage. For example, if 15 out of 100 voyages arrive late in the relevant month, the reliability index is calculated as 85, showing that 85% of that month's voyages were made on time. During the calculation process, ships arriving 1 day after their estimated time of arrival (ETA) were also considered to have arrived on time. The index is published monthly by Sea Intelligence (2023). In the chart presented in Figure 1, the change in schedule reliability over time can be observed. The index, which followed a stable course and was around 75 until the start of the pandemic period, then fell to 30 with a rapid decline. The factors that cause this can be counted as the imbalance of supply and demand due to the pandemic, the closure of the Suez Canal, hurricanes, and port congestion.

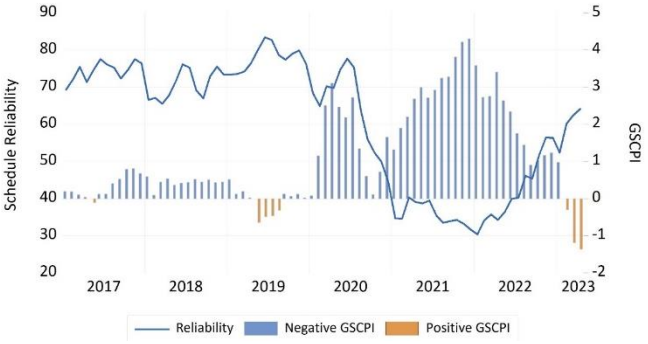

Figure 1. Global supply chain pressure vs service reliability

The Global Supply Chain Pressure Index (GSCPI) variable was proposed by Benigno et al. (2022) and published by the Federal Reserve Bank of New York to monitor the healthy functioning of the global supply chain by integrating transportation costs and some global production indicators (New York FED, 2023). The developed index consists of normalized values and can be interpreted in 3 different situations. First, the fact that the index is around 0 is interpreted as the normal functioning of the global supply chain. Second, a negative index indicates a very well-functioning supply chain without any significant pressure. Third, a positive index indicates that the supply chain is under pressure. In general, the index value is expected to be negative. However, it cannot be deduced that the supply chain works well in every negative situation, because in cases of economic recession, the index can take negative values because demand also narrows (Transport Geography, 2023). For instance, the negative values experienced since 2023 are

due to this situation rather than the perfection of the supply chain.

When the course of the index is analyzed in Figure 1, it is seen that it followed a normal course until the start of the pandemic, which moves around the 0 value. However, with the onset of the pandemic, it rose to very high levels. Factors such as factory closures, restriction of worker mobility, supply and demand imbalances, and online shopping trend exploding due to lockdown in the pandemic have increased disruptions in the supply chain. The index has started to decline since the second half of 2022. The main reasons for this can be shown as softening customer demand, decrease in real wages due to inflation, tightening monetary policies, and falling container freight rates (OECD, 2023). The index also successfully represents other important macro events in the period covered. For example, Hurricanes Maria and Harvey in 2017 caused delays and port congestions by disrupting the voyages of ships. Subsequently, this has increased the pressure on the global supply chain. Similarly, the blockage of the Suez Canal by a ship in March 2021 increased the pressure on the supply chain, causing increased voyage times and costs. The historical tightness of supply in the Los Angeles/Long Beach areas was another factor that increased the pressure. Finally, Russia's war against Ukraine in February 2022 disrupted the global optimization of container transportation and put pressure on the supply chain (Transport Geography, 2023).

Although the correlation between raw data in general seems to be significant with -0.74 (t= -9.59, p=0.00), raw data contain unit root, and means and variances of the variables change over time. The correlation between the differentiated series was insignificant with-0.02 (t= -0.25, p=0.79). In other words, there is no linear instantaneous relationship between the series.

The descriptive statistics values presented in Table 1 provide information about the movements and distribution characteristics of the variables in the period under consideration. The service reliability index took a relatively low value of 60% on average in the period under consideration. The highest reliability level was 83%, while the lowest level was 30%. The GSCPI variable, on the other hand, does not show much variation because it is related to how much standard deviation is deviated from the mean. The highest positive deviation was 4.30 while the highest negative deviation was 1.36.

When the variability of the variables was examined, the ratios of the standard deviation to the mean were calculated as 117% for GSCPI and 27.7% for GSR variable. In other words, while the supply chain pressure was highly variable, the confidence index followed a relatively stable course. Considering the distribution characteristics of the variables, the normality hypothesis is rejected at the 5% level for both variables. In other words, the series do not have normal distribution properties and contain asymmetrical structures. This is also supported by the fact that the skewness values are different from 0.

Table 1. Descriptive Statistics

	GSCPI	GSR
Mean	1.127985	60.80803
Median	0.596636	67.48200
Maximum	4.307350	83.47160
Minimum	-1.364702	30.41170
Std. Dev.	1.322246	16.90202
Skewness	0.638617	-0.538236
Kurtosis	2.477378	1.720295
Jarque-Bera	6.030796	8.855379
Probability	0.049026	0.011942
Observations	76	76

Source: Sea-Intelligence (2023); New York FED (2023)

To reveal the asymmetric structure in the variables more accurately, we presented the Quantile-Quantile Plots of both variables in Figure 2. These plots compare the distributions of the variables against the normal distribution. This means that the further away from the theoretical 45-degree straight line, the further away from the normal distribution. As can be seen, especially the tail values are located far from the normal distribution line. The distributions of both variables are S-shaped, and this is more evident in the GSR variable. These findings on the distributions of the variables show that using methods that consider asymmetry rather than linear analysis methods can provide more valid results.

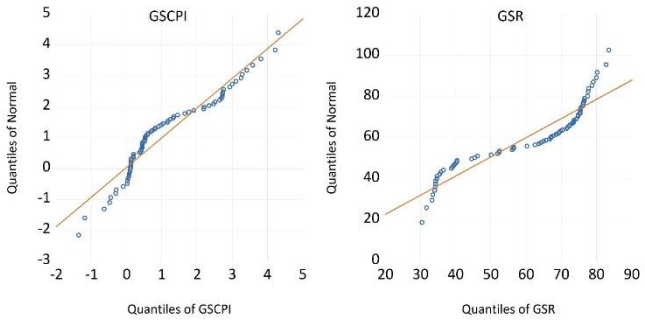

Figure 2. Quantile – quantile plot of the variables

Considering the asymmetric structure of the variables, we preferred to use asymmetric causality analysis in our study. In addition, the method we have chosen makes it possible to analyze the fact that the reactions of the players in the market may differ according to the market conditions because the players may be heterogeneous. Also, the information in the market may be spreading asymmetrically (Erdogan et al., 2022). The method was developed by Hatemi-J (2012) and makes it possible to test the relationships between the positive and negative shocks of the variables in 4 different combinations, i.e. (i) from positive to positive, (ii) from

positive to negative, (iii) from negative to negative, (iv) from negative to positive. The philosophy of the method is the same as the linear Granger (1969) causality analysis, only it uses the values of the shocks instead of the past values of the variables.

Since the Toda and Yamamoto (1995) process is followed in this method, the series does not have to be stationary. However, it is necessary to determine the maximum integration degrees of the series using unit root tests (Umar and Dahalan, 2016). If one or both of the series contains unit root, the maximum integration value is set to 1, while if neither of the series contains unit root, it is set to 0. Another advantage of determining the maximum degree of integration in the analyze process and adding it to the unrestricted VAR model is to overcome the long-term loss of information, because when the difference-taking process is applied to the series, it causes loss of information in the long run (Alola and Uzuner, 2021).

RESULTS

Augmented Dickey-Fuller (ADF) (1981) and Philips-Perron (PP) (1988) tests were applied to the series to determine the maximum degree of integration used in the asymmetric causality test, and the results are presented in Table 2. The ADF test assumes error terms to be independent and have constant variance. The PP test is an improved version of and is robust to autocorrelation and heteroscedasticity in the series (Enders, 2004). When the Q-stat (Ljung and Box, 1978) values of the series were examined up to 32 lags, there was a high rate of autocorrelation in both series. Therefore, in addition to the ADF test, the PP test was also applied. The null hypotheses of the tests indicate the existence of a unit root. In the results obtained, both tests revealed the same findings. While both variables contain a unit root at the level, they become stationary when their first difference is taken. For this reason, the maximum degree of integration was determined as 1 in the asymmetric causality test. In addition, econometrically, the unit root in the series shows that the mean and variances change over time. Such series are difficult to predict and carry the shocks to which they are subjected.

While applying the asymmetric causality test, the GAUSS software code was used. 1 was set as the maximum integration degree and 6 was set as the maximum number of lags in the model. AICc, which is the improved version of AIC for small samples, was preferred for the selection of the most appropriate lag value. The number of bootstrap simulations used to calculate critical values was determined to be 1000. The asymmetric causality test was tested in both directions, from GSR to GSCPI and from GSCPI to GSR. The null hypothesis of the test indicates noncausality between the variables. According to the results presented in Table 3, the null of the noncausality hypothesis was rejected in only 1 of the relationships analyzed in 8 different combinations. Since the data are not normally distributed, the null hypothesis of non-causality is rejected at the 5% confidence level when the MWALD test statistic is analyzed according to the bootstrap critical values. In this relationship, negative shocks in service reliability were identified as the cause of positive shocks in pressure in the global supply chain. However, an inverse relationship could not be determined. In addition, no significant relationship was found from the pressures in the supply chain to the reliability variable.

Table 2. Unit root test results

Test	Variable	Level		First Difference		Conclusion
		Intercept	Intercept & Trend	Intercept	Intercept & Trend	
ADF	**GSR**	-1.42	-1.41	-6.30***	-6.30***	I (1)
	GSCPI	-1.86	-1.48	-6.11***	-6.22***	I (1)
PP	**GSR**	-1.04	-0.86	-6.21***	-6.19***	I (1)
	GSCPI	-1.38	-0.33	-5.99***	-6.08***	I (1)

Notes: (1) CVs for ADF and PP are -3.52 for ***1%, -2.90 for **5%, -2.58 for *10% at intercept; -4.08 for ***1%, -3.47 for **5%, -3.16 for *10% at trend and intercept. (2) Schwarz Information Criteria was used in the selection of lag length in ADF. (3) Barlett kernel spectral estimation and Newey-West Bandwidth methods were used in PP.

Table 3. Asymmetric causality test results

	GSR^+ to $GSCPI^+$	GSR^+ to $GSCPI^-$	GSR^- to $GSCPI^-$	GSR^- to $GSCPI^+$	$GSCPI^+$ to GSR^+	$GSCPI^+$ to GSR^-	$GSCPI^-$ to GSR^-	$GSCPI^-$ to GSR^+
Optimal Lag	1	1	1	1	1	1	1	1
Additional Lag	1	1	1	1	1	1	1	1
Test Stat	1.52	0.21	1.74	7.76	0.20	0.06	0.01	1.60
Asymp. P Value	0.21	0.64	0.18	0.00*	0.65	0.79	0.89	0.20
CV 10%	2.99	2.70	2.98	2.85	2.85	2.60	2.99	2.96
CV 5%	4.79	4.21	4.86	4.18	3.96	3.87	4.58	3.97
CV 1%	9.75	9.79	11.18	7.80	6.86	8.75	9.38	7.65

Note: *Null of noncausality was rejected.

DISCUSSION AND CONCLUSION

Container transport vehicles mostly perform their activities in accordance with a certain schedule. The ports they will call at, the times they will arrive, and the routes they will follow are determined in advance. However, due to some circumstances, there may be delays in their arrival. Adverse weather conditions, storms, and rough seas can make it difficult for ships to navigate and cause changes in routes, contributing to ship delays. Congestion at their port of call can delay loading and unloading activities, delaying their arrival at the next port. In addition, strikes at ports can delay operations. In addition, delays may occur as it becomes difficult to perform port operations and sail on certain routes in geopolitically risky areas. Finally, rare global events such as the blocking of the Suez Canal can also cause ships to arrive late at their destination (Janic, 2022). Whatever the reason, these delays have great effects on the global economy.

In our research, we aimed to determine the effect of the late arrival of ships of companies engaged in container transportation to their destinations on the pressure in the global supply chain. The effects of delays in maritime transport will be much greater than in other modes of transport, as approximately 90% of the world's manufactured goods in quantity are transported by container shipping (Song, 2021). The possible consequences of late arrival of ships are: (i) freight rates will increase as the supply of ships in the market is restricted, (ii) goods will be in short supply and prices will increase due to longer delivery times in international trade, (iii) inventory costs will increase due to longer holding times, and this will be reflected in prices of the goods, (iv) production processes will be disrupted because the production of goods is carried out in different countries due to the global integration of supply chain, (v) production and consumption activities will slow down as the confidence in transportation modes will decrease and uncertainty will increase, (vi) because the optimization of other transportation modes will deteriorate due to delayed ships, costs of them will also increase. In addition, since the delayed ships will increase their speed in order to reach the schedule on time, the emission rates they release will increase and thus the environmental cost will increase (Song, 2021). All these developments will be reflected in the country's economies as inflation and economic slowdown, as researched in the literature (Andriantomanga et al., 2023; Liu and Nguyen, 2023; Ye et al., 2023). In addition, as this situation increases uncertainty, investors can follow the developments in the global supply chain and switch to safe haven (Li et al., 2023; Qin et al., 2023b; Su et al., 2023) and alternative (Qin et al., 2023c) investment instruments, which contribute to the economic slowdown by causing a decrease in the demand for goods and services.

When we examined the data we used in the research, their distributions were not normal and they may contain asymmetrical relations, considering the tail effects. As a result of the asymmetric causality test that we applied, we were able to detect a significant result for only 1 of the 4 possible outcomes. Negative shocks in the schedule reliability variable are the cause of positive shocks in the GSCPI variable. In other words, as the rate of ships arriving at their destinations late increases, the pressure on the global supply chain also increases. In addition, the optimum delay for relationships was determined to be 1, which can be interpreted as the delays of ships in the current month affect the supply chain pressure in the next month. However, we could not detect any significant results from the increase in the rate of ships arriving on time to the decrease in pressure. This situation can be explained by several different reasons. First, market players may place more emphasis on negative news than positive news, which can also be supported by the negative bias in behavioral economics (MacFadyen, 2015). Second, negative news may also negatively impact future expectations, causing supply chain pressure to remain sticky. Third, shipowners may be trying to compensate for losses caused by ship delays by keeping freight rates higher for a longer period. Fourth, input prices, which have risen due to pressure from delayed shipping, may not fall afterwards. For the remaining 2 combinations, i.e., positive to positive and negative to negative, it is a reasonable result that no significant result can be obtained. The increase in the rate of on-time arrivals does not increase the pressure on the global supply chain, on the contrary, it can be expected to reduce it (although we cannot support this situation statistically). Similarly, as the rate of ships arriving on time decreases, the pressure on the supply chain does not decrease, but rather increases (we were able to support this statistically). Insignificant results meet our theoretical expectations. From the perspective of the components of GSCPI, the decrease in ships arriving on time may lead to a decrease in the number of available ships in the market, resulting in an increase in freight rates due to the shortage of supply side. In addition, there may be cost increases due to the optimization problems, as disruptions occur in intermodal transport modes due to delayed ships. In general, the increase in supply-demand imbalance increases the pressure on the global supply chain.

Based on these results, some suggestions can be made for policy makers to prevent ship delays. First, investments in facilitating the transfer of containers between ports can be increased and thus an alternative route can be offered to the container in case of any setback or congestion. Second, even if relatively small ports cannot be invested in, hub ports can

be developed to handle a large amount of cargo traffic by optimizing their location and equipment reserve. Third, the cargo operation capacity can be increased by increasing the stock of mobile and floating equipment and positioning it in the optimum position, providing rapid dispatch to the needed area. Thus, the need for fixed investments that require high costs can be reduced. Of course, improvements made only on the port side are not enough to eliminate the negative effects of the pressure on the supply chain. Some suggestions can also be offered to line operators against the pressure in the supply chain. First, by strengthening the communication channels with the ports and the shippers, it can be ensured that the congestion at the port does not increase due to delays. Second, increasing container inventories can enable faster circulation. Third, in case of congestion, relations with alternative ports can be developed and cooperation in relevant alternative regions can be increased. Fourth, they can prepare risk management plans and thus be agile in ship planning and emergency actions in case of any congestion.

On the other hand, it could theoretically be expected that the pressure on the increasing supply chain would significantly affect the late arrival of ships as more ships could be delayed due to increased pressure. However, our empirical findings did not provide any significant evidence regarding this relationship. The biggest limitation of the study is related to data availability. The GSCPI variable can be obtained much earlier than the GSR variable. However, the scope of the research remained relatively narrow since the values of the GSR variable dated before January 2017 could not be reached. Particularly, including the effects of the Chinese boom effect in the process until the 2008 global economic crisis and thereafter the effects of oversupply in the maritime industry can bring important findings to the literature. In addition, it can be examined in which periods the pressure of reliability on the supply chain is significant with time-varying approaches. Also, models and simulations can be made on major events that significantly disrupt the global supply chain and their possible consequences can be investigated.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

The author declares that formal consent is not required for this type of study.

Data Availability

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

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Distribution of endemic *Garra culiciphaga* (Pellegrin, 1927) in the Ceyhan River System, some diagnostic characteristics, habitats and conservation requirements

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A B S T R A C T

In this study, the distribution and some diagnostic features of the endemic *Garra culiciphaga* belonging to the Cyprinidae family in the Ceyhan River systems were determined. Accordingly, the average total length of *G. culiciphaga* individuals is 49.58 mm, and their average weight is 1.32 g. Line lateral scales are 30-33, line transversal 8/7, and pharyngeal teeth are 3.3.5-5.3.3. *G. culiciphaga* has a very limited distribution in the Ceyhan River basin and has been identified from the Kumaşır Lake, Aksu Stream and Akçasu Stream. However, *G. culiciphaga* individuals were detected in May 2015 in Aksu stream could not encountered in the following year (April 2016) due to habitat loss.

INTRODUCTION

Garra culiciphaga was first described by Pellegrin in 1927 under the name *Hemigrammocapoeta culiciphaga*. These fish, which are included in the *Hemigrammocapoeta* genus, were included in the *Garra* genus by researchers after DNA borcode studies conducted in 2015 (Chapuis et al., 2015). It is reported that the *Garra* genus has spread from west to east from the Himalayas (Menon, 1964; Goren and Ortal, 1999). In recent studies in Türkiye, it has been stated that *Garra caudomaculata* is endemic species of the Orontes River, *Garra culiciphaga* is found in the Seyhan, Ceyhan and Orontes River systems, and *Garra turcica* is the synonym of *Garra rufa* (Temiz, 2019; Bayçelebi, 2020). Additionally, the existence of endemic species, including *Garra kemali* and *Garra menderesensis*, has been reported in Türkiye (Çiçek et al., 2018). *G. rufa* individuals are reported to have a very wide distribution in the Ceyhan River system (Kara and Alp, 2005; Kara et al., 2010). *G. culiciphaga*, endemic to Türkiye, has a very limited distribution in the Ceyhan River system. There are very few research on *G. culiciphaga*. In this study, it is aimed to reveal the distribution and some of its diagnostic features of endemic *G. culiciphaga* in the Ceyhan basin.

MATERIALS AND METHODS

This study was carried out in streams in the Ceyhan River basin between April 2014 and May 2016. The Ceyhan River is one of the important rivers of Türkiye, and it arises from the mountains at an altitude of approximately 2200 m in the Göksun, Elbistan, and Afşin districts of Kahramanmaraş and is fed by springs and streams. The Ceyhan River forms a wide delta in Çukurova and empties into the Iskenderun Bay. The most important streams of the Ceyhan River are Söğütlü, Nergele, Hurman, Kömür, Törbüzek, Fırnız, Aksu, Savrun, Yarpuz, Akçasu and Hemite (Kara et al., 2023).

Fish samples were caught in streams by using electroshock devices. The GPS coordinates of the sampling stations were determined. The caught fish samples were transferred to the Hydrobiology Research Laboratory in 5 liter plastic containers in 4 % formaldehyde solution. Then, the length measurements (mm) of the fish were made with a digital caliper with a precision of 0.01 mm, and the weight measurements were made with a digital scale with a precision of 0.01 g. The localities where *G. culiciphaga* individuals were caught are shown in Figure 1.

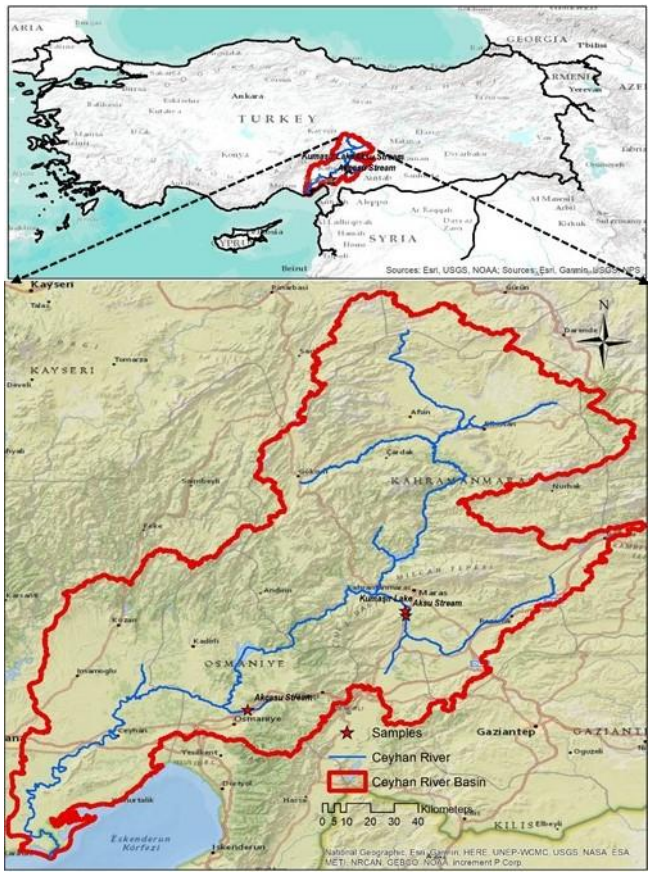

Figure 1. Distribution of *G. culiciphaga* in streams in the Ceyhan basin

RESULTS AND DISCUSSION

The bodies of *G. culiciphaga* are relatively high and slightly flattened from the sides. The lips are thin and keratinized. The caudal fin is deeply forked. The dorsal fin islocated near the midpoint of the body. The back of the body and the upper part of the lateral line are dark gray, the lower part of the lateral line and the abdomen are light silvery or gray. There is usually a thin black spot at the base of the caudal fin and a black band along the line lateral (Figure 2, 3). Within the scope of the research, the colors and patterns of *G. culiciphaga* individuals differed partially in the habitats detected in the Ceyhan river system, and there is always a thin black spot on the base of the tail fin (Figures 2 and 3).

Figure 2. *G. culiciphaga* specimen from Aksu Stream (A) and Kumaşır Lake (B) (Photo: C. Kara)

Figure 3. *G. culiciphaga* specimen from Akçasu Stream (Photo: C. Kara)

It has been determined that *G. culiciphaga* individuals generally prefer gravelly, sandy and slightly flowing waters (Figure 4).

Figure 4. A view from the habitat of *G. culiciphaga* in Akçasu Stream

In addition, the individuals detected in the Kumaşır Lake were determined from the littoral region of the lake, where aquatic plants are abundant (Figure 5).

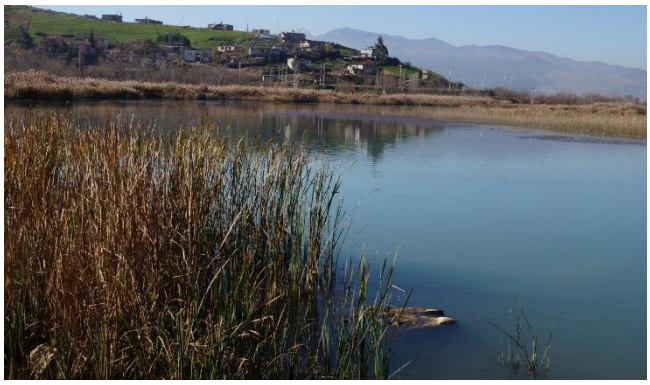

Figure 5. A view from the habitat of *G. culiciphaga* in the Kumaşır Lake (Kahramanmaraş)

The free edge of the dorsal fin of *G. culiciphaga* is straight and the ray number is D II 7-8. The number of line lateral scales varies between 30 and 33. The ventral fins are short, with one rigid and seven branched rays. The base of the anal fin is short and the free edge is slightly convex. Pharyngeal teeth are in the rows anda are in the form of 3.3.5-5.3.3 (Table 1). The length and weight of *G. culiciphaga* individuals identified from the research area in question are given in Table 1. According to this, the length of the individuals (n: 11) caught from Aksu and Akçasu Streams, and the Kumaşır Lake varied between 42.24-58.75 mm, and their weight varied between 0.29-3.15 g, and their average length was 49.58 mm, their average weight was 1.32 g (Table 1).

Table 1. Length, weight and some diagnostic features of *G. culiciphaga* individuals detected in the Ceyhan river basin (TL: Total length (mm), W: Weight (g), SD: Standard Deviation)

Localities	N	Mean TL (mm)	Min.-Max.	SD	Mean W (g)	Min.-Max.
Aksu Stream	5	47.54	42.24-55.28	5.41	1.18	0.29-1.93
Akçasu Stream	3	49.93	47.36-54.56	4.01	1.86	1.20-3.15
Kumaşır Lake	3	52.64	47.72-58.75	5.60	1.02	0.66-1.44
Mean	11	49.58	42.24-58.75	5.11	1.32	0.29-3.15
Dorsal	Anal	Ventral	Pectoral	Pharyngeal teeth	L. lateral	L. transversal
III 7-8	II 5	I 7	I 13	3.3.5-5.3.3	30-33	8/7

Bostancı (2006) found that individuals (n: 24) in the Ceyhan River Aksu stream had a standart length of 51.0-58.0 mm. On the other hand, İnnal et al. (2016) stated that the length of *Garra (Hemigrammocapoeta) culiciphaga* individuals (n: 16) in the Seyhan River was 4.3-6.0 cm and their weight is 0.96-3.04 g, which is partially similar to our research findings.

Figure 6. A view from the habitat of *G. culiciphaga* around Aksu Stream, Kahramanmaraş-Osmaniye road sand-gravel quarry (May 2015)

As a result of this research, *G. culiciphaga* individuals showed a very limited distribution in the streams of the Ceyhan River system. In addition, the habitats of *G. culiciphaga*, which lives in small ponds around the Aksu Stream (May 2015), have been destroyed due to the pollution of the stream (Figure 6, 7). For this reason, no *G. culiciphaga* samples were found during the fıled studies conducted in April 2016.

Figure 7. Aksu Stream, a view from the locality of the habitat of *G. culiciphaga* (April 2016)

As a result of this research, where slow-flowing aquatic plants were dense in Aksu and Akçasu streams, and the vegetation of *G. culiciphaga* in the Ceyhan River system was dense in the littoral region of the Kumaşır Lake. This species is not important for fishing. However, Geldiay and Balık (2009) reported that species belonging to the genus *Garra (Hemigrammocapoeta)* feed on mosquito larvae and is very importance mosquito control in ponds and swamps.

Deterioration of habitats of endemic *G. culiciphaga* in Ceyhan River is presented in Figure 7, pollution ect. It is under significant pressure due to anthropological activities. Such as according to Eschmeyer's Catalogue, *G. culiciphaga* is an important species for aquarium fisheries (https://www.aquariumglaser.de). Innal (2022) states that *Garra (Hemigrammocapoeta) culiciphaga* is an important fish species because it consumes mosquito larvae as food in the fight against malaria. Abak and Bonner (2020) stated that *G. culiciphaga* was a declining and less concerned species. According to the latest red list (IUCN) evaluation, *H. culiciphaga* is considered as missing data (DD). Endemic *G. culiciphaga* has biological and ecological importance and should be protected by relevant institutions and organization in the Ceyhan River system.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

The author declares that formal consent is not required for this type of study.

Data Availability

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

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Investigation on the effects of the number of main engines in sailing yachts in design and engineering perspectives: A case of Bodrum Gulets

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Research Article

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Engine room layout
Yacht design

A B S T R A C T

Yacht design consists of multidisciplinary processes to obtain optimum solution that satisfies the requirements of the users as well as regulations to assure the safety at sea. Following the determination of the yacht type, processes such as preparing the general layout plan in line with the demands and expectations of the user, making hydrostatic calculations and speed-power calculations, determining the hull and superstructure design are followed. In these processes, the main engine selection, which is made depending on the speed and performance expectations, affects not only the engine room, but also many details such as the shaft angle of the boat, the propeller-hull clearance, the placement of the areas adjacent to the engine room. In this research, Bodrum Gulets, which are among the boats unique to Türkiye and produced with custom design and manufacturing processes, are discussed and it is aimed to examine the effects of the number of engines from the design and engineering perspectives. In this context, a total of 46 Bodrum Gulets were examined, and in line with the values obtained, selected parameters have been compared from the design and the engineering perspectives. While the engine room layout plans of the investigated yachts were used for comparison in terms of design, shaft angle was used in comparison in engineering-based evaluation. Moreover, investigated models' resistance and consequently the power requirements have been compared with the installed engine powers. The results show that models with single main engine are advantageous in terms of requiring less height and consequently less space for the engine room and propulsion efficiency perspectives. The mean value for the ratio between the required height to the height of the engine is calculated as 1.428 for the single engine and 1.982 for the twin engine configuration. Moreover, the results show that the mean value of the shaft angle is 5.29 for single engine and 8.16 degrees for the twin engine configuration. Additionally, the study shows that there is a gap between the calculated power and the installed power, which causes over consumption especially for the twin-engine configuration for the Bodrum Gulets.

INTRODUCTION

Ship design, which has a multidisciplinary structure, is a process in which it is aimed to meet as the factors required in terms of engineering as well as the user expectations and limitations. Hamlin (1996), Larsson and Eliasson (2007), and Papanikolaou (2014) describe the ship design process as a spiral which constitutes of iterative sub-processes. Analyzing the requirements, generally through the utilization of either empirical formulas or by using scaled versions of a proven design establish the initial parameters of a new ship design (Moody, 1996). Unlike many other ship types, in the design process of yachts, beside concern related to functional use, operability, cost and manufacturing; aesthetic and design-related expectations are at the forefront. It is the designer's task to develop a proper layout, efficient hull form, attractive and well-balanced sheerline and superstructure (Dubois, 1998). Determining power requirements and the performance of the ship is among the fundamental keystone in ship design process (Akman and Turan, 2023). Beside the concerns about functionality and aesthetics, finding the

optimum solution to provide the most efficient propulsion system in terms of the number and the power of the engine(s) affects not only the yachts' characteristics, but also the environmental impact of the yacht to be produced. The study of Akman and Turan (2023) shows how engine selection affects the amount of consumption and released emissions of Bodrum Gulets.

Bodrum Gulets are listed among yacht types specific to Türkiye (Kükner, 2009; Turan et al., 2021; Turan and Akman, 2021). Even the word gulet is defined as the equivalent of schooner type sailing boats (Fossati and Diana, 2004; Köyağasıoğlu, 2014; Turan and Özcan, 2023), this word has started to be used to identify a hull type with distinctive characteristic lines in Türkiye (Gür, 2020; Turan et al., 2021; Turan and Akman, 2021). Elliptical shaped stern form and a concave stem form are among the distinctive geometric features of Bodrum Gulets (Kükner, 2009; Köyağasıoğlu, 2014; Gür, 2020; Turan and Akman, 2021). Satisfactory sailing performance, comfortable interior areas and proven seaworthiness are some of the characteristics of these yachts (Gammon et al., 2005). Figure 1 shows a profile drawing and a general arrangement plan drawing of a Bodrum Gulet.

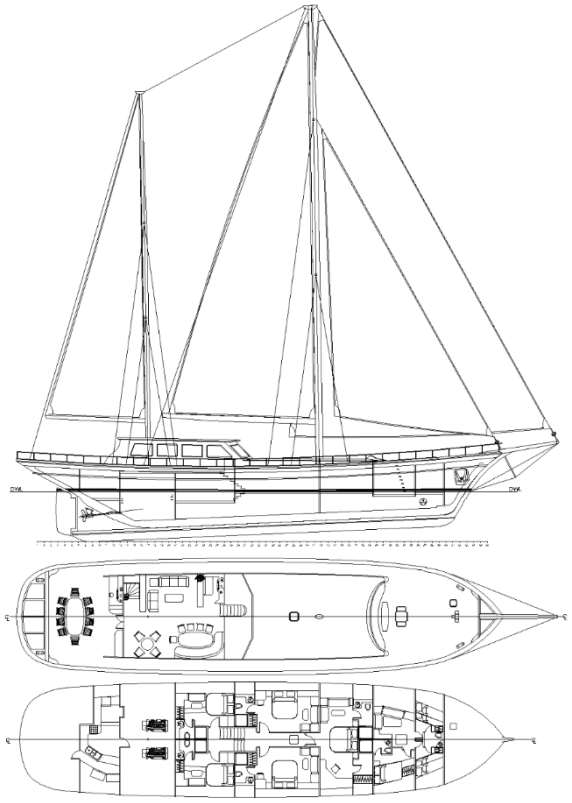

Figure 1. Profile and general arrangement drawings of a Bodrum Gulet

According to the results of the study conducted by Turan (2021b), for Bodrum Gulets, the mean value of the engine room length to the L_{OA} ratio was calculated as approximately 15%. Both single and double engine configurations are found in the Bodrum Gulets used. Ships with twin shaft and engine configuration are known to have a high maneuverability characteristic. By commanding one shaft to move the ship forward and the other to move the ship backward, a turning moment can be created, in the twin shaft configuration (Tupper, 2004). Single engine configuration, on the other hand, is advantageous in that it requires less space in the engine room, leaving more space for other equipment such as tanks, generators etc. Figure 2 illustrates layouts and sections of a yacht with a single-engine (top) and with a twin-engine (bottom) configuration.

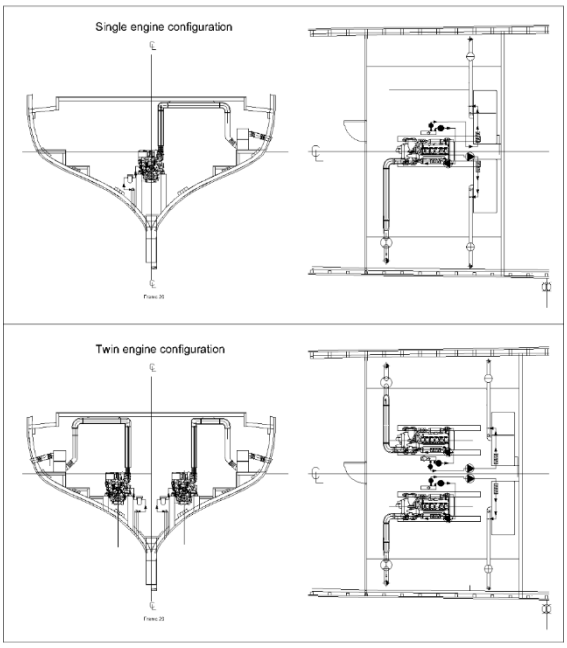

Figure 2. Section and layout of a yacht with a single-engine and with twin-engines

Previous studies address various engineering-based and design-based characteristics of Bodrum Gulets. Turan and Akman (2021) investigated hull form parameters and analyzed resistance characteristics of Bodrum Gulets. In the research of Sarıoğlu and Kükner (2018), a model was developed for form factor estimation of Bodrum Gulets by using the numerical tools. In the project conducted by Kükner et al. (2009), hull forms of Turkish type gulets are analyzed and optimized. In the research of Gammon et al. (2005), resistance, seakeeping and stability characteristics of Turkish gulets were investigated and a genetic algorithm was used for hull form optimization. Kınacı (2009) used 1-prismatic coefficient (C_P) method to model the gulet type yacht series and developed a computer program for the pre-design phase. Akman and Turan (2023) studied the Bodrum Gulets in terms of the required engine power and compered the required engine power with the installed engines to make energy efficiency-based evaluation.

All of the research conducted on Bodrum Gulets makes great contributions to both the literature and the sector by providing design parameters or improving various methods

to be used in the preliminary design process. On the other hand, evaluating the effects of choices based on the number of machines on a sailing yacht in terms of engineering and design parameters will make a great contribution to the design process of these special yacht types. In this research, Bodrum Gulets, a sailing yacht type, were discussed and it was aimed to evaluate the single and double engine configurations for these yacht types in terms of propulsion efficiency, closed volume and parameters affecting the general layout. Moreover, the research also aimed to suggest the optimum solution by comparing the results of two different configurations depending on the number of machines in terms of energy efficiency, design solutions and dispatch efficiency. The results obtained reveal how a single decision made at the design stage has a huge impact on the production and use of a yacht.

MATERIALS AND METHODS

For the analyses, 46 Bodrum Gulets; which are still in the service are selected. LOA of the investigated yachts varies between 18.00 m to 39.00 m. Study conducted by Turan (2021a) underlines the effects of the purpose of usage in Bodrum Gulets' hull forms. Moreover, various purposes require diversity in power and speed expectations in these vessel types. To increase the accuracy and reliability of the results obtained within the scope of the research, only the Bodrum Gulets that provide charter services have been selected, and the gulets which are being used for daily cruising or fishing with different power requirements have not been included in the research. Consequently, all of the investigated yachts are equipped with sail & rigging equipment. Figure 3 represents the process flow of the research. In the research, actual measurements on the yachts regarding shaft angles and engine placements have been taken. Rhino3D, Version 7 (2020) is used for modeling the hull of the investigated Bodrum Gulets. Modeler and Resistance modules of Maxsurf (2022) are used for hydrostatic and resistance calculations. Rhino3D program is utilized by yacht designers worldwide as one of the three-dimensional modeling programs (Özgel Felek and Arabacıoğlu, 2019). Moreover, this software has been used in modeling process of the previous studies (Turan et al., 2021; Turan and Akman, 2021; Turan, 2023).

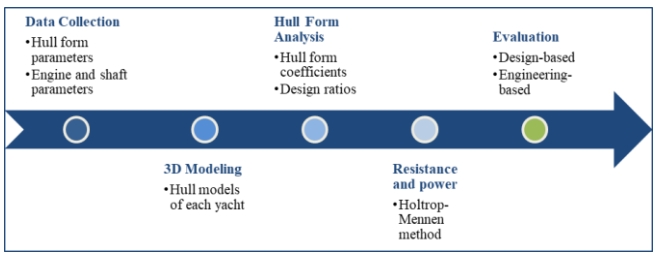

Figure 3. Process flow of the research

In the resistance calculation process of the research, Holtrop-Mennen method has been used. Holtrop-Mennen method, which bases on the regression analysis of trial data and model tests with different scales, is a useful resistance prediction method for displacement type hulls (Birk, 2019; Turan, 2009). In the study conducted by Turan (2009), the method that gave the closest results to the model test results for the gulet hull form was stated as the Holtrop-Mennen method. Moreover, this method has been used for predicting resistance and power values of Bodrum Gulets in the previous studies (Turan et al., 2021; Turan and Akman, 2021; Akman and Turan, 2023). Accordingly, the Holtrop-Mennen method has been used in resistance calculations in this research.

In the research, this method has been used for estimating the resistance of the Bodrum Gulets at 8, 10 and 12 knots. According to the mathematical model (Holtrop and Mennen, 1982; Elkafas et al., 2019), the total resistance; R_T of the ship can be calculated as summing the viscous resistance; R_V and the wave-making resistance; R_W.

The viscous resistance is calculated as;

$$R_V = (1 + k)R_F \quad (1)$$

where R_F is the frictional resistance. The form factor k is a function of the some main parameters as follows (Elkafas et al., 2019);

$$k = f\left(\frac{B}{L}, \frac{T}{L}, \frac{L}{L_R}, \frac{L^3}{\nabla}, C_P, c\right) \quad (2)$$

where L_R is the length of after body and c is the coefficient after body shape. The second component of the total resistance, R_W is calculated as:

$$R_W = c_1 c_2 c_3 \nabla \rho g e^{\left(m_1 F_n^d + m_2 \cos(\lambda F_n^{-2})\right)} \quad (3)$$

where c_1, c_2, c_3, m_1, m_2 and λ are the coefficients which are related with the hull form (Holtrop and Mennen, 1982). Froude number F_n depends on the velocity of the vessel. It is possible to calculate effective power, P_e with the following formula:

$$P_e = R_T V \quad (4)$$

The brake power can be obtained approximately by multiplying effective power by 2 (Blount and Fox, 1976).

RESULTS AND DISCUSSION

The results are discussed in different perspectives. In the hull form parameters section, some critical parameters to be used in the preliminary design phase of Bodrum Gulets are

given. In the design-based evaluation, effects of the engine number selection from the design choices are discussed. In the efficiency-based evaluation, effects of the engine number selection are discussed from the engineering perspective.

Hull Form Parameters

Hull form parameters are useful determinants for predicting hydrostatic and hydrodynamic characteristics of a yacht (Turan and Akman, 2021). In this research, dimensionless ratios and coefficients of the investigated Bodrum Gulets were calculated not only to determine the specific characteristics of the hull forms, but also to obtain input parameters for the parametric model. The data collected within the scope of hull form parameters were converted into dimensionless ratios and minimum, maximum, and mean values were calculated for the examined boats. This method is a common method applied in previous research (Gammon et al., 2005; Kükner et al., 2009; Turan, 2022; 2023) examining the hull form characteristics of various boat types.

The results show that L_{OA}/L_{WL} ratio for Bodrum Gulets varies from 1.192 to 1.321 and its mean value is calculated as 1.252. B/L_{OA} ratio has a mean value of 0.254 and it has a range between 0.224 and 0.300. Position of the LCB as a percentage of the L_{WL} ranges from 44.359% to 49.821% with mean value of 46,624%. Mean value of the C_B is calculated as 0.216 and the range varies between 0.196 and 0.243. C_P has a mean value of 0.622 and is varies from 0.605 to 0.697. C_M value varies from 0.318 to 0.401 and the mean value is calculated as 0.347.

Design-based Evaluation

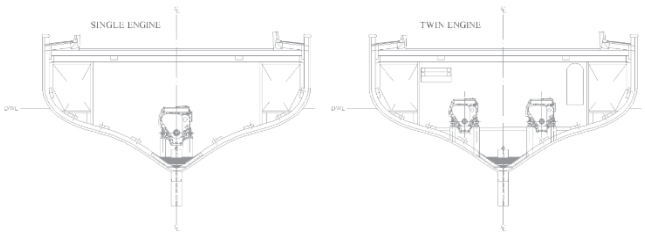

Figure 4. Transversal sections of Bodrum Gulets with a single and twin engines

Figure 4 shows the difference in engine room section for twin engines and a single engine configuration of a Bodrum Gulet with a L_{OA} of 23.90 m. As can be seen in the figure, the single engine configuration allows the engine to be positioned in lower area than the double machine configuration. This difference has a positive effect on the engine room height of the boat and the circulation areas in the engine room. Also, positioning the engine as low as possible has a contribution on the yacht's stability by decreasing the KG value. Moreover, selecting single or twin-engine configuration has a significant effect on the overall propulsion efficiency by causing the shaft angle to change. To evaluate consequences of selecting single or twin-engine configurations, length and height of the installed engines as well as the shaft angles have been used. Table 1 represents the minimum, the maximum and the mean values for the ratio of required height (from the inner keel to the top of the installed engine), to engine height for Bodrum Gulets in two different engine configurations. The difference between the minimum and maximum ratio values may increase depending on many variables such as the dimensions of the engines used and the cross-section geometry where the engines are located. Depending on the number of engines in the engine room layout, the placement of engine-related elements such as shafts, machine ventilation layouts, exhaust pipes and bearings also changes. Since these elements will require less space in a single engine configuration, there will be much more space for many auxiliary elements such as the generator, fuel tanks, battery group, boiler.

Table 1. Required height to engine height ratio for Bodrum Gulets

Required height/Engine height ratio		
	Single Engine	Twin Engine
Minimum	1.0204	1.7217
Maximum	1.5417	2.2081
Mean	1.4279	1.9817

The results show that single-engine requires less height in engine room when compared to twin-engines. Required height effects not only the available space for the other systems and equipment, but also the saloon floor level in Bodrum Gulets. engine number selection influences the closed volume and Gross Tonnage of the Bodrum Gulets.

Efficiency-based Evaluation

According to the results, the total angle obtained from the sum of the gearbox output angle and the engine angle varies between 4-6 degrees for Bodrum Gulets with single engine; 6-11 degrees for Bodrum Gulets with twin engines. The mean value of the total angle is calculated as 5.29 degree for single engine configuration and 8.16 degree for the twin engine configuration. Increase in the total shaft angle is seen as a factor that decreases the overall efficiency. As the propeller shaft angle increases, due to difference in the water flow in the top and the bottom of the propeller disk, uneven loading in propeller blades; which can cause vibration, occurs (Gerr, 2013). Due to high shaft angles, changes in the tangential component of the velocity field can cause root and butt cavitation in the propellers (Molland, 2008). Figure 5 illustrates the difference in shaft angle for according to the number of main engines in two different Bodrum Gulets. As

shown in the Figure 5, there is no significant difference in the length of the shafts for two different configurations.

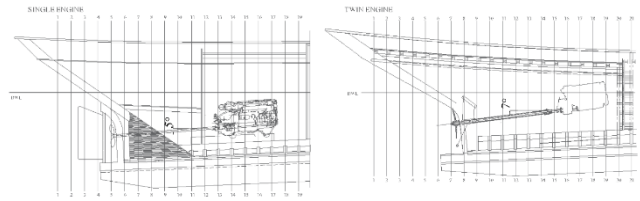

Figure 1. Bodrum Gulet with a single engine (on left) and with twin engines (on right)

Based on the modelled hulls, resistance values for 8, 10 and 12 knots speeds have been calculated with Holtrop-Mennen Method. Figure 6 illustrates the resistance values with respect to LOA of the investigated 46 Bodrum Gulets.

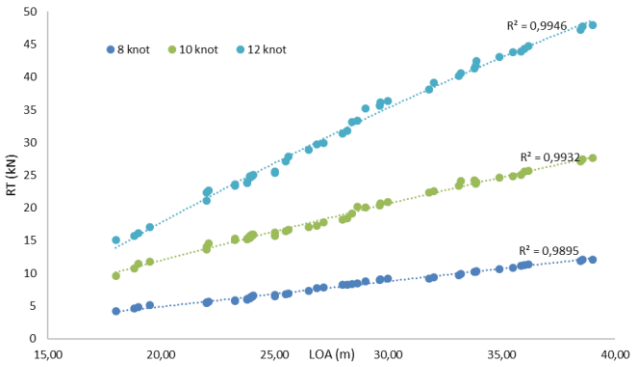

Figure 2. Resistance values with respect to LOA of the investigated Bodrum Gulets

The results show that the difference between the calculated break power in kW and the installed power in kW is greater in twin engine configuration than that of the single engine configuration in Bodrum Gulets. Figure 7 represents the distribution of the calculated and the installed power with respect to LOA of the investigated yachts. Moreover, the gap between the calculated and the installed power increase as the LOA increases for Bodrum Gulets with twin engines. It is seen that the single machine configuration is not used in Bodrum Gulets with a LOA over 30 meters.

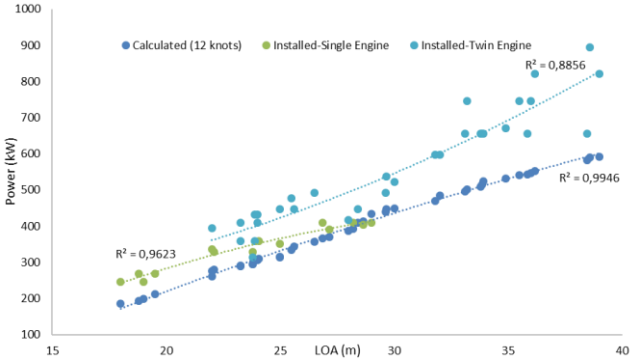

Figure 3. Calculated power-installed power comparison for Bodrum Gulets

Bodrum Gulets with single and twin-engine configurations have been analyzed to evaluate the effects in design and engineering perspectives. Moreover, hull form parameters, which can be used in pre-design stage have been obtained from the investigated yachts. According to the results obtained, following conclusions are drawn for Bodrum Gulets:

- Single engine selection provides advantage in the layout and reduced required space for Bodrum Gulets. Related with the less required height for the engines in single-engine configuration, it is possible to reduce the gross tonnage of the yacht by moving the saloon floor to the lower level.
- To provide the clearance between the propeller and the hull of Bodrum Gulets, the shaft angle in twin engine configuration is greater than that of the single engine configuration. Due to increased shaft angle, it is possible to state that twin engine configuration has a negative effect in terms of overall propulsion efficiency.
- The results of the study show that in the engine power selection of Bodrum Gulets, engine power of the installed engines is much higher than the calculated engine power. This finding is consistent with the results of the previous study conducted by Akman and Turan (2023) . The gap between the installed power and the calculated required power is greater for the Bodrum Gulets with twin-engine configuration when compared to the ones with single-engine configuration. Moreover, it is seen that the gap increases as the LOA is greater than 30 m. It is thought that the engine options available on the market or the user's preferences have an impact on this result determined in the research. In instances where a machine with half the computed power is unavailable and two machines with higher power are chosen, the disparity per engine is amplified, effectively doubling the observed difference. In this content, single engine is seen as the favorable selection especially for the Bodrum Gulets with LOA greater than 30 m. Calculated power requirement data can be used for choosing the proper engine in these yachts.

This research contributes the design process for an energy-efficient yacht design by focusing on a specific sailing yacht type, Bodrum Gulets. The results obtained reveal the effects of the decision made on the number of machines, not only for Bodrum Gulets but for all yacht types, in terms of both design and engineering.

The results of the study generally show that single engine selection has positive effects on overall propulsion efficiency and general layout-oriented design choices in Bodrum Gulets. In the examined Bodrum Gulets, the maneuvering advantage provided by the twin-engine configuration can be balanced with bow-thruster, stern-thruster or water jet systems used for maneuvering. It is possible to apply innovative system solutions such as hybrid propulsion

system for backup power that can be used in case of emergency, which is another advantage provided by choosing a double engine configuration, on Bodrum Gulets.

CONCLUSION

In the study, it was observed that the steering system with a single rudder was used in both single and double engine configurations. Investigating the effects of the double rudder usage in Bodrum Gulets on the resistance and maneuverability characteristics of these yachts, and determining the effects of the appendages as well as the changing parameters such as the propeller dimension, number of bearings, geometry of the brackets, depending on the number of engines on the flow distribution at the cruising speed of the boat using CFD analysis are considered among the possible research topics in the future.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

Author BIT is responsible for the whole research and writing process of the article.

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

The author declares that formal consent is not required for this type of study.

Data Availability

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

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Histological description of the internal organs in smooth scallops (*Flexopecten glaber*) caught in Black Sea waters near Cape Shabla

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A B S T R A C T

Assessing the possibility for cultivation of the smooth scallops (*Flexopecten glaber*) along the Bulgarian Black Sea coast requires a form one side very good knowledge of the biology of species, and from the other side internal organs and reproductive tissues, also the changes occurring during reproductive processes. Thus, the study aimed to investigate and evaluate the histological structure of the internal organs of the *Flexopecten glaber* caught in the Black Sea. Three samples were collected in June 2022 from commercial fishing in Black Sea waters near Cape Shabla. The shell length and weight of each mussel were measured and recorded. The study was carried out by making histological preparations of gonads and internal organs in adult smooth scallops. Histologically organs of smooth scallop showed that the tissues were in normal cytological condition. The microscopic analysis showed that the heart is located dorsal to adductor muscle. The kidneys are situated in the anterior margin together with gonads which cover the last one. Ventral to the gonad are attached pairs of gills. The histological structure of the gonads and internal organs of scallops was identified and described. The results of the current investigation expand the field of knowledge on the anatomy and histology of smooth scallops.

INTRODUCTION

The smooth scallop (*Flexopecten glaber*) is a Mediterranean edible marine bivalve that is distributed in the Black Sea. Initially, the smooth callop in the Black Sea was considered to be a distinct subspecies, but recent data have shown it to be identical to Mediterranean populations and belong to the Pectinidae (Bondarev, 2020). Inhabits coastal areas with sandy or stony bottom substrates with depths of up to 40 meters (Mendo et al., 2016).

In the Bulgarian Black Sea waters, *Flexopecten glaber* is not very evenly distributed and according to previous reports, it probably disappeared in the second half of the last century. In June 2020, as a result of dredging activities in the Mangalia area (close to the Bulgaria border), three living specimens of *F. glaber* were found at 25 meters depth (Filimon, 2020). In 2021, an adult population of them was found along the Bulgarian Black Sea coast during marine monitoring surveys (Todorova et al., 2022). This species has the potential to be exploited for human food and aquaculture, considering their spat is easy to collect on artificial substrates (Marčeta et al., 2016).

The assessment of the possibility of farming *F. glaber* along the Bulgarian Black Sea coast requires a from one side very good knowledge of the biology of species, and from the other side internal organs and reproductive tissues, also the changes occurring during the reproductive processes. Thus, the study aimed to investigate and evaluate the histological structure of the internal organs of *F. glaber* caught in the Black Sea.

MATERIALS AND METHODS

During the commercial fishing which was performed along the Bulgarian Black Sea coast three smooth scallops (*F. glaber*) were collected close to the Cape Shabla as bycatch. The biometric measurements were undertaken with a digital caliper (nearest 0.1 mm) including anterior-posterior length (L), dorsal-ventral length (W), the distance between two valves (D), total weight (TW), wet weight of the soft parts (WWSP), the weight of shell (WS) (Table 1). Biometrically, (L, W, D, TW, and WWSP) values of the smooth scallops (SS) examined in this study (n=3) was determined 40.21; 39.41; 10.25; 8.7296; 3.1907; 5.5389 for SS_1, 36.40; 36.06; 9.89; 7.2120; 2.9658; 4.2462 for SS_2 and 54.68, 49.10, 16.14, 18.9040, 8.4919, 10.4121 third species respectively. In the field, the material for the histological study of smooth scallop samples was fixed in 10% neutral buffered formalin and later processed by standard histological technique. All samples were dehydrated with a graded series of ethanol, cleared in xylene, and embedded in paraffin wax. Paraffin blocks were cut (4-5 μm) with a microtome (Leica RM2125, Germany) and stained with hematoxylin (Sigma- Aldrich-HHS16) and eosin (Merck 109844, Merck KGaA, Germany) (H&E) (Roberts, 2012). Slides were examined under a light microscope (Olympus BX51) equipped with a digital camera (Olympus DP72).

RESULTS AND DISCUSSION

In this study, adult scallops have fully formed and their anatomy has a similar form and structure described by other authors (Beninger and Le Pennec, 2016; Revkov et al., 2021). Histological analysis of the heart, mantle, kidney, and gonad are present in the figures below (Figure 1-4) with all samples demonstrating the normal cytological state of analyzed tissues.

The main function of the scallop mantle is a secretion of the shell but also has other several key functions, such as sensory, respiratory, etc (Beninger and Le Pennec, 2016). The scallop mantle is a complex, multi-tasked organ composed of an internal epithelium that contains the following cells: columnar epithelium (CE), adipocytes (AC), and myocytes (MC) (Figure 2a). The middle mantle includes hemocytes (HC) and is covered with cilia columnar epithelium (CE) (Figure 2b).

In the center is situated the adductor muscle. The heart is located dorsal to him, while kidneys are situated in the anterior margin together with gonads which cover the last one (Figure 3). Ventral to the gonad are attached pairs of gills (Beninger and Le Pennec, 2006).

It is known that smooth scallops (*Flexopecten glaber*) are simultaneous hermaphrodite species with rapid sexual maturation (Marčeta et al., 2016). The sexing of pectens like as a bivalve mollusc cannot be accomplished based on gonad color but the development phase of pectens like as a bivalve mollusc could be identified by microscopic inspection (Sühnel et al., 2010; Beninger and Le Pennec, 2016). The analyzed smooth scallops were predominantly in the initial spawning stage. In female gonads, follicles appeared. The pedunculated (i.e., young) oocytes were situated close to follicle walls, while mature oocytes occupied the center of the follicle (Figure 4a). The abundance of mature oocytes was equal to those attached to the wall. The male gonad was in a stage of active spermatogenesis and the gonadal acini, which are irregularly bulb-shaped structures contained mature spermatozoids (Figure 4b).

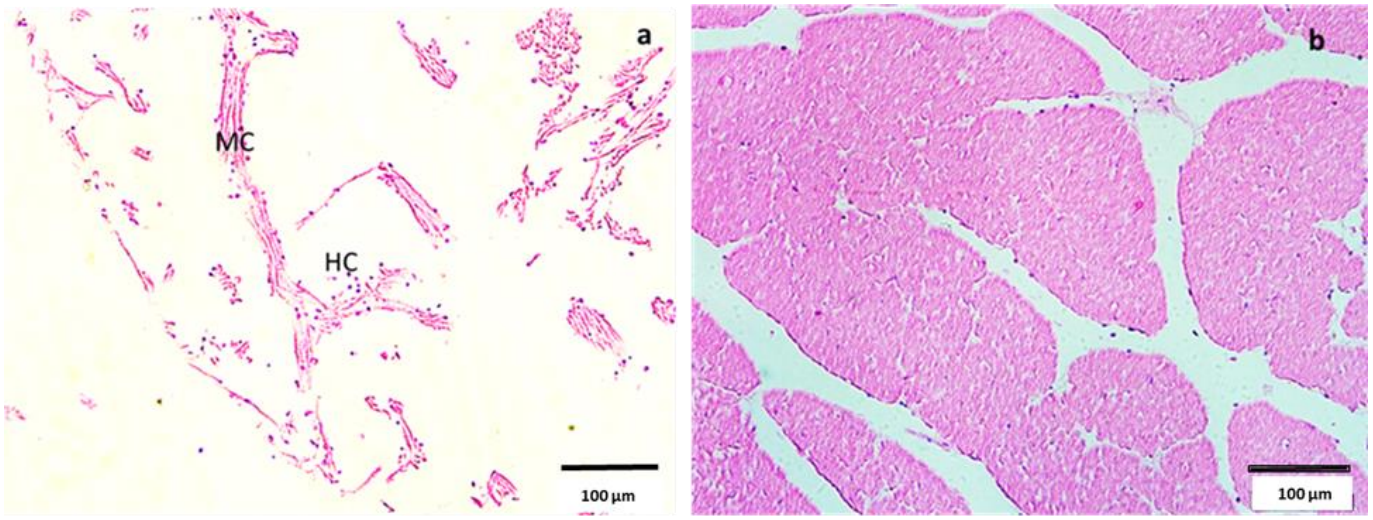

Figure 1. Frontal section of the ventricle portraying branched cardiac myocytes (MC) and hemocytes (HC) **(a), sagittal** section of adductor muscle **(b)** (H&E)

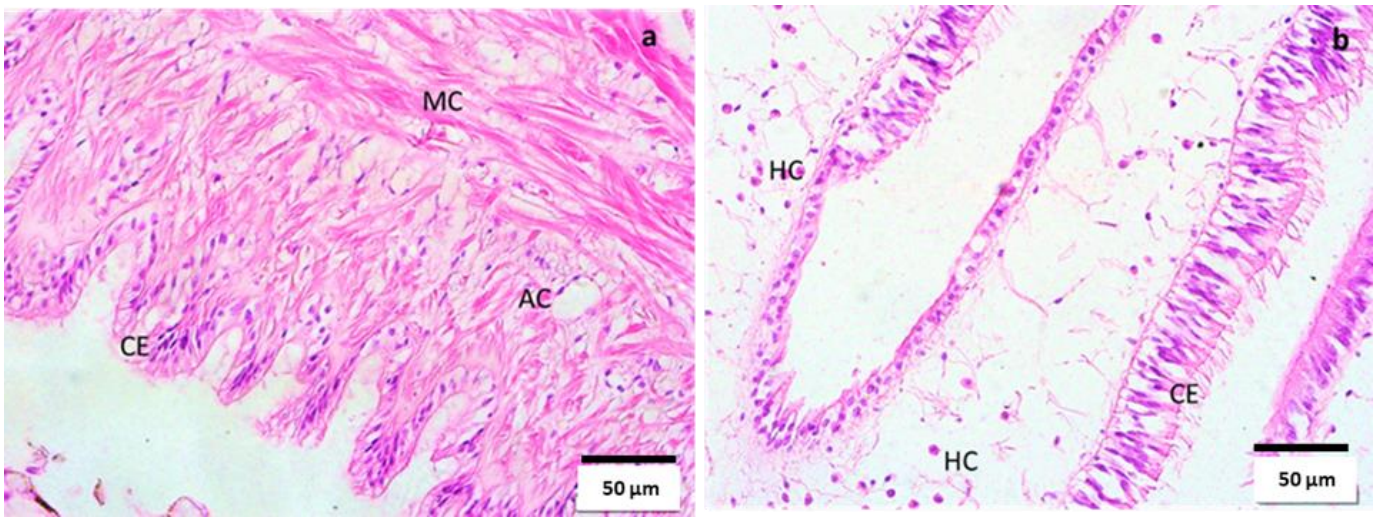

Figure 2. Transverse section of the ventral epithelium of the base of the mantle edge showing columnar epithelium (CE), myocytes (MC), and adipocytes (AC) **(a)**, middle mantle including hemocytes (HC) and covered with cilia columnar epithelium (CE) **(b)** (H&E)

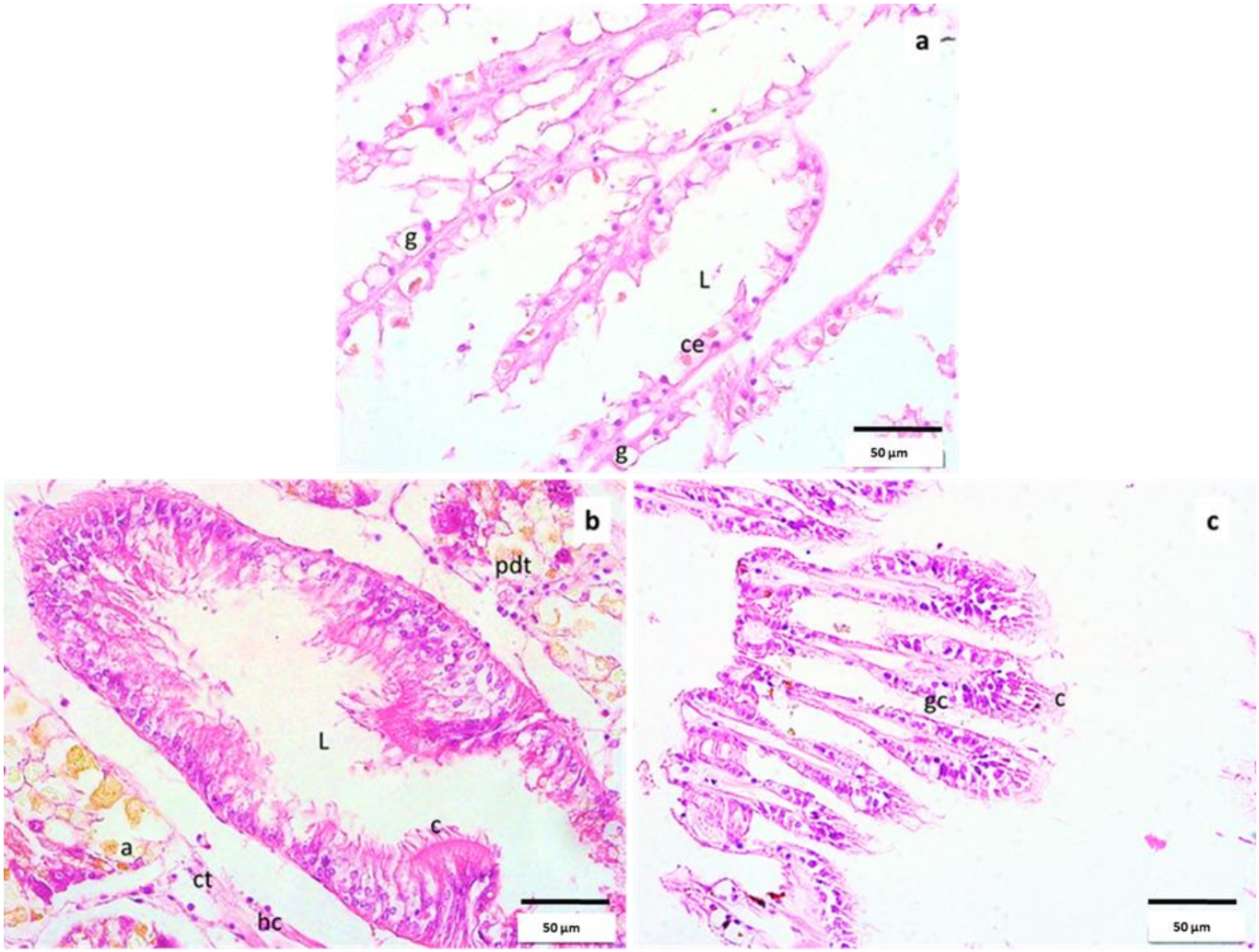

Figure 3. Histological section of the kidney tubules containing cubic epithelium (ce), showing vacuolated gland (g) cells **(a),** secondary digestive tubule **(b),** and gills covered with cilia **(c)** (H&E). (**L:** lumen, pdt: primer digestive tubule containing adipocyte-like digestive cells, **gc**: goblet cell, **ct:** connective tissue, **hc:** hemocyte cell)

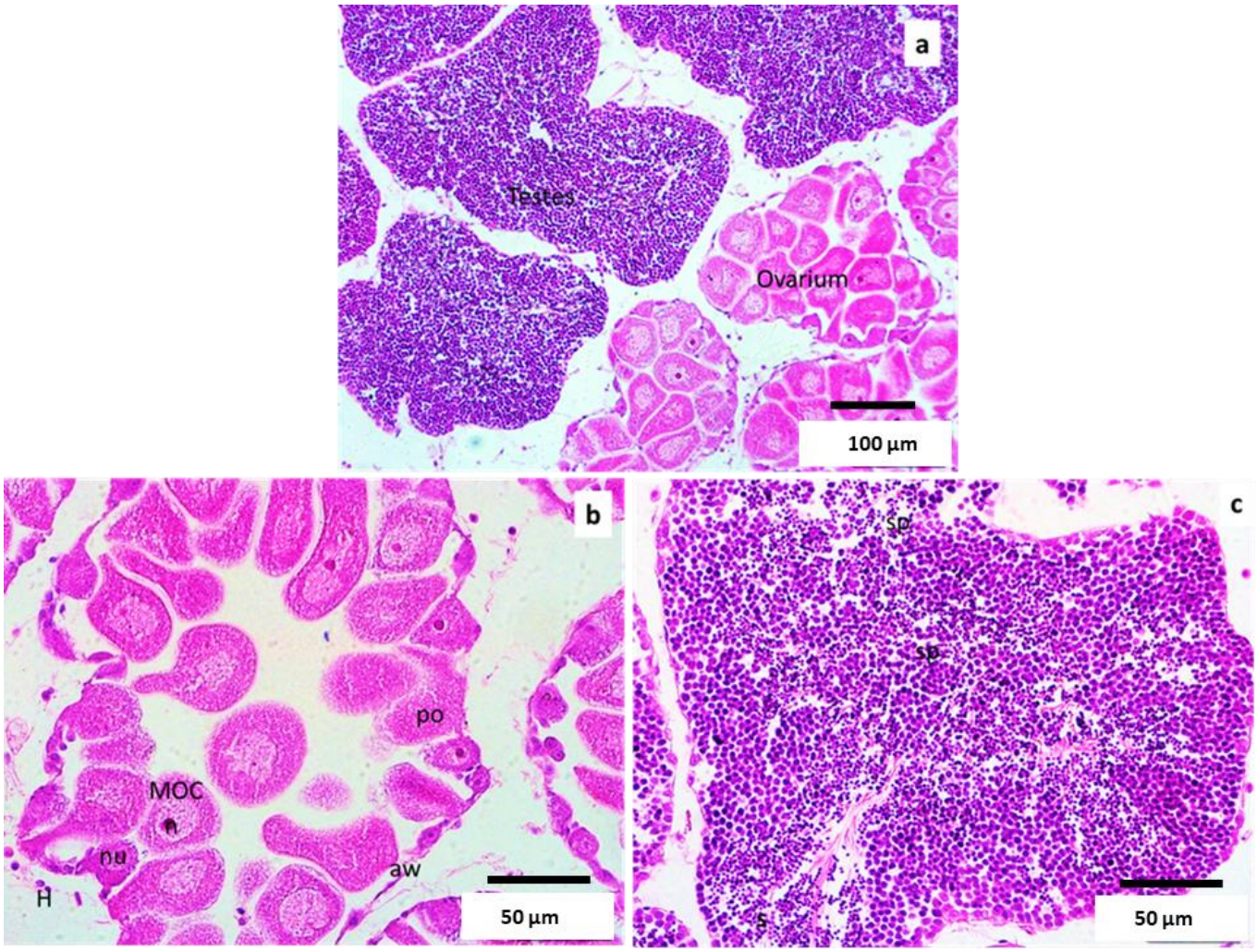

Figure 4. Gonad histology of hermaphrodite *Flexopecten glaber* **(a)** transverse section of ovarium **(b)** and testes **(c)** (Spawning stage) (H&E) (MOC: mature oocyte, n: nucleus, nu: nucleolus, po: pedunculated oocyte, sp: spermatocytes, s: spermatids, aw: acinus wall)

CONCLUSION

The current study carried out a baseline description of the anatomy and histological of smooth scallops (*Flexopecten glaber*) along the Bulgarian Black Sea coast and was not designed as a trial. Considering previous studies, the number of samples used is sufficient for histological studies. However, increasing the sample size regarding the morphometric structure of this creature is among our goals in future studies. In addition, since it is a rare species, the data in the present study is very valuable. They have shown that the histological characterizations of the reproductive organs are similar to other species in the genus Pecten. In conclusion, further investigations should be performed to ascertain how environmental and climatic factors influence their growth and reproduction.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

Authors contributed equally to this paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

The authors declare that formal consent is not required for this type of study.

Data Availability

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

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Regional assessment of important biological indices in the population of red cornetfish (*Fistularia petimba* Lacepède, 1803) along the eastern Mediterranean coasts of Türkiye

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A B S T R A C T

The Lessepsian migrants of the family Fistulariidae, which are widely distributed in the Eastern Mediterranean coasts of Türkiye, are represented by two species, *Fistularia commersonii* and *Fistularia petimba*. This study focused on estimating various biological indices of red cornetfish *Fistularia petimba* Lacepède 1803, eastern Mediterranean coast of Türkiye. The biological indices determined were: FI- Fullness index, HSI-Hepatosomatic index, GSI-Gonadosomatic index, EQ-Encephalization quotient, VSI-Visceral index, IWL-Zihler index, Fulton-K: Fulton-Condition. For this study, 65 red cornetfish specimens (♀:40, ♂:23, immature: 2) caught as by-catch in the nets of commercial trawlers, operating in the study area in the winter of 2021 were studied. The estimated length-weight relationship (LWR) was $W=0.0001L^{3.34}$ (R^2= 0.89) and the species exhibits a positive allometric growth. The mean index (M±SD) and range values calculated from the obtained data are as follows: FI 1.05±0.13 (0.83-1.26); HSI 0.43±0.05 (0.23-0.62); GSI 1.27±0.20 (1.08-1.46); EQ 0.0024±0.0003 (0.0022-0.0025); VSI 3.14±0.39 (2.08-4.20); IWL 12.37±1.54 (4.41-20.3) and Fulton-K 0.47±0.06 (0.43-0.51). According to these results, it can be hypothesized that this Lessepsian species is well established and thrives in the eastern Mediterranean coasts of Türkiye. Although it is evaluated as the least concern category (LC) in the IUCN Red List 2013, we believe that the species has an invasive potential. Therefore, this study, in which biological index parameters were presented for *Fistularia petimba*, may be important in terms of fisheries management, planning measures to reduce distribution and combating invasiveness.

INTRODUCTION

Türkiye's eastern Mediterranean coast is home to vital areas for many Lessepsian species, providing feeding and breeding grounds. Over the years, there has been a significant increase in the number of migrating species, with fish being among the top vertebrate migrants. As of 2021, it is known that 80 non-native fish species are distributed along the Mediterranean coast of Türkiye (Çınar et al., 2021). The family Fistularidae is represented by two species in the Mediterranean: *Fistularia commersonii* Rüppell, 1838 and *Fistularia petimba* Lacepède 1803, which are frequently encountered (Stern et al., 2017; Karan et al., 2019; Ergüden et al., 2023). *F. petimba* is a congeneric species with *F.commersonii*, and its distribution area extends to the western and eastern Atlantic coasts worldwide (Froese and Pauly, 2023). The presence of *F.petimba* in Turkish waters is relatively recent, with the first records reported by Ünlüoğlu et al. (2018) and Çiftçi et al. (2019), respectively. Subsequently, Cerim et al. (2021), provided additional

records in Güllük and Gökova Bays, while Crocetta et al. (2021) provided records in Iskenderun Bay and Bandırma Bay (Marmara Sea). It is essential to gather information about the distribution areas, population densities, interspecific and intraspecific interaction indicators of Lessepsian fish species, regardless of their economic values.

The species *F. petimba* is classified as "Least concern" (LC) on the IUCN Red List (Carpenter et al., 2015). However, further research is needed to fully understand its population structure due to insufficient information. Previous studies have examined the length-weight relationship, condition, determination of reproductive season, feeding composition and values of morphometric and meristic (Ragheb, 2022; Ergüden et al., 2023; Papageorgiou et al., 2023), but temporal and spatial detailed examination of these biological data is also necessary.

This study aims to identify and interpret the key indicators that are closely related to the growth and distribution performance of the species found in the eastern Mediterranean coast of Türkiye (legal fishing ground between Narlıkuyu and Yeşilovacık in Silifke along the coastline of Mersin). These indicators include the visceral index (VSI), fullness index (FI), hepatosomatic index (HSI), gonadosomatic index (GSI), Encephalization quotient (EQ), Zihler index (IWL), Fulton-K, and the length-weight relationship (LWR). Therefore, in this study, we aim to address the lack of data on the species' physical performance as well as to determine the potential effects of current fishing activities on this performance, despite being discard species in trawling processes.

MATERIALS AND METHODS

This study was carried out on 65 specimens of red cornetfish commonly found along the eastern Mediterranean coasts of Türkiye, which were caught as bycatch by commercial trawlers operating in the coastal area of Mersin province during the winter season of 2021 (Figure 1). The specimens were transported to the laboratory under cold chain conditions and stored in the freezer for further analysis. The total length measurements (TL, cm) of the samples were taken using a measuring tape, and the weight measurements (W, g) were taken using a scale with a sensitivity of 0.01 g. The sexes of the dissected specimens were identified through macroscopic examination of the gonads (Figure 2).

The weights of the internal organs were measured separately to determine the following indices: VSI index, HSI index, GSI index, EQ Encephalization Quotient, and FI index. Additionally, the relative gut length (RGL) was used to determine the Zihler's index. To determine the length-weight relationship, the equation $W=aL^b$ (Pauly, 1983) was used, where W represents the body weight in grams, L represents the length in centimetres, a represents the intersection point, and b represents the slope. After converting the data to log_{10}, the values of a and b were determined. While $b=3$ indicates isometric growth, values other than 3 represent allometric growth ($b<3$ negative allometry and $b>3$ positive allometry).

Figure 1. The sampling areas along the coastal area of Mersin province (fishing ground between Narlıkuyu and Yeşilovacık in Silifke) in the eastern Mediterranean, Türkiye

The hepatosomatic index (HSI) was calculated as HSI=100 × Liver weight / body weight (Sulistyo et al., 2000). For the gonadosomatic index (GSI) of mature specimens, the formula GSI= Gonad W (g) / total W (g) × 100 was used, along with the Fulton-K= (100×Wt) / Lt^3 equations (Ricker, 1979). Depending on the weight of the consumed food, the stomach fullness index (FI) was calculated as FI =Full gut W / W × 100 (Hureau, 1969), and the visceral index (VSI) was calculated as VSI = all internal organs W / body W × 100 (Cheng et al., 2005) Encephelization quotient EQ= Brain W(mg) / $(W)^{2/3}$ (Pauly et al., 2011). The relative gut length (RGL) and TL relationship were evaluated according to Zar (1999). In the obtained values, RGL<1 represents carnivorous feeding, 1<RGL< 3 represents omnivorous feeding, and RGL>3 represents herbivorous feeding (Karachle and Stergiou, 2010). The obtained data was evaluated using the Statistica package program. The *student-t* test was used to evaluate index values and determine the statistical difference between sexes. All statistical differences were evaluated according to $p<0.05$.

Figure 2. The red cornetfish, *Fistularia petimba* Lacepède, 1803. (Photographed by S. Bozkaya)

RESULTS

The sample group included 40 females, 23 males, and 2 immature specimens. The length-weight relationships for females, males and all individuals were calculated as $W=0.0006L^{2.93}$ $R^2=0.89$; $W=7e\text{-}06L^{4.08}$ $R^2=0.92$; $W=0.0001L^{3.34}$ $R^2=0.89$, respectively. The findings showed negative allometric growth in females the winter season, while males and all specimens (males+females+immature specimens) showed positive allometric growth as illustrated in Figure 3.

The determination of red cornetfish's stomach fullness index (FI) has been conducted separately for males and females. Upon examining stomach fullness ratios, it was found that approximately 24.62% of females had empty stomachs, 21.54% had full stomachs, and 15.38% had half-full stomachs. In males, these values were determined as 13.85%, 9.23%, and 12.31%, respectively. Empty stomachs were more common (38.5%) depending on season and sample size.

Table shows that although females have a higher index value in terms of average stomach fullness values, the difference is not statistically significant ($t_{(40)}$:0.98, p:0.332, p>0.05). The feeding frequency of females is higher than males, and it was determined that the TL-FI regression relationship is positive in females (FI= 0.0219L+0.186, R^2= 0.056).

Hepatosomatic index values, which reflect changes in liver tissues depending on feeding in the habitat, show that the average HSI value of females is relatively higher than males, but statistically insignificant ($t_{(40)}$: -0.475, p:0.635 p>0.05). Accordingly, the TL-HSI regression relationship is positive in females depending on the increase in body size (HSI= 0.0101L+0.0311 R^2= 0.035).

The Female/Male ratio in the samples is 1:0.57. There was no difference between sexes in terms of GSI values, which represent gonad development during reproduction ($t_{(40)}$: 0.735 p:0.464 p>0.05). According to the TL-GSI regression relationship of females, it is understood that the oocyte production capacity decreases with increasing body size of females (GSI= 0.0716L-2.542 R^2= 0.3062).

The Encephalization quotient values indicating the index of brain development, which have been determined for the first time for *F. petimba*, show higher results in males compared to females although there is no significant variation between the sexes ($t_{(23)}$: -1.111, p: 0.272, p>0.05). In males, there is a low regression in the EQ-TL relationship (EQ = -8E-05L + 0.0064, R^2= 0.147).

The visceral index, which reflects the results of food causing fat accumulation in internal organs, is higher in females than males; however, this does not create any difference between the sexes ($t_{(40)}$: 1.165, p: 0.248, p>0.05). In females, there is a positive regression relationship in the VSI-TL relationship (VSI= 0.0724L + 0.0017, R^2 = 0.297). The Zihler's index values indicate that both males and females show a carnivorous diet tendency (1<RGL), with male individuals having a higher index value than females. However, this does not indicate any statistical difference between the sexes ($t_{(23)}$: -0.737, p: 0.463, p>0.05). In males, there is a positive regression value in the GL-TL relationship (GL= 0.0039L+1.999, R^2 = 0.5792).

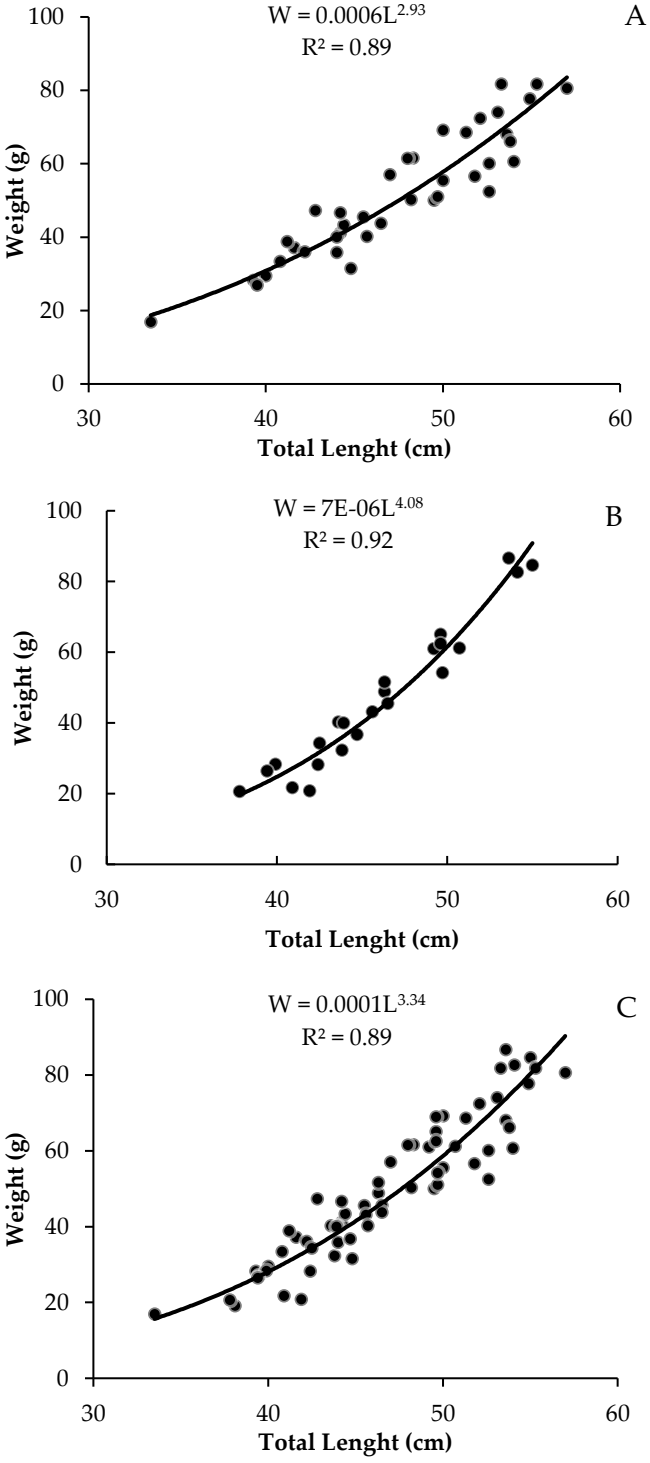

Figure 3. The length-weight relationships of *Fistularia petimba* caught sampling area (A: Female, B: Male, C: All specimens)

Table 1. Biological index results of *Fistularia petimba* (Mean ± SE)

Biological Indexes	Female	Male	All	P
Fullness Index	1.43±0.23	1.05±0.22	1.05± 0.13	p>0.05
Hepatosomatic Index	0.46± 0.07	0.43±0.09	0.43±0.05	p>0.05
Gonadosomatic Index	1.27±0.20	1.16±0.24	-	p>0.05
Encephalization quotient	0.0016±0.0003	0.0024±0.0005	0.0024±0.0003	p>0.05
Visserasomatic Index	4.02±0.64	3.14±0.65	3.14±0.39	p>0.05
Zihler Index	0.03± 0.01	0.05±0.01	0.05±0.01	p>0.05
Fulton- K	0.51±0.08	0.47±0.10	0.47±0.06	p>0.05
Sample size	**40**	**23**	**65**	

Lastly, the Fulton-K condition value, which is an interpretation of the body mass index values of the species in the region, was examined. Although the average condition of females is higher than that of males, the values found do not indicate any statistical difference between the sexes ($t_{(40)}$: 1.23, p: 0.220, p>0.05). In both males and females, the regression is positive, and it is understood that they show a carnivorous diet tendency in the IWL-TL relationship. In females, the TL-Fulton-K relationship was found as Fulton-K = -6E-05L + 0.0502, R^2= 0.003.

DISCUSSION

In this study, we examined the body index values of *F. petimba*, a closely related species to *F. commersonii*, along the coasts of the Eastern Mediterranean. The species was first observed in Spanish coasts in 1996 (Cárdenas et al., 1997), and subsequent studies have been conducted in Israel, Cyprus, and the Eastern Mediterranean coasts (Papageorgiou et al., 2023). When comparing the length-weight relationship calculated in this study with those provided by the existing studies, we concluded that female specimens generally exhibit a larger size and weight in comparison to males, however, no statistically significant difference was observed between the sexes. The length-weight relationship indicates positive allometric growth (*b*=3.34) for all specimens examined, suggesting that the weights of individuals increase as they grow in size. According to Tesh (1971), the values that *b* takes typically range from 2 to 4, often close to 3. In this case, several factors can influence the values that *b* takes. According to Bagenal and Tesch (1978) and Froese (2006), the important factors are as follows: season, habitat structure, sample size, sampling method, physico-chemical parameters, sex, gonad development, food, fish condition, and stomach fullness. According to Froese (2006), when the *b* value is higher than 3.5, it suggests that there is a significant increase in weight relative to the size of the fish. In our study, we found a high *b* value (*b*: 4.08) in the LW relationship of male individuals. This could be because we evaluated a small number of male individuals that were captured and also due to the higher Zihler index value among male specimens, which supports the idea of excessive proportional growth in weight. These findings align with the values given for *F. petimba* along the coasts of Cyprus and the Eastern Mediterranean (Ergüden et al., 2023; Papageorgiou et al., 2023). Actually, when evaluating its distribution on the eastern Mediterranean coasts, it is evident that the species *F. petimba*, similar to *F. commersonii*, has the potential to adapt well to the Mediterranean geography in the future. The studies conducted on the advantages that the eastern Mediterranean coasts offer for *F. petimba* are noteworthy, although they have not presented body index values. *F. petimba* is a carnivorous species, just like *F. commersonii*. The conducted studies have determined that commercially important fish species such as Sparidae and Mullidae (Corsini et al., 2002; Bariche et al., 2009), as well as invertebrate species (Froese and Pauly, 2023), are found in the stomach contents of *F. petimba*. This serves as an important indication that invasive fish species are exerting population pressure on the existing economic species in the region.

In our study, we found that female individuals consumed more prey than males during the winter period when examining stomach contents. The relationship between total length (TL) and fullness index (FI) showed that as the size of females increased, their stomachs were fuller. This suggests that larger females have higher metabolic needs, as discussed by Odum and Odum (1959), indicating a connection between metabolic activity and energetic requirements based on fish size.

We also observed higher values for hepatosomatic index (HSI) and Fulton-K values in females. Therefore, we expect the fish to improve their condition by actively feeding even during the winter season. They will allocate energy towards both gonadal development and metabolic activities using their energy reserves. However, in order to fully confirm this prediction, it would be beneficial to monitor monthly or seasonal index values throughout the year.

Stomach morphology also plays a significant role in the trophic relationships of species. Different methods, including

the analysis of stomach and intestinal contents, are used to determine feeding patterns and trophic positions in animals (Planas, 2022). The visceral index serves as an indicator of the effects of carbohydrates and proteins in the fish's diet on their internal organs (Gurkan et al., 2021). For instance, a high-fat diet can lead to lipid accumulation in internal organs, such as muscles and liver (Imsland et al., 2003). Some pelagic fish, like tuna (Scombridae) and herring (Clupeidae), store glycogen between their muscles for energy purposes (Timur, 2006). In our study, we observed that females have higher index values (mean 4.02) compared to males, and these values (mean 3.14) increase with body size. This suggests that the higher values may be attributed to the metabolic and energetic needs of females (Odum and Odum, 1959). A condition value close to *1* indicates optimal growth conditions for the fish species in the region. When examining the condition values of the *F. petimba* species, it is observed that females generally have a higher condition. The condition of all individuals ranges from 0.47 to 0.51, which is relatively lower compared to the population in İskenderun Bay. However, several factors such as habitat, food composition, sex, sample size, season, and physicochemical parameters influence the variation in these values (Ragheb, 2022; Ergüden et al., 2023). Therefore, in our study, the lack of a sexual difference based on condition between males and females may support this opinion. Encephalization quotient values in the *F. petimba* species show higher results in males, but there is no significant difference between the sexes. This study is the first to determine encephalization quotient values associated with the brain of the *F. petimba* specimens captured from the Turkish coasts.

CONCLUSION

In conclusion, we conducted a pioneering study to determine some sex-related biological parameters and body indices of the *F. petimba* species, which is widely distributed around Taşucu Bay, the eastern Mediterranean coast of Türkiye. In our study, we attempted to correlate the developmental level of the invasive species *F. petimba* with body indices. Although the obtained results are based solely on the winter season, they may help to fill the data gap concerning fish biology. Therefore, besides completing the missing information on the species, it is also important to consider the presented results in the near future for fisheries management.

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COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

This study was derived from the master's thesis titled "*Determination of Biometric Features of Red Cornet, Fistularia petimba Lacepède,1803 in Tasucu Bay (Eastern Mediterranean)*" of the first author, and the contributions of the authors are as follows: **SB:** examination of the specimens in the laboratory, preparation of the article; **SG:** statistical calculations, writing of the article, **ET:** obtaining the specimens, preparing the text for publication.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

The authors declare that formal consent is not required for this type of study. All relevant international, national, and/or institutional guidelines for the care and use of animals were adhered to.

Data Availability

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

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