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Growth rate of farmed Mangrove oysters (*Magallana bilineata*) at Laucala Bay, Suva, Fiji

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ABSTRACT

The cultivation of oysters has a significant historical background in the South Pacific region. The cultivation of pearls has been a significant source of livelihood for numerous island nations. Despite the significant cultural, dietary, and subsistence value of bivalve molluscs among Pacific Islanders, there has been limited advancement in the aquaculture of edible oysters in the region. To enable a comprehensive assessment of the viability of cultivating edible oysters in Fiji, an estimation was conducted pertaining to the growth rate of mangrove oysters *Magallana bilineata*. A total of 105 oyster spat were cultured in Laucala Bay, Suva, Fiji, over the course of one year, from January 25th, 2021, to January 26th, 2022. The investigation documented exponential growth in oysters, with measurements of 87.3 ± 1.0 mm in length, 67.4 ± 0.7 mm in width, 49.8 ± 0.6 mm in depth, and 104.90 ± 22.6 g in weight. The findings of the study indicated the occurrence of positive isometric growth in relation to weight, length, width, and depth. The observed survival rate was 94%. The growth rates observed in oyster farming in Fiji exhibit similarities to those documented in other geographical locations, thereby providing a favourable indication for the progress of oyster aquaculture in the region.

Keywords: Growth rate, Oyster, Fiji. *Magallana bilineata*

INTRODUCTION

The aquaculture-based cultivation of edible oysters holds substantial economic significance, with a valuation of USD 34.6 billion in the year 2020. According to the 2022 report by the Food and Agriculture Organisation (FAO), the prevailing species in this context are *Crassostrea gigas* and *C. virginica*, which belong to the temperate category. Based on the 2019 report published by FAO, it is evident that the production of tropical species constitutes approximately 1% of the overall production. Nevertheless, due to their accelerated growth rates and the wider variety of species that are deemed suitable for cultivation, there is a growing inclination towards utilising tropical rock oysters in aquaculture, as indicated by the research findings of Nowland et al. (2019).

The cultivation of tropical edible oysters through aquaculture has been implemented globally, with notable examples including Brazil (Maccacchero et al., 2007), Taiwan (Huang & Lee, 2014), Vietnam (Pierce & O'Connor, 2014), Colombia (Cassis et al., 2011) and Australia (Nell, 2001). The Pacific Island Countries and Territories (PICTs) have a significant historical heritage in the cultivation of ornamental oysters,

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particularly mabe (half-pearl) and pearl varieties. Nevertheless, the development of the edible oyster cultivation industry is still in its early stages, with its current cultivation limited to small-scale livelihood projects in Fiji and the Northern Marianas.

According to a report by Vereivalu (1989), the establishment of oyster cultivation in Fiji's aquaculture sector commenced in 1969 through a government-led endeavour supported by FAO. The communities chose not to maintain their aquaculture endeavours, but rather persisted in the traditional practices of gleaning oysters from natural stocks. In Fiji, there has been a recent upswing in the level of oyster fishing activity. This can be ascribed to two primary factors: a noticeable escalation in demand within the local market and a corresponding elevation in the cost of living. The presence of these drivers has generated a renewed sense of enthusiasm within communities, prompting increased engagement in the practice of oyster fishing. In 2018, the Women's Group of Muanaira, Vutia, in partnership with the Fijian Ministry of Fisheries and the Pacific Community, commenced the establishment of an oyster farm. The primary objective of this initiative was to improve the quantity, quality, and ease of access for oyster harvesting. The selected site was located in close proximity to the oyster fishery, which was under the management of the women themselves.

The fishery was situated in the periphery of a bay on Laucala Island, Viti Levu. In order to enhance the evaluation of oyster farming, it is essential to possess a comprehensive understanding of growth rates. This knowledge serves as a fundamental prerequisite for conducting technical and economic feasibility assessments of oyster aquaculture. The primary objective of the current investigation was to assess the growth patterns of *Magallana bilineata* oysters, specifically from the initial collection of spat to the final stage of harvest. A total of 105 oysters were cultivated at Laucala Island, Suva, Fiji for the intended objective.

MATERIALS AND METHODS

Study site

In oyster farming, the oysters were caught as spat and raised until they were ready for harvesting. This was done in a bay on the island of Laucala, which belongs to the fishing rights of Vutia in the province of Rewa, Fiji (Figure 1). Laucala Island is a part of the Rewa River delta, which is considered the largest river/delta system in Fiji. Other waterways, including creeks and stormwater channels, feed into Laucala Bay from the Suva Peninsula. Collectively, these water channels facilitate the transport of significant amounts of water and terrigenous sediments consisting of silt and clay for eventual deposition in Laucala Bay. The experimental site was chosen in an elongated, shallow bay (~0.5 m at low tide, ~1.2 m at high tide) at the south-western end of the island, where oyster fishing is practised. The coordinates of the study site are 18°09’16’’S - 178°31’03’’E.

Study species

According to Kinch et al. (2019), the morphometric analysis conducted determined the presence of two distinct species within the oysters obtained and marketed by the Women's Group of Muanaira. The identified species were

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Saccostrea mordax and *Magallana bilineata*. The first of the two species, *S. mordax*, is categorised as an indigenous oyster species. The observed characteristics of this species generally include a smaller size and the presence of a white abductor muscle scar. In contrast, the second species, *M. bilineata*, is classified as an introduced species.

The aforementioned species is recognised for its ability to attain larger sizes and exhibits a distinct black abductor muscle scar. Based on the findings of the 2019 report by the Pacific Community, it was observed that *M. bilineata* accounted for approximately 40% of the oyster population surveyed in Fiji. The introduction of this species to Fiji can be traced back to the 1970s, when it was originally brought from the Philippines. The study area is home to both oyster species, which in their natural habitat grow on mangrove roots and other forms of hard substrate. The oysters cultured in this study were morphologically identified as *M. bilineata* (Kinch et al., 2019). One hundred and five oysters were collected from spat collectors consisting of PVC plastic strips attached with wires to wooden racks in Vutia Bay. The oyster spat was allocated to one of three plastic grow-out baskets with a mesh size of 15 x 15 mm and a size of 150 x 500 mm. Each basket was initially stocked with 35 oysters. The baskets were attached to rebar stakes and underwent a 12-month culture period from 25 January 2021 to 26 January 2022.

Data collection and analysis

As in the study conducted by Piyathilaka et al. (2012), a monthly sampling of twenty oysters was performed from each of the three grow-out baskets. The oysters were randomly selected, and their shell length, shell width, and shell depth were measured using a Vernier calliper. Additionally, the shell body weight was measured using a portable electronic balance with a precision of 0.01g. Physico-chemical parameters of water at the farm site were recorded using HOBO data loggers (U24-002-C and MX2501). Water parameters including temperature, salinity and pH were monitored every six hours for the entire duration of the grow out cycle.

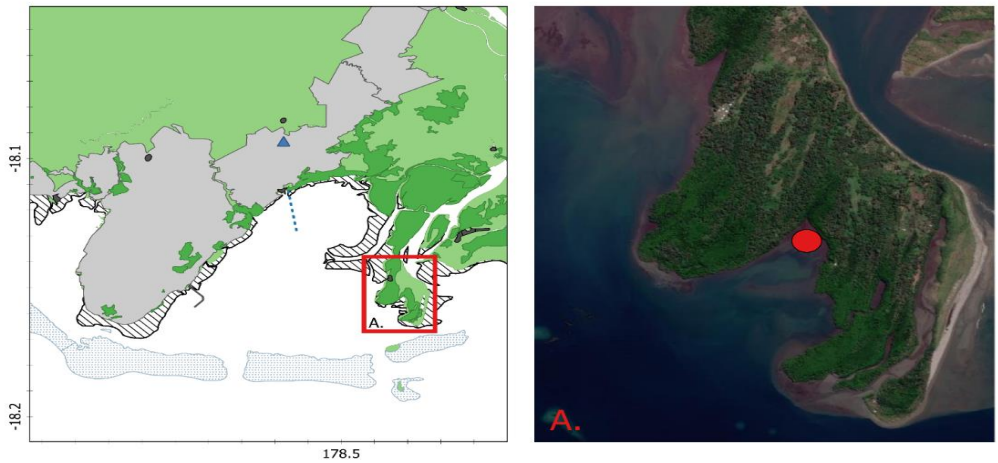

Figure 1. Map of Viti Levu, Fiji showing Laucala Island. The point A represents the study site where oysters are farmed.

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The current investigation involved the determination of the instantaneous growth rates of shell length, shell width, shell depth, and body weight, along with the assessment of mortality rates. The formulae utilised for these calculations were previously described in Cassis et al. (2011). The calculation of the annual mortality rate was derived from the initial number of oysters stocked and the subsequent count of deceased oysters per basket. The analytical and computational procedures were executed utilising Microsoft Excel 2016. The data is reported in terms of mean ± standard deviation (mean ± SD).

RESULTS

In January 2021, oyster spat were placed into grow out baskets and were found to have an average shell length (SL) of 45.40 ± 0.63 mm, an average shell width (SW) of 38.30 ± 0.66 mm, an average shell depth (SD) of 11.20 ± 0.23 mm, and an average body weight (BW) of 11.75 ± 3.45 g (Table 1). The average dimensions of the oysters in January 2022 were as follows: SL (shell length) measured 87.30 ± 1.04 mm, SW (shell width) measured 67.40 ± 0.67 mm, SD (shell depth) measured 49.80 ± 0.61 mm, and BW (body weight) measured 104.94 ± 22.55 g. The study computed the instantaneous growth rates for a 12-month period, which were as follows: SL: 0.11 mm/day, SW: 0.08 mm/day, SD: 0.11 mm/day, and BW: 0.25 g/day, (Figure 2 and 3). Throughout the course of this study, the yearly rate of mortality was recorded at 6%.

Table 1. Average length (mm) ± SD, width (mm) ± SD, depth (mm) ± SD and weight (g) ± SD of cultured oysters (*M. bilineata*) in Laucala Island, Suva, Fiji.

Month/No. samples		Length (mm)	Width (mm)	Depth (mm)	Weight (g)
Jan-21	Range	29 - 60	30 - 59	7 - 18	5.2 - 23.3
Initial measurement	Mean ± SD	45.40 ± 0.6	38.30 ± 0.7	11.20 ± 0.2	11.80 ± 3.5
n = 60					
Jan-22	Range	66 - 120	54 - 82	34 - 63	66.10 - 159.4
Final measurements	Mean ± SD	87.30 ± 1	67.40 ± 0.70	49.80 ± 0.60	104.90 ± 22.60
n = 60					
Instantaneous growth rate	Range	0.01 – 0.24	0.03 – 0.65	-0.01 – 0.01	0.10 – 0.62
	Mean ± SD	0.11 ± 0.6	013 ± 0.6	0.11 ± 0.2	0.33 ± 1.5

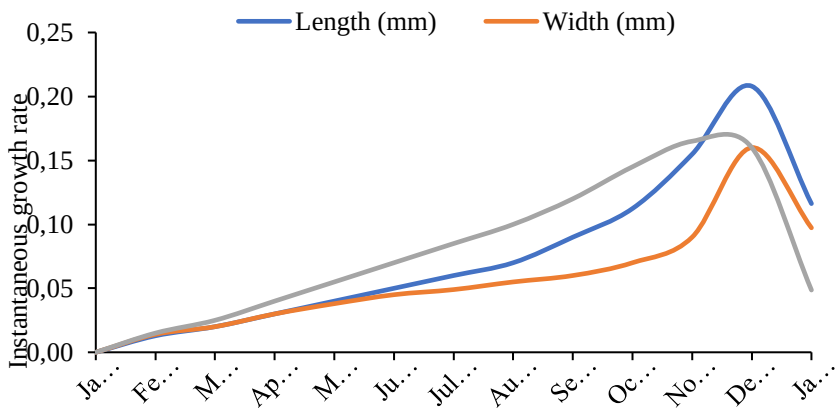

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Figure 2. Mean growth rate of oysters (*M. bilineata)* in length (mm), width (mm) and depth (mm) in Vutia, Laucala Bay, Suva, Fiji.

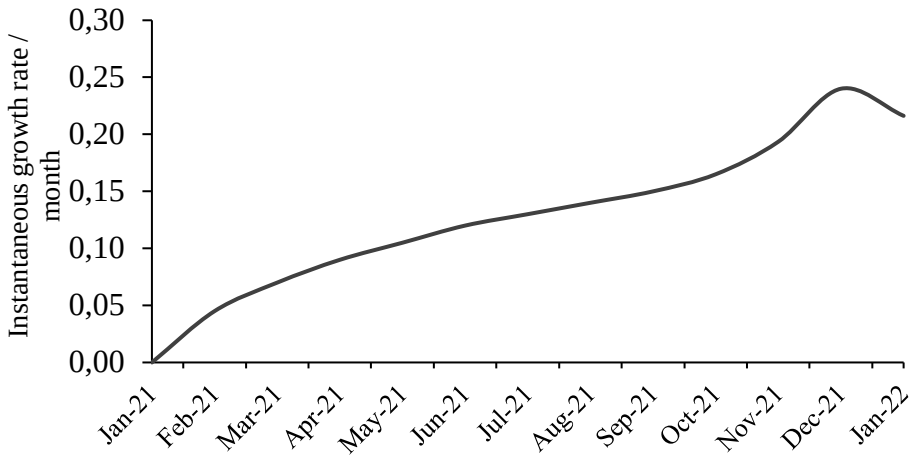

Figure 3. Mean growth rate of oysters (*M. bilineata*) in weight (g) in Laucala island, Suva, Fiji

Physicochemical parameters of the water for the 12 months of culture at the farm site ranged between 24.5 – 34.8 °C for temperature, 1.8 – 25 PSU for salinity and 6.6 – 8.4 for pH with an average of 28.0 ± 0.6 °C, 16.4 ± 0.2 PSU and 8.1 ± 0.2 for temperature, salinity, and pH respectively.

DISCUSSION

This study represents the initial assessment of the growth rates observed in edible oysters (*M. bilineata*) within an established culture system located in Fiji. Throughout the duration of the 12-month culture period, a noticeable rise in the mean oyster shell length and body weight was observed. Specifically, the measurements increased from an initial value of 45.4 ± 0.63 mm and 11.75 ± 3.45 g to a final value of 87.30 ± 1.04 mm and 104.94 ± 22.55 g, respectively. The study mentioned in this context plays a vital role in assessing the feasibility of developing an edible oyster aquaculture industry in Fiji, as well as in other Pacific Island Countries and Territories (PICTs) that have similar species and environmental conditions. The current study aims to conduct a comparative analysis of the growth rates of *M. bilineata*, the species under investigation, with those of other commercially exploited oyster species found globally. The results indicate that the species, techniques, and culture conditions utilised at the Fiji site have the potential to achieve growth rates that are similar to those observed in well-established oyster aquaculture industries. The average growth rate of oysters in this study exceeds the reported values of eight out of the 17 studies presented in Table 2 and is comparable to six of these papers. Only three of the additional research studies demonstrate growth rates that exceed those of the oysters recorded in this investigation. Specifically, Graham et al. (2020); Góngora-Gómez et al. (2017); and Lodeiros et al. (2018) report growth rates in shell length ranging from 92 to 112 mm in the edible oyster *C. gigas* in Italy, USA, and Ecuador over a 12-month period.

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Table 2. Growth rates of commonly cultured edible oysters from around the world.

Species	Country	Growth Rates				12 months approximate	
		Shell Length (mm)	Body Weight (g)	Period (months)	Source	Shell Length (mm)	Body Weight (g)
O. edulis	France	20 – 30	10	21	Robert et al. (1991)	~ 11-17	~ 5.7
	England	60	-	24-60	Richardson et al. (1993)	~ 17	-
	Germany	16.70-30.80	- 6.50	7 5	Pogoda et al. (2011)	~ 28 -52 -	- ~ 15.6
	USA	-			Mann (1979)		
C. virginica	USA	13.88	-	4	Thomas et al. (2019)	~ 41	-
	USA	21 - 44	-	27	Grizzle et al. (2017)	~ 9 - 19	-
	USA	22.2 – 27.9	-	12	Loosanoff & Nomejko (1955)	~ 22 – 28	-
C. gigas	Germany	6.1 – 27.6	- 61.4 – 88.1	7 12	Pogoda et al. (2011)	~ 10 - 47 ~ 38 – 51	- -
	France	38.6 – 51.5	-	12 6	Gangnery et al. (2003)	~ 35 - 53 ~ 92	- ~ 108
	Germany	35 - 53	54.10	5	Diederich (2006)	~ 46	-
	Italy	46	-	12	Graham et al. (2020)	~ 112	-
	Malaysia	19.23	-	7	Yoo & Ryu (1982)	~ 92 - 107	-
	USA	112.57	-		Góngora-Gómez et al. (2017)		
	Ecuador	54.3 – 62.8			Lodeiros et al. (2018)		
O. angasi	Australia	7 – 28	35.4 – 57.8	12	Mitchell et al. (2000)	~ 7 – 28	~35 – 57
S. cucullata	India	3.68 – 4.65	-	9	Bhattacharyya et al. (2010)	~4 - 6	-
C. iredalei	Philippine	5.69 – 6.88	8.26 - 8.85	7	Lebata-Ramos et al. (2021)	~9 -12	~ 14 - 14.5

In a similar vein, the study conducted over a period of 12 months revealed that the mortality rate of oysters fell within the lower spectrum of mortality rates documented in previous studies conducted at well-established international farms (Table 2). According to the findings of our research, it is evident that *M. bilineata* demonstrates a notable capacity to withstand abiotic factors, coupled with a comparatively diminished incidence of mortality. *M. bilineata* is a tropical oyster species with excellent potential for aquaculture due to its sweet flavour, rapid growth, and marketability. It is easy to farm and manage, making it attractive for seafood production.

However, more research on its population dynamics is needed for sustainable stock management (Doinsing & Ransangan, 2022). The oysters' survivability is minimally affected by the inherent variations in environmental factors, including tides, salinity, temperature, and pH. The water quality

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parameters are critical factors to consider in oyster culture. Temperature fluctuations can influence metabolic rates and growth patterns, while variations in salinity can impact osmoregulation and physiological well-being. Additionally, the pH range plays a significant role in shell development for oysters (Yang & Min, 2019). Acidification was evident as the data loggers recorded pH values as low as 6.6. Understanding these water quality conditions is essential for assessing their influence on oyster growth and overall aquaculture success. However, it was observed that there were numerous fouling organisms, including crabs, algae, tube worms, and limpets, present on and inside the grow-out baskets.

The collective mortality rate can be ascribed to these organisms, alongside the inherent mortality of vulnerable individuals and the manipulation of spat. It is recommended that further investigation be undertaken to accurately ascertain the influence of these factors on the growth and sustainability of oyster populations in Fiji. This study presents the primary published baseline data regarding the growth and mortality rates of cultured mangrove oysters in Fiji. The results achieved by the Women's Group of Muanaira, in relation to the species studied, geographical distribution, and research methods employed, bear resemblance to those observed in commercial oyster aquaculture across different regions worldwide.

The evaluation of growth and mortality rates in an aquaculture farm cultivating edible oysters in Fiji demonstrates promising prospects for its sustainability, thereby potentially enabling its expansion into additional geographical areas. Additional research is necessary to address various areas of limited understanding, such as the assessment of the industry's value chain, the establishment of a sustainable market, the identification of patterns and hotspots for oyster spat recruitment, the implementation of measures to ensure food safety, and the determination of the nutritional composition.

Data availability:

The data sets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no conflicts of interest.

Declaration of Funding

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