This article was written by Herbert Wenskus in German and I tried to translate it with automatic support. Please forgive all the mistakes and miss-understandings - it was the biggest opus I've ever done. Othmar Karschulin - www.multihull.de

Does the Proa still have a future?

'If you wish to preserve things you must change them' (Tomaso di Lampedusa)

Admittedly, the title of this contribution may irritate some adherents of the Proa concept. But what is the situation? It does not do to think that the Proa, which is regarded as the fastest historical sailing vehicle, has not yet made a break-through in modern times. Attempts to establish this type - (also in the racing scene) - were surely not missing. The experiments were however rather disappointing. But therefor are reasons. The speed potential is one thing, the basic conditions which must be fulfilled in order to reach this potential, is another.

The special wind -, sea -, climatic -and operating conditions, under which the Proa developed, are not the same like in our high latitudes. In the Tropics there are better conditions for sailing a Proa than with us. But this is not the only reason, why this type became forgotten. There are also the changed technical conditions, which brought catamaran and trimaran forward in the multihull-scene. The technical possibilities have determined the development of shipbuilding today much like in those days in the South Seas. I am against a "Sanctification" of the Proa. The Proa is not an idol, no "non plus ultra", that has no more room for improvement. As surely as the Dutch windmill represents the summit of a century-long technical development, so surely we would prefer different technical solutions, if we must grind our grain again with wind power today . All technical solutions are only one intermediate step on the way to the next better solution! There is never an end of development, also with the Proa.

I. Technical and basic conditions of the historical Proa

Thesis 1:

The historical Proa owed its development to the inadequacies of the available boat building material.

The early discoverers and the scientists later reported that double boats (thus the forerunners of our catamarans) and Proas often existed next to each other and that between them existed a certain functional division. The double boats were preferably used as cargo boats for all possible goods and for long journeys, while the outrigger canoes were used rather for exploration and courier travels. During the preparation of the journeys with the double boats one paid attention very carefully to the weather development and one avoided journeys in heavy weather. This had a good reason. As we know from catamarans, the hulls operate mostly in different wave systems, which causes substantial torsion loads on the bridge/beams depending upon loading. These forces threatened to loosen the cocos fibre lashings, with which hulls were connected with the bridge. The danger that the boat connection structure would come apart in heavy weather was always present and was always emphasized in the contemporary reports. These loads, not the danger of a capsize, were the main problem of the double boats. Metals, which would have made a more permanent and stronger connection of the sections possible, were not available.

We know of the Micronesian Proa, which is equated mostly with the flying Proa, that the described weakness of the traditional double boats was structurally avoided, as the size of the Ama was minimized and besides on journeys it was attempted to keep the Ama flying which continued to lower the load on the bridge (beams) and its connections. That thereby another speed increase resulted, the Oceanics have enthusiastically welcomed. The easy flying Ama was therefore an important condition for the preservation of the structural integrity of the hull structure and its connections. The Oceanics have made a virtue from difficulty. On the double boats the idea to fly the windward hull was completely impossible because of the flexible connections. Such pressing would not have got the Polynesian double boat over the seaway without damage. Nevertheless these double boats in the given technical conditions were shipbuilding masterpieces. Before this background the question come into view whether the Oceanics would have developed the Proa at all, if they had not had the problems of structural integrity with their double boats. The question is not exaggerated as the flying Proa has some serious weaknesses, which limited their use at that time like today:

(1) High tendency to capsize. The Proa gets its stability almost exclusively from the living ballast, i.e. from the ability of their crew to hold the Proa in equilibrium by shifting their weight (that this at the same time its largest advantage, is another thing). This requires highest concentration and reactions of the crew, because we have to work here with unstable equilibria. We remember: As soon as the Ama flies, we already are on the descending branch of the stability curve!

(2) The Proa can't stay autonomic (aside of days without wind). It must be sailed from the crew with permanent concentration. Nevertheless capsizeing was not rare also at the trained Ozeanics. The Proa missed the 'buffer of stability' of the double boats which gives them more security at gusty weather and at night.

(3) The most dread situation on a Proa was back wind and an Ama to leeward. Then capsizing was unavoidable by the small buoyancy of the Ama. Then the danger rises of capsizing 180 degrees and much more dangerous - that the Aka would crack by the high speed and the great twisting force.

(4) Because of the small buoyancy of the Ama the Proa was very sensitive in trimming, it's capacity of load limited. On several islands of Micronesia was tried to optimize load and trim using a lee pod.

The advantages of the Proa must be paid with high virtuosity in boat handling of the crew.

II. The Mirconesian Proa as the racing yacht of the future?

Thesis 2:

The necessity to introduce the Micronesia Proa as racing boat are not relevant, because today catamarans and trimarans could sail with a flying luff or main hull otherwise as at the time of the old double boats.

I ask myself, why one should use a Proa as a racing boat, if hightech cats and tris can fly the hulls/ amas already at 12 knots of wind or earlier without the special Proa problems like rudders, rig and shunting. Where should be the Proa's benefit? Could the small advantage of less weight and less wind resistance countervail the difficulties in handling? And how good is the capacity of resistance in heavy weather? The wind on open sea doesn't blow in the same steadily manner and the sea is often very rough, what makes the theoretic considerations mostly irrelevant.

Isn't it characteristically, that the 'Crossbow', exclusively built for high speed records would be later replaced by the 'CrossbowII' - a catamaran? May be though sometimes someone will do it to establish an Micronesian Racing Proa , perhaps because the claims are high for the crew like in 'Liberas' or 'Australian Skiffs'. Probably Racing Crews will first climb on foilers as struggle with the 'climbing wall' of a capsized Proa.

III. The Micronesian Proa as a model of a crusing yacht

I think the reasons, which speaks against the Proa as a Racing Yacht, are the same and more against the use as a Cruising Yacht. For cruising the Micronesian Proa is not useful by he following reasons:

A lot a the potential in speed is crucially dependent from the action of the 'living ballast', from the ability and the readiness of the crew to keep the ama flying by shifting their weight. The problems begin already with the recruitment of the crew. The procurement of a sufficiently strong and skilful crew for trimming might not have a problem with the South Seas peoples. In the crusing today it looks quite differently. Normally you sail singlehanded and undermanned. So the Proa (aside of small Proas for the lagoon travel) will come fast into difficulties and their average speed will disappoint. The Micronesians have had a long training untill they were perfect in handling their Proas. In our times there are only professional sailors on their racing boats comparably, which are skilful to sail 'flying'. For cruisers it's normally not possible to get such experiences. Also the conditions are not the same to make fast journeys. The Miconesians have a constant Passat, an equable seaway and tropical temperatures, which allow to stay on the (beam)bridge for days. I don't think that it's possible in our latitude to send a crew for longer as an hour onto a spumed and choppy bridge (in cold water), with the imagining to threw 10 or 20 m into the air by a heavy gust like a stone in a catapult.

The pictures of the record runsof the Proa 'Crossbow I' give of it an idea (there a crew member is to have always led a sharp knife in the hand to be able to cut the sheets in case of emergency). On the mikronesischen Proa in most cases it was possible to rigthen the capsized Proa again with the united power of the crew. Without considering that todays cruising sailors has no chance to get a numerous crew, this maneuver would be - because of the water temperatures - no game for children. Which cruising sailor would like to sit permanent in a diver suit? To high-motivated racing crews, which are able to sleep sitting on the high edge, these objections may not apply to. As always said before, the Proa cannot leave itself. It is trim sensitive and has the dangerous inclination to capsize over the Ama when backwinded. This characteristic will become fast a problem on longer trips, in heavy weather, cold weather or at night (a cruising yacht must be night suitable!), in particular, if the Proa is under-manned. It is not forgiving errors!

The development of the mikronesischen Proa to a cruising yacht seems not to be successful. It is altogether too complicated, it is very exacting to their crew untill artistic claims. Especially the Proa shows, that theory and reality are divided far away.

IV. Historic experiences

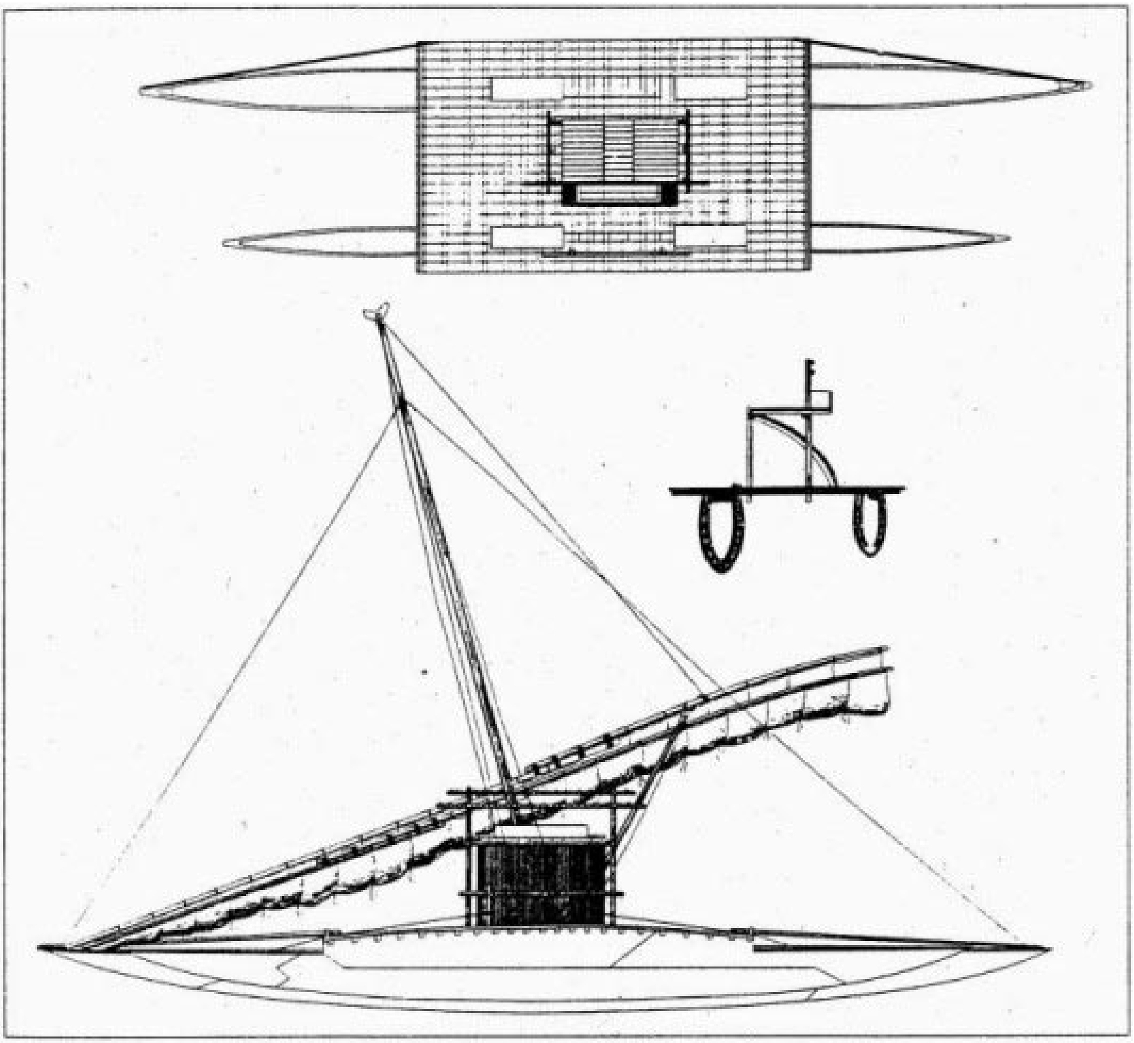
'The sea konws no fashion, the laws be valid from the beginning' (Joseph Conrad) (Beg you pardon. Joseph. OK)

Should the idea of the Proa move in the museum? Not at all. The Proa concept is not limited in the Micronesian model, although the discussion is mostly fixed on this type. There are Proa types, which I consider are more evolved. A view into history is helpful. The Pacific was over centuries an intensively used research laboratory for the development of multihulls. In relation to the purely theoretical view the historical research has the advantage, that one view thereby ship forms and special features of handling which already have passed the practice test. So you have not to try to invent the wheel again. This comes also to a result, but continues longer and costs more. A true quarry for authentic information about the multihull development in the Pacific are the books of: 'Canoes of Oceania' of Haddon and Hornell, which I can recommend everyone who is interested in the topic.

V. The end of the historical multihull development

It is not well-known that the double boat, the model of our modern catamaran, was outdated in the final phase of the autonomous Polynesian culture. On Fiji, the interface between the Polynesian, Micronesian and Melanesian culture, was the double boat of the type 'Tongiaki' (a 1:2 reproduction is in the ethnological museum of Berlin), at the time of journeys of James Cook already a running out model. It became rapidly replaced by the 'Ndrua', which after exported to Tonga were named there 'Kalia' .

The Ndruas/Kalias, of which Admiral Paris has left the drawing of an impressive exemplar of 15,5 m length, are no more tacking like the old double boats, they shunt like the pure doubleender - the flying Proas. Also the mast was amidship on the luff board of the main hull. The sail (crabclaw) was equivalent to the Micronesian latin sail, however with fewer spreading and with curved spars instead of straight ones. The observation platform on the drawing of Admiral Paris shows - how the mast



support on different Mikronesian Proas - the function to prevent the mast tilting to the Ama side.

Obviously the development of the Ndrua was started by contacts of the Fijian with the Micronesian. The flying Proa originating from Mikronesien must have impressed the Fijians because of their superior speed and also perhaps because of their maneuverability with the oceanic latin sail. The Fijian developed also its own flying Proa type with the name 'Thamakau' (on Tonga: 'Hamatafua'), which differentiate from the micronesian Proa in the hull by missing asymmetry and the small freeboard in front and aft. This hulls were 'wave piercer', like the Ndrua/Kalia of Admiral Paris drawings, which cut the waves smoothly. This confirms the report of Th. West about a fast trip with a large Ndrua in strong wind in 1865.

VI. Features of the Ndrua/Kalia

The most remarkable difference between the flying Proas (and Thamakaus/Hamatafuas) on the one hand and the Ndruas/Kalias on the other hand consisted of the fact that the Ama of the Ndruas/ Kalias was clearly larger. This was a dug out out like the main hull and showed the same construction features. The Ama of the Ndruas/Kalias might have been able to carry the ship weight. Further characteristic of differenece is the evident smaller width over all of the Ndruas/Kalias, which is commensurably with the double boats. The Kalia after the drawing of Admiral Paris shows with a length of 15.5 m width over hulls measured of even 3.1 m (with a total width of 3.7 m).

The rapid expulsion of the traditional double boats of the type Tongiaki by the Ndruas/Kalias might cause on the following factors :

- The Ndrua was reputed as more maneuverable and more seaworthy. For tacking the bow must no more pass through the wind, which brought known problems from catamatans with wind and waves.
- The building process was facilitated by the smaller Ama, the problems of the structural firmness were reduced. An additional benefit was saving weight.
- Less weight, less draft of the Amas and less wetted surface produce better sail performances.
- The use of crabclaw sails, which could be more steeply set with the higher mast than the sail of the Tongiakis resulted in better performances on sailed courses closer to the wind.
- Because the Ama was shorter than the main hull, the hulls hit the waves simultaneous during sailing close hauled. This reduces the load on the laschings and the life on board improved.

There are reports that Ndruas were built up to a length of 118 feet and that up to 250 people on them could be transported. The building period of a Ndrua was generally seven years. Thomson said about the speed: 10-15 knots on a half wind course. West told us, that the boats are sailing close to the wind up to 3 lines? (35 degrees). In addition you can read at Haddon and Hornell:

„The one course the ndrua could not sail on was with the wind directly aft; the great weight of the sail, held down at the tack to the head of the canoe, combined with the pressure of the wind upon it, caused the canoe to run under instantly when set square before the wind.“

The Ndrua had to tack before the wind to avoid submerging the bows. The small freeboard of the 'wave piercing' hulls was a result of the limitation on the diameter of the available trunks, which formed the base for keeping the longitudinal rigidity of the long hulls. This is a further design feature, which was due to the technical possibilities at that time.

It must have had its reason, why in Fiji and Tonga - after the contact with the Micronesian Proa - beginning at this time the Ndrua/Kalia was built as an independent boat type for long journeys as a substitute of the 'old' double boats. Obviously this ship type had advantages versus the Micronesian Proa. These were in particular:

- The large volume of the Amas protected the boat for the dangerous capsizing when the sails come aback. The Ndrua/Kali could leave autonomous for a time during sailing.
- The voluminous Vaka allows a higher additional load and made the boat less sensitive against bad trim than the Micronesian Proa. The weight of the Amas, which could be increased by appropriate distribution of the load, granted more stability if necessary.

By the way it was not the size of the boat which determined the selection between the Thamakau and the Ndrua. The Thamakau was built nevertheless also up to lengths of 100 foot.

VII. In the trap of stability

Thesis 3:

The large advantage of the flying Proa was their 'variable stability', which allows to minimize the water resistance.

It might be indisputable that the marvelous speed of the historical Proas were dependent from the fact that their stability could be flexibly adapted to the wind and sea-conditions with living ballast, so that the water resistance was minimized by flying the Ama. The small basis stability, which could be variable increased, represented a substantial advantage.

Thesis 4:

Unused stability is harmful.

A comparison of the double boats of the Polynesier with the modern Catamarans shows immediately that they are substantially wider. The frights of capsiszing on open sea led to the fact that the designers of cruising multihulls draw their vehicles increasingly more wider for the increase of the lateral stability. In some cases the length/width relation of these monsters already approaches the value 1: 1. For the alleged security by the large width the catamaran sailor pays a high price:

- The construction becomes more expensive, complex and finally heavy to control the masts pressure. The CE of the total boat moves higher?
- The distance beteween (beam)bridge and water surface must be increased
- Creeping grow the dangers of the insufficient longitudinal stability
- The Catamaran plows with both hulls the water and fights particular in light winds against the high resistance of both hulls.

How important the last feature is, shows the clear superiority of a well designed trimaran at light winds, while it runs on the main hull with the Amas outside the water (with increasing wind it becomes again more similar to a catamaran). The Catamaran sails with a large starting stability, which is not needed most time, but slow down the boat all the time. In this point there are a parallels to a mono.

Now one could say, I'm willing to pay this price for security, if thereby security were given against the capsizing. Unfortunately it is not. The sailor on a sturdy cruising multihull can feel never quite safe. To capsize by heavy gusts or big waves are always possible. And if the very wide and 'secure' multihulls heel? Is an angle of 90° reached - nothing stops the movement until the boat has turned to the back.

Near to the coast, in warm water and in races with appropriate support capsizing may acceptable. But what happens under other condtions: Far from the coast, wait weeks passively for rescue is always a disaster! Also escape hatches and the knowledge not to sink cannot convince me to the opposite. Understandably that designers and cruising sailors beware of use the stability to it last. The fear of capsizing are always with you. In doubt the multihull sailor most time uses a small sail area to increase security, especial at night. This might be also the reason, why the average speed of the multihulls on longer journeys not much differs from that of Monos. The circumstance that the capsizing cannot be excluded, lets me doubt to the sense of this strategy of safety.

VIII. The other beginning: Ability to uprear

Why the large majority of sailing peaople buy still Monos with it's clubfoot and all the disadvantages like sinking, big draft, slowness, permanent heeling, etc.? Because they can trust in the fact that the ship, once flat on the water, turns back again like a skip-jack. I allege this is the crucial reason for purchase a Mono. What would happen, if the multihulls could offer the same ability?

Thesis 5:

Not the avoidance of capsizing, but the ability to uprear should take the first place in the considerations.

After capsizing I would like to be able uprear the boat by myself to continue my trip without help from outside. Without support of any salvage enterprises which only damage the boat. If the problem of uprear is solved , I can dedicate with much more composedness in the stability question, work again with variable stability as traditional on the flying Proa. I am not more subject to the temptation to buy security by extreme width, which additionally slow down my speed.

IX. The Ndrua as model of a seaworthy cruising yacht

The Ndrua with-one-and-a-half hulls is historically the recent Proa development. It unites the advantages of the Micronesian Proa and the Polynesian double boat. In short: It is a Proa with voluminous Ama and small width. Could the Ndrua be the model for the cruising yacht of the future? I think, yes! It has all qualification thereto especially the possibility of uprear after capsize without outside assistance.

The Ndrua has the advantage to have passed her practice test as cruising ship during a period about 100 years. It proved sufficiently that it combines speed, load capacity and security. With modern building materials, which are on hand today, it would become still more efficient. One could even try to fly the Ama. It offers with its distribution of buoyancy between main hull and Ama to be able to sail alternating as Pacific and as Atlantic Proa, eg. to tack in narrow waters.

The Polynesians experimented proved with large variety of frame designs. The asymmetrical hull of the Micronesian Proa was not taken over by the Polynesians however. The Fijians has used a round frame or elliptical frame with their flying Proa 'Thamakau' and with the Ndrua. From measurements in test tanks we know that the asymmetrical frame has a higher resistance than that round frame. This experience had to make also Rudy Choy. That round frame gives also more security during 'wave-riding' in storms, because the boat has less resistance when drifting, especially if the daggerboard is in the Ama or lift up if in the main hull.

The temptation is large to copy the elegant model of the Ndrua like seen at the drawings of Admiral Paris, but I think that a modern seaworthy cruising yacht need same changes:

- A reliable construction, which turns the Ndrua after a Knockdown automatically again into the upright position.
- A reliable solution, to uprear the ship single-handed again after capsizing.
- A reliable helm, which can be used by a single person without effort?
- A rig, which can be used by small crew and allows tacking in narrow space.
- More freeboard at the ends of the main hull, to avoid the submerging if sailing beam reach.

With modern high-strength building methods, with which the Ndrua could fly their Ama too, it would be interesting to compare it with the Micronesian Proa. Weight and air resistance of the larger Ama of the Ndrua might be partly compensated by the shorter bridge deck. Due to its strengths the Ndrua could sail harder and longer under rough conditions and might reach higher average speed especially the long distance.

1. The capsize recovery function

„At sea, where failures are the rule, equipment should be kept basic and simple.“ (Frank G. Bilek)

The uprear without other assistance is a central topic since beginning of the multihull development. Relevant attempts with catamarans and trimarans are not convincing till today. This might have primarily the cause in the geometry of these multihulls. How we have read, is no chance to hold such very wide boats with their central mast in a 90° horizontal position and to beware them of total capsizing. And after capsized they have an enormous stability against uprear actions.

With the Proa it looks better to hold it in a stable lateral position, because of the mast position. Now we have to concern with the question of the uprear function. Both situations (90° and 180°) require different concepts. Only uncomplicated, reliable solutions are useful. One may expect not much action of a crew in such an extreme situation.

1.1 Fall A: 90° capsize

With sufficient buoyancy in the mast the traditional Proa should remain after capsizing in a 90°-position. But how I turn it again into the upright position? And how I can avoid a to fast reaction? In my opinion are solutions, like casting the rig or bending the mast to lee with winches (e.g. 'Gourgeon 32') are to complicated and unsafely. They work only on paper or on a smoothly lake. Their largest deficiency is that these concepts require a full powered crew instead a lot of ship wrecked sailors. This imagining is not very encouraging, so I prefer a solution, with which the crew must intervene as few as possible.

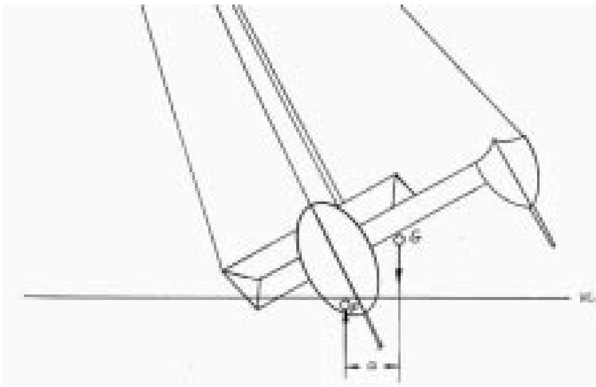


fig. 3

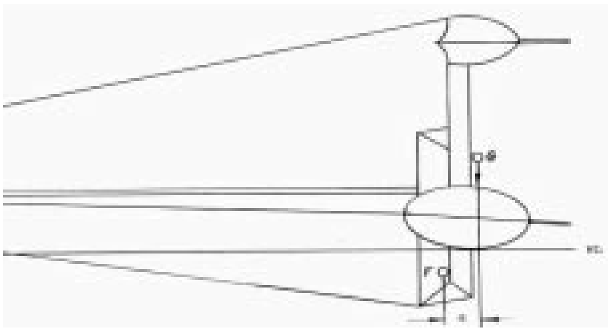


fig. 4

This solution is already present: For years Russel Brown on his Proas practices successfully the solution with the additional buoyancy in Lee by an extension of the cabin roof after Lee (Lee Pod). It returns the Proa not only from a 90° heel , but - and that is important - with immersing of the pod the falling stability curve begins to rise again (at the Proas of R. Brown this starts already in a angle fewer than 25°) and stays beyond 90° in the positive range. It is similar to the curve of a Monohull in this range (fig. 2 and 3). This very important in the daily work, because it avoid that the Proa become throw down in full speed, which is not very pleasant, yet dangerously. This component gives you the safety you need to sleep aboard whilst sailing and to carry more sails.

The lee pod resembles the lee platform, which was used on the flying Proas of different archipelagoes of Micronesia. But this didn't produce buoyancy, except there were loaded with coconuts. The pod offers also a good base for the rig and sail fittings, if a standard Western Rig was used. The volume of the pod, should not exceed 100 % of the displacement. The line of the stability curve can be adapted to the needs by an individual shaping of the pod. Unfortunately R. Brown has merged its invention till today only with the model of the Micronesian Proa and not with the Ndrua design. Thereout may be arise some of his problems. In an interview he explained:

'The big danger is getting caught aback. It´s never happend to me in tough conditions, but I worry about it. I have trouble sleeping while someone else is sailing my boat. A good trimaran will take care of itself, but a proa won´t.'

This problem must have to be solved with the Ndrua.

1.2 Fall B: 180° capsize

It is well-known that all ships under certain circumstances can capsize 180° heavy keel yachts too. Differently as with cats and tris capsize with the Ndrua should be the exception (perhaps in very heavy sea). By of the distribution of the buoyancy of the Ndrua an automatic recovering cannot be expected.

A reliable solution:

- Flood the Ama by opening the valves
- After this the Ndrua turns by itself in an inclination of approx. 60 ° direction to the Ama (fig. 4 and 5) (correct distribution of the buoyancy presupposes).
- Evacuate the Ama until it emerges.

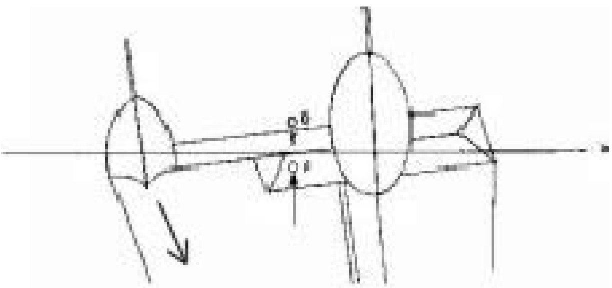


fig. 4

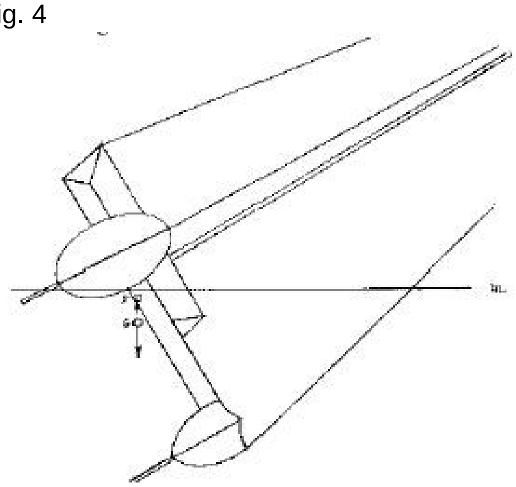


fig. 5

Important for that is the following design detail: So that with upside-down position no water penetrates into the main hull and so disturb the recovery conditions, the companionway must be designed as short shaft, with a depth larger than the submerged depth of the swimming cabin roof (a side should be reasonable formed by the luv side of the hull where you climb the cockpit). The efficient pump should be served from the cockpit or from inside. The valves should also to be served from the inside and from the outside. For this solution the Ama must be made from a heavy not swimmable material or loaded with adequate material like anchor and chain, etc. The advantage of this solution is that the Proa turns, after opening the valves, automatically into a position, in which it is reasonable, to overtake the pumping by the crew with the prospect: 'each pump brings you back a little bit into normal position'.

I am sure that the Ndrua has only a chance of success, if it can upreared without assistance from the outside to counterbalance the complications of handling the rudder and sail. This would be a crucial advantage opposite cats and tris. An exotic view alone will not effect the Ndruas break trough in the future.

2. Water ballast

I regard the relatively small width of the Ndrua rather as an advantage. It should not given up following the today's trend. The small width lowers costs and weight as well as air resistance and above all. It lowers the starting stability compared with the today's over-broad catamarans. Thus the rig will fewer stresses and the Ama can already fly with middle winds. The catamarans of Rudy Choy have provedthat they can run very well with small width too. If necessary stability could be increased effectively by filling water ballast in the Ama,. The volume of the Ama would allow to replace a numerous crew. The advantage of the water ballast is demonstrated by WOR 60-Racer which have supported their superiority opposite to the Maxi Yachts in the Whitbread Race. Also the fast 9.75 m catamaran 'Gougeon 32' with its max. width of 2,5 m proved the use of this concept. Differently than with the Gougeon 32 the water ballast didn't need to be pumped from one side to the other onboard of the Ndrua.

Purists among us, that reject each thought of water ballast, are reminded of the fact that humans consist to over 80 % of water. Thus, traditional water ballast only has had two legs. The water ballast has the incontestable advantage that it is permanent available and free and that I can get rid of it at any time, if I don't need him any longer; thus a real gift. But who can get a numerous and motivated crew on his Proa, should do it. As long as the crew is with mood, he will be able to trim the Proa faster than I could fill water in or out. Who likes, can also take a long ladder with him on which the crew climb out after extend it out to windward. But what one makes with the hungry heap, if the wind becomes weak? In Australia it has had races around 1900, in those it was sufficient, if only one were on board if passing the target line. Shark ahoi!

3. The largest technical problem of the Proa: The rudder

The rudders of the traditional Proas, consisting of one (or several) aft in the water dipped oars, corresponded also to the technical possibilities of the Oceanians. This solution might be, apart from temporally limited experiments in protected waters, no principle for the future The forces at the rudder during high speed and high waves must be enormous. So enormously that 'how in the reports is to read' the helmsperson on large Ndruas would hurted by the oar and some lost their life.

The special difficulties for the steering of a Proa result as well known from their characteristic to have an end-to-end symmetry, which makes two rudders necessary, if one does not want to drag the rudder back and forth. A further demand is that both rudders should be designed for lift up, in order to lift the exposed front rudder for the advantage of the small draft of the Proa in shallow waters.

Russel Brown use on its Proas the rudder concept of Newick, which consists of two 'rudderboard', which are lead in daggerboard boxes. The advantage of this solution is that in the hull only two daggerboard boxes must be built. The disadvantage consists of the fact that these rudders function only if fully out. As soon as a rudder is partly lift up, it is blocked. R. Brown works in this case with a long oar.

Another interesting solution shows the 'Vario Rudder' of the Norwegian Birger Kullman, which works very simple. It's a daggerboard, which ca pulled up and down in a drum, which turns in a cylinder, which is fixed on the boats bottom. Drums and therefore the rudders can be turned 360° by a tiller or by cables or chains. B. Kullmann developed this rudder for a 46' yacht with a swing keel . This kind of steering has many advantages:

- The rudder can be adjusted like a daggerboard infinitely variable to different depths and remains thereby fully functional, i.e. fully turnable. Thus the wetted surface of the rudder can be reduced if necessary.
- The rudder balance (the rudder pressure) remains the same with all adjusting depths of the rudder.
- The rudder is very strong, since at the rudder blade has no constuctive weak points over the whole length.
- In the case of damage of the rudder blade it can pulled simply upward and exchanged against a new one
- Less bearing problems because of large bearing surfaces of the drum
- The rudder has less weight, because a heavy shaft is omitted.
  B. Kullmann saved 30 kg thereby with its 46' racer.
- No gap between rudders and hull, no turbulences
- The entire drum could be pulled out on deck for easily inspection, also on sea.

It would be optimal, if the hull were flat in the area of the rudder. In this case the streaming system between the below surface of the drum and the nearby hull will not disturbedif the rudder works. With an asymmetrical hull this kind of rudder is not useful. For the same reason there is a natural delimitation of the drum diameter at a rounded hull. The diameter should not have more than approx. 50% of the hulls width, because then with normal rudder deflections the step between drum and hull remains negligibly small.

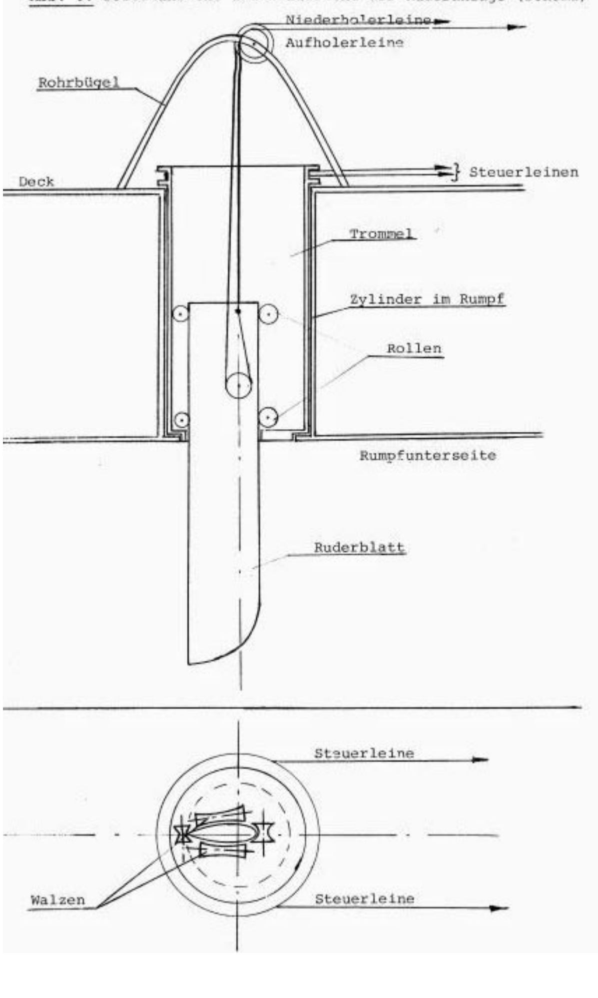


Abb. 6: Seitenansicht und Draufsicht der Ruderanlage (Schema)

The best hull form for this steering system will be a trapezoid or U-shaped hull. Because the drum turns 360° the axis should stay vertical onto the boats bottom. To get the diameter large enough, the drum should built in nearly a quarter after the CWL, where the rudder don't catch air in high and steep waves. To reduce the friction when the pulled up and doen the rudder blades these should be stored in the drum in length and also athward between large roles made of eg. Delrin. There is enough space available inside the drum (fig. 6).

The lower free space of the drum should be filled with foam till over the CWL. By combine the ropes for pull up and down on a lever in the cockpit the rudders could be handled like tandem daggerboards. A synchronization of the rudders by a precise transmission (eg. by chain) is neither necessary nor sensful. Better is a connection via ropes to two steering wheels in the cockpit. These are set on one common axis both nearby, so you can use them synchronous if necessary. In this way you can play with all possibilities which are given by the angles of both rudders and different adjusted draft for trimming ot self-steering. With the right trim may be both rudders could adjusted to produce a movement to luv and improve in this way the boats windward ability - more as any asymmetrical hull.

Admitted, one because of their variability a little bit complex helm (with the installation of roles and drums), but at present I do not know a better solution. The use of the two rudders as tandem daggerboards offers quite new possibilities for trimming the Ndrua and the disadvantage of two helms could still grow to an advantage.

With a large cruiser version of the Ndrua one could think about whether the two daggerboards could be changed against appropriate streamlined shafts for hydraulic actuated folding propellers, which could be installed as with a Saildrive at the lower ends of the profiles. The rudders would be thereby carry the propeller. With the fully turnable two-propeller drive the Ndrua could go each thinkable way into close ports.

4. The cruising rig

It needed the wind channel tests of C A. Marchaj, to show us, which amazing efficiency a crab claw sail has on beam reach courses. The crab claw of the Fijis is a more efficient variant of the triangular lateen sail, how it was used from the Micronesians (Marchaj discovered that a crab claw with bended edges is more efficient as with straight ones). The main advantage of this sail for the Oceanics was that the hulls must absorb only few forces of the rig in opposite to other rigs like the eg. Bermudian rig - important in dependance from the historic building methods and materials.

However what's with the handling of the crab claw? I think, not so enticing! The handling is laboriously, elaborately and can become also dangerous with strong wind and sea. During shunting the whole rig with sail and to long spars must carried from one end of the boat to the other. Without a strong crew barely feasible. In the spacious Pacific tacking maneuvers might have been rather rare. And at last you lost some distance to luv and some time. Thomson said in his report that the hole action needs about a minute, if all are well done (he writes also, that sometimes.members of the crew are falling overboard). For tacking in narrow waters this sail is absolutely unusable. But who will build a Proa, if he can't satisfyingly taking up a big river? And annother topic: Reefing.

As I could overlook the crab claw can't become reduced. In best way you can try to minimize the area of sail by forming it to a half cone. In my opinion no convincing substitute for smaller or reefed sails in heavy weather . Additionally the both spars can make a lot of problems at strong winds. In the same reason, the try sail will used without boom. Furthermore: the weight. In dimensions to a Thamakau with nearly 46' length, the spars has had a length of nearly 85 percent of the main hull. This corresponds 38 to 39 feet, which needs a noticeable diameter if it should resist the forces of a hard course close hauled. So a lot of weight comes up which needs an adequate power during shunting. One could try to use long rails deck on which the sail could moved back and forth, but in my opinion it is very complex and needs even now to much time in narrow waters. I imagine an other solution:

Marchajs measurements resulted in a superiority of the crab claw if sailing on a beam reach course, not if tacking. Since cruising multihulls have, because of their big part of speed generated wind, mainly close hauled courses. Hence a Bermudan rig is a good alternative for a proa. This rig (with main and jib) is more simple in handling and easy to reef. Reefing as an counterpart to the variable stability. With this rig a conventional tacking in narrow waters is possible, which would evidently extend the use of the Ndrua (because fast change of the Jibs are no ore necessary, one could abandon the expensive roller furls). An additional advantage is the setting, hauling and reefing of the main sail at all courses without getting problems with the stays (opposite to cats and tris). On courses beam reach in a heavy gust one could unload the pressure in the main sail only by loosening the sheet. A dangerous heading up for reefing is no more necessary. An not underestimating safety factor! For sailing maneuvers in small areas the main sail is even usable as a brake. Because the mais is fixed on the lee side of the mast, no turbulence will produced on close hauled courses, even without a rotating mast. If I prefer the Bermudan rig, by the named reasons, as the working sail, I would use the crab claw instead of an asymmetrical spinnaker on courses beam reach if possible. On these courses it works as a lifting rig too. So if the crab claw is not the workung sail it could be made lighter overall. The sail could made of a meterial similar to a spinnaker and the spars could be made from bamboo. In this function as an additional - sail shunting will be more rare. A comparison between a crab claw and an adeqate asymmetrical spinnaker would be very interesting.

With the use of the a Bermudan and a crab claw it would have to be still decided, how the mast can be supported against overturn to luv. On different Micronesian islands a mast support was set on the bridge against the mast. This solution would still be possible today, however with more weights and air resistance than a lee stay, how it was set on flying Proas with platform to lee. Since a mast support would not set up to the top of the mast, the mast wouldn't be sufficiently supported, if the Ndrua should sometimes tack as an Atlantic Proa. With a Pod to lee a sufficiently broad base for the lee stay would be given (double, since it would have to be removable like a back stay). For the position of the mast on the bridge (like the Proas of R. Brown) two stays and a shroud could be enough, but the load on the mast will better intercepted on the main hull. Also in case of a 90 degrees capsize a mast on the main hull is more safety as on the (beam) bridge.

X. How to continue?

It would be an advcance in multihull design, if the designers concerned themselves more with the historical models of the Pacific. Not in the sense of an experimental archaeology, but to excerpt conclusions for modern constructions. I think e.g. at the high stems/bows of the Proa of the Mariana Island against capsize head foremost in high aft coming waves. As well known the Pacific Islanders observed very exactly. They have had a lot of creativity and innovation ability, everytime willing to replace good things by better.

A impressionful example of their innovation strength is the rapid break with over centuries the developed double boat Tongiaki and its replacement by the more efficient Ndrua/Kalia. For me the most interesting construction in the Pacific at all, with the biggest potential for development in connection with modern materials. In technical view our work is today much more easily and we can realize ideas from which the ancient Islanders could only dream, The development of multihulls has not finished yet. The door is wide open. Let's pass through!

Herbert Wenskus