COMPARATIVE BIOECOLOGICAL CHARACTERIZATION OF *CHTHAMALUS MALAYENSIS* (BARNACLES) FOUND AT SANDSPIT AND HAWKSBAY BEACHES, KARACHI

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ABSTRACT

Barnacles are generally found to be attached on the hard substrata and are abundantly found in the intertidal zones. Acorn barnacles (*Chthamalus malayensis*) are found abundantly in upper littoral zones and have ability to tolerate strong waves action, high temperature and desiccation Shell of *Chthamalus malayensis* is elongated, egg-shaped and is greyish-white. In Pakistan, *C. malayensis* are abundant in different intertidal zone of Sindh and Balochistan coast including at Sandspits and Hawksbay which has abundant population of this barnacle on their rocky shores. A comparative study of bioecological characteristics of *Chthamalus malayensis* from Sandspit and Hawksbay beaches was made during which the distribution of *Chthamalus malayensis* at these beaches was study and compared. The population density of *Chthamalus malayensis* at Kakka Pir Sandspit and Hawksbay show higher during the month of November and January due to distinct intertidal zonation and some distinctive environmental factors .The *Chthemalus*

malayensis samples that were collected from Hawksbay shore, displayed highest variation within weight and length over the year as compared to Sandspit.

KEY WORDS

Barnacles, *Chthamalus malayensis*, rocky shore, intertidal zone, Karachi. Sandspit, Hawksbay, bioecology

INTRODUCTION

Barnacles are abundantly found in the intertidal zones, especially acorn barnacles (Zabin, 2009). The barnacle species *Chthamalus malayensis* belong to family Chthamalidae is reported from different littoral zones of equatorial and tropical oceans of the world. *Chthamalus malayensis* is found abundantly at upper littoral zone on the rocky shores and as they tolerate strong wave action, high temperature and desiccation. The reproduction of *C. malayensis* is reported to take place throughout the year. The rate of reproduction is high during monsoon season and no reproduction occurs during August (Chan and Benny, 2007).

The species of genus *Chthamalus* are cosmopolitan distributed all over the world. They are present in the supra-littoral zone of rocky shores and are sometimes found attached to different species of gastropods such as *Cellana karachiensis* and *Cellana radiata*. In 2022 Bahrehmand *et al*., reported *Chthamalus malayensis* as a paraphylum in South China Sea clustered with *Chthamalus barnesi* group.

Pakistan has coastal line of about 1050 km long, which is divided into Sindh and Balochistan province. The coastline has 800 km of Balochistan province and 250 km of Sindh province bordering to the north of Arabian Sea. (Saifullah and Fayyaz, 2002). The Karachi coast is about

30 miles of seashore. (Ali and Afsar, 2013). The beaches of Karachi coast have been a variety of fauna which has been distributed through different zones till intertidal zones of marine ecosystem. The Hawksbay and Sandspit beaches are situated in the southern areas of Karachi (Firdous, 2001). There are different species of invertebrate and vertebrate in the intertidal zones of Hawksbay and Sandspit. Due to the abundance of marine fauna these beaches serve well for research purpose. Sandspit and Hawksbay contain large varieties of vertebrates and invertebrate fauna such as: gastropods, molluscans, pieces and sea turtles etc. Besides all these fauna Sandspits and Hawksbay had abundant number of barnacles found.

Chthamalus malayensis is an intertidal zone species of rocky shores of Pakistan, spreading along the coastline of Sindh and Balochistan. *Chthamalus malayensis* was reported for form a distinct zone at high water mark on exposed rocky shores including at Paradise Point (Haq *et al*., 1978). It was reported from other rocky shore along the coast of Pakistan (Rizvi and Moazzam, 2006). In the present study, the specimens were collected from rocky shores of Sandspit and Hawksbay Karachi. This is the first detailed study on bioecological characterization of *Chthamalus malayensis* from Pakistan which may pave way for further studies on barnacles and other invertebrates.

MATERIALS AND METHODS

The study was carried out on two rocky shores of Karachi coast i.e. Sandspit and Hawksbay which are located about 45km from Karachi city. The beach of Sandspit at southwest of Karachi, consist of white sandy and rocky area at Kakapir village. (Qari and Shaffat 2015).

Hawksbay beach situated at north west of Karachi city consist of rocky and sandy area (Jan *et al*., 2022) . *Chthamalus malayensis* are the most common specie of barnacle found attached to the hard substrates such as rock (Haq et al., 1978) and gastropod mollusks. *Chthamalus malayensis* were collected from 15 different stations of Sandspit and Hawksbay beach from January 2022 to December 2022.

Quadrate method was used for sampling technique. A wooden quadrate of 25 x25 cm^2 was placed in the study area and the target species were counted, identified and their quantity was recorded Quadrate methods are a time-tested sampling technique that is used for the study of sessile animals. The quadrates of 25×25 cm^2 were at four different places at distant from one another.(Chan and Williams, 2004; Chan, 2007).*Chthamalus malayensis* were removed/collected from the hard substrate using scrapper and preserved into the jar with 100% ethanol and bought to the lab for determination of the length and weight . Specimens were measured in cm, weight of each specimen was taken by analytical balance in mg. Analytical balance (MODLE No: PA-214-OHAUS) was used. For result of the length and weight Pearson's correlation test and ANOVAs were performed.

The observed data was statically calculated through the Graphpad prism version 8.0 software. Chi square test was conducted to estimate the population density of *Chthamalus malayensis* from 15 various sites of Kakka Pir, Sandspit and Hawksbay shore of Karachi from January 2022 to December 2022. To test the hypothesis of a weight – length ratio of *Chthamalus malayensis* from each respective shore Mean and Standard deviation (Mean±SD) were used. To investigate the variation of weight and length of Hawksbay and KakkaPir Sandspit's collection, Two-way ANOVA was applied through t-test method for comparison of multiple variables.

RESULTS

Chthamalus malayensis shell is elongated, egg-shaped and is greyish-white in color. Size of *C. malayensis* ranges from 3-10 mm. The shell has 6 plates which consist of one carina which was larger than rostrum, carinal latus two in number, two latus and one rostrum. Parietes are calcareous symmetrical, and solid. The parietes has smooth inner surface. Operculum plates are symmetrical and the articulation of opercular valves is broad. Scutum is larger than Tergum and is separable. Scutum was expanded and triangular. For lateral depressor muscle stergum was wider with four specific crests. Four mandible teeth are present at the lower margin. At the edges, there are three large setae, I cirri was with conical spines and II cirri was with multi-cuspidate setae and basal guard. (Pochai *et al*., 2017).

Comparative Analysis of *Chthamalus malayensis's* Population Density on Sandspit and Hawksbay Shore

The comparative study of the population of *C. malayensis* indicated the significant variation of population between Sandspit and Hawksbay shore represented in Fig 1. The overall highest population density was observed in the month of April on Hawksbay shore. The comparative graph indicated the population variation with in a same season from different shores represented the Mean±SD of 3.289±2.199 (Sandspit) and 28.141±1.822 (Hawksbay) in the month of April, the Sandspit's population appeared as a P value <0.05 and Hawksbay data was indicated P value <0.001. The comparative data indicated the variable physiochemical and substratum effects on the population of *C. malayensis* on Hawksbay and Sandspit shores.

Weight and Length Analysis of population of *Chthamalus malayensis* from Sandspit and Hawksbay shore

The monthly weight analysis of *C. malayensis* was calculated with the help of Mean±SD. The overall highest mean ratio of *C. malayensis* was indicated in the month of October that attains weight of mean 128± 5.921 mg presented in figure.2. The highest weight ratio of *C.malayensis* on Hawksbay was 207± 4.922 mg observed in the month of January represented in figure. 2 . The comparative study indicated the variation in length ratio of *C. malayensis* that show effectiveness of the study according to the different shores. The highest length sizes species of *C. malayensis* was observed in Hawksbay shore. The Fig 7 indicated the highest Mean±SD ratio of length factor was detected in the month of February and December i.e., 0.57± 1.88mm and 0.5± 1.92mm.

Length-weight relationship of population of *Chthamalus malayensis* from Sandspit and Hawksbay shore through Two-way ANOVA

Length-weight relationship of population of *Chthamalus malayensis* from Sandspit and Hawksbay shore was calculated through Two-way ANOVA by using student t-test with significance level of <0.05 P value. (Table.2) indicated the significant relation between two variables from Hawksbay and Sandspit shores. The result indicated that the length –length relationship (Sandspit-Hawksbay) displayed $F(11, 11) = 5.985$ with $P=0.0031$ that show significance whereas length-weight (Sandspit-Hawksbay) relationship appeared $F(1, 11) = 9.868$ with $P=0.0094$. the weight-weight (Sandspit-Hawksbay) relationship indicated the significant results with evidence of $P=0.0010$. The Fig. 8 and 8 indicated the QQ plot of weight and length variation through Two-way ANOVA.

Shore	Months	Sampling sites	Population density (Mean± SD)	Significance Level	DF	Sampling sites	Shore	Population density (Mean±SD)	Significance Level	DF
Sandspit	January	**S-01-S-15**	19.950± 2.907	<0.05	11	**S-01-S-15**	Hawkbay	16.479±2.737	<0.05	11
	February	**S-01- S-15**	5.574±1 .184	ns	11	**S-01-S-15**		9.950±2.847	<0.05	11
	March	**S-01-S-15**	7.841±2 .823	<0.001	11	**S-01-S-15**		6.764±2.184	Ns	11
	April	**S-01-S-15**	3.289±2 .199	<0.05	11	**S-01-S-15**		28.141±1.822	<0.001	11
	May	**S-01-S-15**	14.947± 4,245	ns	11	**S-01-S-15**		9.278±2.199	<0.05	11
	June	**S-01-S-15**	4.078±1 .623	ns	11	**S-01-S-15**		11.647±6.545	Ns	11
	July	**S-01-S-15**	7.696±3 .220	<0.05	11	**S-01-S-15**		7.324±3.733	<0.001	11
	August	**S-01-S-15**	3.967±2 .012	<0.001	11	**S-01-S-15**		8.786±4.210	<0.05	11
	September	**S-01-S-15**	8.054±1 .352	ns	11	**S-01-S-15**		14.867±3.012	<0.001	11
	October	**S-01-S-15**	2.308±1 .452	<0.001	11	**S-01-S-15**		7.452±2.752	Ns	11
	November	**S-01-S-15**	12.849± 2.964	<0.001	11	**S-01-S-15**		19.668±2.252	<0.001	11
	December	**S-01-S-15**	6.479±2 .737	Ns	11	**S-01-S-15**		13.649±1.954	<0.001	11

Table I. Population density ((Mean±SD) of *C.malayensis* populations per sampling site, month, (standard deviation (SD), degrees of freedom(DF), chi-square values corresponding to the statistic obtained with an indication of their significance at 95% confidence level (X^2), ns (no significance)) in Sandspit and Hawksbay shore in January 2022 to December 2022.

	SS (Type III)	DF	MS	F (DFn, DFd)	P value	Significant
Length-Length (Sandspit-Hawksbay)	0.1413	11	0.01285	F (11, 11) = 5.985	P=0.0031	yes
Length-Weight of (Sandspit-Hawksbay)	0.02118	11	0.02118	F (1, 11) = 9.868	P=0.0094	yes
Weight-Weight of (Sandspit-Hawksbay)	10572	11	10572	F (1, 11) = 19.73	P=0.0010	yes

Table:2. Two-way ANOVA showing the variation of Length-weight characters of *Chthamalus malayensis* among the Hawksbay and Sandspit Shore from January2022-December 2022.

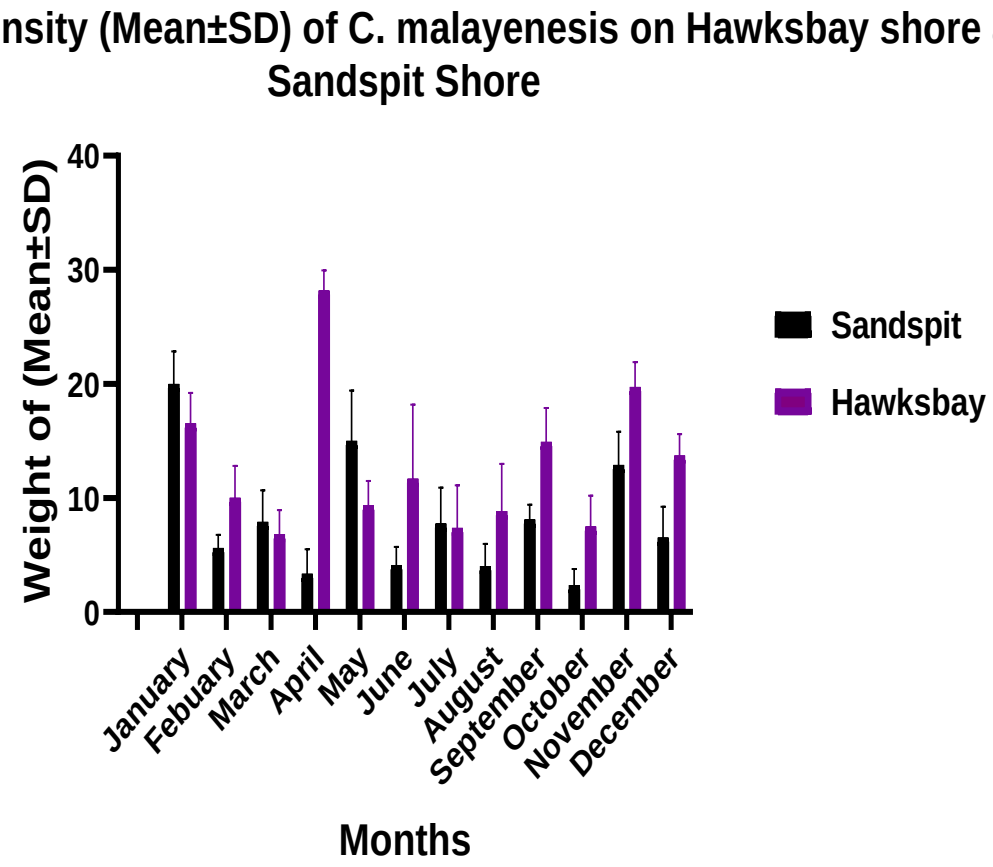

Figure.1 Population Density of *C.malayensis* on Sandspit Shore and Hawksbay shores in 2020-2021

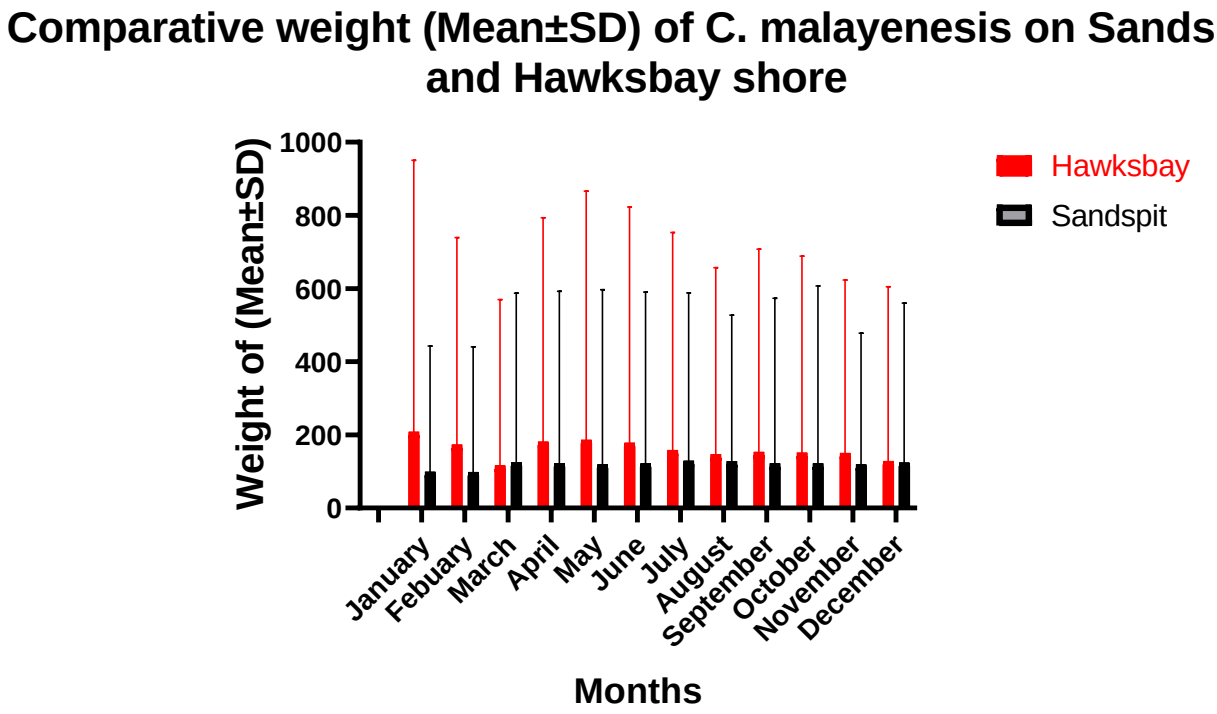

Figure: 2. Comparative weight (Mean±SD) of *C. C.malayensis* on Sandspit and Hawksbay Shore in January 2022- December 2022

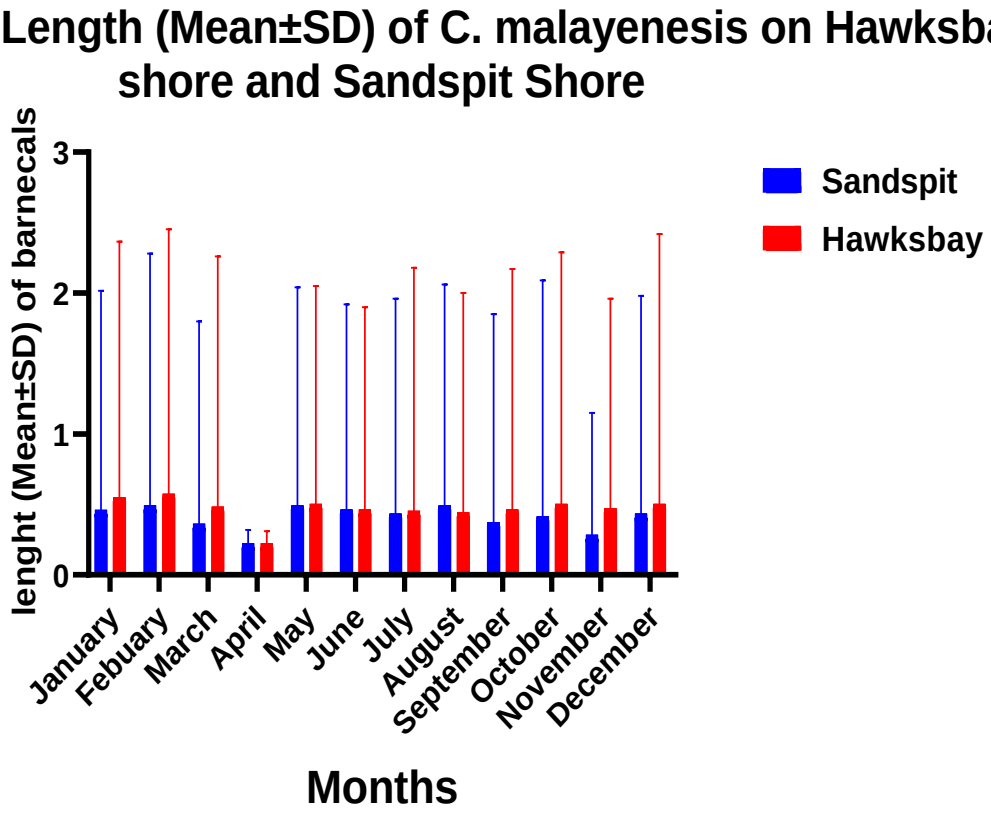

Figure: 3. Comparative Length (Mean±SD) of *C. C.malayensis* on Sandspit and Hawksbay shores in January 2022- December 2022

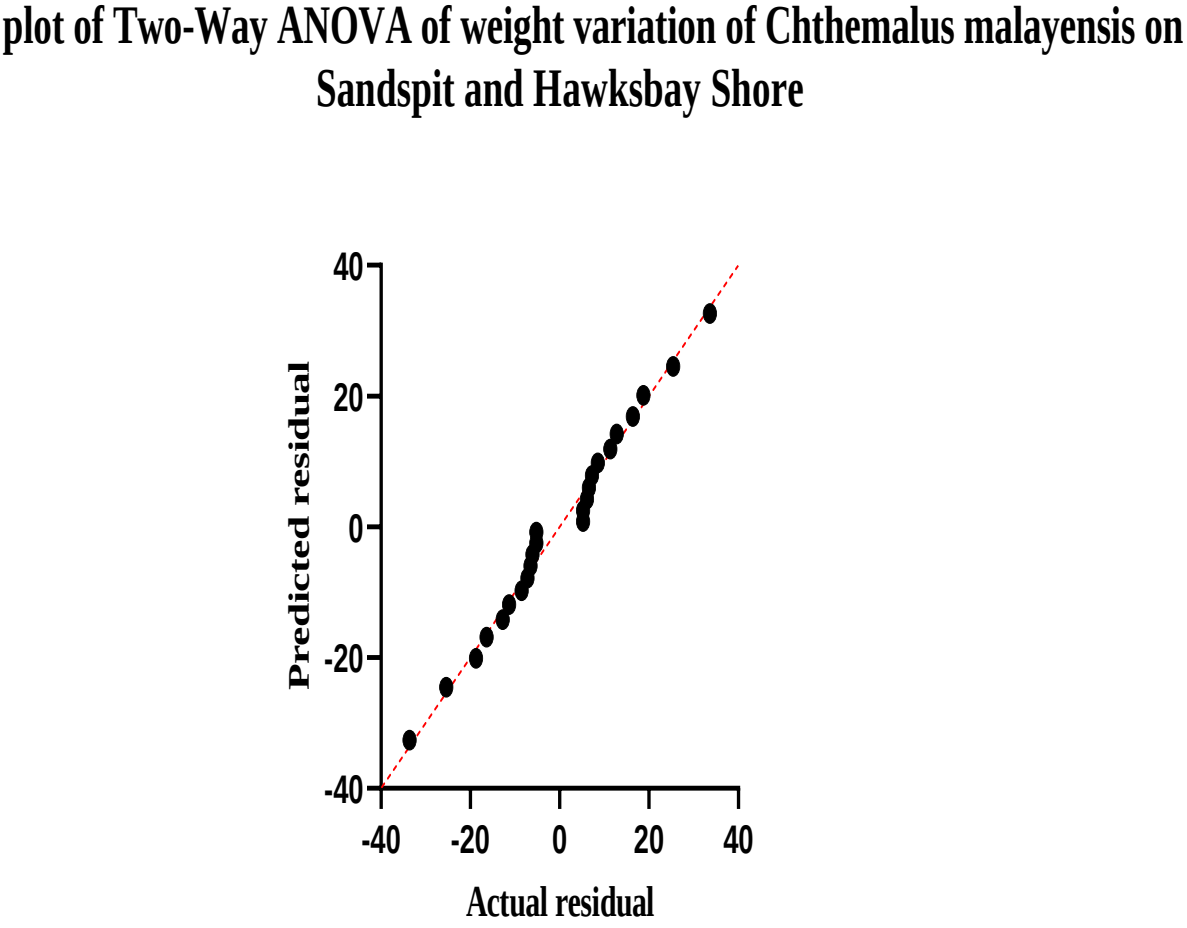

Figure: 4. QQ plot of Two-Way ANOVA of weight variation of *Chthamalus malayensis* on Sandspit and Hawksbay Shore

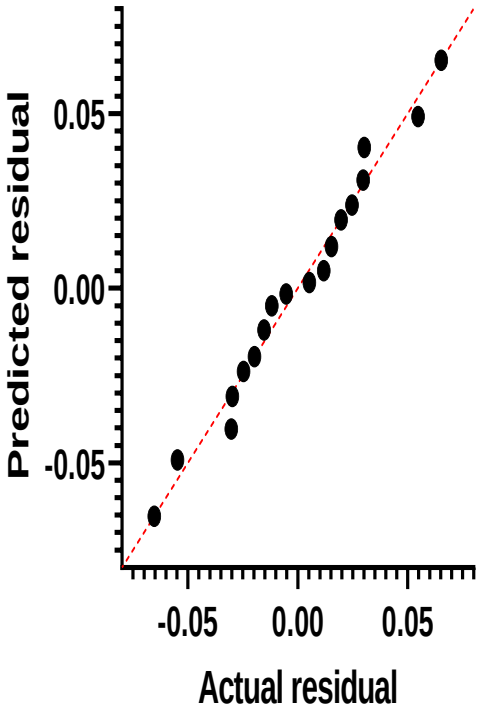

Figure.5 . QQ plot of Two-Way ANOVA of Length variation of *Chthamalus malayensis* on Sandspit and Hawksbay Shore

DISCUSSION

Chthamalus malayensis is a common barnacle which found intertidal zone of rocky shore atKarachi coast. The present study was based on comparative study of bioecological characterstics of *Chthamalus malayensis* from Kakka Pir Sandspit and Hawksbay beaches of Karachi coast.

The *Chthamalus malayensis* species was found to be the most common acron barnacle at Kakka Pir Sandspit and Hawksbay beaches of Karachi. Haq *et al*. (1978) noticed that this species form a distinct zone on the rocky shores at Paradise point. Similar zonation was found during the present study. Ashok and Palekar (1963) has observed the *Chthamalus malayensis* in huge number at Bombay India, while according to Tsang *et al*., (2012) species of *Chthamalus* was locally abundant. Southward and Newman in 2003 reported the wide distribution of *Chthamalus malayensis* in tropical Australian and Indo-Malayan waters from Pacific northward to Vietnam, Ryukyu Island and China. During the present study, it was observed that *Chthamalus malayensis* attached most abundantly approx 65% with rocks at intertidal zone of Kakkapir Sandspit and Hawksbay in the form of cohorts along with different species of barnacles and other fauna. In Hong Kong *Chthamalus malayensis* was found to have high abundance nearly 60% at Cape d'Aguilar, in Japan Okinawa *Chthamalus malayensis* mostly cover the shore (Chan, 2007) and 2-3 cohorts at intertidal zone with approximate age three years (Yan, 2003). The acorn barnacle *Chthamalus malayensis* Pilsbry, 1916 (Thecostraca: Chthamalidae) are dominant space occupiers, contributing more than 50% of overall biomass on rocky intertidal shores on the west coast of Thailand (Wangkulangkul & Promdam, 2018). They are recognized as ecosystem engineers that have impacts on the abundance and distribution of other species on intertidal rocky shores (Amnuaypon & Wangkulangkul, 2018). n the present study, the length of *Chthamalus malayensis*

0.4-1.6 mm, height is 0.3-0.6 mm and diameter 0.3-1.2 mm, rounded shape stony structure, grayish white color with black tinge from KakkaPir Sandspit and Hawksbay beaches, while Ashok and Palekar (1963) studied the average diameter 9-10 mm and height was 14 ram, color grey to brown with greenish tinge.

The result indicated the significant variations of *Chthamalus malayensis* species between Hawksbay and KakkaPir Sandspit shore lines. The population density of this species displayed greatest variations among both shores. The highest population density Sandspit shore was attained January, May and November whereas on Hawksbay shore, highest observed in April, November and January,whereas the least detected values of Mean±SD was obtained in the months of March, July and October i.e, 6.764±2.184, 7.324±3.733 and 7.452±2.752. According to Tsang *et al*., (2008) the population density of *Chthamalus malayensis* have distinct vertical zonation at intertidal zone and respond to distinctive environmental factors.

The analyzed results of Chi-square test of both shores indicated the significant values at95% confidence level with P value <0.05 to <0.001. on Sandspit shore only 5 values displayed non-significant result whereas on Hawksbay shore, only 2 values displayed non-significant result.

The monthly weight analysis of *C. malayensis* from Kakka Pir Sandspit and Hawksbay shore were calculated with the help of Mean± SD. In the month of October that attain weight of mean 128± 5.921 mg disappeared from the population in November The mean ratio of *C.malayensis* weight in November was 117± 2.623mg. In January and February, the least mean ratio of *C.malayensis* weight were detected due to the presence of young ones i.e., 98± 1.33mg and 99 ± 6.14mg. That's indicated the highest rate of population density within the month of January-

Febuaray on Kakka Pir Sandspit shore of Karachi. The *Chthemalus malayensis* samples that were collected from Hawksbay shore, displayed highest variation within a weight over the year. The highest weight ratio of *C.malayensis* was 207± 4.922 mg observed in the month of January. Whereas the least mean ratio of *C.malayensis* weight was observed in March i.e., 114± 4.24 mg. The Hawksbay shores carries highest weighted *C.malayensis* in January i.e., 207± 4.922 mg whereas in the same month, Kakka Pir Sandspit's collection appeared as least weighted i.e., 98± 1.33mg due to presence of young ones. the result indicated the nature of shore's substrate was influenced on the variation of weight and number of *C.malayensis* species.

The monthly length analysis of *C. malayensis* of both Kakka Pir Sandspit and Hawksbay shore was deliberate with the help of Mean±SD. The overall highest length mean ratio of Sandspit was detected in February that attain length 0.49±1.56mm whereas in March and April, the least mean length was in all over season i.e., 0.36±0.44mm and 0.22±0.1mm that was the smallest size individuals of *C.malayensis*, whereas from Hawksbay the highest length Mean±SD of *C.malayensis* was 0.57± 1.88mm observed in the month of February, whereas the least Mean±SD ratio of length was observed in April i.e., 0.28± 0.9mm. The highest length Mean±SD of *C.malayensis* from Hawksbay was 0.57± 1.88mm observed in the month of February, whereas the least Mean±SD ratio of length was observed in April i.e., 0.28± 0.9mm indicated the seasonal variations on both shores. The highest length sizes species of *C.malayensis* was observed in Hawksbay shore.

Length- weight relationship was investigated through Two-way ANOVA. The length (mm) and total weight (mg) of *Chthemalus malayensis's* from Kakka Pir Sandspit and Hawksbay shores, determined individually through Mean±SD as per figures- 2-7. The proportional study indicated the difference in weight of *C.malayensis* that displayed sufficient fluctuation because of different

nature of both shores. The highest weighted species of *C.malayensis* was observed in Hawksbay shore i.e., 207± 4.922 mg in January whereas in the similar month, Kakka Pir Sandspit's showed as minimum weighted i.e., 98± 1.33mg. Comparative length of Sandspits and Hawksbay shore observed the great variation among specie. The highest Mean±SD ratio of length factor was detected in the month of February and December i.e., 0.57± 1.88mm and 0.5± 1.92mm on Hawksbay and Sandspit. whereas the least mean rate of length was detected on both shores in April i.e., 0.22±0.1mm and 0.28 ±0.9mm respectively.

The present study result indicated that the length –length relationship (Sandspit-Hawksbay) displayed $F(11, 11) = 5.985$ with $P=0.0031$ that show significance whereas length-weight(Sandspit-Hawksbay) relationship appeared $F(1, 11) = 9.868$ with $P=0.0094$. the weight-weight (Sandspit-Hawksbay) relationship indicated the significant results with evidence of $P=0.0010$.

CONCLUSION

The intertidal zone of these rocky shore at Sandspit and Hawksbay are densely populated with *Chthamalus malayensis.* The present investigation is the first ever comparative study on bio ecological characteristics of *C. malayensis* which indicate the population density among the rocky shore of Kakka Pir Sandspit and Hawksbay. The study also focus on comparative weight and length analysis of *Chthamalus malayensis* rocky shore of Kakka Pir Sandspit and Hawksbay which shows seasonal variations.

Figure 10 *Chthamalus malayensis* **along with other fauna at Hawksbay**

Figure 11 Sampling of *Chthamalus malayensis* **by Quadrate Method**

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