National Journal of Multidisciplinary Research and Development
ISSN: 2455-9040
Impact Factor: RJIF 5.22
www.nationaljournals.com
Volume 3; Issue 3; September 2018; Page No. 36-47

General and relative growth of fresh water crab, *Barytelphusa lugubris* from Kathmandu, Nepal

Dr. Saroj Rana
Tribhuvan University, Amrit Science Campus Lainchaur, Kathmandu, Nepal

Abstract
A total of 692 with 352 males and 340 females with a minimum of 50 freshwater crabs per months of genus *Barytelphusa lugubris* were collected from bog paddy field Sangla village development committee, Kathmandu, Nepal from April, 2007 to April, 2008 (13 months). Attempt was made to determine the general and relative growth. Then each crab was weighed and measured (carapace width and length). Correlation and regression lines were drawn to compare the significance of relative growth, using software SPSS ver. 20. Among the different size groups collected in January 2008, 23 to 25mm, females and 19 to 21 mm males were more abundant. This abundance gradually shifted to 25 to 27 in females and 23 to 25 males groups in February and 31 to 33mm females and 25 to 27mm males in March. The female grew from 23 to 33mm in 3 months duration and males grew from 19 to 27 mm in same time period. Similar relation was found between the weight and carapace width of male (0.977) and female (0.983). Carapace length and width of male (0.973) and female (0.971) also showed the positive relation. It was concluded the rate of change in growth was higher in male when compared to female.

Keywords: *B. lugubris,* growth, Kathmandu, size frequency distribution

Introduction

When one talks about growth and development of the crustacean decapods one must consequently talk about the molt cycle or ecdysis (Yamaoka and Scheer, 1970) [58]. It is intermittent owing to periodic molting of exoskeleton. The life cycle of decapods alternates, between a relatively long intermolt period during which the animal feeds and remains active and a relatively short molt period during which it casts off its old hard body covering called molt and thus increases in size (Passano, 1960; Teissier, 1960) [43, 51]. Showing discontinuous growth and maturation in crustaceans, which can be to be easily broken down into stages with distinct growth rate (Hartnoll, 1978) [19] and maturation known as maturational molt that starts from the juvenile stage with immature exoskeleton and to the adult stage with secondary sexual characters that can be observed from the relative growth pattern in brachyuran crabs as pubertal molt, (Kobayashi, 2003) [27]. In some brachyuran crabs, maturational molt could be terminal molt (Van den Brink, 2006; Fuseya and Watanabe, 1993) [13, 54], after which they do not molt and grow. This is closely related with the process of growth; as molt is the only way by which a crustacean with hard skeleton can grow or increases in size (Reddy and Reddy, 2006).

In an organism, the growth is reflected either in size, bulk or both, or in the time scale of the birth, maturity and death (Tondon and Johal, 1996). It is most essential to know at what age or size of their life history they become mature and exploitable or profitable. Relative growth reflects the life history of a given species (Hartnoll, 1988) [51]. Information on the absolute growth patterns is determined by the molt increment or growth factor and the inter molt period or molt interval (Hartnoll, 1985; 1982) [17, 18], which helps to analyze population structure. Due to the rigid integument and possibility of accurate measurements, together with the discontinuous growth pattern make the decapods group an ideal for allometric studies (Hebert, *et al*., 2002; Hartnoll, 1982) [18, 22]. Besides absolute growth, there are numerous studies on poputation structure, general and relative growth and reproduction of the brachyuran crabs, (Cobo and Fransozo; 2005; Luppi, 2005; Luppi, *et al*., 2004; Colpo and Negreiros- Fransozo, 2003) [8, 9, 32, 35]. Growth indicates the health of an organism and environmental factors and qualities of food influence the growth rate survival, (Paola and Mura, 2004; Srivastava, 1985) [42, 48]. There are scattered studies in weight width (length weight) relationship of decapod crustaceans including crabs and described by few reporters (Afzaal *et al*., 2018; Noori *et al* 2015; and Krouse, 1972) [1, 39]. It is as most important parameter for the health of the crustaceans and fishes (Srivastava and Singh, 2003). Many researchers reported age, general growth and relative growth of different market crabs, (Arimoro and Idoro, 2007; Kobayashi, 2003 [27]; Kobayashi and Matsuura, 1995; 1993; 1992) [28, 29, 30]. When the growth of an organ is more or less rapid, than the reference organs of rest of the body are said to be allometry (Teissier, 1960) [51]. Crabs commonly show a degree of allometric growth on these features compared to a reference structure- usually the carapace width, abdominal width and chela on reaching reproductive maturity (Hartnoll, 1978; 1988) [19, 51]. The puberty molt (maturational molt) is far more obvious in females than in males (except pleopods in males in some caces) as it can involve allometric change in the pleopods, sternum, and most obviously, the width of the abdomen in many female brachyuran crabs (Hartnoll, 1982; 1978; 1974) [18, 19, 20]. Hickey delivered the massage that relative growth throws light on the life history of a given species Hickey, (2007) [25].

Study Site

The study area is a terraced bog paddy field carrying only 30 m in length and 12 m in width, at Singla Kunchi Pwakal Village Development Committee (V. D. C.). It situated between $27^{0}47'$ North latitude and $85^{0}22'$ East longitudes from Budhanilkantha; and

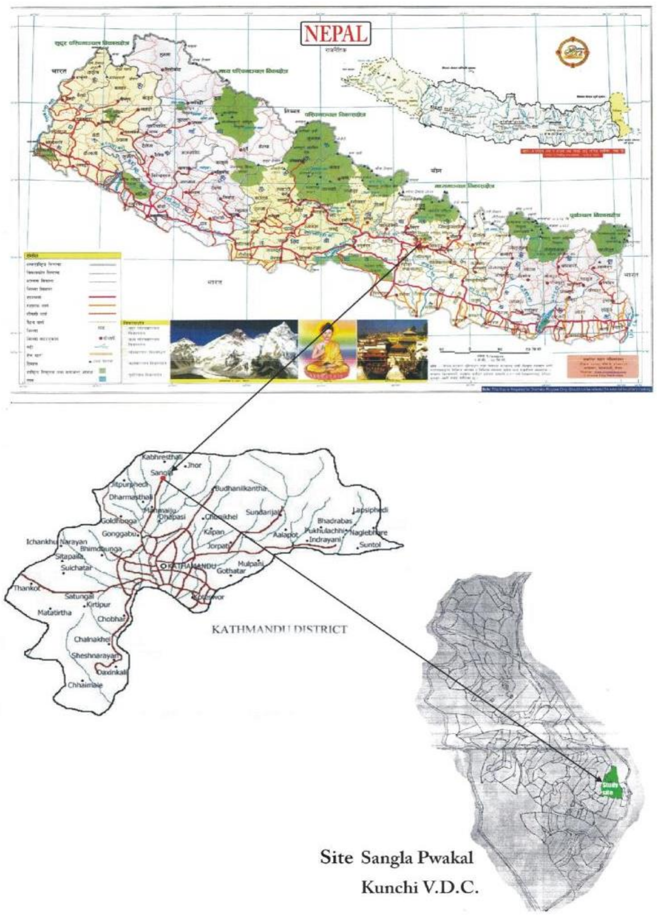

Plate 1

$27^{0}45'$ North latitude and $85^{0}15'$ East longitude from Nagarjun, remains extremely on Northwestern hill of Katmandu. Sangla is the mid hill mountain tract, located at the bank of Baundeshwar stream. Sangla. It is bounded by Jhor, Mahankal V. D. C. on the east; on its southeastern border is Chandeshwari. Pulung is to its South and Nuwakot is on the northern border and western region demarcated by Kabhresthali. Baundeshwar is a perennial hill stream originating from a high mountain. Water from the stream is canalized for drinking purpose, leaving little of it for the use of local people. Large and small boulders with rotten woods providing the hideouts for crabs, occupy their habitat. Bushes and a few small trees on sides, grasses, weeds and reeds in the field surround it. It is situated on the north- western region of the hill where the sun sets early during both summer and winter and the location is comparatively colder. Baundeshwar stream being deep from the paddy fields, all water from the study area drains into the river. Even then there is always a direct impact of river water on the paddy fields and the vice-versa, as water from the stream is used for irrigation in the fields and seeping water from the fields drains into the river. The stream is 4 m to 3 m deep from the paddy field. The width of the stream ranges from 1.5 m to 3 m., but water depths in the stream vary with seasons. During rainy season water depth ranges from 40 to 15 cm. It remains 7 to 5 cm and 3 to 1 cm during autumn and winter respectively.

Materials and Methods

The fresh water crab of genus *Barytelphusa lugubris* were collected from Sangla village development committee, Kathmandu Nepal in April, 2007 to April, 2008 (13 months). Minimum 50 crabs were collected from bog paddy field; collected crab was weight and measured. Monthly size frequency distribution of carapace-width at 2 mm size interval was plotted in histogram as a reference dimension to assess general or absolute growth in the naturally occurring population (Diwan, 1973) [11]. The length-weight relationship was used in the determination and prediction of absolute growth of the crabs in nature. For this assessment, carapace-width (CW) and carapace length (CL) were used as reference dimensions, and weight (W) as dependent variable (Hartnoll, 1988) [51], for comparison of all other measurements of total (T) (692) (A), males (352) (B) and females (340) (C) crabs. Following formula provided by Hartnoll, (1974) [18] was used to assess the relationships:

$$W (y) = ax^{b} \text{ and } W (y) = aL^{b}$$

Where, 'W' (y) represents the weight and 'x' and 'y' represent CW and CL of the crab respectively, 'a' and 'b' here, were two constant to be calculated empirically. The equation was altered to log -log transformation to allow for estimation of the parameters by linear regression:

$$\text{Log } W = \log a + b (\log x) \text{ and } \log L = \log a + b (\log x)$$

CW and CL relationship was established to determine relative growth pattern of a naturally occurring population. Analyses of relative growths were calculated using the growth equation described by Warner (1977) and Cumberlidge (1999) [12].

$$y = ax^{b} \text{ and } y = a + bx$$

Where y is the dimension (the dimension of interest), x is the reference dimension (CW in all cases), a, is the y- intercept and b is the relative growth rate; Warner (1977) and Hartnoll (1974 and 1988) [20]. Slope of the regression's' is the allometric constant that expresses the relationship between two variables; a 95% confidence interval of the slope was calculated Hartnoll (1982) [18].

Results

General growth and Relative growth

General growth

Total 692 crabs (340F + 352M) were collected. Male were comparatively larger then female. Maximum and minimum size of carapace width observed in female was 77.2mm and 19.7mm; and in male 78.9mm and 19.8mm respectively. The observed maximum size and minimum size of the CW, CL, total weight (TW) and of total length (TL) all the crabs collected are presented in following table (Table 1).

Table 1: Maximum and minimum size of male and female CW, CL and

Sex		Carapace width in mm	Carapace length in mm	Total weight gm.	Total length in mm
Male	Minimum	19.8	14.8	1.5	28.2
	Maximum	78.9	58.4	121.8	93.3
Female	Minimum	19.7	14.8	1.64	25.9
	Maximum	77.2	59.2	106.37	107.7

It was observed that the crab numbers were high in the month of July and in the month of October, November, December, January and February. It was found that the males and females were abundant throughout the year and described by the size frequency distribution of width 2mm. The juveniles were in a particular trend from the month of September to March. There were very low presences of the juveniles below the size of 31 to 33 mm. The small sized juveniles started to appear in the month of October gradually increased in the month of November. There were abundance of small size from 19 to 37mm. in the month of November and the most abundant size is of group 23 to 27 mm. in the month of December the size 25 to 31mm were most abundant and in January the abundant size was 29 to 33mm. this was observed due to the gradual growth of the crabs, it seems that the growth is not continuous. According to the size frequency distribution, the size of the juveniles increased gradually from the month of October. Before that the juveniles were very small. Among the different size group collected during the month of January 2008 the size group 23 to 25mm, female were more abundant and in 19 to 21 mm size group males were more abundant. This abundant gradually shifted to 25 to 27 females group and 23 to 25 males group in month of February. In the month of March males were more abundant size group 25 to 27mm and females were more abundant in 31 to 33mm size group. The female grew from 23 to 33mm in the duration of 3 months and males grew from 19 to 27mm in the same period.

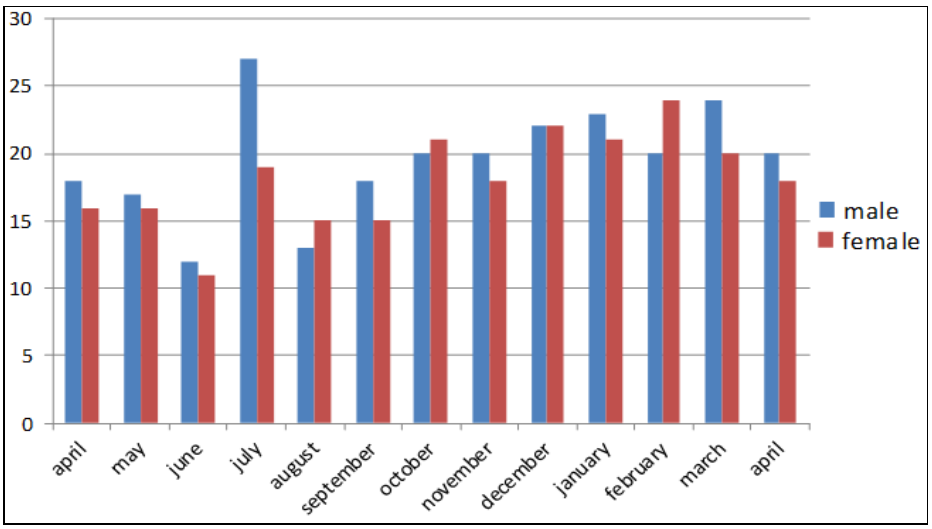

Fig 1: Number of Juveniles in different months

The size frequency distributions for different months are as follows.

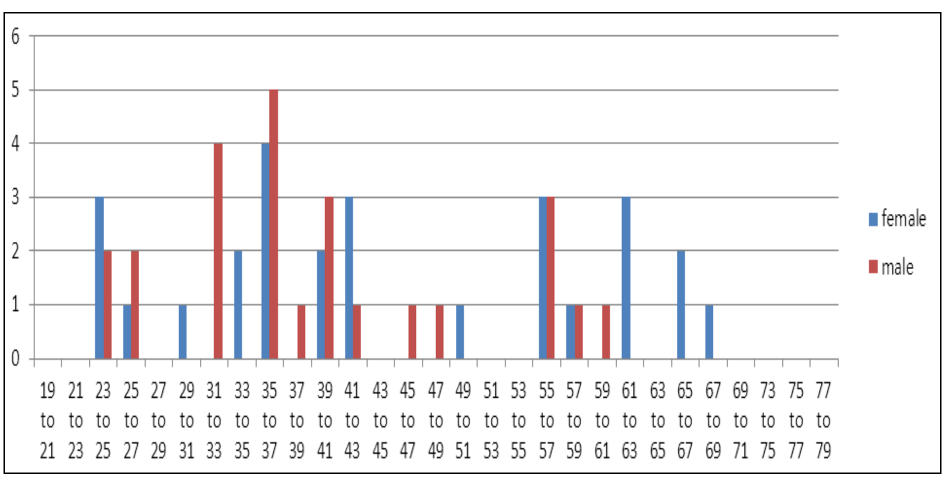

Fig 2: Size frequency distribution for the month of April

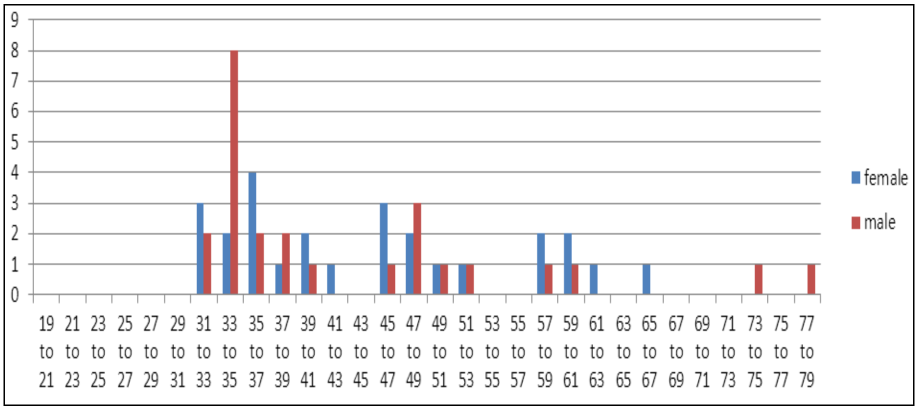

Fig 3: Size frequency distribution for the month of May

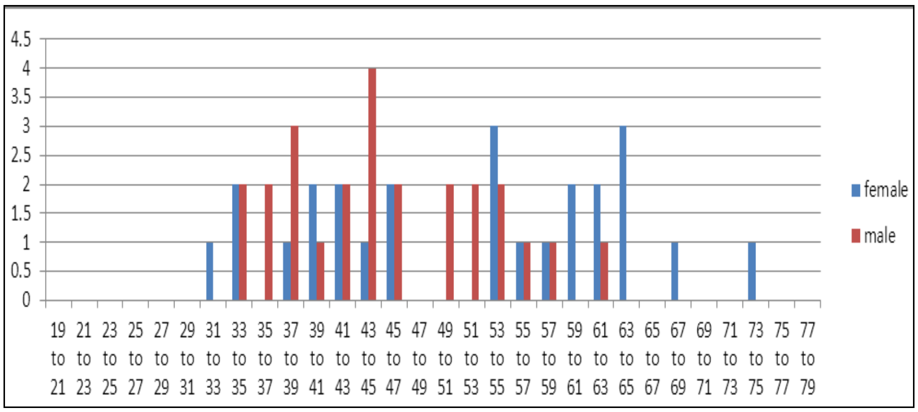

Fig 4: Size frequency distribution for the month of June

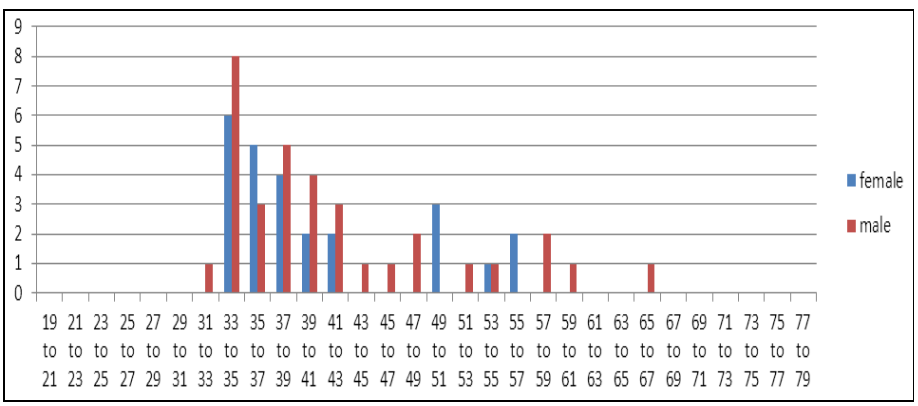

Fig 5: Size frequency distribution for the month of July

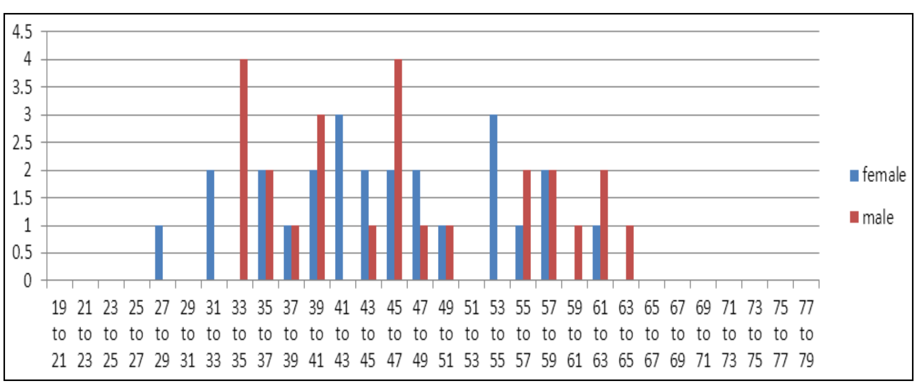

Fig 6: Size frequency distribution for the month of August

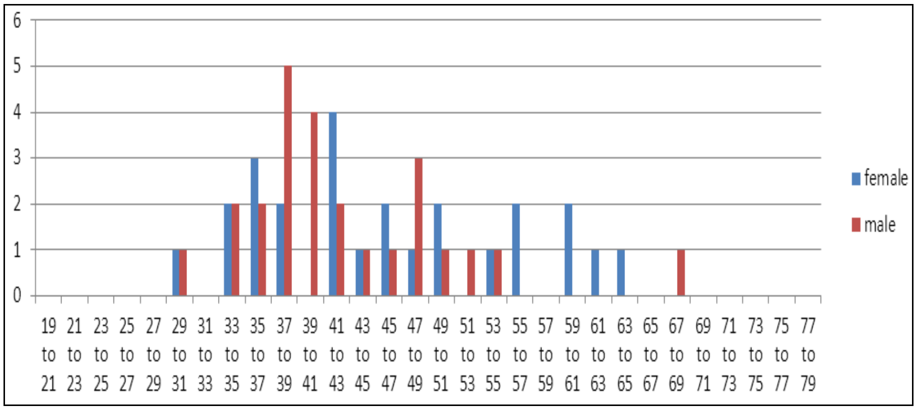

Fig 7: Size frequency distribution for the month of September

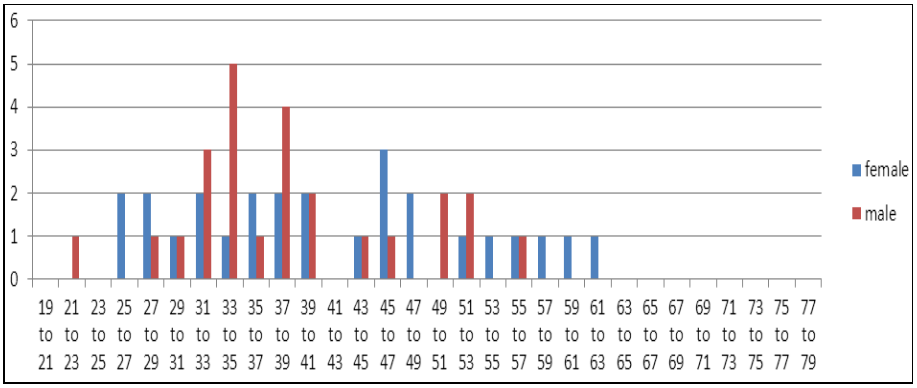

Fig 8: Size frequency distribution for the month of October

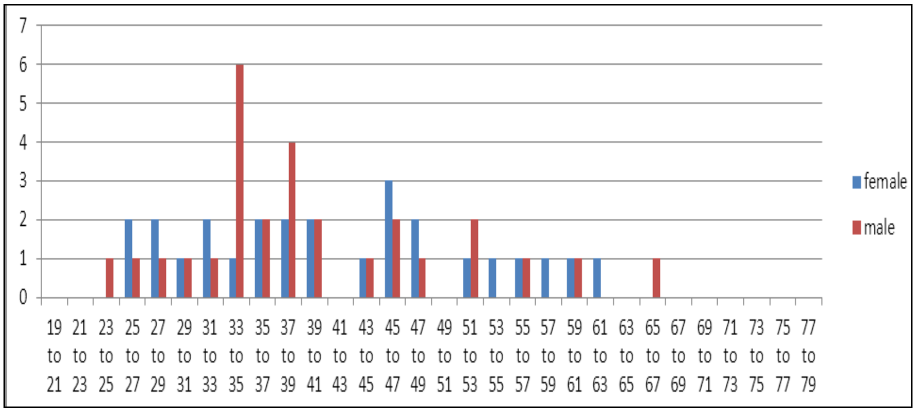

Fig 9: Size frequency distribution for the month of November

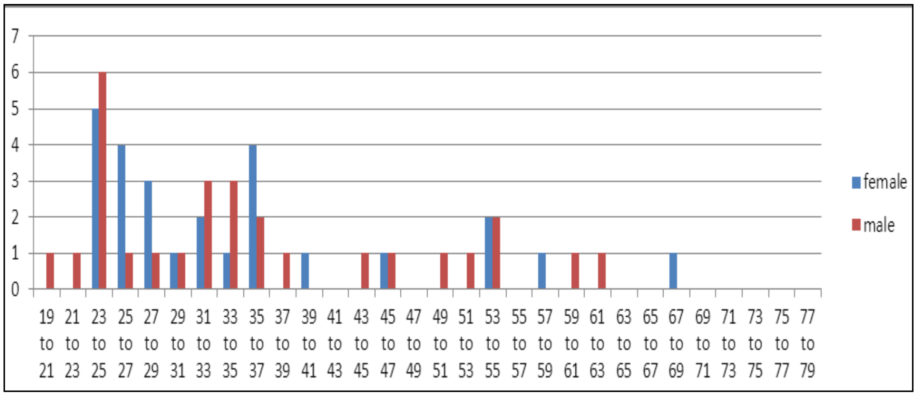

Fig 10: Size frequency distribution for the month of December

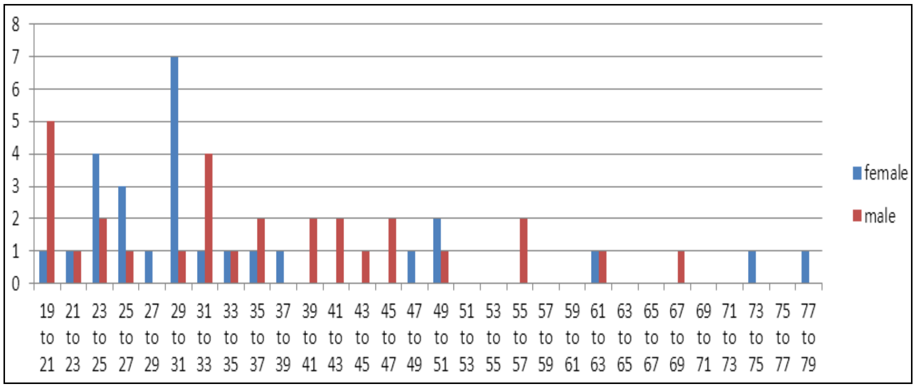

Fig 11: Size frequency distribution for the month of January

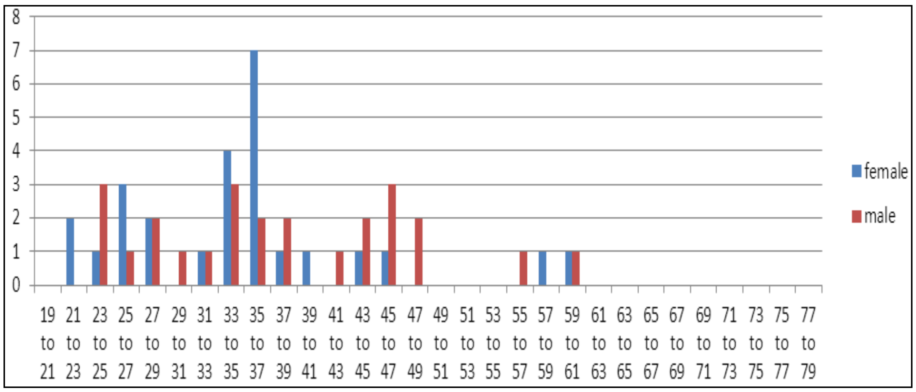

Fig 12: Size frequency distribution for the month of February

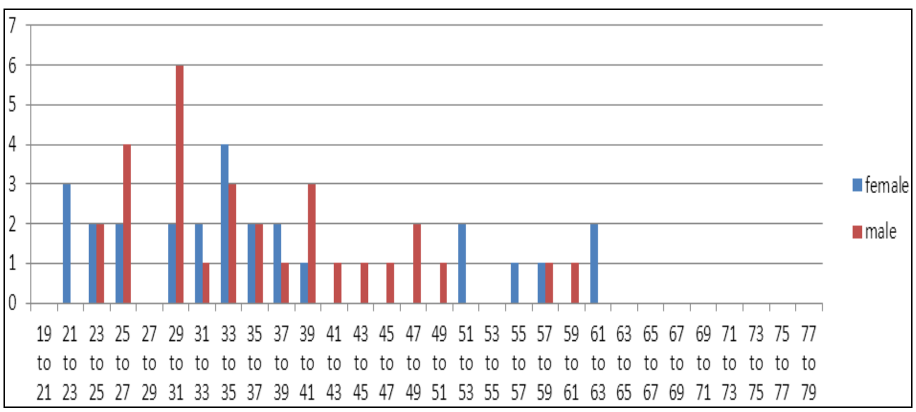

Fig 13: Size frequency distribution for the month of March

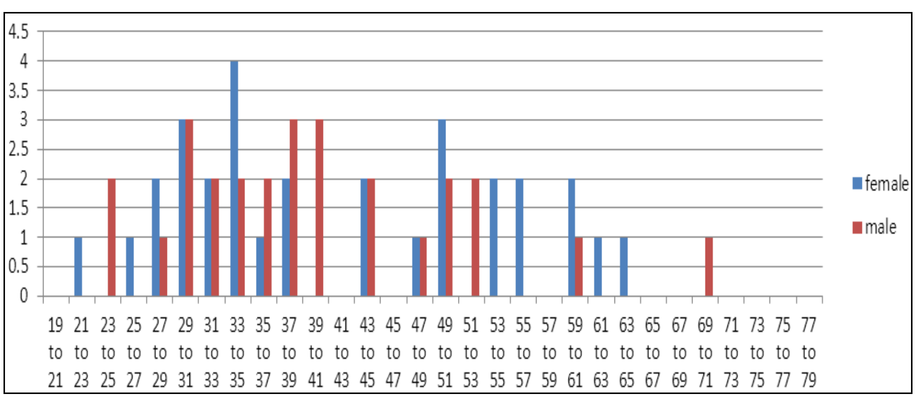

Fig 14: Size frequency distribution for the month of April

This provided that rate of growth for male to be about 2.6mm per month and rate of growth for female is 3.33mm per month.

Relative growth between different variables

Carapace width and total weight

Comparative study of the carapace width and the total weight showed following pattern for male and female samples.

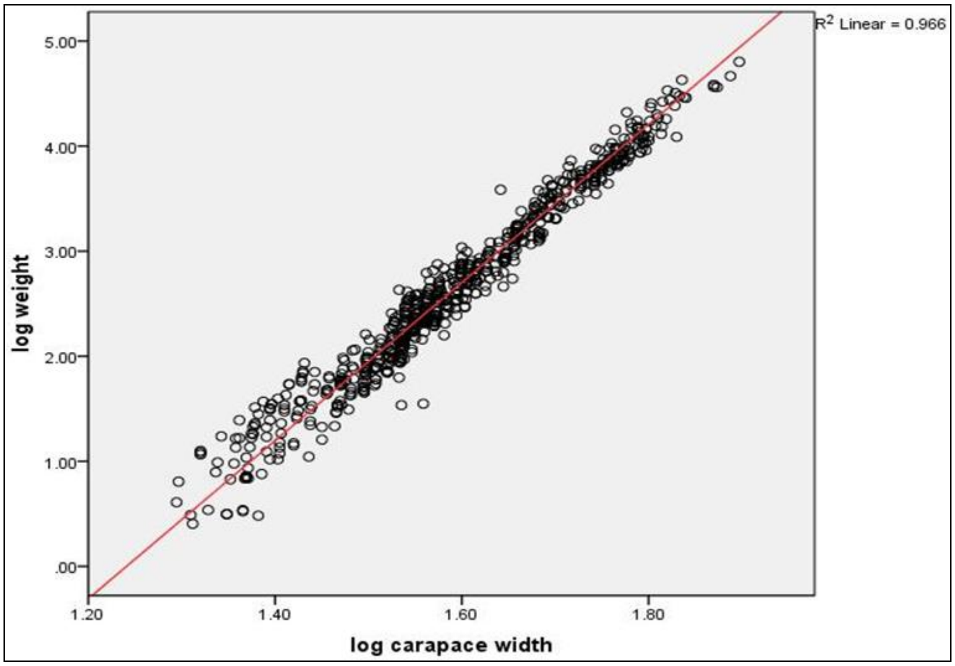

Fig 15: Straight line pattern of CW and TW for male sample

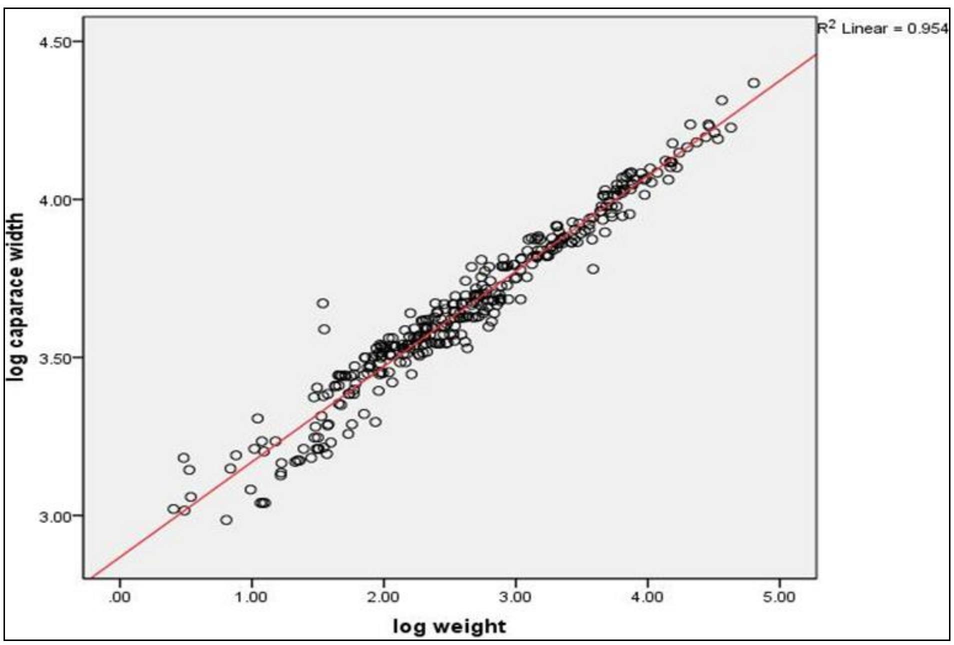

Fig 16: Straight line pattern of CW and TW for female sample

The logarithmic straight line regression equation for CW as independent variable and TW as dependent variable is as follows:

y = -8.960+3.166x …………… i
y = -8.747+3.106x……………. ii

With the correlation coefficient of 0.977 and 0.983 respectively for the males and females presented in equation i and ii, where y is the log TW and x is log CW. This shows that the total weight and carapace width have positive relation and rate of change is higher for female than for the male population when the unit value of the carapace width changes.

Carapace length and total weight

CL and the TW relationship showed following pattern for male and female samples.

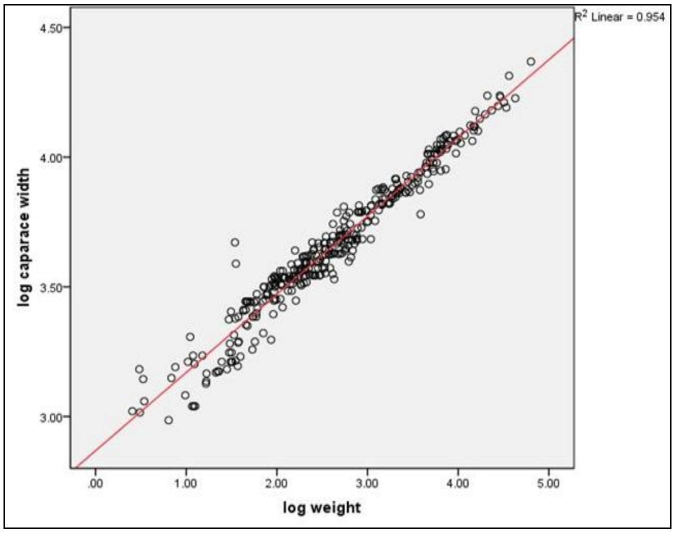

Fig 17: Straight line pattern of CL and TW for male samples

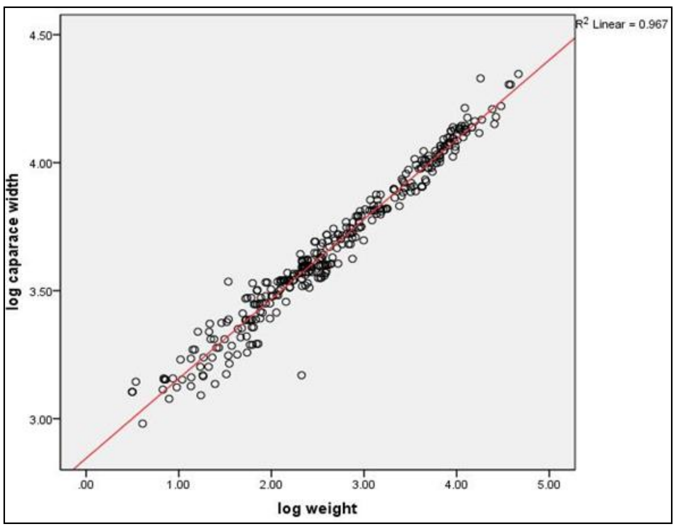

Fig 18: Straight line pattern of CL and TW for female samples

The logarithmic straight line of regression equation for carapace length as independent variable and total weight as dependent variable is as follows.

y=-8.490+3.269x………………………iii
y= -8.120+3.154x……………………...iv

with the correlation coefficient of 0.969 and 0.968 respectively for the males and females presented in equation iii and iv respectively where y is the log TW and x is log CL. This shows that the TW and CL have positive relation and rate of change is higher for male than for the female population when the unit value of the CL changes.

Carapace width and carapace length

Comparative study of the carapace width and the carapace length showed following pattern for male and female sample.

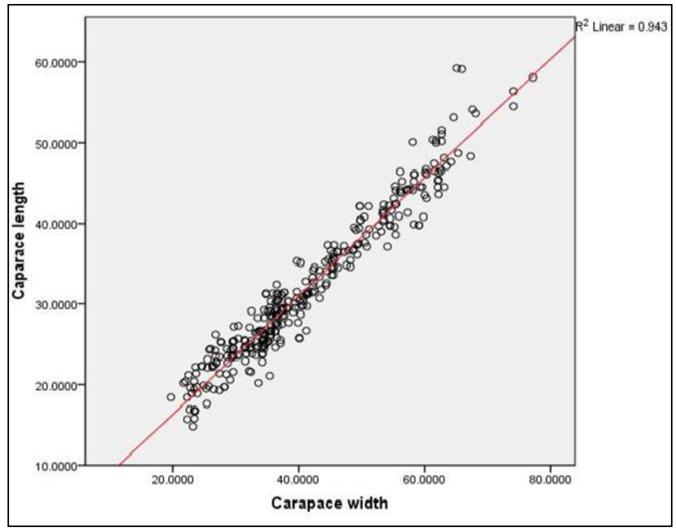

Fig 19: Straight line pattern of CW and CL for male sample

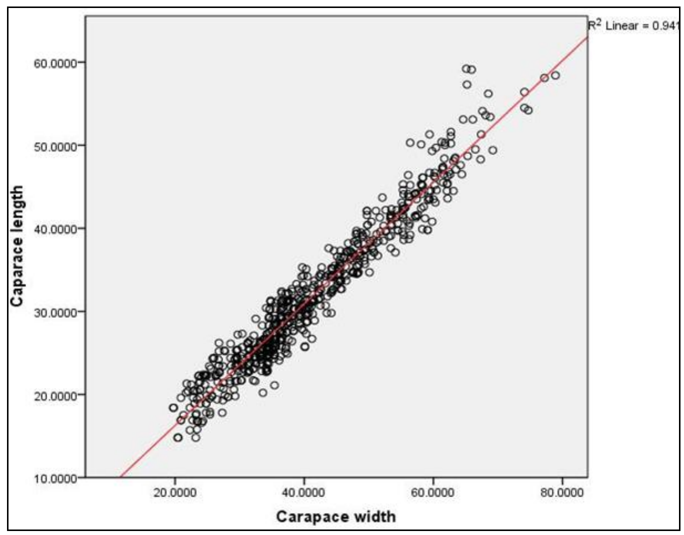

Fig 20: Straight line pattern of CW and CL for female sample

The straight line relation was observed between CW and CL. The straight line regression equation for carapace width as independent variable and carapace length as dependent variable is as follows,

y= 1.680+0.729x…………………………………………..v
y= 1.606+0.734x…………………………..……………….vi

With the correlation coefficient of 0.973 and 0.971 respectively for the males and females presented in equation v and vi respectively where y is the carapace length and x is carapace width. This shows that the carapace length and carapace width have positive relation and rate of change is higher for male than for the female population when the unit value of the carapace width changes.

Discussion

The growth of an organism varies in different environment;

further in the same environment the growth also varies with season (Hartnoll, 1988) [16]. It is due to the variation in the bed content, water quality and interactions between living and nonliving factors as well. The information on growth rate may be helpful in assessing the holding ability of rearing ponds as well as the potential output of a particular stock, (Bisht, *et al*., 2002) [7]. The study of growth is fascinating from the economic point of view. It is most indispensable to know at what age or size of their life history they become mature and exploitable or profitable. The growth in decapods crustacean is irregular owing to periodic molting (absolute growth) of hard exoskeleton (Reddy, *et al*, 2006; 2004) [44, 45] relating post moult to pre moult size in crustaceans; size in this contest is mostly defined by a linear measurement of carapace width or carapace length (Mauchiline,(1976) [36]. General growth in crabs is mostly studied directly by frequency of molt cycle and indirectly by size frequency distribution. As stated by Thurman, (1985) [52], the size-frequency distribution of a population is a dynamic characteristic that can change throughout the year as a result of reproduction and rapid recruitment from larvae or juveniles.

Out of 692 crabs collected for 13 months, 340 were females and 352 were males. Male were comparatively larger then female. Maximum and minimum size of carapace width observed in female was 77.2mm and 19.7mm; and in male 78.9mm and 19.8mm respectively. The observed maximum size and minimum size of the CW, CL, total weight (TW) and of total length (TL) all the crabs collected are presented in Table 1. Bandral *et al.*, (2015) [4] found Carapace width and mean body weight of males *Maydelliathelphusa masoniana* ranged from 2.0 to 6.3 cm and 16.674 to 90.186 gms respectively while, In females of the same species, the carapace width (CW) ranged from 2.0 to 6.0cm and the mean body weight ranged from 18.7770-64.850gms. Sharifian *et al.*, (2017) [47] found no significant differences between male and female carapace widths of fresh water crab *Sodhiaba iranica* from the south of Iran.

The pattern of specific or absolute growth of a freshwater crab *Geothelphusa dehaani* (White) was studied by Akira and Matsura, (1995) and it was reported that juvenile crabs showed limited growth in the year at hatching. After the initial winter the crabs repeatedly molted two or three times in a year and it was estimated that these crabs take 4 years to reach the maturity. The maximum size of female at maturity is about 19 mm CW and that of the male is 18 mm CW mm. They revealed slow absolute growth rate in *Geothelphusa dehaani*. But in *B. lugubris* the size of the juveniles increased gradually from month of October. Before that the juveniles were very small. Among the different size group collected during the month of January 2008 the size group from 23 to 25mm, female were more abundant and 19 to 21 mm size group males were more abundant. This abundance gradually shifted to 25 to 27 females group and 23 to 25 males group in month of February. In the month of March males were more abundant size group 25 to 27mm and females were more abundant in 31 to 33mm size group. The female grew from 23 to 33mm in the duration of 3 months and males grew from 19 to 27mm in the same period. This provided that rate of growth for male to be about 2.6mm per month and rate of growth for female is 3.33mm per month with definite absolute growth rate for male and female per month. But in present results both male and female mature in about one year. Tao, *et al*., (1994) [50] reported the growth of the Chinese freshwater crab *Sinopotamon yangtsekien*, from the hill stream of Changjiang river valley. These crabs reached the maturity after 1 or 2 years concede with present study, but they could not trace the growth rate from size frequency distribution. Micheli, *et al*., (1990) [38] studied the absolute growth in the freshwater crab, *Potamon fliviatile* inhabiting in hill stream close to Florence, Italy by lengthening of molting interval in the females. They inferred that soft individuals, smaller than 20 mm CL were found all year round, especially in autumn and spring, and showed that correlation between percent increment at molt and CL was not quite significant. They could not trace out the exact absolute growth rate in *Potamon fliviatile*. In *B. cunicularis* the growth rate (CW increment) of juvenile males was 2.5 mm, whereas in juvenile females it was 3.0 mm per month, (Diwan, 1973) [11] also male increased 2.6 mm and 3.33 mm in female per month with slower growth in male than female substantiate with the present findings. In case of the intertidal crab (*Ilyoplax deschimpsi)* new recruits of 2 mm CW in the month of July and August reached 4 mm CW by December, and to 7 mm CW by the following July with less than two year life span, (Henmi and Koga, 2009) [23] but in present study the growth rate observed in size frequency distribution were 3.33 and 2.6mm in female and male *B. lugubris* in a month, so the life span is more than 3 years. They also delivered the same message that during early juvenile stages the absolute growth rate of this crab was slow and could not be traced unlike *B. lugubris*. Otani, *et al*., (1997) [41] reported that size sample in each month was not so large. It was not always possible to detect year group in monthly histograms, *and Uca arcuata* survived for more than five years. In spider crab *Pugettia quadridens quadridens* (de Haan) the absolute growth was 19.9 mm in male and 17.5 mm in female and the lifespan was of one year only, (Fuseya and Watanabe, 1993) [13] being smaller sized and only one year lifespan might have lesser growth rate. The absolute growth in brachyuran crabs- whose lifespan is only one year -could easily be traced, as there may not be the overlapping population of smaller crabs. Litulo, (2005) [33] and Luppi, (2005) [32] also could not trace out the absolute growth of *Macrophthalmus boscii* of Inhaca island, southern Mozambique. Bas, *et al*., (2005) [3] also could not estimate the growth of different size group from the analysis of successive size frequency distributions because of long succession of successive field collections; although they had collected a total of 2047 crabs. Hebert, *et al*., (2002) [22] opined the difficulty of establishing growth increment at molt for adolescent males of *Chionoecetes opilio* based on size frequency distributions as their growth processes were extremely variable. The growth of *B. lugubris* agreed with the sayings of Hebert, *et al*., (2002) [22]. As stated by Thurman, (1985) [52] the size-frequency distribution of a population is a dynamic characteristics that can change throughout the year as a result of reproduction and rapid recruitment. Present finding of *B. lugubris*, substantiate that the left skewed distribution has been indicated by high mortality in larger size classes with the dominance of smaller juveniles, in *Macrophthalmus boscii*. Furthermore, the low frequency of adult crabs sampled in the study area may be due to the fact that they were in the peak of molting activity because most crabs were found hidden inside burrows and crevices apparently inactive; as they are vulnerable to desiccation and are easily consumed by the predators (Litulo, 2005) [32].

Length-weight relationship helps in the prediction of possible yield and determination of proper size to harvest for maximum sustained yield of an aquaculturable species. It helps to establish mathematical relationship between length and total weight (TW), and derives to facilitate their inter-conversion and computation in the natural population expressing the relative health of the aquaculturable species. The CW-TW relationship was plotted as it indicated an exponential relationship, but showed linear relationship after logarithmic transformation. The log linear regression equations and their respective correlation co-efficient were calculated for the relationship between TW against CW in males (A-352) and females (B-340). The correlation co-efficient values of 'r' were 0.977 and 0.983 for the two sets (A and B). The CL-TW relationship was plotted. It indicated similar type of exponential relationship, as shown by CW, but showed linear relationship after logarithmic transformation. The log linear regression equations and their respective correlation co-efficient were calculated for their relationship between TW against CL. This also showed similar type of relationship as shown by CW and TW. Male and female sets showed strong positive correlation between CW-WT; CW-CL CL-TW in *Barytelphusa lugubris*. This relationship indicated an increase in CW and CL and TW to a corresponding increase in weight for all sets of crabs corroborate the findings of Afzaal *et al*., (2018) [1]. Noori *et al*., (2015) [39] described the body TW-CW relationship indicating positive allometric growth in males and isometric growth in females. Body weight was higher in males than females of equivalent CW, and the means for condition factors were always higher in females than in males, due to the heavier gonads in the former, an expected pattern for many crabs confirms the present findings. Ondes *et al*., (2017) [40] recorded the negative allometric growth between the CL–CW for both male and female of *Cancer pagurus* in the Isle of Man, Irish Sea differed from present finding due to different environmental condition. But, Zainkal, (2017) found positive allometric growth of different body dimensions relative to the body weight and carapace width on both sex of *Portunus pelagicus* from the Kingdom of Bahrain authenticate the present findings. Bezerra Ribeiro, *et al*., (2017) [6] also showed positive allometry between CW and all dimensions analyzed. Hernáez *et al*., (2017) [24] recorded, the general scheme of growth being positive allometric throughout development of both sexes of *Hapatus epheliticus*, from Yucatan Peninsula, Mexico. Similarly, in the both sexes of orange mud crab, *Scylla olivacea* positive linear relation was recorded between Carapace width and Growth band count, Ismail *et al*., (2017) [26]. Gamblewood *et al*., (2018) [14] showed linear regression relationship between crab carapace length and weight in the crab *Cancer Magister* (F1, (ANOVA) 444 = 2895, $p < 0.01$, $r^2 = 0.87$). Similarly, Viswanathan *et al*., (2016) [55] also found linear regression between carapace width and weights in both the sexes concede with present findings. Waiho *et al*., (2016) [5+] found, the males of *Scylla olivacea* exhibited positive growth allometry all the above results concede with present finding whereas the females exhibited negative growth allometry in (CW/WT and CW/CL) length–weight relationships differed from present finding? Sharifian *et al*., (2017) [47] found no significant differences between male and female carapace widths of fresh water crab *Sodhiaba iranica* from the south of Iran like the result of *B. lugubris*. Din *et al*., (2017) [10] recorded the male crab, *Scylla tranquebarica* showed positive allometric growth while the female exhibited negative allometric growth from the waters of Peninsular Malaysia? Rivera *et al*., (2017) [46] found that the growth of the carapace width of mud crab (*Scylla serrata*) is influenced by the growth of its body weight corroborate with the present results.

The results of Arimoro and Idors, (2007) in the crab *Callinectes amnicola* of Lower Reaches of Warri river, Delta State, Nigeria, with values of 'x' ('b') (regression constant) was 2.4137, 3.4050 for two sets (CL). Krouse, (1972) [31] reported the value of 'x' ('b') was 2.82 and 2.94 for combined sexes of rock crab *Cancer irroratus* in Gulf of Maine, Boothbay Harbor and Casco Bay. The present findings seemed to have the impact of various abiotic and biotic factors such as- temperature, availability of food, habitat ecology, and physical condition of the crab at the time of collection etc Mauchline, (1976). The relative growth of CW and CL showed straight line (linear) relationships for the two sets (male and female) of crab with the correlation co-coefficient values of 'r' were 0.973 and 0.971 for male and female and showed high positive correlation between carapace-width and carapace-length in all sets of crabs. The rate of change is higher in male than female crabs. The values of regression constant 'b' (x) were 0.732 and 0.743 respectively showing high positive correlation between carapace width and carapace length of two sets. In male *Chionoecetes opilio*, growth increment in the size of carapace width was influenced by sexual (presence of spermatophores in the vas deferens) and morphometric maturity, (Hebert, *et al*., 2002) [22]. The rate of change is higher in males than in mixed sexes and females; as females were smaller than males in this case, like most of the brachyuran crabs, such as *Helicarcinus cookii*, *Rhynchoplax coralicola*, and *Cancer irroratus* (Mclay and Van den brink, 2009; Gao, *et al*., 1994; Krouse, 1972) [37]. These results substantiate the present findings.

References

1. Afzaal Z, Kalhoro MA, Buzdar MA, Tariq S, Shafi M, *et al.* Carapace length-weight and carapace width-weight relationship of *Portunus pelagicus* (Linnaeus, 1758) in Pakistani waters northern Arabian Sea. Indian Journal of Geo Marine science. 2018; 47(04):890-896.
2. Akira Araki, Matsuura Shuhei, Growth of a freshwater crab Geothelphusa dhaani (White). Sci. Bull. Fac. Agr, Kyushu University. 1995; 49:125-132.
3. Arimoro FO, Idoro BO. Ecological studies and biology of *Callinectes amnicola* (Family: Portunidae) in the Lower Reaches of Warri River, Delta State, Nigeria. World journal of Zoology. 2007; 2(2):57-66.
4. Bandral M, Gupta K, Langer S. Morphometric studies of fresh water crab, *Maydelliathelphusa masoniana* from lower reaches of river Chenab (Gho-manhasan) (Jammu, north India). International Journal of Recent Scientific

Research Research. 2015; 6(1):7209-7214.
5. Bas C, Luppi T, Spivak E. Population structure of the South American, Estuarine crab, *Chasmagnathus granulatus* (Brachyura: Varunidae) near the southern limit of its geographical distribution: comparison with northern populations. Hydrobiologia, 2005; 537:217-228
6. Bezerra Ribeiro F, Matthews Cascon H, Arruda Bezerra, LE. Morphometric sexual maturity and allometric growth of the crab *Sesarma rectum* (Crustacea: Sesarmidae) in an impacted tropical mangrove in northeast Brazil. Lat. Am. J Aquat. Res. 2017; 41(2):361-368
7. Bisht HCS, Kumar S, Johi N. General and relative growth studies on the common coldwater prawn, *Macrobrachium assamensis peninsularis* Tiwari from Kumaon Himalaya. Him. J Environment. Zool. 2002; 16(1):103-112.
8. Cobo VJ, Fransozo A. Physiological maturity and relationships of growth and reproduction in the red mangrove crab *Goniopsis cruentata* (Latreille) (Brachyura, Grapsidae) on the coast of São Paulo, Brazil. Revista Brasileira de Zoologia. 2005; 22(1):219-223.
9. Colpo KD, Negreiros-Fransozo ML. Reproductive out-put of *Uca vocator* (Herbst, 1804) (Brachyura, Ocypodidae) from three subtropical mangroves in Brazil. Crustaceana. 2003; 76(1):1-11
10. Din NMB, Das SK, Bakar Y. Carapace width-weight relationship of the mud crab (*Scylla tranquebarica* Fabricius, 1798). Indian journal of geo marine sciences. 2017; 46(8):1667-1672.
11. Diwan AD. Studies on the sexual maturity and growth rate studies of the freshwater crab, Barytelphusa cunicularis. Marathwada Univ. Jour. of Sci. 1973; 12:125-145.
12. Cumberlidge N. The freshwater crabs of West Africa: family Potamonautidae. Institut de Recereche pour le Developpement: Collection Faune et Flore Tropicales n. 36, Paris. 1999,1-382
13. Fuseya R, Watanabe S. Growth and reproduction of the spider crab, *Pugettia quadridens qradridens* (De Haan) (Brachyura: Majidae). Crustacean Research. 1993; 22:75-81.
14. Gamblewood SK, Gibson J, Barber JS. Examination of length-weight relationship in dungeness crab, *Cancer magister*, within Whidbey basin and recommendations for more robust data collection. A Swinomish Indian Tribal Community Technical Report La Conner, WA 98257. 2018, 12.
15. Gao T, Tsuchida S, Watanab S. Growth and reproduction of *Rhynchoplax coralicola* Rathbun (Brachyura: Hymenosomatidae). Crustacean Research. 1994; 23:108-116.
16. Hartnoll RG. Growth and Molting: In biology of the land crabs edited by Burggren, W. W. and Mc Mahon, B. R., pp 186-210. Cambridge University Press, New York, 1988.
17. Hartnoll RG. Growth, sexual maturity and reproductive output. p. 101-128. *In*: A.M. Wenner (Ed.), Factors in adult growth**.** Rotterdam, A. A. Balkema, 1985, 362.
18. Hartnoll RG. Growth. The Biology of Crustacea, embryology, morphology and genetics: In: L. G. Abele (Ed.). 1982; 2:111-196.Academic Press, New York.
19. Hartnoll RG, The determination of relative growth in Crustacea. Crustaceana. 1978b; 34:281-293.
20. Hartnoll RG. Variation in growth pattern between some secondary sexual characters in crabs (Decapoda, Brachyura): Crustaceana. 1974; 27(2):131-136.
21. Hartnoll RG. (1969).
22. Hebert M, Benhalima K, Miron G, Moriyasu M. Molting and growth of male crab, *Chionoecetes opilio* (O. Fabricius, 1788) (Decapoda: Majidae), in the southern gulf of St. Lawrence. Crustaceana. 2002; 75(5):671-702.
23. Henmi Y, Koga H. Growth and reproduction of the intertidal dotillid crab Ilyoplax deschampsi. Journal of crustacean biology. 2009; 29(4):516-522.
24. Hernáez P, Rombenso A, Pinheiro MA, Simões N. Population structure and sexual maturity of the calico box crab *Hepatus epheliticus* Linnaeus (Brachyura, Hepatidae) from Yucatan Peninsula, Mexico. Submission article platform-Latin American Journal of Aquatic Research. 2017, 40(2).
25. Hickey F. Marine ecological baseline report for Amal Crab Bay Tabu Eria, Malekula Island, Vanuatu IWP-Pacific Technical Report (International Waters project). 2007, 45.
26. Ismail NH, Safwan AA, Fozi NF, Megat FH, Farouk HM, *et al*. Study on Carapace Width Growth Band Counts Relationship of Orange Mud Crab, *Scylla olivacea* (Herbst, 1796) from Terengganu Coastal Waters, Malaysia. Pakistan Journal of Biological Sciences. 2017; 20:140-146.
27. Kobayashi S. Process of maturity and reproduction of female Japanese mitten crab *Eriocheir japonica* (De Haan). Crustacean Research. 2003; 32:32-44.
28. Kobayashi S, Matsuura S. Egg development and variation of egg size in the Japanese mitten crab *Eriocheir japonica* (De Haan). Benthos Research. 1995; 48:29- 39.
29. Kobayashi S, Matsuura S. Ecological studies on the Japanese mitten crab *Eriocheir japonicas* De Haan-III. Relative growth of the chela and soft-hair distribution on the chela. Benthos Research. 1993, 1-9
30. Kobayashi S, Matsuura S. Morphological changes of the exoskeleton of the female Japanese mitten crab, according to growth and maturity. Research on Crustacea. 1992; 21:159-168.
31. Krouse JS. Some life history aspects of the rock crabs, *Cancer irroratus*, in the Gulf of Maine. J Fish Res. Bd. Canada. 1972; 29:1479-1482.
32. Litulo C. Life history of the crab, *Macrophthalmus boscii* (Audouin, 1826) (Decapoda, brachyuran, Ocypodidae). Crustaceana. 2005; 78(6):665-676.
33. Litulo C. Population structure and breeding biology of the hairy crab *Pilumnus vespertilio* (Fabricius, 1793) (Crustacean: Brachyuran: Pilumnidae) in southern Mozambique. Journal of Natural History. 2005; 39(17):1359-1366.
34. Litulo C. Population structure and reproductive biology of the fiddler crab *Uca urvillei* (Brachyura: Ocypodidae) in Maputo Bay (south Mozambique). Journal of Natural History. 39(25):2307-2318.
35. Luppi TA, Spivak ED, Bas CC, Anger K. Molt and growth of an estuarine crab, *Chmagnathus granulatus*

(Brachyura: Varunidae), in Mar Chiquita coastal lagoon, Argentina. Jour of Applied Ichthyology. 2004; 20:333

36. Mauchiline J. The Hiatt growth diagram for Crustacea. Marine biology. 1976; 35:79-84.

37. Mclay CL, Van Den Brink AM. Relative growth and size at sexual maturity in *Halicarcinus cookii* (Brachyura: Hymenosomatidae): why are some crabs precocious moulters? Journal of Marine biological association of United Kingdom. 2009; 89(4):743-752.

38. Micheli F, Gherardi F, Vannini M. Growth and reproduction in the freshwater crab, *Potamon fluviatile* (Decapoda, Brachyuras). Freshwater Biology. 1990; 23:491-503.

39. Noori A, Moghaddam P, Kamrani E, Akbarzadeh A, Neitali BK, Pinheiro MAA. Condition factor and carapace width versus wet weight relationship in the blue swimming crab Portunus segnis. Animal Biology. 2015; 65(2):87-99.

40. Ondes F, Kaiser MJ, Murray LG. Relative growth and size at onset of sexual maturity of the brown crab, *Cancer pagurus* in the Isle of Man, Irish Sea. Marine Biology Research. 2017; 13(2):237-245.

41. Otani T, Yamaguchi T, Takahashi T. Population structure, growth and reproduction of the fiddler crab, *Uca arcuata* (De Haan). Crustacean research. 1997; 26:109-124.

42. Paola Z, Mura G. The effects of food on length-weight growth, sexual differentiation, and survival in *Chirocephalus ruffoi* (Anostraca) cultured under standard conditions. Journal of Crustacean Biology. 2004; 24(2):225-231

43. Passano ML. Molting and its control. In: T. H. Waterman (ed), The physiology of Crustacea. 1960; 1:473-535.

44. Reddy PR, Nagaraju GPC, Reddy PS. Involvement of Methyl farnesoate in the regulation of molting and reproduction in the freshwater crab, Oziotelphusa senex senex. Jour of Crustacean Biology. 2006; 24(3):511-515.

45. Reddy PR, Reddy PS. Isolation of peptide hormones with pleiotropic activities in the freshwater crab, Oziotelphusa senex senex. Aquaculture. 2006; 259:424-431.

46. Rivera RR, Requina FG, Mino SA, Fernandez KT. Allometric relationship of width carapace and body weight of mud crab (*Scylla serrata*) in Panguil Bay, Philippines. Journal of Higher Education Research Disciplines. 2017, 2(2).

47. Sharifian S, Kamrani E, Safaie M, Sharifian S. Population structure and growth of freshwater crab *Sodhiana iranica* from the south of Iran. Fundamental and Applied Limnology/Archiv für Hydrobiologie. 2017; 189(4):341-349.

48. Srivastava CBL. A text book of Fishery Science and Indian Fisheries: Published by Kitab Mahal 15, Thornhill Road, Allahabad Industrial Printers, 1985.

49. Allahabad Srivastava VK, Singh SR. Seasonal dynamics of zooplankton in Ganga River (between Brxar nd Ballia) in relation to water quality. Proc. Acad. Environmental Biol. 1995; 4(1):83-89.

50. Tao C, Wei L, Nan-Shan D. Growth, reproduction and population structure of the freshwater crab *Sinopotamon yangtsekiense* from Zhjiang, China. Chininese Journal of Oceonology and Limnology. 1994; 22(1):34-39.

51. Teissier G. Relative growth, In: The Physiology of Crustacea. (Edited by T. H. Waterman) Vol. 1. Metabolism and Growth, 537-560. Academic Press, London. 1960, 1.

52. Thurman CL. Reproductive biology and population structure of the fiddler crab Uca subcylindrica (Stimpson). Biological bulletin, 1985; 169:215-229.

53. Tondon KK, Johal MS. Age and growth in the freshwater fishes. Narendra Publishing House. 1996. ISBN. 81-89376-26-7, Dehli.

54. Van den Brink AM. The reproductive Ecology and Biology of the Pill-box Crab: *Halicarcinus cookie* (brachyuran: Hymen osomatidae) Filhol. 1885. M.sc thesis. University of Canterbury, 2006.

55. Viswanathan C, Pravinkumar M, Suresh TV, Elumalai V, Raffi SM. Carapace width-weight relationship, age, growth and longevity of the mud crab *Scylla olivacea* (Herbst, 1796) in the Pichavaram mangroves, south-east India. Journal of the Marine Biological Association of the United Kingdom. 2016; 96(7):1379-1386.

56. Waiho K, Fazhan H, Ikhwanuddin M. Size distribution, length–weight relationship and size at the onset of sexual maturity of the orange mud crab, Scylla olivacea, in Malaysian waters. Marine Biology Research, 2016; 12(7):726-738.

57. Warner GF. The biology of crabs. First published in Great Britain, Paul Elek (Scientific books Ltd.), Caledonian Road, London. 1997; 202: 54-58.

58. Yamaoka LH, Scheer BT. Chemistry of growth and development in Crustaceans. Chemical Zoology: Vol. V, edited, by Marcel Florkin, Academic Press New York, 1970, 321-341.

59. Zainal KA. Relative Growth and Heterochely in the Blue Swimmer Crab *Portunus pelagicus* (Linnaeus 1758) from the Kingdom of Bahrain. Arabian Journal for Science and Engineering, 2017; 42(1):75-84.