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Comparative study of two artisanal fishing units efficiencies (catamaran and trimaran) from the northwest part of Lake Tanganyika: some socio-economic outcomes

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Abstract

A comparative study to assess some socio-economic activities and annual profitability of two artisanal fishing Units (AFUs) namely catamaran and trimaran/appolo was carried out in the extreme northwestern Lake Tanganyika (Uvira and Fizi territories) from September 2012 to October 2013. This region is facing increased uncontrolled fishing effort due to a lack of fishery management measures to develop the fisher's entrepreneurships.

Total annual turnover was estimated to US$624,492 for total investments valued to US$1,414,398 during the study period. These investments of catamarans (57%) and trimarans (43%) covered the global costs of 5,112 and US$6,740 per unit respectively. The monthly turnover was US$2,496 for catamaran and US$2,556 for trimaran boats which carried out the yield of 124.2 kg and 134.5 kg respectively per night and unit. AFUs equipment included mainly the costs and investments of vessels, fishing gears, engines and fishing-lamps. The number of lamps was superior for trimaran (20±3) if compared with catamaran (16±3). The charges of both AFUs were 71% of turnover. The mean lengths of vessels were 6.8±0.9 and 7.9±0.8 m for catamaran and trimaran, powered by the engines of 17.2 and 36.2 HP and provided with liftnet mean lengths of 68.0±12.7 and 86.1±17.6 m respectively. Different positions allocated to fishing-activities consisted primarily of engine-fuel and lamp-oil. Catamaran was the most common and economic boat in the study area with monthly revenue estimated to 901 against US$445.5 for trimaran which incurring higher operating costs. Results of this study suggest that effectiveness fishery management on Lake Tanganyika need control and community surveillance to assess the role of each stakeholder using these fishing boats by supporting fisher's initiative and orientation.

Key words: *catch, entrepreneurship, fishing effort, investment, management*

Introduction

Lake Tanganyika is one of the largest inland fisheries in Africa, second in volume production after Lake Victoria (Hanek 1994, Coulter 1991). More than 90% of catches in the lake are consisting of two pelagic sardines: *Stolothrissa tanganicae* (Regan 1917) and *Limnothrissa miodon* (Boulenger 1906) and four species of Lates, mainly *Lates stappersii* (Boulenger 1914) (Roest 1978; 1992; Mannini and Aro 1995; Mölsä et al 1999). Pelagic artisanal fishery is very great socio-economic interest in the lake basin as vital source of proteins for 10 millions of people living in the four neighboring countries (LTA 2011; 2012). There are generally three main types of fishery in Lake Tanganyika including industrial, artisanal and traditional fisheries (Hecky et al 1981; Sarvala et al 2006; Van der Knaap 2013). Artisanal fishery took over the larger scale industrial fishery that was carried out by the end of last century and ceased because of both the lower catch yielded and the rapid development of artisanal fishing techniques.

The artisanal fishery is more specialized in the pelagic waters with two main fishing units including two (catamaran) or three (trimaran/appolo) wooden boats with 4.5 and 7.8 fishers using liftnet respectively (Coenen 1994; Coenen and Nikomeze, 1994). Both catamaran and trimaran are found in the four neighboring countries (Burundi, Tanzania and DR Congo) except in Zambia where trimaran, the higher-powered catamaran is absent (LTA, 2013). Since their introduction from 1980s till now, catamaran boats increased enormously with higher dispersal capacities in the lake and no sufficient socioeconomic informations were, therefore, carried out on the lake. The latest lakewide frame survey conducted in 2011 by Lake Tanganyika Authority (LTA) yielded a total of 27,535 active fishing units; the number of catamaran and trimaran assessed in Congolese waters were 2,169 and 396 respectively (LTA 2012). The numbers of fishers operating with these units and active fishing-boats have almost doubled between 1995s and 2011 in Lake Tanganyika whereas catch declines were accordingly reported since the same period (LTA 2011; Mushagalusa et al 2014; Van der Knaap et al 2014).

Due to that fact, local fishers' entrepreneurship and interventions to support fishing measures are facing socio-economic constraints particularly in the northwest of the lake. There are also limited previous socio-economic studies available (Kees and Mambona 1992; Breuil, 1995; LTA 2012) in this area and most of them are not updated. Very few informations dealing with fishing effort, costs, investments and revenues as well as technical organization of artisanal fishery on Lake Tanganyika are available now. Similarly, high fish protein demands, food insecurity and poor fishing plans, compounded by the high annual rate of human population growth (2.5-3.1%) are observed along the lake coasts (Reynolds 1998; Jorgensen et al 2005). This progressive increase in population pressures lead with intense fishing activities such as increased uncontrolled fishing effort and current socio-economic trends assessment, therefore, became essential. This paper aims to assess two fishing methods effectiveness and to evaluate some socio-economic factors of them at Uvira and Fizi territories. An overview is provided on the technical organization and way forward given to support local fishers' entrepreneurship with further propositions for fisheries management and food security in Lake Tanganyika basin.

Materials and methods

Study area and selection of the sites

The study was carried out in the extreme northwest part of Lake Tanganyika (03°28'S, 29°17'E) in the Democratic Republic of Congo. Two large scale fishing centers (territories), which contribute highest fish production, namely Uvira in the north and Fizi (Baraka) in the south were chosen (Figure 1). Lakewide frame survey conducted in 2011 has identified 304 landing sites on Congolese shorelines of which 9 at Uvira and 130 at Fizi (LTA 2012). Among them, three representative landing sites were chosen randomly in each territory according to their accessibility and level of fishing activities. They were Kilomoni, Mulongwe and Kalundu at Uvira; and Mwemezi, Mwandiga and Baraka at Fizi. In these sites, people are living mainly through agriculture, livestock, small trade, but mostly by fishing activities on Lake Tanganyika.

Figure 1. Lake Tanganyika with sampling stations: white circles= Uvira and Fizi fishing sectors (Adapted from: Bwebwa 1996).

Sampling frame and size

The sampling frame was distributed over time (from September 2012 to October 2013) and space in purposefully selected landing sites. The artisanal fishery is the most dominant economically in the study area and data were carried out among artisanal fishers (75.4% fisher-employer, 14% member and 10.5% captain) as well as their associations twice a month. Only fishers using either two (catamaran: 63.7%) or three (trimaran: 36.3%) light-boats, equipped with liftnet and usually powered were targeted randomly in each site. The sample size comprised 199 respondents (Uvira: 55% and Fizi: 45%) majorly males (98%).

Data collection

The data were gathered using semi-structured interviews (SSI) with the managers of fisher's associations and individual questionnaire schedule as well as direct observation in the fieldwork. The questions were addressed directly when fishers were landing on beach in morning (7-9 am) or while they were mending their fishing-equipment. The questionnaire was designed to obtain information about fishing-equipment (e.g. number of vessels, liftnet, engine with their respective features such as length, duration time and fishing-lamp), composition and structure of investments as well as fishing activities (e.g. variable and fixed costs, operating charges, fish catch price/kg) in order to evaluate some socio-economic indicators. Daily total catch (kg) of two sardines (*S. tanganicae and L. miodon*) and one *L. stappersii* were weighted and the number of AFUs per landing site indicated.

Digitalization and analysis of the data

The catch per unit effort (CPUE) was calculated by dividing the total catch (TC) by the number of active AFUs. Initial investment was the total values of AFUs. Operating charges, turnover and generate revenues were calculated following Breuil (1995) and FAO (2009). Descriptive statistics such as frequencies, percentages and weighted means were applied to summarize data. Data were entered and analyzed using Excel 2007 and SPSS 16.0 softwares. Analyses of variance (ANOVA 1-way) were performed to compare significant differences at $p<0.001$.

Results

Technical factors of AFUs

The main equipment of AFUs was including vessels, fishing gears, lamps and engines. The number of vessels was two (catamaran) and three (trimaran) with no significant difference for their respective lengths (6.8±0.9 and 7.9±0.8 m). The average cost per boat were respectively 620.3±102.0 for catamaran and US$ 696.1±91.2 for trimaran. The mean power ($F=114.6$, $p<0.001$) and the respective mean cost of engine ($F=109.8$, $p<0.001$) for both AFUs were superior with trimaran during the study period. The means time duration of engine ($F=4.5$, $p>0.001$) and vessel ($F=4.0$, $p>0.001$) did not vary considerably for both catamaran and trimaran (Tableau 1).

Table 1. Principal features (means ±SD) of AFUs vessels and engines in the northwest of Lake Tanganyika during the period study (n = 248 AFUs). Nb = number of boats/AFU, L= length of boats (m), C= cost per boat or engine (US dollar), D= time duration (year), P= power of engine (HP), CC= engine fuel-consumption (l) and V= fuel-value/fishing-night (US dollar).

	VESSEL				ENGINE				
AFUs	**Nb**	**L**	**C**	**D**	**P**	**CC**	**C**	**D**	**V**
Catamaran	2.2±0.4	7±0.9	620.3±102	4.4±2.3	17±13	19±6	1769±398.8	2.8±1	32±10.3
Trimaran	3±0.4	7.9±0.8	696±91	5±3.5	36±14	24±6.5	2327.8±412.4	2.5±1	41±10.9
Total mean	2.5±0.6	7±1	647.8±104.6	4±2.8	24±16	20.9±6.7	1971.8±484.6	2.7±1	35.4±11.3

The fishing gear of AFUs was the liftnet which showed difference in its length ($F=87.7$, $p<0.001$) and cost ($F=80.4$, $p<0.001$), globally higher for trimaran/appolo in the study area compared with catamaran (Table 2). The total number of liftnet per unit was generally single.

Table 2. Main characteristics (mean ±SD) of liftnet of two AFUs in the northwest of Lake Tanganyika.

Fishing gear	Nb of net	Length (m)	Width (m)	Cost (US$)	Duration (year)	n
Liftnet	1	68±12.7	19.5±2	1254±174.5	4±2	158
Appolo	1	86±17.6	21±4	1455±160.6	3.7±2	90
Total mean	1	74.6±17	20±3	1327±195	4±1	248
	$F=0.4$	$F=87.7$	$F=15$	$F=80.4$	$F=0.9$	
	$p>0.001$	$p<0.001$	$P<0.001$	$p<0.001$	$p>0.001$	

The average number of fishing-lamps was respectively estimated to 16±3 for catamaran and 20±3 for trimaran with no difference in their time duration (2.4±0.8 years) per lamp (Table 3). The daily lamp-oil consumption (l) was logically superior for trimaran than catamaran per fishing-night ($F=41.6$, $p<0.001$) during the study period.

Table 3. Main characteristics of fishing-lamp of AFUs in the northwest of Lake Tanganyika.

AFUs	Nb of lamp	Cost/lamp (US$)	Lamp-oil consumption/night (l)	Duration/lamp (yrs)	n
Catamaran	16±3	33±2.4	25±7	2.4±0.7	158
Trimaran	20±3	33.3±1.7	31.5±8	2.3±0.8	90
Total mean	17±4	33±2.5	27.4±8	2.4±0.8	248

Fishing activity and trade

The total annual fish catch analyzed was 31.7 tons and 19.6 t (61.6%) were reported by catamaran and 12.1 t (38.4%) by trimaran. The monthly mean CPUE per fishing-night (F=1.7, p>0.001) were slightly higher for trimaran (134.5 kg) compared with catamaran (124 kg). These CPUE increased in January (157 kg) and April (188.3 kg) 2013 for trimaran and declined in September (91 kg/night) (Figure 2A). *S. tanganicae* was the most common pelagic species (22.3 t) and mostly captured by catamaran boats (Figure 2B).

A B

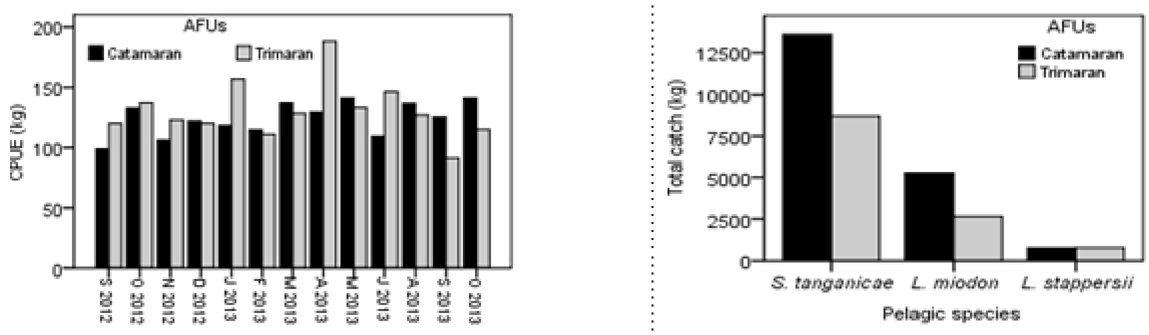

Figure 2. Monthly mean CPUE (A) and annual total catch per species (B) of AFUs in the northwest of Lake Tanganyika during the study period.

The monthly average of turnover (TO) was approximately US$ 2,496 per catamaran against US$ 2,556 per trimaran (Table 4). The rate of charges was 64% of TO for catamaran and 83% for trimaran which has engaged higher operating charges (taxes and certain fixed costs were not taken into account) during the study period. The operating result or revenue was lower for trimaran (17% of TO) if compared with that of catamaran (36% of TO) which was generally more profitable.

Table 4. Monthly averages (±SD) of turnovers (TO) and charges, charges/TO ratio and revenues (in US$) of AFUs in the northwest of Lake Tanganyika during the study period.

AFUs	TO	Charge	% of charge/TO (pretax)	Operating result (pretax)	% TO
Catamaran	2 496±648	1 595±398	64	901±691	36
Trimaran	2 556±632	2 111±473	83	446±749	17
Total mean (+ %)	2 518±642	1 782±493	71	736±744	29
	F=0.5	*F*=83.6		*F*=23.4	
	p>0.001	*p*<0.001		*p*<0.001	

In the detail analysis of initial investments (F=207.8, p<0.001), the mean cost per catamaran was estimated to $US 5,112.5±851.4 against 6,740±861 per trimaran (Table 5). The engine and fishing gear were around 50% of these investments for both AFUs (Figure 3).

Table 5. Initial (±SD) and total annual investment of AFUs in the northwest of Lake Tanganyika during the study period.

AFUs	Investments/AFU	Total Investments	%	n
Catamaran	5 112.5±851.4	807 776	57	158
Trimaran	6 740±861	606 622	43	90
Total mean	5 703±1159			
Total		1 414 398	100	248

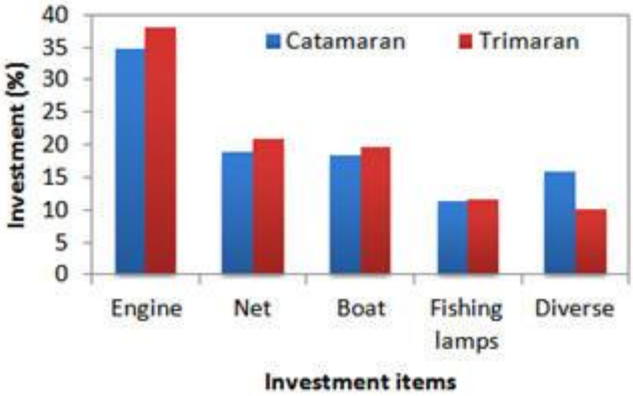

Figure 3. Composition of investments and fishing items value (%) of AFUs in the northwest of Lake Tanganyika.

The profiles of operating charges were almost similar for both boats and were including mainly the engine-fuel and the lamp-oil (more than half of expenses off tax) (Figure 4).

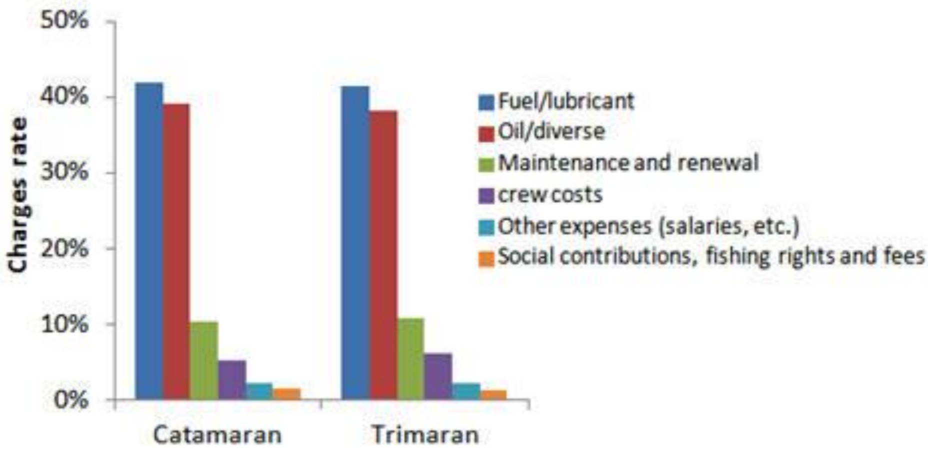

Figure 4. Profiles of items and distribution of their respective expenses per AFUs in the northwest of Lake Tanganyika during the study period.

The monthly fish catch (kg) and turnover (US$) evolutions of both AFUs have shown similar trends and short increased peaks from April to May 2013 in the study site (Figure 5).

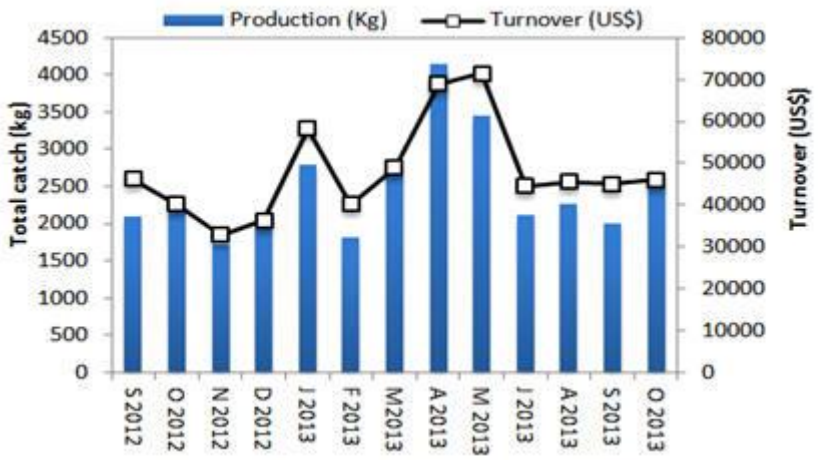

Figure 5. Monthly total catch (kg) and turnover (US$) evolution of AFUs in the northwest of Lake Tanganyika during the study period.

Discussion

Technical interventions

The Artisanal fishery of catamaran and trimaran boats is playing important roles in terms of employment, food security, social and economic benefits in Lake Tanganyika, particularly at Uvira and Fizi, which are major fishing centers (FAO 2009; Lindley 2000). Both the increases of the number of these fleets and the fish catch decreases are among the main difficulties previously in the sector (LTA 2012; Mushagalusa et al 2014), compounded by the involvement of many different types of fisher socio-economic constraints related to poverty, poor fishing plans, loss assessment and fragmented infrastructural environment in the study area. There are also complexities in fishing techniques/methods and the involvement of many different types of stakeholders and socio-economic factors related to poverty, skills, access to services, culture and traditions in the study area. However, among important technical features of catamaran and trimaran in the study area there were capacities of their vessels to be powered in order to ensure movement from a landing site to a fishing site and vice versa or a fishing site to another in the pelagic waters; or even a market trade to another on the shorelines of the lake. A good sized and powered boat was a tremendous asset to improve good specific composition (size) and fish catch yield (volume) (Breuil 1995). Accordingly, the size of catamaran boat was slightly lower if compared with that of trimaran; that figure had affecting the respective cost of both boats in our results, which had showing the same proportions. Generally, according to Coulter (1991), Breuil (1995) or LTA (2012), AFUs consist of two (catamaran) or three (trimaran) wooden canoes with average lengths of 8.2 and 8.8 m and powered by engine of 20 and 37 HP respectively. But, boats surveyed during this study have been equipped with engines of mean power slightly lower for catamaran (17.2 HP) and approximately the same for trimaran as from these early results (36.2 HP).

The fishing gear used by AFUs was function of their type and investment, but substantially a same liftnet might be used by both catamaran and trimaran. There were two most operational nets in the study area, simple liftnet attached to catamaran and appolo, the most sized liftnet, associated to trimaran. Previous studies stipulated that catamaran and trimaran are equipped with liftnet of 70 and 110 m and from 6 to 8 or 10 fishing lamps respectively (Mannini et al 1997). These sizes of liftnet were quietly approximate to our results while the number of lamps per unit has remarkably doubled these last two decades (16 for catamaran and 20 for trimaran). Consequently, the lamp-oil consumption (l) for both AFUs was logically increased in the same proportions of their number, higher for trimaran during the study period. The higher lamp-oil and the engine-fuel consumptions (l) of trimaran boat, compounded with significant initial investments and variable costs, have made considerably this boat most exigent and expensive in the study area compared with catamaran. So, the optimum number of fishing-lamps emphasis from this study to be modulated with catamaran could be 15 and roughly 20 lamps for trimaran though the performances of these boats could be depending on many other factors such as fishing location, duration and intensity, species composition, lake state and social level. Also, despite the extension of the number of lamps per boat was the accurate attraction mode of sardine fish, it was evidently perceived by the fishers as a constraint and emerged barrier in fishing technologies in terms of oil consumptions and mending costs. The use of lamps could increase the catch capacity certainly, but it was requiring more oil consumption, regular maintenance and purchase of spare parts such as glasses and sleeves. Implementation of other sources of fishing-light to attract sardines such as projectors and bigger torches lit from solar or generator energies or other reasonable light sources to minimize higher daily fishing charges should be envisaged by the fishers.

Effort and trade

The relative costs (initial investments) of AFUs were greatly influenced by the differences in fishing engine, vessel, net features and the number of lamps and daily expenses, generally higher for trimaran boats during the study period. As it was reported by Sarvala et al (2006), fish catches (composition and volume) from Lake Tanganyika are mainly reflected by the changes in fishery practices or effort. But, since 1990s, the most common observation is there similar decreases of CPUE reported by all AFUs in the lake, especially in the study area (Sarvala et al 2006; Van der Knaap et al 2014). This fact made trimaran boats less effectiveness though they have deployed consistent effort to access resources as reported in our results. There were remarkable differences in the daily fishing charges and operating costs which were affecting negatively the fishing capacity and incomes of trimaran in the study area. The fishing engine and gear costs, therefore, have been represented more than 50% initial investments for both AFUs, followed by vessels because they were either doubled (catamaran) or tripled (trimaran). Previous results of Breuil (1995) stated that the mean cost of powered catamaran was estimated to $US 3,600 and 5,200 for trimaran in Burundi. However, results of this study were indicated significant evolutions in total amount invested for each boat, higher for trimaran compared with catamaran. Besides of this higher investment and operating charges of trimaran, this boat performed the monthly turnover slightly higher (US$ 2,556±632) compared with catamaran (US$ 2,496±648). These figures are important if paralleled with previous estimates which were showing the amount of US$ 10,000 and 12,000/year (an average of US$ 833/month) for both AFUs (Breuil 1995). Additionally, the monthly rate of charges incurred by trimaran was also higher (83% of turnover) compared with that of catamaran (64%).

The most relevant fact of AFUs in the study area was the monthly mean revenue or operating result which was lower for trimaran versus catamaran. This trend could however be considered with attention when taking into account the low number of trimaran boats sampled during the study period. But, globally, trimaran engaged considerable effort in its deployment on the lake. All of these factors were reinforced by the current significant decreases of CPUE in the lake since 1990s (Van der Knaap et al 2014), just after the introduction of trimaran/appolo in the lake from Burundian waters. This is another further aspect which enhances how fishing planning is important throughout the study area where additional investment of trimaran or the increase of the numbers of their boats and fishers are not required to maintain the fish stock. An assessment of fish stock to determine or limit the optimum number of both catamaran and trimaran boats to be likely endured by resources would rather be adopted because of socio-economic prominences and poverty in the study area. The examination of fish biology for example could supply that socio-economic effectiveness of AFUs.

Conclusion

- Technically and socio-economically, the entrepreneurship of fishers met a wide range of equipment and significant investments, most exigent for trimaran boats during the study period. The analysis of performance rate, expense incurred and revenue generated have varied in the study area, but catamaran was most common, less expensively and cost effectiveness compared with trimaran. More informations to elucidate the specific role and intervention level of each stakeholder still necessary to parallel these results with biological parameters of artisanal fishery. These future figures could determine, therefore, the extent of fish stocks and the optimum number of each AFU to be supported by the resources for sustainable fisheries management and local entrepreneurships development in Lake Tanganyika basin.

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