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Roko MARKOVINA

Korčula's Shipbuilding: *Gajeta Korčulanka* - the Best Small Wooden Ship Form at the Adriatic Sea

Original scientific paper

This paper presents the results of research into the beginnings of navigation and shipbuilding in the Adriatic Sea area, dating, according to the recent archaeological results, from the period between 8th and 7th millennium B.C. The author analyzed possible ship forms at the beginning of trans-Adriatic navigation during that historical period, as well as the main characteristics of the *Gajeta Korčulanka*, which proved to be the most successful form among all small wooden fishing boats not only in the Adriatic, but also in the Mediterranean Sea.

Keywords: *form, Gajeta Korčulanka, navigation, shipbuilding*

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Korčulanska brodogradnja: *Gajeta Korčulanka* - najbolja forma malog drvenog broda na Jadranu

Izvorni znanstveni rad

U radu su prikazani rezultati istraživanja početaka plovidbe i brodogradnje na Jadranskome moru, koji datiraju, prema posljednjim arheološkim rezultatima, između VIII. i VII. tisućljeća pr. Kr. Prema tim rezultatima autor je analizirao moguće forme na počecima prekojadranske plovidbe u tom povijesnom razdoblju, kao i glavne osobitosti *Gajete Korčulanke* kao najbolje forme među malim drvenim ribarskim brodicama na Jadranu, pa i Mediteranu.

Ključne riječi: *brodogradnja, Gajeta Korčulanka, oblik, plovidba*

1 Introduction

1.1 The history in short

The Island of Korčula is situated in the southern part of the Dalmatian Adriatic littoral, and is divided from Pelješac peninsula by a narrow channel. The island, which dominates the Pelješac channel, had had an important strategic position, and during the long history had always been very important for the maritime powers, because the master of the island was to be absolute master of that important maritime road. That was the reason that the Island of Korčula frequently changed its masters: the ancient Greeks, Romains, Venetians, English, French, Austrians, Russians and Italians. The history of the Island of Korčula begins in the Neolithic era according to the numerous archeological finds (Vela Spila in Vela Luka, Jakasova Spila in Žrnovo). The name of the island derives from Korkyra, given by the founders of it, the Dorians, from the Greek town of Knidos, the same name like the island of Corfu on Ionian Sea, but with an adjective Melaina (black) in VI century B.C. Its first Slavonic name Kurkra and Krkar appeared in the 10th century, and the Venetians, the years after, gave it the name Curzola. From this name, in more recent time the present name Korčula came. In 3rd century B.C. the Knidian colony in Korčula obtained its subcolony in Lumbarda, by the infiltration from the island of Issa ("*Lumbarda's psefism*"). The Illyrians, aboriginals of the island, become more organized, and in the 2nd century B.C. the whole island becomes the stronghold of the Illyrian pirates. With much exactitude it can be assumed that Korčula had, at that time, a well-developed shipbuilding production of typical Korčula's boat forms, using its own construction method named "*Mezza-luna-buška*" and very precise and artisan's building technology, started then, thanks to important maritime road and especially voluminous pine forest, which had been used as a source of very good wooden material for building boats and ships.

However, there is a reliable written document which appeared in the 13th century and the Statute of the town and the island of Korčula from 1214, witnessed by the clauses about cutting of the trees, forbidding the export and production of the pitch and the other, directly connected with shipbuilding etc. The Island of Korčula and its shipbuilding had a very lively economic relationship with Dubrovnik Republic, and its various rich men participated in orders for their ships in Korčula, and they helped the Korčula's people to establish the much known maritime fleet, especially strong in the 16th century.

The areas for building ships were situated on the western and eastern sides of the suburbs called *Borgo superiore* and *Borgo*

inferiore and had the advantage of a shallow sea in front of them which made easier the launching of the ships [9].

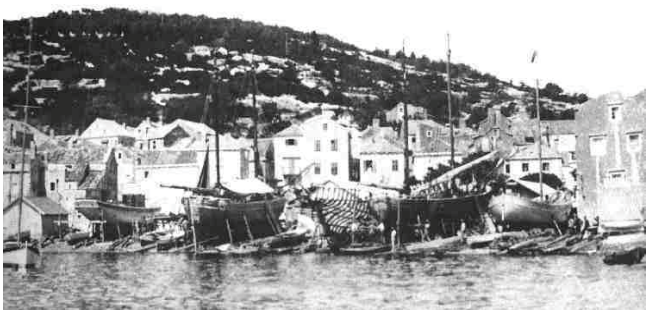


Figure 1 **The East shipyard in Korčula (*Squero famoso*) from the end of the 19th century**
Slika 1 **Istočno brodogradilište u Korčuli (*Squero famoso*) s kraja 19. stoljeća**

The Korčula's shipbuilding knowledge had been much known in the entire Mediterranean area, so that the Venetian's cartographer Vincenco Mario Corronelli, in old drawing (from 1688) called the Korčula's shipyards as "*squeri famosi*". Korčula's shipbuilding in the period between 1798 and 1879 increased the ship production by building a number of big sailing ships (*trabakul, brigantin, brik, škuna, loger*). From the year 1815, Korčula Island came under the authority reign of the Austrians, and at the end of the 19th and the beginning of the 20th century, especially because of the negligence of the state, Korčula's shipbuilding passed trough a hard period. The secret of shipbuilding trade was passed on beyond of mouth (to the youngest brother or the eldest son) and was performed using primitive hand operated tools, which had negative influence on the shipbuilders earnings.

The end of 19th century brought great historical changes: the fall of Venetian Republic, the reign of Austria, France, England, Russia, and finally Austria until the year 1919. In spite of that, Korčula's shipbuilders went on with production working hard, and had built during that time two significant ships. Thus, in the year 1875 the biggest Korčula's wooden sailing ship named *Fratelli Fabris* was built for the stone builders owner from Islet Vrnik (L = 44 m; B = 9 m, and D = 6 m, deadweight of 550 tons, and 10 crew members). She came to grief and disappeared with all the crew members in the shallows of Vllisningen (Netherlands). The second vessel was built in 1903, and was the biggest wooden sailing ship during the Austro-Hungarian reign. That was the yacht *Nirvana* (L = 30.6 m, B = 3.60 m, and D = 2.90 m) built for Bernardo Caboga, the count of Dubrovnik. She was built from the best wooden materials: Korčula's holm oak, American and Slovenian oak, Korčula's mulberry-tree, Korčula's pine etc. [9].

For the reason of the enormous shipbuilding crisis in Korčula, at the end of the 19th century and during the First World War many masters from Korčula had their colonies in Sfulin (Romania), Istanbul (Turkey), Alexandria (Egypt) and other overseas countries. Also, in the period between the 1st and 2nd World Wars, because of the very hard economic situation and absence of job, a number of shipbuilders emigrated, but the ones who stayed at home were building small boats, in most cases *gajetas*, *leuts*, *gucs*, *pasaras*, *kajićs*, and smaller *logers*, as well as the fishing boats for Istria, Albania and Greece.

In the 2nd World War the Italian occupying forces organized a private shipyard *Navi Curzola* and the first boats built were motor launches (*motolancie*) for the Italian Navy forces. However, these boats were never included in the war operations due to the sabotages executed by the Korčula's patriots. After the capitulation of Italy the first Partisan shipyard was founded in Korčula at the same place, and Italian motor launches were repaired and placed in the function of the Partisan's Navy, but in the autumn of 1943, because of the vicinity of the powerful German forces on the peninsula of Pelješac, the shipyard was relocated in Vela Luka, at the north-western tip of the Island of Korčula. A few months later, for the war Allies needs, the Korčula's shipbuilders founded a small shipyard in Komiža (Island of Vis), as well as on the Island of Lastovo and in Bari (Italia), working on English torpedo-boats repairing.

After liberation of the whole Island, at the end of 1944 one of the shipyards was renovated and was named *Korčula*, and shipbuilders started with the new production of wooden boats: trawlers, *leuts*, *gajetas*, tugs and other types of small wooden boats up to the deadweight of 400 tons.

At the end of 1949 the shipyard was relocated out of the town to the location called *Dominče* (where is still today) and continued, during 50 years, the production of different types of wooden and steel ships, hatch covers, hatch comings and other types of ship's outfitting. At first it was named *Ivan Cetinić*, then it was renamed into *Brodograditelj*, then *KBI*, and finally into *Inkobrod*. From the beginning of 1991 till 1996, the shipyard passed through a very hard period again because of the Croatian War of Independence and the severe economic situation in the State. The insufficiency of jobs, crossing over the more of ship's orders on Far East shipyards, unreal exchange rate of domestic currency, which damaged heavily the export production, crime in privatization, and negative activities of some groups of shipyard workers as "small stockholders" were the reasons why *Inkobrod* shipyard went into bankruptcy. Currently, the State has given the shipyard in concession to the Holland Company *Peters Shipyards*, and today it as the shipyard *Leda* is building hulls for river ships.

1.2 About the early beginnings of shipbuilding

The earliest material proof of navigation across the Adriatic Sea are a few artifacts made of gabrodiorite (volcanic stone) from the islet of Palagruža, recovered from the Mesolithic levels of Vela Spila in Vela Luka (north-west of the Island of Korčula, Croatia) and attributable to the transition from the eighth to the seventh millennium B.C.

Due to globally depressed sea levels (about 150 m) during the Late Pleistocene, the Adriatic Sea covered just slightly more than a half of its present area. The northern part of the Adriatic basin was a steppe, while the river valleys that separated the present-day islands were inhabited by large animals, primarily deer, horses and cattle. Preconditions for trans-Adriatic (or, more generally, offshore) navigation were created at the beginning of Holocene, with the formation of the present Adriatic Sea.

The earliest evidence for such navigation was recovered from Burial 2 in Vela Spila, (Čečuk and Radić 2005), which contained an artifact made of igneous rock gabrodiorite, Figure 3. Based on their stratigraphic positions, Burial 2, the three child burials related to it, as well as another adult burial some 15 meters away, unquestionably belong to the Mesolithic [1].

The position of the islet of Sušac (part of the East Adriatic coast, near the river Neretva valley) during the Mesolithic was just one of the way stations on trans-Adriatic navigation [8].

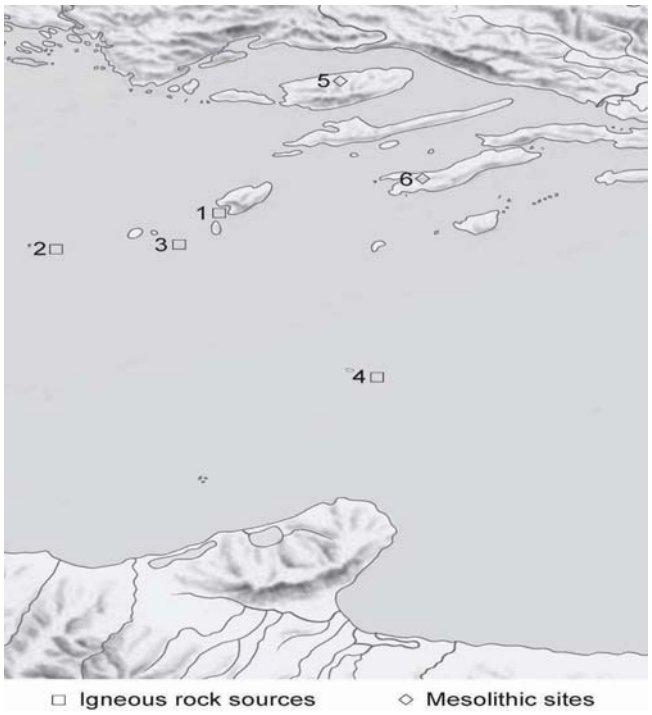


Figure 2 **Igneous rock sources and Mesolithic sites on middle Adriatic islands: 1 Komiža, 2 Jabuka, 3 Brusnik, 4 Palagruža, 5 Kopačina Cave, 6 Vela spila Cave [5]**

Slika 2 **Porijeklo vulkanskih kamenih nalaza i područja iz Mezolitika na srednje-Jadranskim otocima: 1 Komiža, 2 Jabuka, 3 Brusnik, 4 Palagruža, 5 Špilja Kopačina, 6 Vela Spila [5]**

Figure 3 **An artefact made of rock gabrodiorite from Vela spila [1]**

Slika 3 **Ručni izradak od "gabrodiorite"-a iz Vele spile [1]**

The islet of Palagruža (part of the West Adriatic coast, near Gargano) had an especially prominent role. [5] The distance between the two coasts connected by the Sušac-Palagruža line, at the sea level of 150 m below today's level [6], was about 17 Nm, which was then too far away to cross, considering still primitive vessels of that time and insufficient navigation knowledge. However, in the northwestern part of the East Coast the distance was about 3 Nm and this was the optimal position for the transfer to the opposite coast in the 8^{th} -7^{th} millennium B.C. period, as is presented in Figure 4. Between 6^{th} – 3^{th} millennium B.C. the rapidly warmer weather came, the glaciers were liquefied and were releasing enormous volume of waters into the seas. A large number of years later, about 400 years B.C., Greek colonists arrived in Korčula and left their influence on the Korčula's existing ship form. The level of Adriatic Sea was, at that time, about – 2.5 m from today's, as Figure 4a presents.

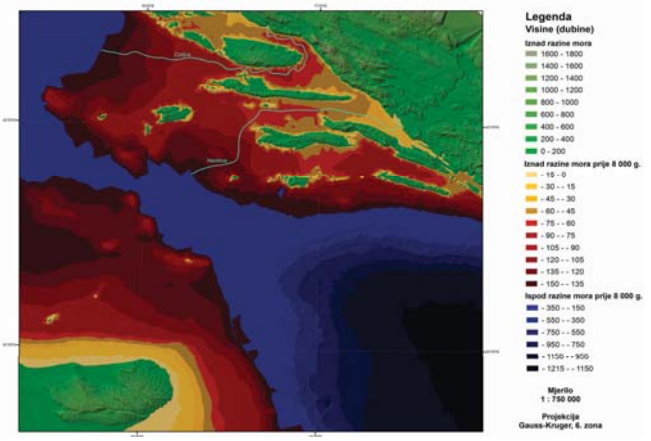
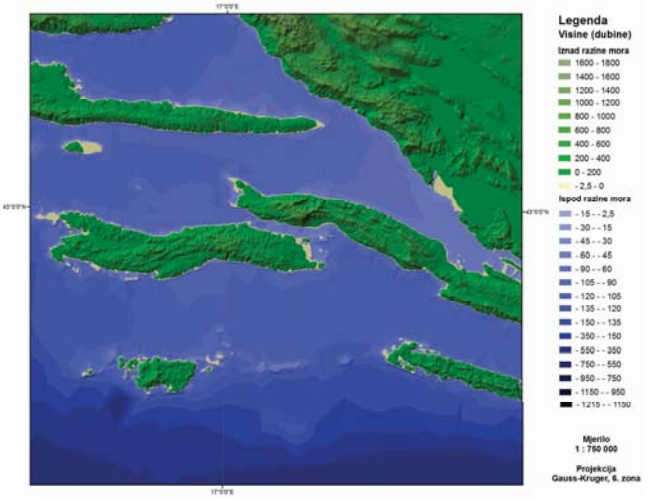


Figure 4 **The Central part of the Adriatic Sea at -150 m from today's level (green: the part above the sea level today; brown and yellow: the part above the sea level about 8000 years B.C.; blue: the part below the sea level) [3]**

Slika 4 **Središnji dio Jadranskog mora na -150 m od današnje razine (zelena: dio iznad razine mora danas; smeđa i žuta: dio iznad razine mora oko 8000 godina pr. Kr. i modra: dio ispod razine mora) [3]**

Figure 4 a **The Central part of the Adriatic Sea (Korčula-Pelješac) at -2.5 m from today's level (green: the part above the sea level today; green and yellow: the part above the sea level about 500 years B.C.; blue: the part below the Sea level) [3]**

Slika 4a **Središnji dio Jadranskog mora (Korčula-Pelješac) na -2,5 m od današnje razine (zelena: dio iznad razine mora danas; zelena i žuta: dio iznad razine mora oko 500 godina pr. Kr. i modra: dio ispod razine mora) [3]**



2 About the possible wooden boat forms at the Adriatic Sea in the early beginnings

At that time, the possible boat forms were as follows:
- multi-layered raft,
- hollowed out trunk (dugout),
- branch raft-catamaran,
- dugout with a primitive side-plates,
- "papyrella"- boat made of papyrus plant (*Cyperus papyrus*)
- branch knitted canoe with the Mediterranean monk seal's skin,
- branch knitted kayak with the Mediterranean monk seal's skin, or
- primitive wooden boat (similar to Egyptian boats) with the square sail, presented in Figures 5 to 12.

Old and experienced shipbuilders were very well aware of the three basic sea laws:
1. It is possible to resist the sea-force only by non-resistance,
2. The quickest way is not always the shortest distance, but the safest one,
3. At the right time all the seas are very reliable.

These laws are applicable today as well.

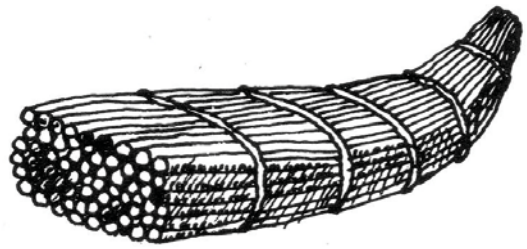


Figure 5 **The multi-layered raft**
Slika 5 **Višeslojna splav**

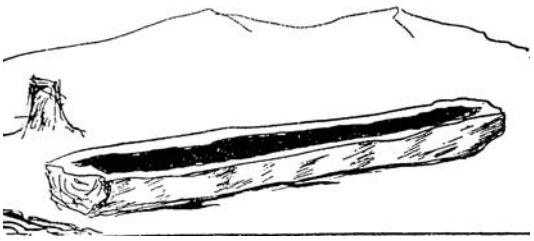


Figure 6 **The dugout [7]**
Slika 6 **Dubenica (monoksil) [7]**

Figure 7 **The branch raft catamaran [7]**
Slika 7 **Dvotrupna splav**

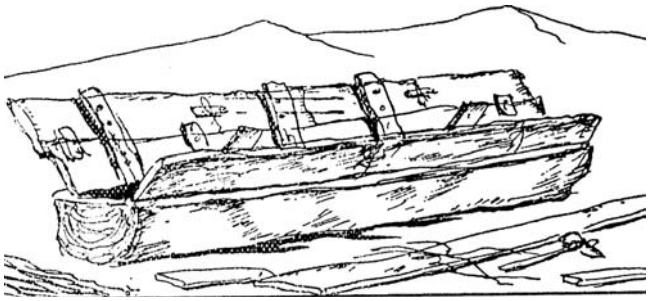


Figure 8 **The dugout with the simple side-plates [7]**
Slika 8 **Dubenica sa jednostavnim bočnim platicama [7]**

Figure 9 ***The Papyrella* - knitted by cane [3]**
Slika 9 ***Papirela* - sastavljena od trstike [3]**

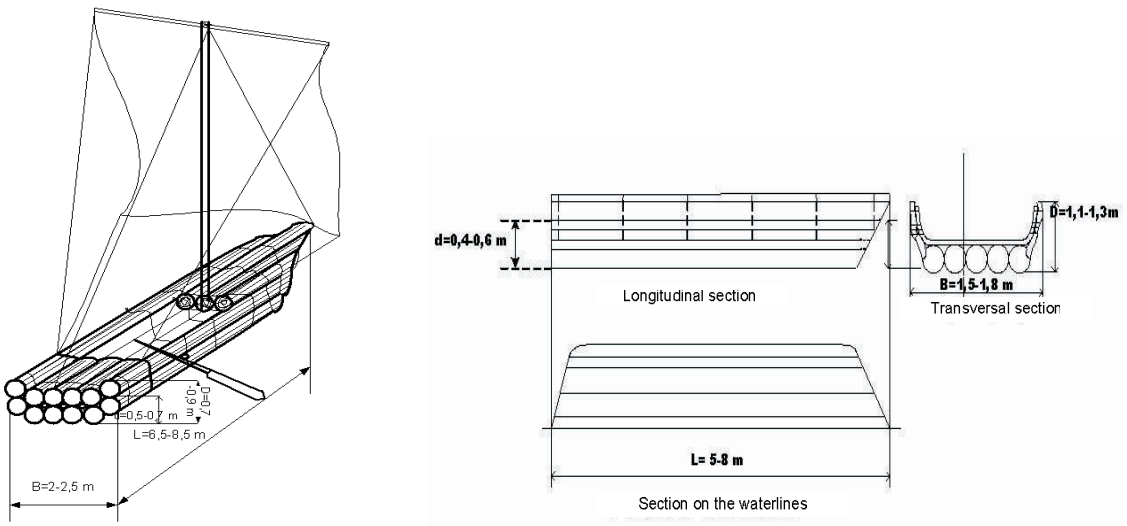
According to the latest research, in 2010 in Plakia (South Crete, Greece), the discovered remains of a maritime basis where warships used to be anchored from 7000 – 3000 years B.C. show that our ancestors navigated across the Mediterranean Sea more than 10000 years earlier than we have thought. What confirms this thesis is that, at that time, the sea level was possibly about 150 m lower than the actual level [6], as Figure 4 presents.

Figure 10 **Branched canoe [3]**
Slika 10 **Kanu ispleten od granja [3]**

Figure 11 **Branched kayak [3]**
Slika 11 **Kajak ispleten od granja [3]**

Figure 12 **Primitive wooden boat with square sail [7]**
Slika 12 **Jednostavna drvena brodica sa četvrtastim jedrom [7]**

Figure 13 **The ship lines of the possible massive boat-raft form [3]**
Slika 13 **Brodske linije moguće forme masivnog splava-brodice [3]**



It is very probable that the old Adriatic shipbuilders used to build some massive boat-rafts with a square sail, as for example, the old Egyptian shipbuilders, who built excellent sailing wooden boats at that time and navigated across the Adriatic Sea. The ship lines of the possible massive boat-raft form are presented, as an idea, in Figure 13.

3 About the *Gajeta* - an excellent form of fishing boat at the Adriatic

According to legend, the name Gaeta originates from the time of Homer's heroes. After the fall of Troy, Aeneas sailed across the Mediterranean Sea searching the New Land in which he would build his new community, and he put ashore on the sands of Naples. His nurse Kaieta died and she was buried on the sands of Naples. On the place where she was buried, Aeneas, the Founding Father of Rome, founded the city, named Gaeta, after the name of his nurse. The type of a small fishing boat, *gajeta*, became the most widely known type of small wooden fishing boat in the Mediterranean Sea, well-known in South Italy, Crete, Catalonia, even in Portugal's rivers and along the Eastern Adriatic Sea Littoral. The *gajeta*, as a coastal sailboat, was firstly used for different type of fishing and thereafter for the cargo transportation on the small coastal distances. The ship hull has rounded sides and bottom with bow and stern angled. The keel contributes to ship's strength and the large and long rudder reaches under the keel. Frames and keels are produced from oak and side plates from the pine-tree board. She did not have a deck over all, but only a small deck on the bow and stern parts of the boat, except for the boats which were built for the cargo transport. She usually had one lateen-sail and one pole mast positioned at the first third of the boat length (L) from the bow. She had no auxiliary boat behind, but two to four long oars, two four branch anchors, two to four crew members and the deadweight of 5 – 12 tons.

The constructive elements that ensured the ship's longitudinal strength were:

- in the bottom part: keel, centre – girder, down side-plating planks.

- on the deck side: the bulwark rail, upper side-plating plank and deck plating.

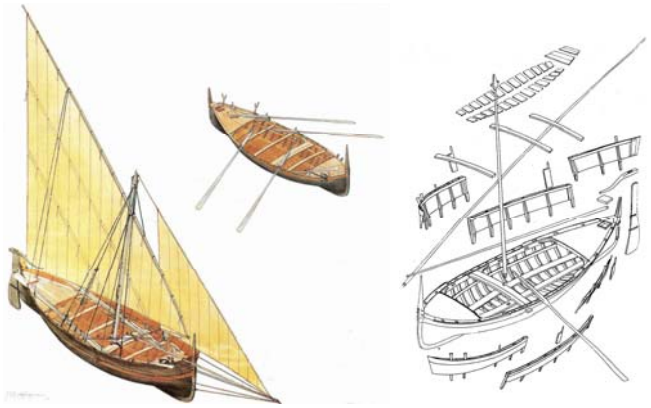
The constructive elements that ensured the transversal strength were:

- frames, connected with deck beams and bottom floors, by brackets.

In the Adriatic the following three typical *gajeta* forms were developed: *Gajeta Korčulanka* (from the Island of Korčula), *Gajeta Betinka* (from the Island of Murter), and *Gajeta Lovranka* (from the North East of Istria), all of them originating from the Korčula "school" of the wooden boat form. There should be also mentioned one extraordinary functional solution of the small wooden fishing boat, named *Gajeta Falkuša*, the invention of Korčula's proto-master Jakov Geričić and his companions for the fishermen of Komiža (Island of Vis) who went on long fishing expeditions in the open-sea around Island of Palagruža, 42 Nm away from Komiža. She is an excellent example of small wooden boat form, named *Adriatic form*, based on more millennia-old knowledge and experience of Korčula's shipbuilders. She has very large functional and relatively small structural complexity, which provides, by modular rearranging, essentially changing the form to the function, a very good harmony of her form solution at all structure levels as well as a very good harmony with complete natural and social environment. The six *"falke"* (for the bow, middle and aft), removable 60 cm high side plates at the both boat sides, assured an additional freeboard of 60 cm while sailing back home with the "fool load" after three weeks of successful fishing. But, without *"falke"* that were removed during fishing, the *Gajeta Falkuša* was transferred in a very fast and manoeuvrable fishing boat. So, with the very attractive form design and the possibility of modular rearranging she actually represents two different boats in one hull form, which can be seen in Figure 14.

Practically, in spite of resemblance of boat forms, each East Adriatic shipbuilding micro-community had its own recognizable "handwriting" and unique "stamp" in the form "styling" of theirs boats (Rovinj, Lovran, Nin, Betina, Neretva valley, Korčula, Dubrovnik, Kotor), which is very important when discussing about the know-how and masterliness in Adriatic and Mediterranean shipbuilding.

Figure 14 ***Gajeta Falkuša*, an excellent fishing boat form, with sail and "falke"(in navigation), with long oars and without "falke"(in fishing) and separable parts of her structure [14]**
Slika 14 ***Gajeta Falkuša*, izvrsna forma ribarskog broda, s jedrom i "falcima" (u plovidbi), s dugim veslima, bez "falaka" (na ribarenju) i rastavljivi dijelovi njezine strukture [14]**



3.1 About the *Gajeta Korčulanka*

Over the centuries, the Korčula shipbuilding excelled across the Mediterranean. In the Middle Ages the Korčula shipbuilding was very known for its sailing ships (*karaka*, *bark*, *brik*, *brigantine*), as well as its small boats (*gajeta*, *leut*, *pasara*, *guc* etc.), and for its excellent ship forms, strength, stability, speed and maneuverability, achieved by using an old unique construction method, named "Mezzaluna-buška"[9].

Being rational and competent in their work, old Korčula's shipbuilding masters perfected their shipbuilding craft so that from an outstanding fishing boat form, named the *Gajeta Korčulanka* several different types of boats were developed and were used:

- for professional fishing,
- for semi-professional fishing (general purpose use),
- for land-tillers and stone-workers (to whom fishing was a casual activity).

The basic principle in Korčula wooden shipbuilding was to ensure the strength of a ship construction while in service. For bigger wooden ships the longitudinal strength was very important, and for smaller ones the transversal strength. For that reason, the wooden ships and boats were built by the transversal system of building, with frames tightly fixed on the keel, with an adequate inter-frame distance (*kanap*), which was as follows:

- l = 0.24 m for the smaller boats (L $\cong$ 5-6 m) to
- l = 0.34 m for the bigger ships (L $\cong$ 17 m) linearly.

The proportions between the length (L), breadth (B) and draft (d) of the ships were very important for their resistance and speed. The principal ratios were:

- for boats L/B = 2.8 -3.2
- for old sailing ships: L/B = 3.75-4.5
- for clippers: L/B = 5-7
- for modern sailing vessels:
  - big:..... L/B = 4.5-6.8
  - medium:... L/B = 3-5.75
  - small :..... L/B = 2-3.

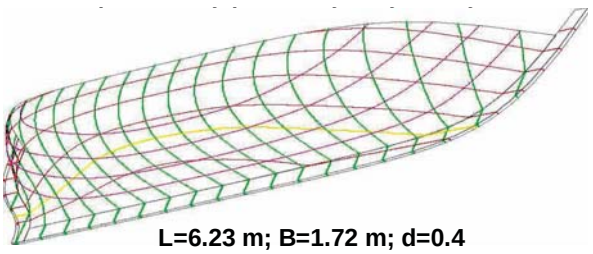
The draft of the wooden sailing ship depends on its stability and the water on which it has to sail.

The optimal proportions for the draft are:

- for wooden sailing ships:
  - big:.....d/B = 0.38-0,48
  - small:.....d/B = 0.25-0.43.[3]

Among the most outstanding forms built by some of the famous shipbuilding families in Korčula (*Sessa, Depolo, Denoble, Ivančević, Sladović, Željković, Foretić, etc.*), the typical ship lines and construction design of the traditional *Gajeta Korčulanka* fishing boat, made by the late Korčula shipbuilder named Jakov Denoble, have been chosen to be the representative of the class (Figures 15 and 19), with the main characteristics analyzed by Fung and Holtrop computer program [3].

Figure 15 **The computer 3D simulation of *Gajeta Korčulanka* form by proto master Jakov Denoble [3]**
Slika 15 **Računalna 3D predodžba forme *Gajete Korčulanke* prema protomeštru Jakovu Denoblu [3]**



L=6.23 m; B=1.72 m; d=0.4

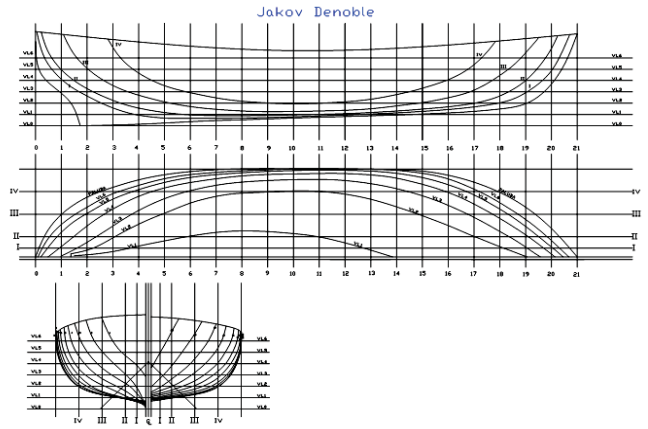


Figure 16 **The ship lines of *Gajeta Korčulanka* by proto master Jakov Denoble [3]**
Slika 16 **Brodske linije *Gajete Korčulanke* prema protomeštru Jakovu Denoblu [3]**

Figure 17 **Typical *Gajeta Korčulanka* - fishing boat form today in Korčula (bow, side and stern) [3]**
Slika 17 **Tipična *Gajeta Korčulanka* - današnja ribarica u Korčuli (pramac, bok, krma) [3]**

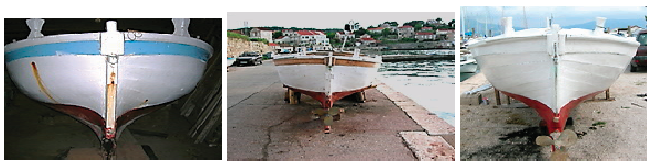


Figure 18 **Typical stern parts of *Gajeta Korčulanka* - existing today in Korčula (for land-tillers, semi-professinal fishing, and professional fishing) [3]**
Slika 18 **Tipični oblici krme *Gajete Korčulanke* - koje postoje danas u Korčuli (težačka, za poluprofesionalno ribarenje i profesionalno ribarenje) [3]**

Figure 19 **Construction design of *Gajeta Korčulanka*, as proto master Jakov Denoble used [4]**
Slika 19 **Konstrukcijski nacrt *Gajete Korčulanke*, korišten od protomeštra Jakova Denoblea [4]**

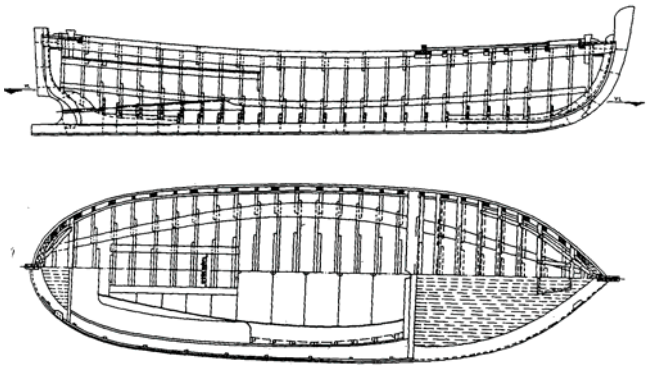


Table 1 **The main characteristics of *Gajeta Korčulanka* fishing boat (built by Jakov Denoble), analyzed by Fung and Holtrop computer program [3]**
Tablica 1 **Glavne značajke *Gajete Korčulanke* - ribarice (izgrađene od strane Jakova Denoblea), analizirane prema Fung i Holtrop računalskom programu [3]**

CHARACTERISTIC	Units	Holtrop	Fung
LWL	m	6.223	6.223
Beam	m	1.72	1.72
Draft	m	0.4	0.4
Displaced volume	m^3	0.722	0.722
Wetted area	m^2	9.066	9.066
Prismatic coeff.		0.589	0.589
Waterplane area coeff.		0.592	--
1/2 angle of entrance	deg.	19.21	19.21
LCG from midship	m	-0.098	--
Transom area	m^2	0.001	0.001
Transom wl beam	m	--	0.066
Transom draft	m	--	0.008
Max sectional area	m^2	--	0.197
Bulb transverse area	m^2	0	0
Bulb height from keel	m	0	0
Draft at FP	m	0.4	0.4
Deadrise at 50%LWL	]	5.1	-

The followers of famous Korčula's shipbuilders in wood, the well known today for the quality and quantity of *Gajeta Korčulanka* building on the Island of Korčula are Marin Šale in Žrnovo and Igor Čulić in Lumbarda.

3.2 About the *Gajeta Betinka*

The *Gajeta Betinka* was produced under the influence of the Korčula wooden shipbuilding "school" when the shipbuilder from Korčula, Pasquale (Paško) Filippi immigrated in Betina (Island of Murter) in 1745, together with his sons and founded there the first shipyard. He kept the original technology of Korčula's wooden boat building (touching method) but adapted its form to the climate conditions of the Kornati Islands and the Island of Murter, as well as to the needs of their inhabitants. It was primarily used as a transport vehicle to the lands on the islands of Kornati (transporting stone, animals, fruits and vegetables, woods, etc.) and only then as a fishing boat. That is the reason why the *Gajeta Betinka* is a little stronger and has a greater deadweight than the others. She is, practically "several boats in one hull form". The bow is markedly higher with rounded stem post and stern a little lower, with the flat stern post, perpendicular to the water line. She had, at the beginning, a flat bottom, and straight sides, which assured good stability, but today, her "main frame" (bottom and sides lines) is a little angled, according to the design idea of master Šime Šandrić (Figure 20). She has no benches, except only one along the inner side, which serves as a step for animal entering inside from the fore deck, and one central transversal beam in the main frame position, for assuring boat's antifracture and for binding all boat ropes. She is operated by 2-4 long oars and one lateen sail, on the one pole mast position. The shipbuilder Tomo Uroda, Filippi's disciple, continued to transfer the shipbuilding knowledge to the new generation of shipbuilders, without using the original Korčula's construction method *Mezzaluna-buška*.

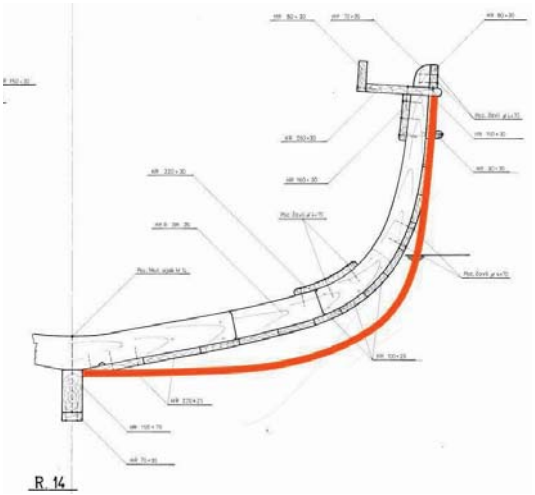


Figure 20 **The "main frame" comparison of the *Gaeta Betinka,* earlier (orange line) and today as designed by Šime Šandrić [13]**
Slika 20 **Usporedba "glavnog rebra" *Gajete Betinke,* ranije (crvena crta) i današnje, prema Šimi Šandriću [13]**

The typical ship lines and construction design of the traditional *Gajeta Betinka* fishing boat, made by an old Betina shipbuilder, named Šime Šandrić, have been chosen to be the representative of the class (Figures 22 and 23) [13].

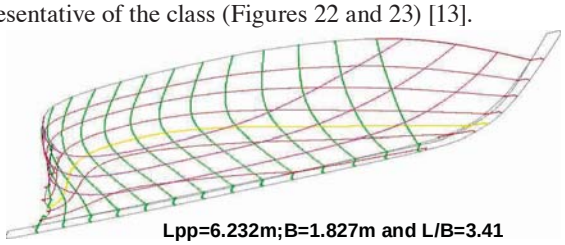
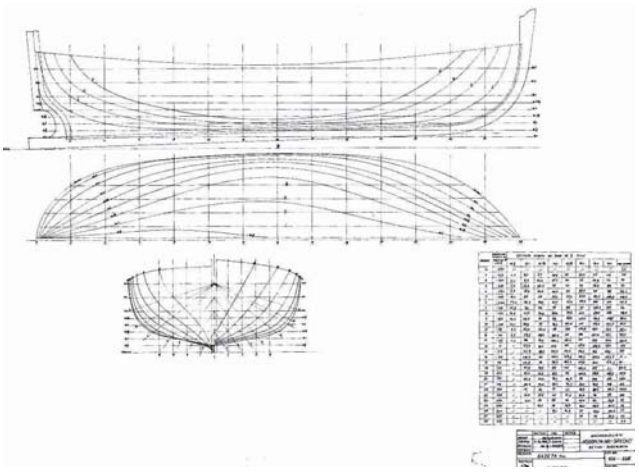


Figure 21 **The computer 3D simulation of the *Gajeta Betinka* form designed by proto master Šime Šandrić [13]**
Slika 21 **Računalna 3D predodžba forme *Gajete Korčulanke* prema protomeštru Šimi Šandriću [13]**

Figure 22 **The ship lines of the *Gajeta Betinka* designed by proto master Šime Šandrić [13]**
Slika 22 **Brodske linije *Gajete Betinke* prema protomeštru Šimi Šandriću [13]**



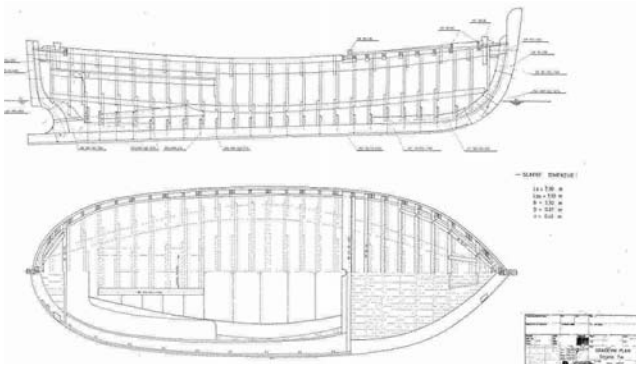


Figure 23 **Construction design of *Gaeta Korčulanka*, as proto master Šime Šandrić used [13]**
Slika 23 **Konstrukcijski nacrt *Gajete Korčulanke*, korišten od protomeštra Šime Šandrićaa [13]**

Figure 24 **Typical *Gajeta Betinka* – "Cicibela", form today in Betina according to the design of protomaster Ćiro Burtina [13]**
Slika 24 **Tipična *Gajeta Betinka* - "Cicibela", današnja forma u Betini protomeštra Ćire Burtina [13]**

Table 2 **The main characteristics of the *Gajeta Betinka* fishing boat (built according to the lines designed by Šime Šandrić), analyzed by Fung and Holtrop computer program [3]**
Tablica 2 **Glavne značajke *Gajete Betinke* - ribarice (izgrađene prema linijama Šime Šandrića), analizirane prema Fung i Holtrop računalskom programu [3]**

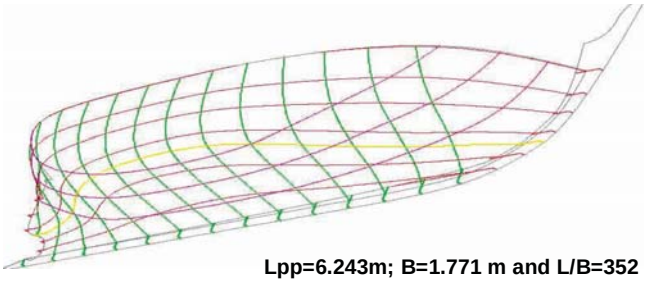
CHARACTERISTIC	Units	Holtrop	Fung
LWL	m	6.232	6.232
Beam	m	1.827	1.872
Draft	m	0.4	0.4
Displaced volume	m^3	0.977	0.977
Wetted area	m^2	8.908	8.908
Prismatic coeff.		0.556	0.556
Waterplane area coeff.		0.611	--
1/2 angle of entrance	deg.	11.93	11.93
LCG from midships	m	-0.423	--
Transom area	m^2	0.006	0.006
Transom draft	m	--	0.097
Max sectional area	m^2	--	0.282
Draft at FP	m	0.4	0.4
Deadrise at 50%LWL	°	13.77	-

Today, more than 30 active shipbuilders in wood live and work in Betina. The well-known shipbuilders, judging by the

quality and quantity of their boats of the *Gajeta Betinka* type are Ljubomir–Ante Fržop, Šime Šandrić and Čedomir-Ćiro Burtina.

3.3 About the *Gajeta Lovranka*

The *Gajeta Lovranka* was also built under the influence of the Korčula wooden shipbuilding "school", remarkably latter, when the shipbuilder from Lovran (Istria) Giovanni (Nino) Gašparinić spent some time in Korčula in 1950 learning the Korčula's wooden building boat technology, without using the original old construction method *Mezzaluna-buška*. After returning to Lovran, he together with his followers, Franko Sirotnjak and Ivan Kalčić, retained the basis of Korčula's building technology of wooden boats and adapted the original Korčula's form to the Istrian littoral conditions, introducing many innovations. The boat had a short mast for supporting the awning, and was operated by two short oars and an inside diesel engine. Her form was designed for sports fishing, family cruising and tourist cruising as a pleasure boat. Her form is also known as *Lovranski guc*. The typical ship lines and construction design of the traditional *Gajeta Lovranka*, made by the late Lovran shipbuilder named Giovanni -Nino Gašparinić, have been chosen to be the representative of the class (Figures 26 and 27) [3].



Lpp=6.243m; B=1.771 m and L/B=352

Figure 25 **The computer 3D simulation of the *Gajeta Lovranka* form designed by proto master Nino Gašparinić [3]**
Slika 25 **Računalna 3D predodžba forme *Gajete Lovranke* prema protomeštru Ninu Gašpariniću [3]**

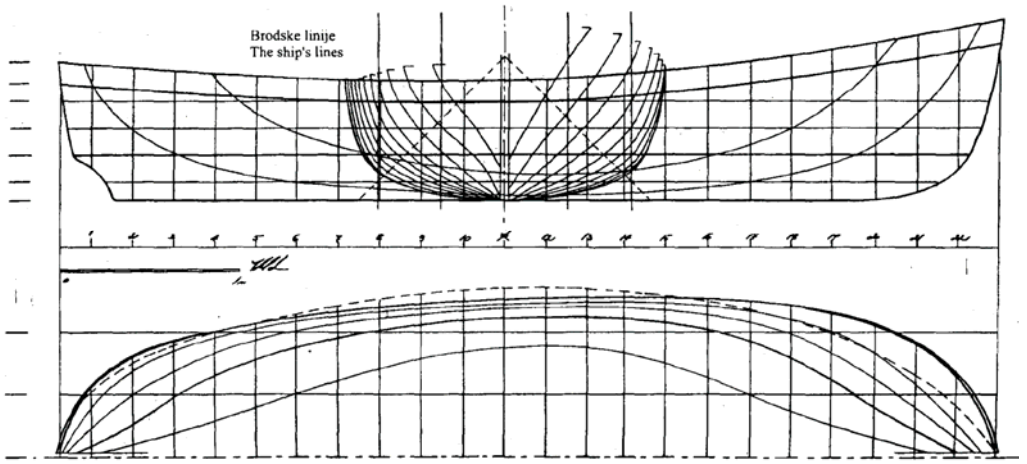


Figure 26 **The ship lines of the *Gajeta Lovranka* designed by proto master Nino Gašparinić [3]**
Slika 26 **Brodske linije *Gajete Lovranke* prema protomeštru Ninu Gašpariniću [3]**

Figure 27 **Construction design of the *Gajeta Lovranka*, used by proto master Nino Gašparinić [4]**
Slika 27 **Konstrukcijski nacrt *Gajete Lovranke*, korišten od protomeštra Nina Gašparinića [4]**

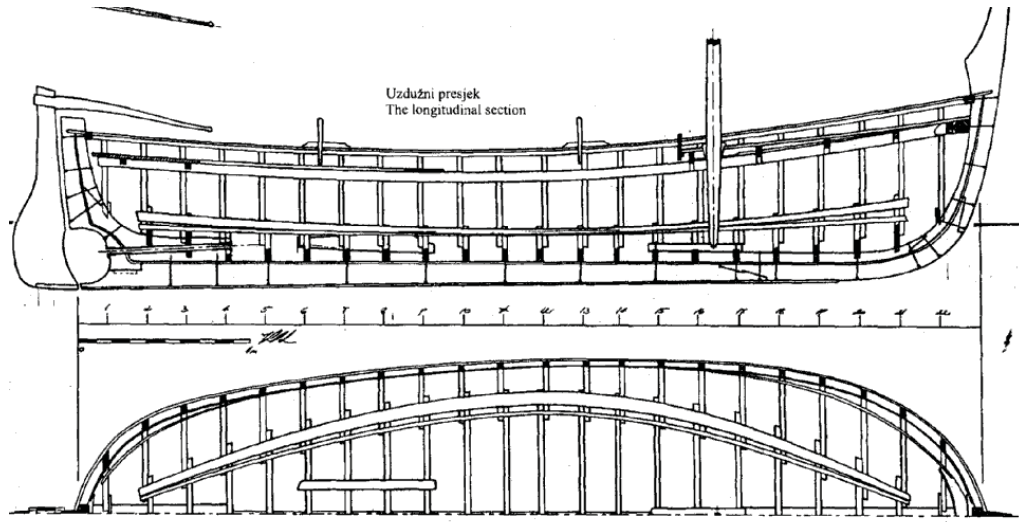


Figure 28 **Typical *Gajeta Lovranka* - fishing and touristic pleasure boat form today in Volosko (Istria) [3]**
Slika 28 **Tipična *Gajeta Lovranka* - današnja ribarica i brodica za turističke svrhe u Voloskom (Istra) [3]**

Table 3 **The main characteristics of the *Gajeta Lovranka* fishing boat (built according to the lines of Nino Gašparinić), analyzed by Fung and Holtrop computer program [3]**
Tablica 3 **Glavne značajke *Gajete Lovranke* - ribarice (izgrađene prema linijama Nina Gašparinića), analizirane prema Fung i Holtrop računalskom programu [3]**

CHARACTERISTIC	Units	Holtrop	Fung
LWL	m	6.243	6.243
Beam	m	1.771	1.771
Draft	m	0.4	0.4
Displaced volume	m^3	1.156	1.156
Wetted area	m^2	8.65	8.65
Prismatic coeff.		0.545	0.545
Waterplane area coeff.		0.576	--
1/2 angle of entrance	deg.	10.82	10.82
LCG from midships	m	-0.306	--
Transom area	m^2	0.001	0.001
Transom draft	m	--	0.007
Max sectional area	m^2	--	0.34
Draft at FP	m	0.4	0.4
Deadrise at 50%LWL	°	16.75	-

3.4 Short analysis of the forms comparison

A short analysis of the performed comparison of the forms using 3-D models and frames, waterlines and buttocks is presented in Table 4, Table 5 and Table 6.

3.4.1 The 3-D models and frames analysis

Table 4 **The analysis of the comparison of 3-D model and frames [3]**
Tablica 4 **Analiza usporedbe 3-D modela i rebara [3]**

Gajeta Korčulanka	*Gajeta Betinka*	*Gajeta Lovranka*
- small deadrise (bottom angle) 5.1°	*-bigger deadrise (13.77°)*	*-the biggest deadrise (16.75°)*
-bigger radius at the bilge	*-smaller radius at the bilge*	*-bigger radius at the bilge with the frames inclined outside*
-"S" frame form with a small entangled at main rail	*-flatted and straightened stern frames*	*-slim bow frames, enlarged V form, at the main frame pass to U form, sharpened V frames form at stern*
- wetted area at main frame: 9.066 m^2	*-smaller wetted area: 8.908 m^2 with the changeover from V to U form*	*-the smallest wetted area: 8.65 m^2*
- more masterful knowledge and exactness needed	*- less masterful knowledge and exactness needed*	*- less masterful knowledge and exactness needed*
- smaller breadth and smaller resistance	*- higher breadth and higher resistance*	*- higher breadth and higher resistance*

3.4.2 The waterlines analysis

Table 5 **The analysis of the comparison of waterlines [3]**
Tablica 5 **Analiza usporedbe vodnih linija [3]**

Gajeta Korčulanka	***Gajeta Betinka***	***Gajeta Lovranka***
- WL rounded at bow and sharpened at stern	*- rounded above part of bow form*	*- rounded above part of bow form*
-underwater part shaped as the fish body	*- sharpened underwater part of bow form*	*-sharpened underwater part of bow form*
-elliptic WL, and changeover to stern part at 2/3 Lpp	*-changeover to stern part at ½ Lpp*	*- changeover to stern part at ½ Lpp with symmetric passing*
-LCG from midship at -0.098 m	*-LCG from midship at -0.423 m*	*- LCG from midship at -0.308 m*
- smaller 1/2 angle of entrance WL (10.48º)	*-the biggest ½ angle of entrance WL (11.93º)*	*- bigger 1/2 angle of entrance WL (10.82º)*
- with bigger camber and sheer has higher reserve displacement	*- with smaller camber and sheer has a smaller reserve displacement*	*- with smaller camber and sheer has a smaller reserve displacement*

3.4.3 The buttocks analyze

Table 6 **The analysis of the comparison of buttocks [3]**
Tablica 6 **Analiza usporedbe uzdužnica [3]**

Gajeta Kočulanka	***Gajeta Betinka***	***Gajeta Lovranka***
- buttocks slightly rounded at the bow	*- buttock flatted and sharpened at the bow*	*- buttock flatted and rounded at the bow*
- buttock form slime at the stern	*-buttock form rounded at the stern*	*- buttock form laid at the stern*
- buttock concentrated to the bottom	*- buttock concentrated to the bilge*	*- buttock concentrated to the bilge*
- displaced volume: 0.641 m^3	*-higher displaced volume: 0.977 m^3*	*-the highest displaced volume: 1.156 m^3*
- slim form with Cb = 0.525 and Cm = 0.567	*-rounded form with Cb = 0.556 and Cm = 0.611*	*-smaller rounded form with Cb = 0.545 and Cm = 0.576*

4 The final three forms comparison

Based on the presented short analysis of the considered forms and the comparison of P-v (power-speed) diagrams (Figure 29) it can be undoubtedly concluded that the form of the *Gajeta Korčulanka*, in comparison with the *Gajeta Betinka* and the *Gajeta Lovranka* has the most exquisite form and maritime characteristics.

In Korčula's shipbuilding, over the centuries, the touching planks method has been used to obtain the ideal form resembling very much the framework form. This method is very demanding and more complex than all other methods, as it requires good knowledge of shipbuilding and much experience. However, the boats/ships built following this method had the longest life (more than 80 years).

The wooden material had to be located in natural environment, sampled and prepared in right size, which required practical experience.

With respect to the main frames (two, the very same, the bow, and stern on the Lpp/2), the centre of gravity (LCG) of the *Gajeta Korčulanka* was slightly moved towards the bow (0.2-0.4 m), since fishermen used to row for hours, first at the speed of about 6 knots (at the beginning) slowing down to 3 knots (at the end), covering the distance of about 30 Nm, which was an extraordinary solution. However, later, when the ship was powered by the internal main engines operating at a higher speed, the centre of gravity (LCG) and the centre of buoyancy (LCB) of the boat were slightly moved towards the stern (0.2-0.4 m) from the stern main frame, which was also an excellent solution, even in the motion with full cargo.

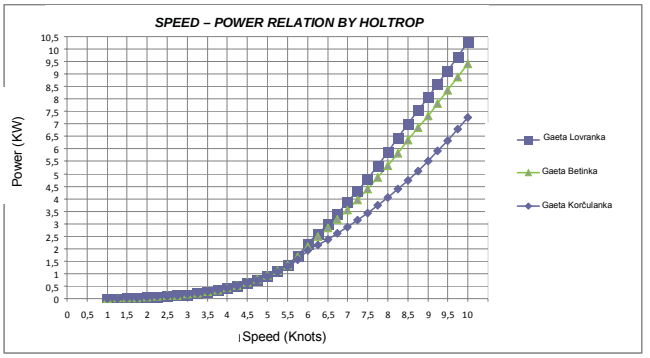


Figure 29 **The comparison of power-speed diagram of the *Gajeta Korčulanka*, *Gajeta Betinka*, and *Gajeta Lovranka* whose design is based on the same original Korčula's form, by Holtrop [3]**
Slika 29 **Usporedbeni dijagram snaga-brzina *Gajete Korčulanke*, *Gajete Betinke* i *Gajete Lovranke* [3]**

Table 7: **Numerical values of the sharp distinction power-speed domains [3]**
Tablica 7: **Numeričke vrijednosti značajnijih razlika područja snage-brzine [3]**

SPEED (knots)	**POWER (KW)**		
	Korčulanka	***Betinka***	***Lovranka***
5	0.87	0.93	0.91
6	1.92	2.1	2.17
7	2.87	3.56	3.85
8	4.04	5.34	5.87
9	5.51	7.33	8.06
10	7.25	9.42	10.27

The fish-like form of the *Gajeta Korčulanka*, i.e. *testa d'orada-coda di brancin* [3] shows some advantages when her maritime characteristics, maneuvering ability, speed and resist-

ance are compared with the *Gajeta Betinka* and the *Gajeta Lovranka*, built according to the same original Korčula's form, but adapted to the local maritime conditions, which can be seen in the power-speed diagram in Figure 29, as well as in considerably different numerical values in power-speed domains for the *Gajeta Korčulanka*, the *Gajeta Betinka*, and the *Gajeta Lovranka* (Table 7).

The form, finesse, master quality, aesthetic and demanding craftsmanship applied on the *Gajeta Korčulanka* have contributed to her highest ranking among all small wooden boats in the Adriatic, as well as in the Mediterranean [3].

5 Conclusion

According to this short analysis in which the form, speed and the required power of the considered boats are compared, the *Gajeta Korčulanka* proves to be the best fishing wooden ship in the class of small fishing wooden boats. Her quality was well-known along the whole Adriatic Coast thanks to the masters who transferred their experience to other parts of the Adriatic and the Mediterranean, and adapted their own traditional Korčula design to the needs of local sea configurations and demands of local ship-owners (Betina, Trogir, Lovran, even Malta in the Mediterranean Sea).

As Seneca, a long time ago, said: "The boat is good, not if she is decorated with expensive paints, nor for other outer effects, but she is good if she has good stability, impenetrability, if she is strong and resists the waves, subservient to the rudder and susceptible to the wind" [10]. This traditional fishing boat form from Korčula meets all these requirements.

The long and very successful shipbuilding tradition, good and unique system of wooden boat construction named *Mezzaluna-buška* and excellent forms suitable for various types of wooden boats and very useful for all situations at sea, have earned the Korčula shipbuilding "school" the first place in the Adriatic wooden shipbuilding, and undoubtedly one of the highest ranking positions in wooden shipbuilding heritage in the Mediterranean.

The Korčula shipbuilding "school", especially the *Gajeta Korčulanka* - fishing boat (her form, design, structure and building) is not only a system of joining different constructive elements together. These boats were the souls of their masters who knew very well how to produce, from the "chaos" of available different materials and constructive parts, the "cosmos" of the boat forms. There lies the secret.

Korčula's shipbuilding and its masters had been known all over the Adriatic and Mediterranean coast in the ancient times. They were building all kinds of wooden boats, from the smallest ones to the largest ones, as well as the steel ships and ship outfitting, for different owners from Korčula to numerous ordering parties outside of Korčula. Their work always was characterized not only by the solidity of construction and good building technology but also by finesse of the ship's form and excellent maritime capabilities, owing to the use of special Korčula's construction method, the so called *Mezzaluna-buška*". Unfortunately, only a few of the wooden boat masters of the much known Korčula's shipbuilding "school" are active in Korčula today, and one of them is on Lastovo Island. And finally, with the thousands of years old love for naval architecture and its long life tradition in shipbuilding, Korčula Island generated, only in the past century, more than 20 graduated naval architects, 12 shipbuilding engineers, 15 shipbuilding technicians, 60 protomasters, more than 350 shipbuilders in wood, more than 500 shipbuilders in steel, and 5 university professors in the area of naval architecture [3].

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