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Traditional Aegean Sailing Boats: A Comparative Study on the Hull Design and Hydrodynamics of Bodrum Çırnıks and Tirhandils

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Abstract

Bodrum Çırnık boats, which were used in the Aegean Sea for many years, are among the traditional sailboat types unique to Türkiye. These vessels share significant similarities with Tirhandil-type boats, which remain in active use in the same geographical region today. This study investigates the hull form design parameters, hydrostatic properties, and resistance characteristics of Bodrum Çırnık-type boats through a comparative analysis with Tirhandil-type boats to identify their distinctive features. In addition to technical analyses, this study also aimed to serve as a means of preserving the cultural and historical heritage of Aegean wooden boatbuilding traditions by documenting and analyzing these significant boat types. The hull form of the Bodrum Çırnık is reconstructed using previous academic research, a scaled model exhibited at the Bodrum Maritime Museum, and technical drawings available in the academic literature. Based on the obtained data, models of a Bodrum Çırnık and a Tirhandil with identical overall lengths are developed. In this context, hull form design parameters and hydrostatic properties are derived for comparative evaluation. Additionally, the Holtrop-Mennen method and the Delft Systematic Hull Form Series method are employed to assess the resistance characteristics of Bodrum Çırnık-type boats. The results indicate that Bodrum Çırnık boats are characterized by their pointed bow and stern forms, longitudinal keel, and distinct sheer line. Their most distinguishing feature, compared to Tirhandils, is their more pronounced bow inclination. Moreover, Bodrum Çırnık boats generally exhibit lower hydrodynamic resistance than Tirhandils at the tested speeds.

Keywords: Bodrum Çırnık, Tirhandil, Hull design, Hydrodynamics, Aegean boat

1. Introduction

Many traditional sailing vessels in the Mediterranean, which were once employed for purposes such as fishing, sponge diving, and cargo transport, have gradually been phased out and eventually discontinued due to sectoral and technological advancements. Some of these vessels, which are still in use, have undergone various design modifications and now feature different hull forms. Primarily constructed from wood and powered by sails, these vessels have been replaced by newer technologies, such as steel-hulled vessels powered by internal combustion engines. However, with the growing emphasis on environmental impacts and sustainability, interest in sailing and sailing ships has once again begun to rise.

The vessels known as Çırnık or Bodrum Çırnık are unfortunately no longer being produced or actively used. A model of the Çırnık-type vessel is displayed at the Bodrum Maritime Museum, where its description lists the Greek equivalent as “tserniki” [1]. In the nineteenth century, while Greek shipowners from the Ionian Islands employed coastal vessel types from the Adriatic and the Italian Peninsula, such as bratsera, trabaccolo, and paranza, their Aegean counterparts remained dedicated to Eastern-origin ships like bombarda, tserniki, and trehandiri [2]. Damianidis [3] states that tserniki is a type of double-ended hull that gradually disappeared from the Aegean Sea after World War II. The term “Çırnık”, originally derived from Slavic languages, has been used throughout history to refer to three distinct types of vessels: the Black Sea Çırnık boat, the Çırnık ship, and

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the Bodrum Çırnık [4]. The Çırnık, traditionally used for sponge fishing in the Aegean, features a sloped stempost, an extended bowsprit, and a short keel [5]. On the other hand, the records of Tirhandil-type boats show that the first Tirhandil was built on Hydra Island of Greece in the 17th century [6]. With a short keel line and wide hull form, Tirhandil-type boats have been widely preferred in Greek, Italian, and Turkish fishing and sponge diving [4]. The origin of the word Tirhandil is "Trea Kena", which expresses the ratio of one-third in the Greek language meaning that the average ratio of L_{OA} to B is 3, while the ratio of the length of the keel to B is 2 [3]. Symmetrical fore and aft form and inverted fore and aft posts are the main characteristics of these boat types used in the Mediterranean for centuries [7]. The overall length of Tirhandils ranges between 8 m and 20 m and the displacement tonnages of these boats vary from 4 to 50 tons [8].

A review of the academic literature on Çırnık-type vessels reveals a significant gap in studies in this field. The dissertation by Damianidis [3] examines boat types built in Greece and provides key characteristics of Çırnık-type vessels, referred to in Greek as *tserniki*. Similarly, the study conducted by Delis [2] includes references to *tserniki* among the vessel types used in the Mediterranean during the 19^{th} century. However, no research has been found that analyzes the engineering characteristics of this vessel type or compares its advantages and disadvantages with similar boats used in the same region. This study aims to document the hull form characteristics of the Bodrum Çırnık and compare them with *tırhandil*-type vessels, which continue to be built and used today. The findings are expected to contribute to reviving this historical vessel type and enhancing the diversity of boat types specific to Türkiye.

2. Methodology

The investigation starts with the data collection process, during which existing hull models, regression data in the literature, and lines plans of Bodrum Çırnıks and Tirhandils are analyzed. Based on the data obtained, hull forms are modelled and form characteristics are calculated. Then the Holtrop-Mennen (H-M) method [9] and Delft Systematic Yacht Hull Series (DSYHS) method [10] are used for the resistance estimation of modelled hulls at varying speeds, and finally the results are evaluated. The flowchart of the analysis process is shown in Figure 1.

During hull modelling, data on the hull form of Bodrum Çırnık type vessels are primarily derived from the model shown in Figure 2, displayed at the Bodrum Maritime Museum, referred to as BÇ-1 in the research. Additionally, hull form plans for another reference model have been obtained from the thesis written by Damianidis [3] as shown in Figures 3 and 4. Based on the collected data, three different Bodrum Çırnık models are created for the study. The CAD models were created in Rhino [11] software shown in Figures 5 and 6. Bodrum Çırnıks are named as BÇ-1, BÇ-2 and BÇ-3, while Tirhandils are named as T-1, T-2 and T-3. The created models are then transferred to Maxsurf® Ver. 2023-Academic Licence [12] software for hydrostatic calculations and hydrodynamic resistance performance analyses. The selected Tirhandil models were carefully chosen to match the L_{OA} of the Bodrum Çırnık hull models developed in this study, ensuring consistency in comparative analyses.

Total hydrodynamic resistance consists of the friction and pressure components that oppose the hull's motion in water. The Holtrop-Mennen method, derived from various scale model tests and trial data, is a reliable tool for predicting the total hydrodynamic resistance of displacement-type hull forms [13]. This method has been used in various studies [14-16] for resistance calculations of Bodrum Gulet and Tirhandil-type vessels. Moreover, the DSYHS was designed for keeled sailing yachts; this resistance estimation model is based on model tests conducted under seven sub-series, encompassing 70 systematically derived hull variations [10]. In their previous research [8], the authors of this study used this resistance prediction method for Tirhandil-type sailing yachts.

3. Results and Discussion

3.1. Hull Form Characteristics and Hydrostatics

Three Bodrum Çırnık models with overall lengths of 11.00 m, 15.00 m, and 11.80 m are created. Hull form coefficients and design ratios are key parameters for predicting hull characteristics in the process of yacht design [3]. The block coefficient (C_B) defines the hull's fullness and significantly impacts weight and resistance [16]. The prismatic coefficient (C_P) describes the fineness or fullness of the hull's ends by considering the immersed volume and midship section area [3]. The midship area coefficient (C_M) is seen as a crucial element for estimating wetted surface area, frictional resistance, and pressure-viscous resistance, especially when combined with parameters such as C_B, bilge radius, and B_{WL}/T ratio [3]. Additionally, the longitudinal center of buoyancy (LCB) is a key factor in determining volume distribution when analyzed alongside C_P. The principal dimensions and hydrostatic values obtained for each hull form are presented in Table 1.

A comparison of the obtained hull form coefficients shows that Bodrum Çırnıks exhibit a fuller form compared to Tirhandils. On the other hand, the displacement, waterplane area, and wetted surface area of Bodrum Çırnıks are observed to be significantly lower than those of Tirhandils of the same length overall (L_{OA}). In the work authored by Brewer [17], a drawing from the first half of the 19th century depicts a double-ender type vessel with an L_{OA} of approximately 9 m, B of 3.04 m and a displacement weight of 18,000 lbs, which corresponds to 8.165 tons. Although the form in question exhibits similarities to the tirhandil-type vessel, in terms of L_{OA}/B ratio, its displacement value indicates that this 9-meter-long example has a higher displacement than the BÇ-1 and T-1 coded hull forms, both of which have an overall length of 11 meters. The hull form design ratios and the values for the investigated Bodrum Çırnıks and Tirhandils are given in Table 2. Ratios related to length to beam, directly influence resistance and, consequently, power requirements [18]. Additionally, the L_{OA}/B ratio indicates the yacht's beaminess [19] and the B_{WL}/T ratio is among key parameters of resistance characteristics. Experimental studies suggest that an optimal beam-to-draft ratio for minimizing frictional and wave resistance is approximately 2.5 [20]. These ratios have been used to obtain distinctive design characteristics for various yacht types' hull forms in different studies [8,16,21-23]. The results of the study conducted by Turan [14] indicate that for piyade-type boats, which are also traditional boats used in the Aegean Region, the average L_{OA}/L_{WL} ratio is 1.129 and it ranges between 1.086 and 1.148. Based on these values, it can be observed that the Bodrum Çırnıks share similarities with the piyade-type boats. In the study conducted by Turan [21], the stem rake angle for piyade-type vessels is reported to range between 48° and 52°. Accordingly, the stem geometry of the examined Bodrum Çırnıks more closely resembles that of piyade-type vessels rather than Tirhandil-type vessels.

Moreover, Bodrum Çırnıks have a significantly greater stem angle rake compared to Tirhandils, with this difference being particularly pronounced in BÇ-1. Additionally, unlike tirhandils, which have an approximately 2° keel angle, Bodrum Çırnıks exhibit a keel angle of 0°. In terms of the L_{OA}/B ratio,Tirhandils demonstrate more beamy hull forms compared to Bodrum Çırnıks.

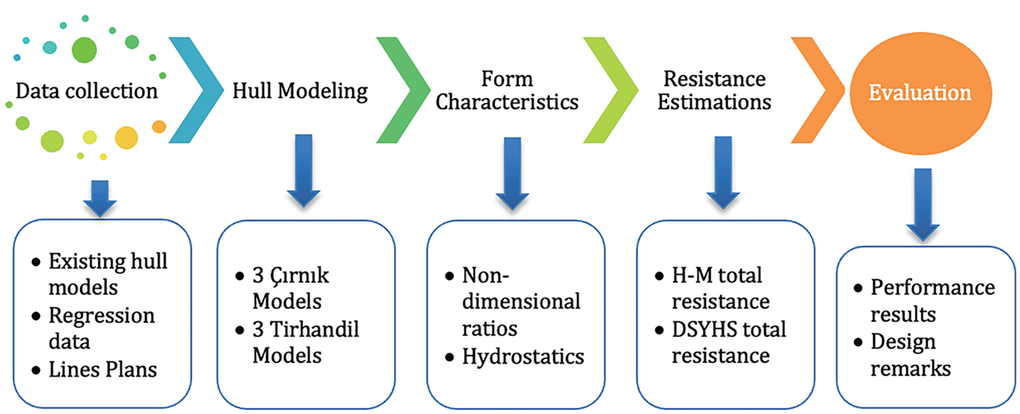

Figure 1. *Flowchart for the analysis and comparison*

DSYHS: Delft Systematic Yacht Hull Series

Figure 2. *Model of a Bodrum Çırnık in the Bodrum Maritime Museum, named as BÇ-1*

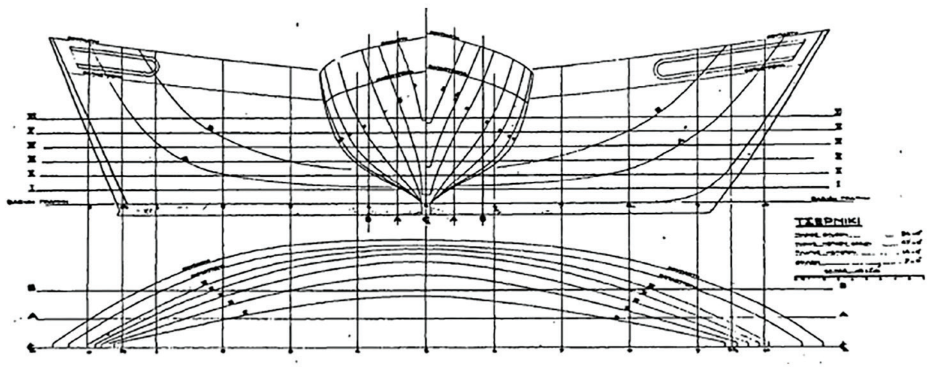

Figure 3. *Hull form plan of a Çırnık [3] named as BÇ-2 in the research*

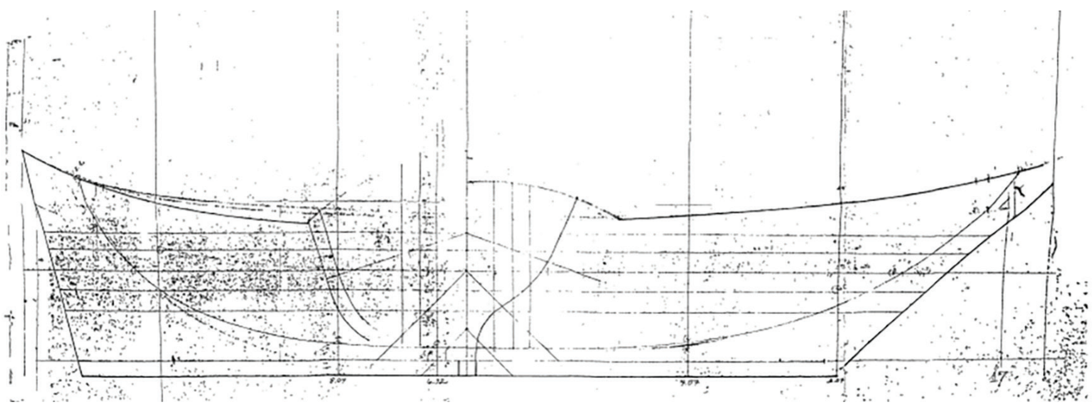

Figure 4. *Hull form plan of a Çırnık [3], named as BÇ-3 in the research*

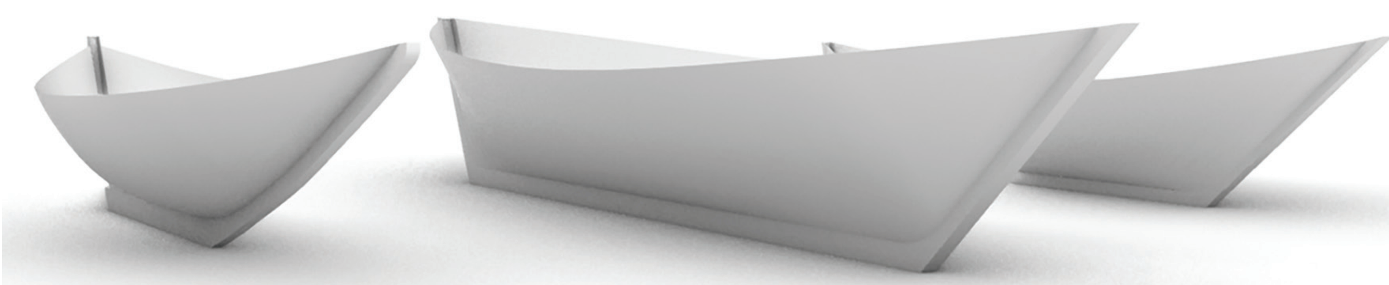

Figure 5. *The hull models of Çırnıks, numbered BÇ-1, BÇ-2 and BÇ-3 (left-to-right)*

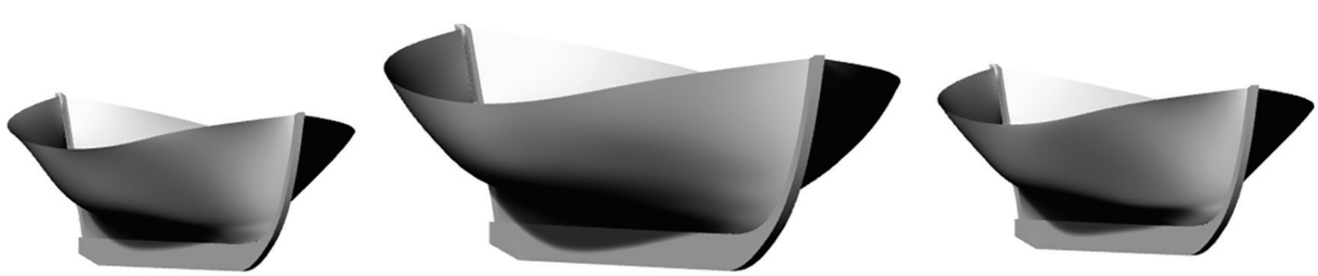

Figure 6. *The hull models of the Tirhandils, numbered T-1, T-2, T-3 (from left to right)*

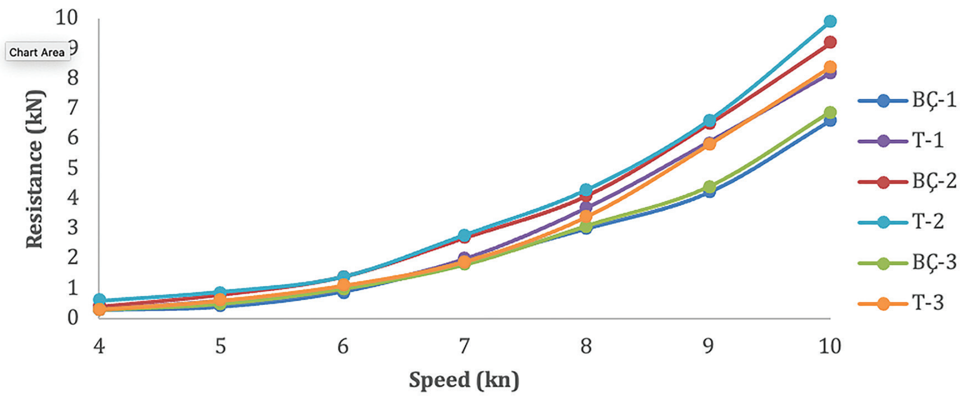

Figure 7. *Resistance of Bodrum Çırnık and Tirhandil hull forms based on the Holtrop-Mennen method*

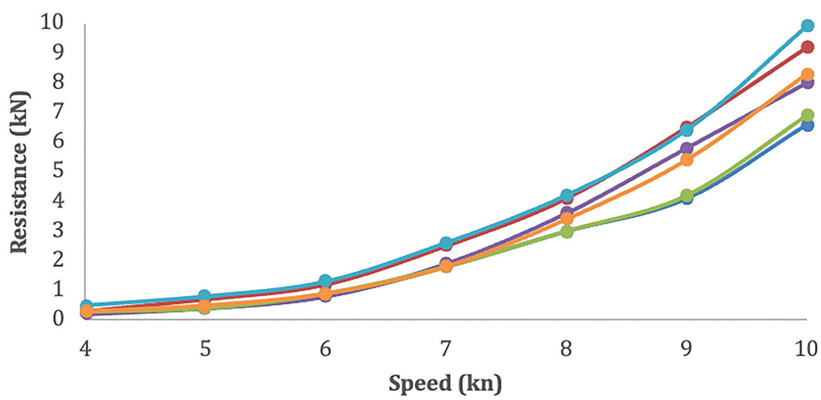

Figure 8. *Resistance of Bodrum Çırnık and Tirhandil hull forms based on DSYHS method*
DSYHS: Delft Systematic Yacht Hull Series

Table 1. *Principal dimensions and hydrostatic values of Bodrum Çırnıks and Tirhandils*

Properties	BÇ-1	BÇ-2	BÇ-3	T-1	T-2	T-3
L_{OA} (m)	11.000	15.000	11.800	11.000	15.000	11.800
B (m)	3.240	4.260	3.430	3.600	5.100	3.940
Displacement (t)	7.278	17.230	8.941	7.679	19.507	9.186
Volume (m^3)	7.100	16.806	8.722	7.491	19.031	8.962
T (m)	1.200	1.380	1.100	1.280	1.580	1.320
L_{WL} (m)	8.064	12.997	9.914	9.657	13.331	10.336
B_{WL} (m)	2.856	2.999	2.614	2.886	4.386	3.268
Wetted area (m^2)	23.714	46.756	28.634	27.734	57.059	33.897
Midship section area (m^2)	1.749	1.934	1.476	1.553	2.668	1.669
Waterplane area (m^2)	14.362	26.691	16.183	17.029	37.011	20.199
Block coeff. (C_B)	0.257	0.312	0.306	0.210	0.206	0.201
Midship section area coeff. (C_M)	0.510	0.467	0.513	0.420	0.385	0.387
Prismatic coeff. (C_P)	0.503	0.669	0.596	0.499	0.535	0.520
Waterplane area coeff. (C_{WP})	0.624	0.685	0.624	0.611	0.633	0.598
LCB (% of LWL)	46.503	48.627	50.005	47.640	47.569	47.621
LCF (% of LWL)	48.469	49.654	51.282	48.992	49.089	48.703

Table 2. *Hull form values and ratios of Bodrum Çırnıks and Tirhandils*

Properties	BÇ-1	BÇ-2	BÇ-3	T-1	T-2	T-3
L_{OA}/L_{WL}	1.364	1.154	1.190	1.139	1.125	1.142
L_{OA}/B	3.395	3.521	3.440	3.056	2.941	2.995
L_{WL}/B_{WL}	2.824	4.334	3.793	3.346	3.039	3.163
B_{WL}/T	2.380	2.173	2.376	2.255	2.776	2.476
L_{WL}/Displacement volume 1/3	4.196	5.074	4.816	4.935	4.993	4.976
Rake of the stem (°)	70.400	45.610	48.000	29.060	37.150	32.230
Keel angle (°)	0.000	0.000	0.000	2.000	2.000	1.950

3.2. Resistance of Hulls

The total hydrodynamic resistance of each Bodrum Çırnık model at different speeds is compared with the resistance values of Tirhandil models. Figure 7 presents the total resistance of Bodrum Çırnık and Tirhandil hull forms based on the Holtrop-Mennen method. At lower speeds (4-6 knots), all models exhibit similar resistance values, though, BÇ-2 and T-2 show slightly higher resistance from 6 knots onward. In the mid-speed range (7-8 knots), resistance increases rapidly for all models, with T-1 and T-2 showing higher values compared to the BÇ models. At higher speeds (9-10 knots), the total resistance of T-1 and T-2 reaches the highest levels, whereas BÇ-1 and BÇ-3 maintain relatively lower resistance. Overall, the BÇ models, particularly BÇ-1 and BÇ-3, tend to have lower resistance than T-1 and T-2, suggesting that Bodrum Çırnık boats may offer better fuel efficiency, especially at lower speeds. However, as speed increases, some BÇ models, like BÇ-2, show resistance values closer to those of Tirhandils.

Figure 8 shows the resistance of Bodrum Çırnık and Tirhandil hull forms based on the DSYHS method. The comparison of resistance values obtained using the Holtrop-Mennen and DSYHS methods reveals that both approaches follow a similar trend, with resistance increasing as speed rises. At lower speeds (4-6 knots), the values from both methods are close, but differences become more pronounced at higher speeds (7-10 knots). The DSYHS method generally predicts slightly lower resistance for Tirhandil models (T-1, T-3) at lower speeds, while the Holtrop-Mennen method estimates consistently higher resistance for T-1 and T-2, particularly at 9-10 knots. Across both methods, Bodrum Çırnık models (BÇ-1 and BÇ-3) exhibit lower resistance than Tirhandils, suggesting greater efficiency in power requirements and fuel consumption. Meanwhile, BÇ-2 shows resistance values closer to Tirhandil models, indicating similar hull performance. Despite minor variations, both methods confirm that Bodrum Çırnıks generally have better resistance performance compared to Tirhandils, at the tested speeds.

4. Conclusion

In this study, three models each of the Bodrum Çırnık and Tirhandil hull forms are modeled, and their design properties are revealed. Hydrostatics is obtained and the resistance of hull forms is estimated using Holtrop-Mennen and the Delft Systematic Yacht Hull Series methods. According to the results, the following conclusions are drawn.

- The stern sections of Bodrum Çırnık and Tirhandil-type vessels are similar, with the most significant design differences found in the bow and longitudinal keel.
- The sloped bow, a distinctive feature of Bodrum Çırnık vessels, is more pronounced in the BÇ-1 model. However, a larger set of reference vessel drawings is needed to generalize regional variations.
- A noticeable resistance difference between BÇ-1 and T-1 is observed at speeds of 6 knots and above, reaching 22.73% at 10 knots, but this difference diminishes at lower speeds.
- Although the resistance values of BÇ-2 and T-2 (both with a L_{OA} of 15 meters) do not show a significant difference overall, BÇ-2 has a lower resistance, particularly at speeds of 8 knots and above, with a 7.61% difference at 10 knots.
- The resistance difference between BÇ-3 and T-3 increases with speed; reaching 21.01% at 10 knots, with BÇ-3 demonstrating lower resistance.
- Beyond the technical scope, the findings contribute to the preservation and recognition of traditional maritime heritage. Tirhandils and Çırnıks are not only functional vessels but also cultural artifacts that reflect the historical identity of Aegean and Anatolian coastal communities. By systematically documenting their form characteristics and evaluating their performance, the study highlights the value of integrating naval architecture with heritage conservation. Such efforts can support the revival of interest in traditional vessels and inspire future research, education, and cultural preservation initiatives.
- The study aims to be a valuable reference for future research on Bodrum Çırnık-type boats, encouraging further investigation into their sail performance and maneuvering

capabilities. Future research should explore the impact of different keel types on the performance of these hulls.

Footnotes

Authorship Contributions

Concept design: B. İ. Turan, and M. Akman, Data Collection or Processing: B. İ. Turan, and M. Akman, Analysis or Interpretation: B. İ. Turan, and M. Akman, Literature Review: B. İ. Turan, and M. Akman,
Writing, Reviewing and Editing: B. İ. Turan, and M. Akman.

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