Exploitation Status	Unknown	
Spanner Crab Sampling Programme Report 2021-2022		
Scientific Name	**Common Name**	**Local Name**
Ranina ranina	Spanner Crab	Krab ziraf

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Abstract

The Spanner Crab fishery in Seychelles started in the late 1980's and is restricted to the Mahé plateau. Due to lack of monitoring for over 30 years, the stock status of the Spanner Crab fishery is currently unknown. To improve our understanding of the status of the stock, a sampling programme was initiated in October 2021 to capture biological and fisheries data. This report presents analyses of the fisheries-dependent data collected from the sampling period of 2021/2022. Statistical analyses were performed to compare size distribution per sampling month between males and females of Spanner Crab. Results show sexual dimorphism in Spanner crab with males being significantly larger and heavier than females. October recorded larger and heavier individuals compared to the remaining sampling months. CPUE indicates stock appears to be stable. It must be noted that the data presented here must be treated with caution as the sampling programme was recently implemented, and it is recommended that continuous monitoring (i.e.; collection of biological data) is necessary before drawing any further conclusion. Sampling operation has experienced some limitations which includes lack of staff or notification of landings However, once a logbook system is implemented and a licensing framework is put in place these issues is expected to reduce significantly.

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1. Introduction

Ranina ranina (Linnaeus, 1758) commonly known as, 'Spanner Crab' (Australia), 'krab ziraf' (Seychelles), 'curacha' (Philippines) or 'kona crab' (Hawaii), is a species of large marine crustacean characterised by its frog-like appearance, reddish-orange colour, and elongated carapace. This brachyuran crab can be found widely distributed throughout the tropical and subtropical Indo-Pacific regions in depths of 10 meters (m) to over 100 m (Matondo and Demayo, 2015). Within the Raninidae family, the Spanner Crab is the only species with great commercial value and is actively exploited in Thailand, Japan, Hawaii and Australia (Brown et al., 2001; Matondo and Demayo, 2015).

In Seychelles, the Spanner Crab fishery dates back to the late 1980's and is restricted to the Mahé plateau (Boullé, 1995). Generally, fishers use schooner fishing vessels to exploit known offshore regions where Spanner Crabs congregate. On average, a fishing trip can last for 10 days, and multiple fishing sites can be visited depending on the catch rate. The main fishing gear used is the baited circular tangle net known as 'kale'. The tangle nets are secured individually to a mainline along with a surface buoy and held on the seafloor by an anchor system (Boullé, 1995). The fishing gear is usually deployed into 1 to 3 sets, with each mainline consisting of 90 to 100 traps. Each set can soak for 20 minutes to 1 hour. Fishing activities take place during the day (Boullé, 1995). The fishery has no specific season set; however, fishing activities mostly occurs from October to April during the northwest monsoon, when fishing conditions are proven to be more favourable (Boullé, 1995). Apart from the Fisheries Act (2014), which restricts the catch of berried crustaceans, this fishery has no other regulations or a management plan in place.

The fishery relies solely on the Catch Assessment Survey (CAS) to record total catch data. However, there are questions about the accuracy and completeness of the current catch record, which may not fully represent the actual catch. With no

monitoring for over 30 years, there is a lack of information on the levels of fishing effort and size structure of the catch, leaving the stock status unknown. To address this issue, the Fisheries Research Department has implemented a fishery dependent sampling programme to gather biological and basic fisheries information from the fishery. This programme aims to improve our understanding of the fishery and ensure the long-term sustainability of this valuable resource.

The main objective of this report is to present the results of the sampling programme over the period of October 2021 to April 2022. In addition, a brief overview of the catch history is presented.

2. Methodology

2.1. Data collection

2.1.1. Catch data

The total catch data presented here was obtained from the Catch Assessment Survey (CAS) undertaken by the SFA Fisheries Statistics Department. The primary objective of the CAS is to collect catch, effort, and species composition data to enable timely monitoring and assessment of status and trends in the major artisanal fisheries including the Spanner Crab fishery. As a catch and effort logbook is still in development phase, the total landed catch and the species for the Spanner Crab is collected by statistical technicians. These are then reported in the fisheries statistical report.

2.1.2. Biological sampling

Sampling was conducted between October 2021 and April 2022 by the Fisheries Research team. Regular inspections were carried out at the Victoria and Providence artisanal fishing ports to monitor the landings of Spanner Crabs. During this period,

a total of 6 vessels actively targeted this species and random samples were recorded from each vessel at least once or more. The sampling size was determined to capture 5% of the total catch landed, ensuring the acquisition of sufficient data to obtain a representative sample of the spanner crab catch.

Depending on the tonnage Spanner Crabs were randomly taken from vessel fish hold and placed into a container for sampling (Gabriel and Ebrahim, 2021). Morphological characteristics such as body weight (grams (g)), sex, carapace length (millimetre (mm)), and reproductive markers (berried state, sperm plaque, setae hair etc..) were measured and recorded. Sexes were identified by abdomen shape whereas, male Spanner Crabs have narrow-shaped abdomen (**Figure 1** A-B), and female crab's abdomen is broader and rounded (**Figure 1** C-D). The carapace length (mm) of the crab was measured to the nearest 0.05 mm from the tip of the rostrum to the posterior carapace margin using a vernier calliper. The body weight (g) of the crab was weighted on a top-loading digital balance to the nearest 0.01 g. A detailed description of the method can be obtained in the Fishery and biological data collection: Standard Operating Procedures and guidelines (Gabriel and Ebrahim, 2021).

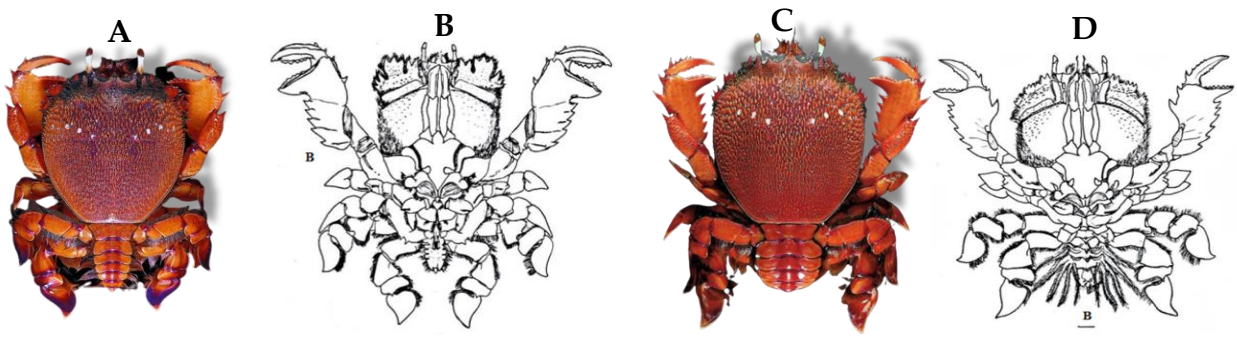

Figure 1: Spanner Crab (*R. ranina*) male and female. A-B) The dorsal and ventral view of a male Spanner Crab. C-D) The dorsal and ventral view of a female Spanner Crab.

2.1.3 Fishery information

During the biological sampling, additional information on the fishing activity was collected on the sampling form. The vessel name, trip duration, number of nets,

number of net lifts, total catch, and fishing location were all recorded to gain an understanding of the catch and effort. The vessel name helped to identify the specific vessel involved in the fishing activity, while the trip duration, number of nets used, and number of net lifts provided valuable insights into the duration and intensity of the fishing effort. The total catch helped to estimate the quantity of spanner crab caught into the fishery, while the fishing location provided important information about the distribution of fishing on the Mahé Plateau.

2.2. Data analysis

The R software (version 4.2.2) and Microsoft Office Excel software (Window 10) were used for the statistical analysis and production of graphs. A significance threshold of $p < 0.05$ with 95% confidence interval was applied.

2.2.1. Catch and catch per unit effort (CPUE)

Based on the data collected from fishers, the CPUE was calculated. Unfortunately, there are no available logbook to verify the accuracy of the information provided by the fishers. As there is no previous data to compare with, the calculation was conducted by month using the year's sampling data. To determine the total catch and fishing effort per month, the sum of catch and effort for each vessel was calculated for each fishing months. The Catch Per Unit of Effort (CPUE) was then calculated by dividing the total catch by the fishing effort, or trip duration, for each month [(1)].

$$1)\ CPUE = \sum total\ \frac{Catch\ (kg)}{Fishing\ Effort\ (trip\ duration)}$$

2.2.2. Size frequency distribution

Length frequency distribution of Spanner Crab was constructed from the carapace length measurements. The length frequency histograms were plotted for both females

and males sampled. The class groups were classified based on the carapace length which ranged from 6 to 14 cm (bin size by 1 cm) including the count or density per each size range. Box plot was plotted to provide visual summary of the data set used. The proportion of crabs in relation to the proposed minimum size limit of 8 cm CL was examined. Size differences between males and females sampled in each month were investigated using Wilcoxon test. In addition, size differences for each sex were compared between months using Kruskal Wallis test. Following a significant difference, a multi comparison test was carried out. The Wilcoxon and Kruskal Wallis test were used as the data did not meet the normality assumptions for a parametric test.

2.2.3. Weight distribution

Weight distribution of Spanner Crab was determined from the body weight of individual after measurements. Individual body weight between females and males were compare. For visual representation of the distribution of the data a boxplot was used. Kruskal Wallis analysis was used to test the significance in size between male and female Spanner Crab. Kruskal Wallis test were used as the data did not meet the normality assumptions for a parametric test.

2.2.4. Sex-ratio

The sex ratio provides the fundamental information on the population dynamics, specifically the reproductive potential of a given species. Data collected from both sexes were used to determine the trend in the sex ratio. The sex ratio is given as (M: F) and calculated using the following equation[(2)]:

$$2)\ \text{Sex Ratio} = Count\frac{Male}{Female}$$

3. Results

3.1. Fishery landing overview

The Spanner Crab landings from 1988 to 2020 is shown in **Figure 2**. Historically, the landings show a fluctuating trend. Over the last 6 years (2014 to 2019), the landings have consistently remained close to and above the long-term average of 21 Metric Tonnes (MT). In 2020, the landings were considerably low with 9 MT as opposed to 36.6 MT recorded in 2019, representing a decrease of 74%. It is to be noted that the data for 2021, is still being captured for the CAS (SFA, 2022).

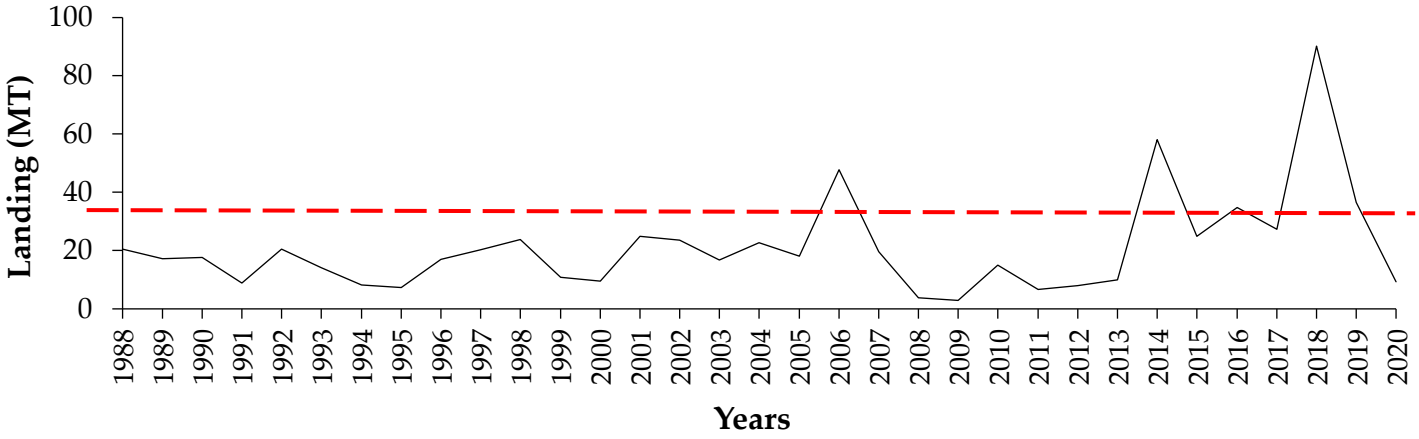

Figure 2: Spanner Crab annual reported landing catch in Metric Tonnes (MT) from 1998 to 2020. Dashed red line indicated the average seasonal catch of 21 MT. **Note:** 2021/ 2022 data are still being captured and are not shown.

3.2. Sampling catch and CPUE trend

The total catch per month is shown in **Figure 3.** For the 2021/2022 fishing season an estimated total catch of 15,150 kg was reported of which 510 kg was sampled under the sampling programme. The highest estimated catch, at 4,700 kg was recorded in December 2021 whilst the lowest, at 800 kg was recorded in April. In terms of CPUE trends, October 2021 exhibited the highest value compared to other months with a CPUE of 280 kg/duration. The lowest CPUE of 100 kg/duration was observed in April 2022.

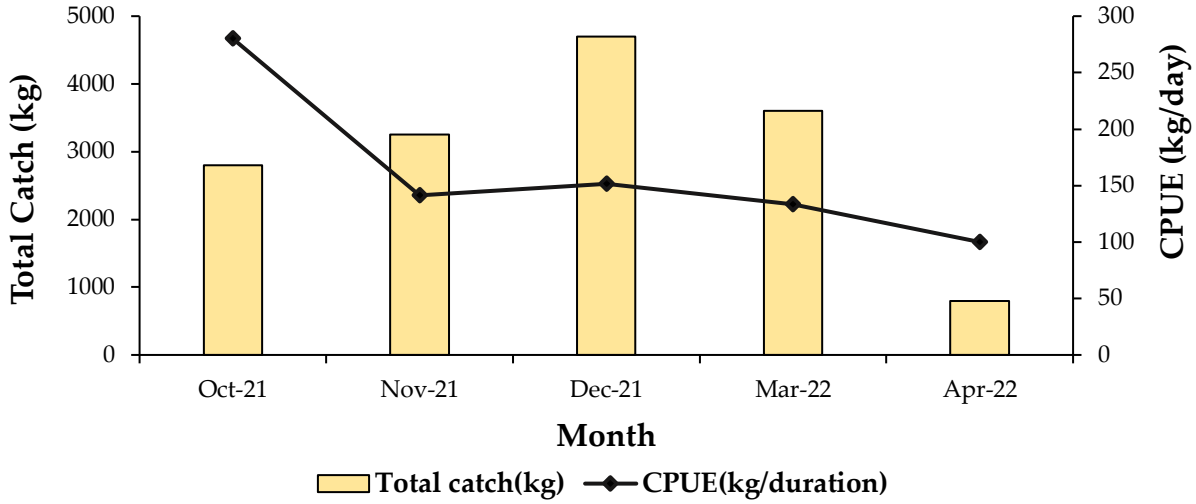

Figure 3: Total catch (kg) and CPUE (kg/duration) from the 2021/2022 sampling period. **Note:** catch and trip duration (days) is an estimation from what fishers provided. No sampling conducted in January and February 2022.

3.3. Sampling effort

A total of 14 fishing trips were sampled between October 2021 to April 2022 (**Table 1**). Eighty-six percent of the sampling was conducted at the artisanal fishing port whilst 14% at the Providence fishing port. As the sampling programme was newly implemented the sampling effort was concentrated on vessel unloading on Mahé island. A total of 1692 individuals were sampled, consisting of 454 female and 1238 males, with a combined weight of 510 kg. Males were almost 3 times more abundant in the samples compared to females, with a ratio of 2.7:1.

Table 1: Sampling summary form October 2021 to April 2022.

MONTH	TRIP SAMPLED	FEMALE	MALE	TOTAL SAMPLED
OCTOBER	2	61	189	250
NOVEMBER	4	77	341	418
DECEMBER	4	148	350	498
MARCH	3	107	319	426
APRIL	1	61	39	100

3.4. Length frequency distribution

The relative size frequency distributions of males and females Spanner Crab sampled during the 2021/2022 period is shown in **Figure 4**. A unimodal distribution can be observed for both sexes. For females, carapace length ranged from 6 to 11.5 cm, with a mean of 8.5 cm, mode of 8.7 and a median of 8.4 cm. Additionally, a slight positive skewness is observed, indicating a higher concentration of individuals in the smaller size classes compared to the larger ones. In contrast, male carapace length ranged from 7 to 13.3 cm, with a mean of 9.5 cm, mode of 9 and a median of 9.5 cm. Male Spanner Crab was statistically significantly larger ($p < 0.05$) than females[1] (**Figure 4**).

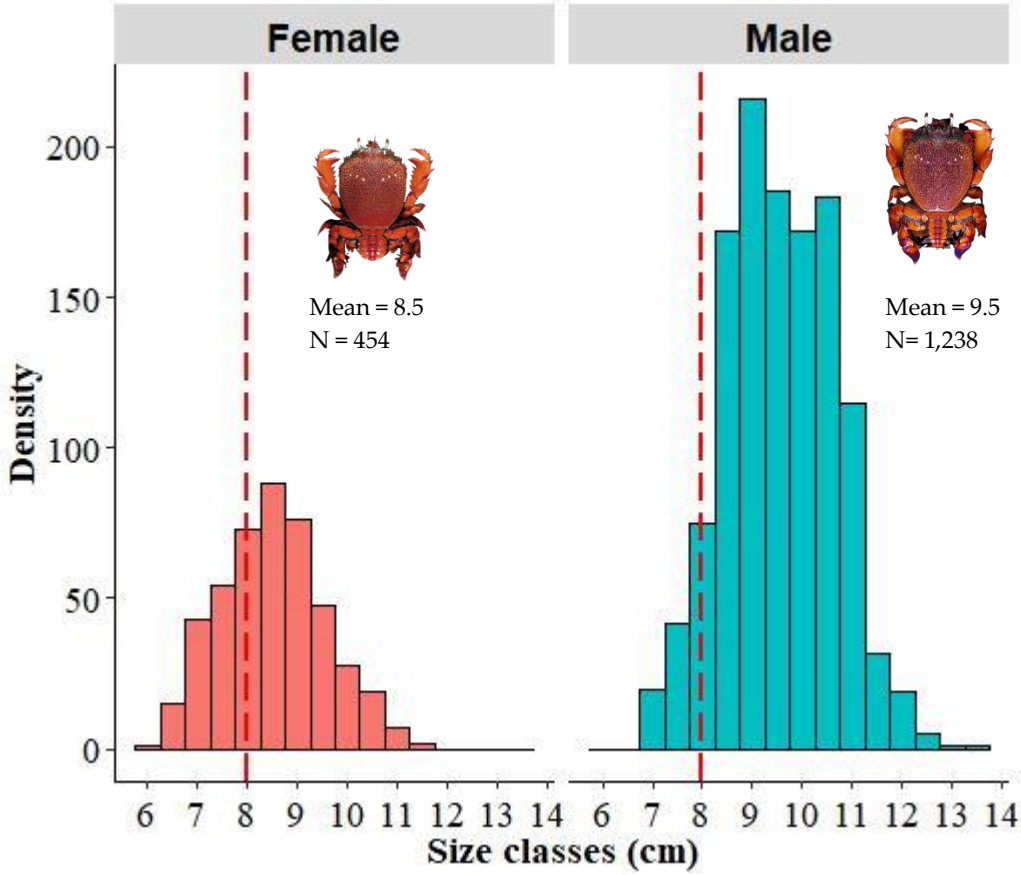

Figure 4: Size frequency distribution (carapace length) of Females and Males for the 2021/2022 sampling period. Density represents the proportion of counts of each size class. Red dashed line represents proposed minimum size of 8 cm. Note: there is no size limit set.

[1] Kruskal-Wallis: $\chi^2_{(1)}=225.21$, $p<.05$

The proportion of male and female spanner crabs below or above the proposed minimum size limit of 8 cm is shown in **Figure 4**. Majority of the spanner crabs caught, which accounted for 86% of the total, were found to be above the proposed minimum size limit. On the other hand, only 14% of the crabs were below the limit. Further analysis of the results shows that the size distribution of the spanner crabs varied between male and female. Among the females, 68% were found to be above the minimum size limit, while 32% were below it (**Figure 4**). Among the males, 93% were above the minimum size limit, while 7% were below it (**Figure 4**).

3.5. Size distribution by month

The carapace length (cm) of males and female across the sampling months is shown in **Figure 5**. Male carapace length was significantly larger (p <.05) across each month compared to the females Spanner Crab (**Figure 5** and **Table 1 Appendix 1**). Carapace length comparison was conducted for both sexes individually per sampling months. Male carapace length varied significantly between months expect for males sampled in December and March[2]. Whilst Female carapace length also varied significantly between months except for November-December, November-March and December-March[3] (**Figure 5** and **Table 2 Appendix 1**). The average size of males and females were larger in October. In contrast, the average size was the smallest in April (**Figure 5**).

[2] Kruskal-Wallis: $\chi^{2}_{(4)}$=231.28, p = <.05
[3] Kruskal-Wallis: $\chi^{2}_{(4)}$=158.2, p = <.05

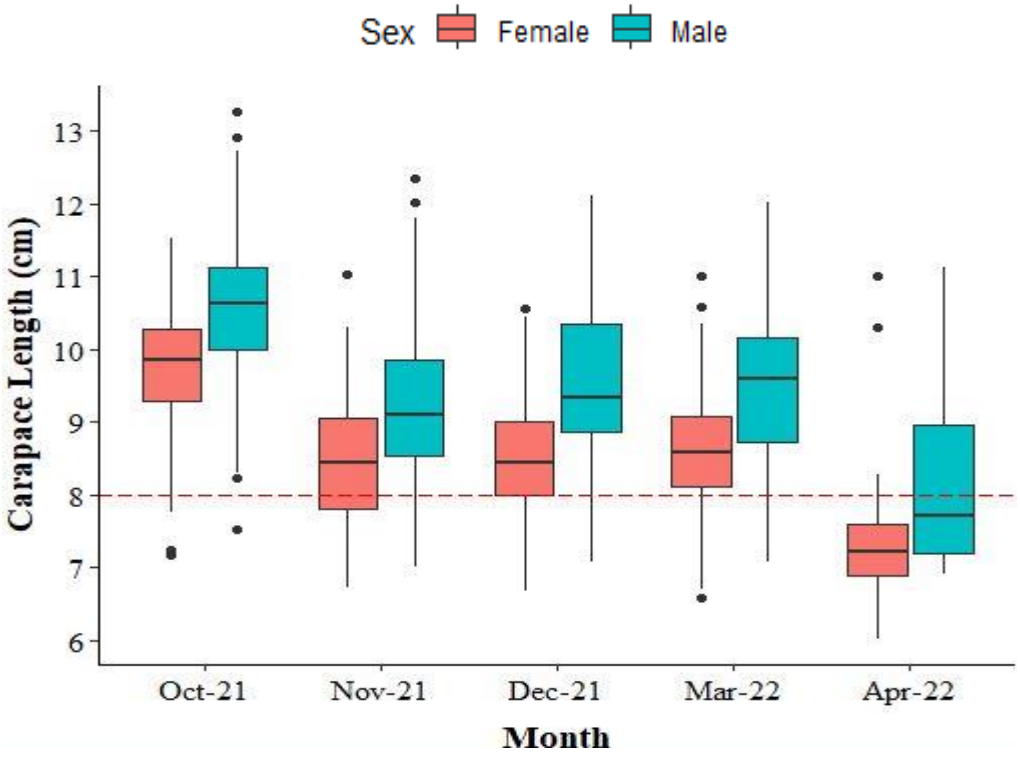

Figure 5: Boxplot of the size distribution of Females and Males across the sampling months. Red dashed line represents proposed minimum size of 8 cm. **Note:** January and February no sampling was undertaken.

3.6. Weight frequency distribution

The relative weight distributions of males and females Spanner Crab sampled during the 2021/2022 period is shown in **Figure 6**. The body weight for all Spanner Crab sampled during this period ranged from 0.1 to 1.3 kg, with a mean of 0.302 kg, mode of 0.200 kg and a median of 0.275 kg. Female body weight ranged from 0.100 kg to 0.590, with a mean of 0.234 kg, mode of 0.170 kg and a median of 0.220 kg. Whiles male weight ranged from 0.110 to 0.915 kg, with a mean of 0.325 kg, mode of 0.220 kg and a median of 0.119 kg. Male Spanner Crab was statistically significantly ($p < .05$) heavier than females[4] during the 2021/2022 sampling period (**Figure 6**).

[4] Kruskal-Wallis: $\chi^2_{(1)} = 224.37$, $p = < .05$

3.7. Weight distribution per month

The body weight across the sampling months for males and females separately varies significantly[5 & 6]. For males body weight was significantly different across month with exception to December-March[5] (**Figure 6** and **Table 1 Appendix 1**). The females body weight was significantly different across month with exception to November-March, December-March and November-December[6] (**Figure 6** and **Table 2 Appendix 1**). Males and females in October were heavier compared to other sampling months.

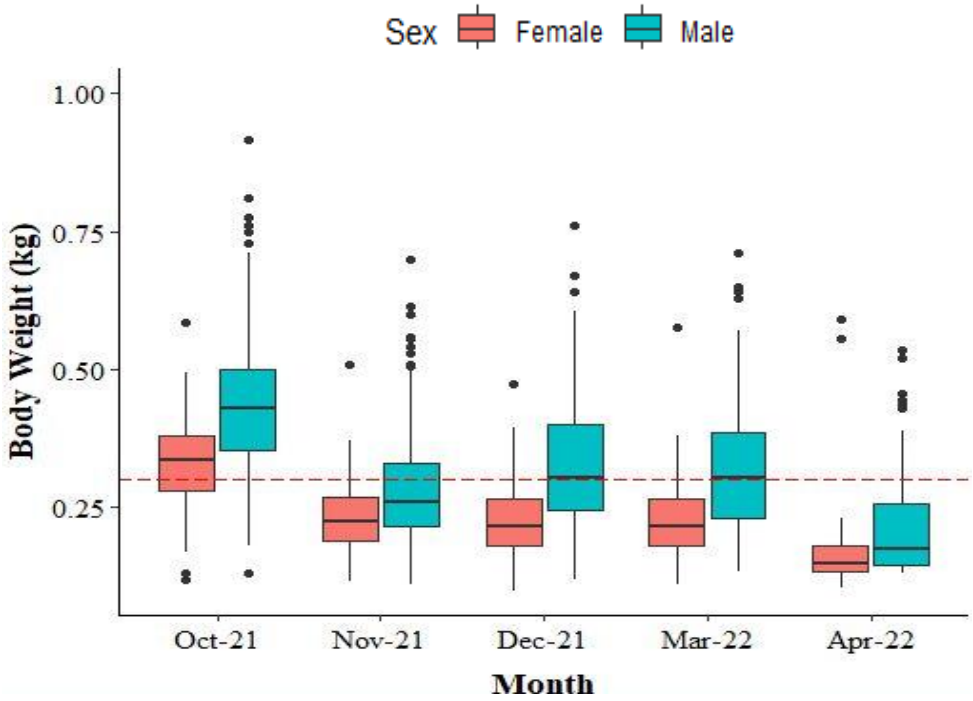

Figure 6: Boxplot of distribution of individual body weight between Females and Males. Red dashed line represents the overall mean of 0.302 kg. **Note:** January and February no sampling was undertaken.

4. Discussion

The trends in the estimated total catch vary from year to year. However, over the past two years, there has been a noticeable decline in the amount of catch landed by

[5] Kruskal-Wallis: $\chi^2_{(4)}=217.66$, $p = <.05$

[6] Kruskal-Wallis: $\chi^2_{(4)}=133.72$, $p = <.05$

commercial fishers. This decline could be influenced by several factors such as fishing intensity, active fishing vessels, market demands, search methods, seasonal variation in environmental factors, or low recruitment (Laevastu and Marasco 1982). As this fishery has remained unmonitored for over 30 years, these uncertainties require a thorough investigation. Currently only 5-6 fishing vessel is actively fishing for Spanner Crab.

The sampled catch and catch per unit effort (CPUE) was compared between months since this is the first year of the biological sampling programme. The catch trend shows that as the fishery progresses there was a peak in total catch reported in December compared to October at the start of the fishery. This peak is assumed to be coincided with the high market demand due to the festive seasons (Christmas and New years). March reported the second higher catch which is assumed to be due to the festive season (Easter). The increase in catch could also be as a consequence of the increase in the number of vessels active in those months (December = 4, March = 3). As fishing month progresses the number of fishing vessel decreases along with market demand. This decrease in fishing effort could be attributed to the fact that Spanner Crab aggregation tend to dissipate beyond the reproductive period between November to February (Boullé, 1995, Kasinathan et al., 2007).

The catch per unit effort (CPUE) (kg/day) which provides an indication of the relative abundance of Spanner Crab, was highest in October with a CPUE of 280 kg/day. It decreased remarkably to 141 kg/day in November and remained relatively stable until March. The CPUE then dropped to 100 kg/day in April. This indicates a decline in the relative abundance over time, which is likely attributed to the removal of larger males at the start of the fishery.

It is imperative to exercise caution when interpreting the catch and the CPUE presented here, as with the lack of a catch and effort logbook, effort is based on estimation from fishers which can be inaccurate. However, once a logbook system

along with a licensing framework is implemented this issue will be addressed and rectified.

Spanner Crab exhibits a clear sexual dimorphism between males and females (Minagawa, 1993; Dichmont and Brown, 2010). Male Spanner Crab sampled were larger and heavier as opposed to its female counterpart. On average the male's carapace length sampled were 9.5 cm while females had an average carapace length of 8.5 cm. This observation can be assumed to be because males grow faster and attain a larger and heavier size as they undergo ecdysis twice as often compared to females (Chen and Kennelly, 1999; Kennelly, 1992). This could also be because males are exposed to more food as they tend to remain emerged for longer periods (Skinner and Hill, 1987). As a reproductive strategy, females invest a greater proportion of energy in storing sperm and fertilisation to increase reproductive success (Kasinthan et al., 2007; Fielding and Hayley, 1976), thus diversion of resources to reproduction suppresses the growth and eventually weight gain (Hartnoll, 2006). Boullé (1995) conducted surveys which reported that male and female spanner crabs showed significant sexual dimorphism, with males reaching an average of 11 cm CL and females 9 cm CL.

Sex ratio provides basic information of a given population, especially the ability to reproduce effectively i.e; the reproductive potential (Vicetini and Araujo, 2003). In general, 73% of the catch sampled were males as opposed to 27% of females. Similar results have been reported in Skinner and Hill (1987), and Brown (1986). Many factors may influence the catchability rate of males and one of which is associated with the behavioural differences between sexes known as agonistic behaviours (i.e., aggression) (Skinner and Hill, 1987). As female Spanner Crab sensitivity to food stimuli is shorter, their response time to baited tangle nets is much faster than their male counterparts (Skinner and Hill, 1987). However, if they experience agonistic behaviours at the food site from larger males, some females may be influenced to

withdraw from the tangle nets before getting entangled. This in turn will result in one sex being easily caught (Skinner and Hill, 1987, Jega et al, 2017). It is important to note that the higher number of male Spanner Crabs compared to females may also be due to fishers releasing berried females, thus influencing the catch ratio.

The monthly statistics pertaining to the carapace length and body weight of the Spanner Crab, showed a noticeable trend. It is evident that Spanner Crab was larger and heavier in the month of October, despite the fact that less sampling was conducted during this period. This could potentially mean that larger individuals are captured first at the beginning of the aggregating period due to the agonistic behaviours display mostly by larger individuals and sex specific to male. This observation is undoubtedly intriguing, as it highlights the significant question of where the specific location of which Spanner Crab form an aggregation. It is evident that further research is required to gain a deeper insight into the reasons behind this trend and its implications for the Spanner Crab population.

4.1. Sampling limitations

There is no system implemented to identify the Spanner Crab fishers making it difficult to cover all landings. Apart from the Victoria artisanal fishing port, fishers frequently offload their catch in various locations on Mahé, e.g., at Providence artisanal fishing port and Anse a la Mouche. Additionally, fishers also offload their catch on other islands like Praslin and La Digue. As all the research staff are located on Mahé, it is somewhat difficult to cover these landings. Lack of staff capacity is another limitation experienced, as a result of other ongoing projects, especially the sea-based cruise which requires scientific personnel, thus on certain days there were not enough staff to undertake sampling. Consequently, no sampling was conducted in January and February 2022.

5. Conclusion

It is important to note that a fishery-independent survey should be implemented to allow a more comprehensive analysis of the Spanner Crab population e.g.: distribution, abundance, etc… In return, this will provide much-needed information that will allow the best-suited management measures to be implemented for this fishery. It must be stressed that the data presented here must be treated with caution as the sampling programme was recently implemented, and it is recommended that continuous monitoring (i.e.; collection of biological data) is necessary before drawing any further conclusion.

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Appendix 1

Table 2: Wilcox test comparisons between male carapace length to female carapace length per month sampled during 2021/2022 period.

Comparison Sex	P value	Significance level
Male – female October	1.384e-09	*P* <0.05
Male – female November	2.163e-08	*P* <0.05
Male – female December	2.2e-16	*P* <0.05
Male – female March	2.288e-16	*P* <0.05
Male – female April	0.0001012	*P* <0.05

Significance level at 0.05. ns; nonsignificant different.

Table 3: Kruskal-Wallis pairwise comparisons of male carapace length and body weight sampled per month for the sampling period 2021/2022. P values adjusted with the Bonferroni method.

Comparison Group	Carapace Length (cm)		Body Weight (kg)	
	P value	Significance level	P value	Significance level
Oct-Nov	2.439015e-41	*P* <.05	3.410630e-40	*P* <.05
Oct-Dec	2.480697e-23	*P* <.05	1.851260e-18	*P* <.05
Nov-Dec	2.954132e-04	*P* <.05	1.049313e-06	*P* <.05
Oct-Mar	4.169396e-25	*P* <.05	3.722427e-23	*P* <.05
Nov-Mar	6.238441e-03	*P* <.05	2.138805e-03	*P* <.05
Dec-Mar	1.000000e+00	**ns**	1.000000e+00	**ns**
Oct-Apr	7.436010e-26	*P* <.05	1.398462e-22	*P* <.05
Nov-Apr	1.192810e-03	*P* <.05	1.365364e-02	*P* <.05
Dec-Apr	9.729050e-08	*P* <.05	2.105607e-07	*P* <.05
Mar-Apr	6.483289e-0	*P* <.05	1.005741e-05	*P* <.05

Significance level at 0.05. ns; nonsignificant different.

Table 4: Kruskal-Wallis pairwise comparisons of female carapace length and body weight sampled per month for the sampling period 2021/2022. P values adjusted with the Bonferroni method.

Comparison Group	Carapace Length (cm)		Body Weight (kg)	
	P value	**Significance level**	**P value**	**Significance level**
Oct-Nov	8.6964393-10	*P* <.05	1.269072e-08	*P* <.05
Oct-Dec	5.381454e-12	*P* <.05	1.267859e-11	*P* <.05
Nov-Dec	1.000000e+00	**ns**	1.000000e+00	**ns**
Oct-Mar	7.680207e-09	*P* <.05	2.068111e-11	*P* <.05
Nov-Mar	1.000000e+00	**ns**	1.000000e+00	**ns**
Dec-Mar	1.000000e+00	**ns**	7.22295e-01	*P* <.05
Oct-Apr	5.662040e-35	*P* <.05	8.599608e-30	*P* <.05
Nov-Apr	1.584589e-10	*P* <.05	2.237897e-09	*P* <.05
Dec-Apr	1.509635e-13	*P* <.05	2.100992e-10	*P* <.05
Mar-Apr	1.448237e-14	*P* <.05	8.5994404e-09	*P* <.05

Significance level at 0.05. ns; nonsignificant different.