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Seasonal Variation in Seaweed Biomass from the Rocky Shore of Pacha, near Karachi, Pakistan (Arabian Sea)

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Abstract
The present study is based on the distribution and abundance of fresh and dry weights of seaweeds from the rocky ledge of Pacha. The study lasted for one year from April, 1993 to March, 1994. A total of 85 species of seaweeds were collected. The abundant seaweeds were: *Codium iyengarii, Iyengaria stellata, Sargassum latifolium, S. binderi, S. boveanum, Enteromorpha procera, Padina pavonia, Gelidium usmanghani, Colpomenia sinuosa, Valoniopsis pachynema, Jania capillacea, Caulerpa racemosa* and *Hypnea musciformis*. Their highest fresh (42230.3 g/m^2) and dry weights (21313.36 g/m^2) occurred in the low-tide zone. The latter zone supported the largest algal population. In winter maximum algal vegetation (58976.5 g/m^2) was noted and the peak growth (21854.1 g/m^2) of seaweeds was observed in January. The maximum biomass was contributed by brown seaweeds. The highest species diversity (2.05) occurred in August, and the highest Shannon-Weiner (0.46) and Evenness indices (0.97) were noted in November.

Introduction
Studies of the distribution, abundance and zonation of seaweeds of Pakistan and neighboring areas are almost non existent, although there are several reports available on the taxonomy of seaweeds of Pakistani beaches and of neighbouring areas. Borgesen (1934) was the first researcher to have worked on the geographical distribution of some marine algae. Anand (1940, 1943), Dixit (1940), Salim (1965) and Nizamuddin and Gessner (1970) worked on the marine algae. Only two occasional papers, those of Saifullah (1973) and Hameed and Ahmed (1999) and Hameed and Ahmed (MS in preparation) are available on the abundance, biomass variations and tidal distribution of seaweeds from Buleji and Pacha, respectively. Saifullah (1977), Saifullah *et al.* (1984) and Qari (1985) worked on ecology and biochemical composition of seaweeds. In 1986 a UNEP regional report also gave an introductory account of the seaweeds of coastal area of Pakistan. Shameel (1987), Qari and Qasim (1988), Shameel *et al.* (1989), Shameel and Tanaka (1992) and Saifullah and Nizamuddin (1992) have dealt with different aspects of seaweeds. Recently Hameed and Ahmed (1999) worked on distribution and seasonal biomass of seaweeds on the rocky shore of Buleji near Karachi.

The present report is based on the biomasses of seaweeds of the Pacha rocky ledge located about 25 km NW from Karachi. This is a wave-lashed rocky beach with an isolated ledge, facing the open North Arabian Sea and has not been studied before for its macro-algae and their distribution, abundance and ecology. The rocky shore of Pacha is free from man-made manipulation and pollution, so that the data obtained from there would serve as base-line data for future comparisons.

Materials and Methods
For the sampling of macro-algae transect lines and a quadrat (1 foot^2 or 0.3048 m^2) were used. For seaweed collection the whole beach was divided into four transect lines viz. transect line A (TLA), transect line B (TLB), transect line C (TLC) and transect line D (TLD). Quadrats were placed every three meters on four transect lines. TLA was 150 m long in which 50-53 quadrats were placed. TLB was 73 m long and contained 24-30 quadrats. TLC was 72 m long and had 25 quadrats and TLD was 72 m long and contained 24 quadrats. Monthly 123-140 quadrats were taken, the number varying according to the tidal height. The details of the sampling procedure have been mentioned in Hameed and Ahmed (MS in preparation). Hydrographical parameters (salinity, pH, dissolved oxygen and water temperature) and air temperature were also recorded. The fresh weight of seaweeds was obtained on a top loading electric balance. Seaweeds were kept in a vacuum oven at 70-80 °C for at least 24 hours. The oven-dried seaweeds were reweighed for biomass determination of each species.

Results
Monthly variation in the total fresh weight of abundant seaweeds: During the study period (April 1993 to March 1994) 85 species of green, brown and red seaweeds were collected. Attention was chiefly given to 53 seaweed species which were abundant in low, mid and high-tide zones. Seventeen species of brown, 15 species of green and 21 species of red seaweeds were weighed (Table 1). The brown seaweeds had highest fresh weight, green seaweeds had the second highest total fresh weight and red seaweeds formed the lowest fresh weight (Table 1). Only one sample of *Melanothamnus somaliensis* was collected due to severe wave action at the low-tide of the exposed rocky ledge in September. In the low-tide zone of exposed rocky ledge brown seaweeds formed highest weight (19884.4 g/m^2) of the standing crop, compared to the green (15733.8 g/m^2) and the red (6612.1 g/m^2; Fig.

Table 1: Seasonal variation in total fresh weights (g/m2) in the low (L), mid (M) and high (H) tide zones during the period April, 1993 to March 1994.

Groups	Fresh weight L	Fresh weight M	Fresh weight H	Total weight	Dry weight L	Dry weight M	Dry weight H	Total weight
GREEN SEAWEEDS								
Caulerpa laetivierens	-	-	70.6	70.6	-	-	4.7	4.7
C. peltata	-	10.7	35.8	46.5	-	3.1	4.4	7.5
C. racemosa	327.6	26.5	545.8	899.9	182.0	6.0	82.0	270.0
C. scalpelliformis	20.0	-	-	20.0	10.4	-	-	10.4
C. taxifolia	2.3	-	0.3	2.6	1.1	-	0.1	1.2
Chaetomorpha antennina	74.8	5.2	0.4	80.4	21.0	2.4	0.1	23.5
Codium iyengarii	12919.9	8471.2	10706.7	32097.8	6338.8	1403.3	1184.5	8926.6
C. flabellatum	527.3	21.3	81.3	629.9	248.0	3.4	7.7	259.1
Enteromorpha sp.	39.2	-	-	39.2	17.3	-	-	17.3
E. procera	846.8	309.5	704.6	1860.9	397.5	105.9	230.5	733.9
Ulva sp.	7.2	-	-	7.2	3.3	-	-	3.3
U. fasciata	182.7	-	869.9	1052.6	83.5	-	194.5	278.0
U. indica	61.0	-	37.4	98.4	29.2	-	8.8	38.0
U. rigida	10.5	-	12.8	23.3	5.8	-	1.7	7.5
Valoniopsis pachynema	714.5	435.8	82.7	1233.0	356.2	51.0	14.0	421.2
BROWN SEAWEEDS								
Colpomenia sinuosa	272.7	708.3	287.4	1268.4	132.8	133.9	56.4	323.1
Cystoseira sp.	73.4	1.3	270.7	345.4	35.6	0.5	48.8	84.9
Dictyota sp.	932.5	633.7	106.4	1672.6	464.5	224.9	35.8	725.2
D. dichotoma	0.9	5.9	-	6.8	0.4	1.9	-	2.3
D. divaricata	131.1	95.6	49.8	276.5	64.4	13.3	5.9	83.6
Iyengaria stellata	1012.4	6989.9	1720.1	9722.4	499.3	994.7	296.6	1790.6
Jolyna laminarioides	1214.3	-	-	1214.3	600.9	-	-	600.9
Padina pavonia	968.6	441.9	159.4	1569.9	382.1	84.9	40.2	507.2
P. tetrastromatica	224.4	380.1	411.5	1016.0	115.9	72.3	47.1	235.3
Sargassum angustifolium	320.3	421.1	-	741.4	149.6	19.3	-	168.9
S. binderi	106.8	4793.7	562.6	5463.1	43.5	107.8	65.6	216.9
S. boveanum	3681.8	99.5	547.7	4329.0	1840.9	151.6	58.4	2050.9
S. crassifolium	32.0	32.6	305.1	369.7	402.3	12.0	31.0	445.3
S. tenerrimum	3353.3	490.8	-	3844.1	1762.9	84.6	-	1847.5
S. latifolium	6520.9	38.8	-	6559.7	3244.5	6.0	-	3250.5
Stoechospermum marginatum	1031.3	3.3	-	1034.6	469.7	0.8	-	470.5
Stokeyia indica	7.7	0.4	2936.1	2944.2	4.3	0.5	790.0	794.8
RED SEAWEEDS								
Acanthophora spicifera	261.1	-	-	261.1	133.9	-	-	133.9
Centroceras clavulatum	104.3	-	-	104.3	48.0	-	-	48.0
Ceramium manorense	508.3	314.9	245.8	1069.0	241.5	82.6	89.3	413.4
Gelidium pusillum	681.8	84.3	81.3	847.4	329.9	22.4	11.1	363.4
G. usmanghani	1041.8	48.4	221.3	1311.5	501.8	16.1	38.3	556.2
Gracilaria dentata	8.8	-	-	8.8	3.3	-	-	3.3
G. corticata	142.0	-	113.0	255.0	70.9	-	11.6	82.5
G. crassa	44.2	-	-	44.2	21.8	-	-	21.8
G. folifera	190.3	-	7.9	198.2	89.4	-	1.7	91.1
G. pygmaea	9.5	-	61.4	70.9	5.5	-	-	5.5
G. verrucosa	11.2	-	-	11.2	5.8	-	5.8	11.6
Hypnea sp.	27.2	30.0	4.2	61.4	14.4	9.5	2.3	26.2
H. musciformis	260.0	3.6	37.7	301.3	128.1	0.9	6.3	135.3
H. pannosa	364.1	118.3	243.8	726.2	180.3	26.9	41.3	248.5
Jania capillacea	596.6	352.9	13.5	963.0	446.0	216.3	12.1	674.4
J. adherans	67.3	-	-	67.3	59.3	-	-	59.3
Laurencia sp.	95.5	22.8	27.0	145.3	43.1	6.6	4.4	54.1
L. obtusa	107.1	-	-	107.1	47.8	-	2.0	49.8
L. pinnatifida	768.8	-	170.0	938.8	376.7	-	32.5	409.2
L. platyclada	23.5	-	15.3	38.8	10.9	-	-	10.9
Melanothamnus somaliensis	1298.7	-	1.0	1299.7	647.2	-	0.3	647.5
Total	42230.3	25392.3	21748.3	89370.9	21313.3	3865.4	3467.8	28646.5

Table 2: Monthly variation in the biomasses (m2/month) of seaweeds during the period April 1993 to March 1994 at Pacha

Biomasses	A	M	J	J	A	S	O	N	D	J	F	M
Fresh weight	60.8	20.4	4.6	5.9	9.3	49.2	23.4	40.2	121.8	143.0	156.1	102.1
Dry weight	3.3	3.5	1.6	1.9	1.6	11.3	7.8	8.6	16.5	17.9	26.5	14.3

Table 3: Morisita (I), Shannon-Weiner (H) and Evenness (J) Indices of abundant seaweed species at the rocky ledge o Pacha (If I = 1:.uniform distribution; I = 1.0 = random distribution; I = > 1.0 to X = aggregated distribution)

Indices	A	M	J	J	A	S	O	N	D	J	F	M
Green seaweeds												
Morisita	1.17	1.4	1.35	1.50	1.65	1.20	1.50	1.09	1.13	1.32	1.26	1.44
Shannon-Weiner	0.46	0.43	0.45	0.47	0.41	0.45	0.45	0.47	0.46	0.42	0.44	0.39
Evenness	0.98	0.92	0.96	1.00	0.86	0.96	0.94	0.99	0.98	0.89	0.93	0.83
Brown seaweeds												
Morisita	1.50	-	0	-	2.00	1.30	1.17	1.06	1.05	1.04	1.18	1.08
Shannon-Weiner	0.41	-	0	-	0	0.42	0.46	0.47	0.47	0.47	0.45	0.47
Evenness	0.86	-	0	-	0	0.88	0.97	0.99	0.99	0.99	0.94	0.99
Red seaweeds												
Morisita	2.50	2.50	2.14	1.50	2.50	1.37	1.12	1.18	1.37	1.40	1.50	1.21
Shannon-Weiner	0	0	0	0.45	0	0.41	0.46	0.45	0.41	0.40	0.39	0.44
Evenness	0	0	0	0.94	0	0.87	0.97	0.95	0.86	0.85	0.81	0.92

2A). The lowest biomass of red seaweeds was recorded in August and highest in September (Fig. 3). Highest collective fresh biomass 20052.3 g/m^2 of red, green and brown seaweeds was observed in January (Fig. 4). The brown seaweeds were more abundant (15136.94 g/m^2) in the mid-tide zone than green (9280.2 g/m^2) and red seaweeds (975.2 g/m^2; Fig. 2A). Figure 1 represents the relative abundance of commonly occurring seaweeds at Pacha.

High-tide zone of Pacha showed less (2%) algal vegetation than mid-tide (35%) and low-tide (63%) zones. Although in high-tide zone only few seaweed species flourished, yet some representatives of low and the mid tidal seaweeds were also recorded.

From low-tide zone 51 (13 green, 17 brown and 21 red), from mid-tide zone 31 (7 green, 16 brown and 8 red) and from high-tide zone 36 (12 green, 11 brown and 13 red)species of seaweeds were collected.

Seasonal abundance of algae:

Period I (January to March, pre-monsoon season): A gradual increase in air temperature (25.3 °C), longer sunshine hours (11:25 hrs.), high water temperature (25.8 °C), high relative humidity (38%), low pH (7.77), high salinity (36.5 l) and high oxygen concentration (5.75 ml/l) occurred during this period. A sudden fall in the duration of submergence (-0.1 m tide) was also observed since the tidal region become exposed for a longer period. The greatest increase in total algal biomass (29390.1 g/m^2) was therefore observed during this period.

Period II (April, transition period): April was the hottest month (with 32.9 °C, air temperature) of the year having the highest values for sunshine hours (12:37 hours) and, a water temperature of 30.4 °C, normal salinity (35.5 l), high relative humidity (53%), decreasing pH (7.61) and decreasing value of oxygen concentration (5.51 ml/l). The was marked increase in the period of exposure (0.0 m tid of the habitat. In April a gradual decrease in the fres weight of algae (8024.0 g/m^2) was recorded. The slowi of growth seen in this month was probably due to th negative effect of greater submersion (than in period which occurred in the tidal region.

Period III (May to September, monsoon season): Since was the rainy period there were conditions of sudd decrease in air (29.82 °C) and water temperatures (27 °C), longer sunshine hours (12:89 hours), highest value relative humidity (56.33%), higher pH (7.93), low wa temperature (27.2 °C), normal salinity (36.02 l) and h oxygen concentration (6.928 ml/l) of the seawater. period of submergence was slightly greater than in April this period the algae showed slight decrease (9870.3 g/ in fresh weight. Conditions in this period were much favourable for maximum development of many algae wh inhabited the infra-littoral fringe. As the lower part of intertidal region was covered by sand at TLA and TLB to high wave action and high wind speed), the growth o algae was affected in this period.

Period IV (October, transition period): During this pe there was increase in surface temperature of water (30. and decrease in relative humidity (18%). There minimum wave action and wind speed which produced low tides (-0.4 m). A gradual increase in total algal gr (2709.2 g/m^2) was observed during this period. This growth might have been due to gradual increase in w temperature (27.5 °C), longer sunshine hours (11:33 ho increase in pH (7.91) and salinity (37 l). In this perio highest value of dissolved oxygen (8.02 ml/l) was reco The degeneration of algal covers which was observ

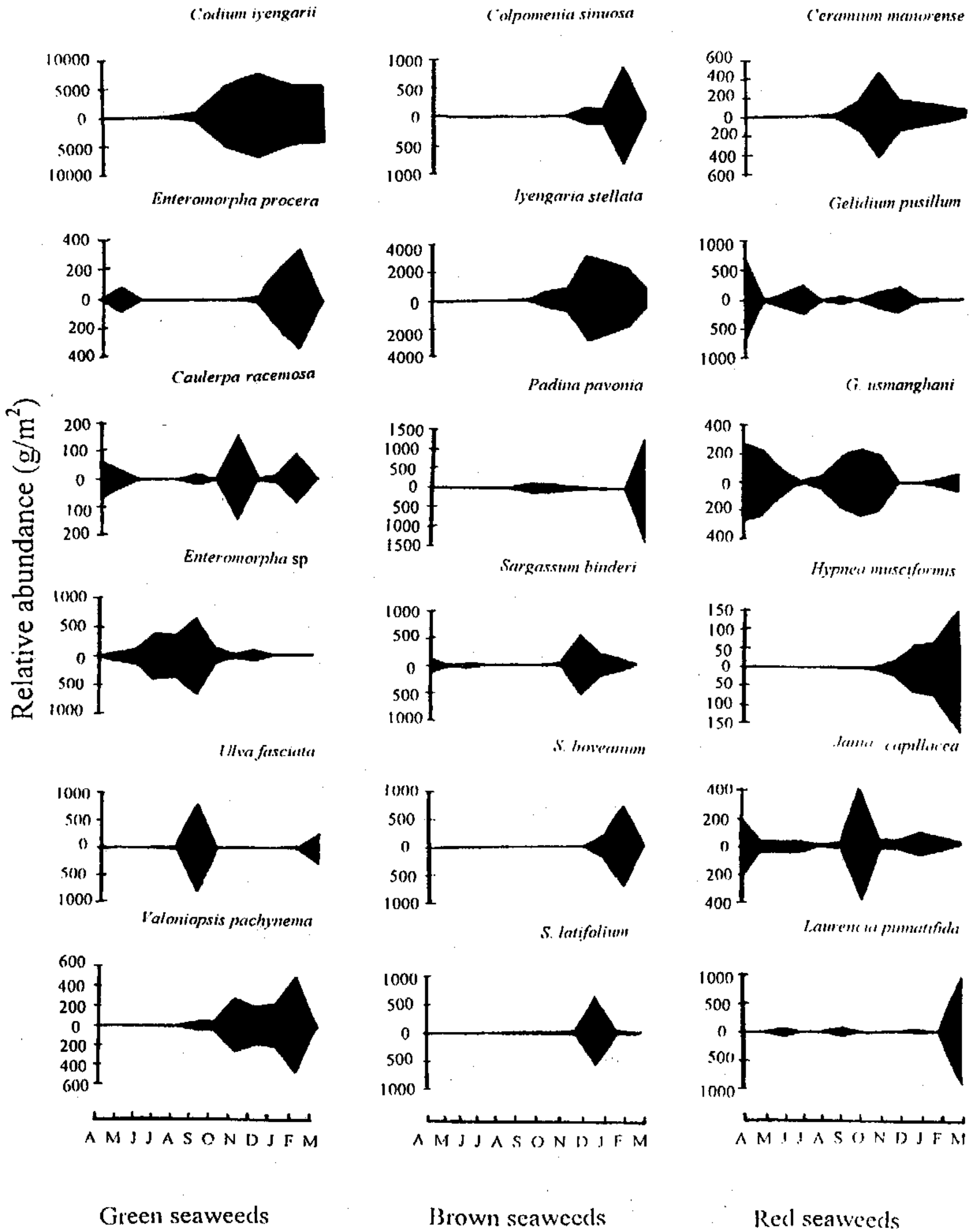


Fig. 1: Relative abundance (g/m^2) of abundant seaweeds at the rocky ledge of Pacha during the period April 1993 to March, 1994.

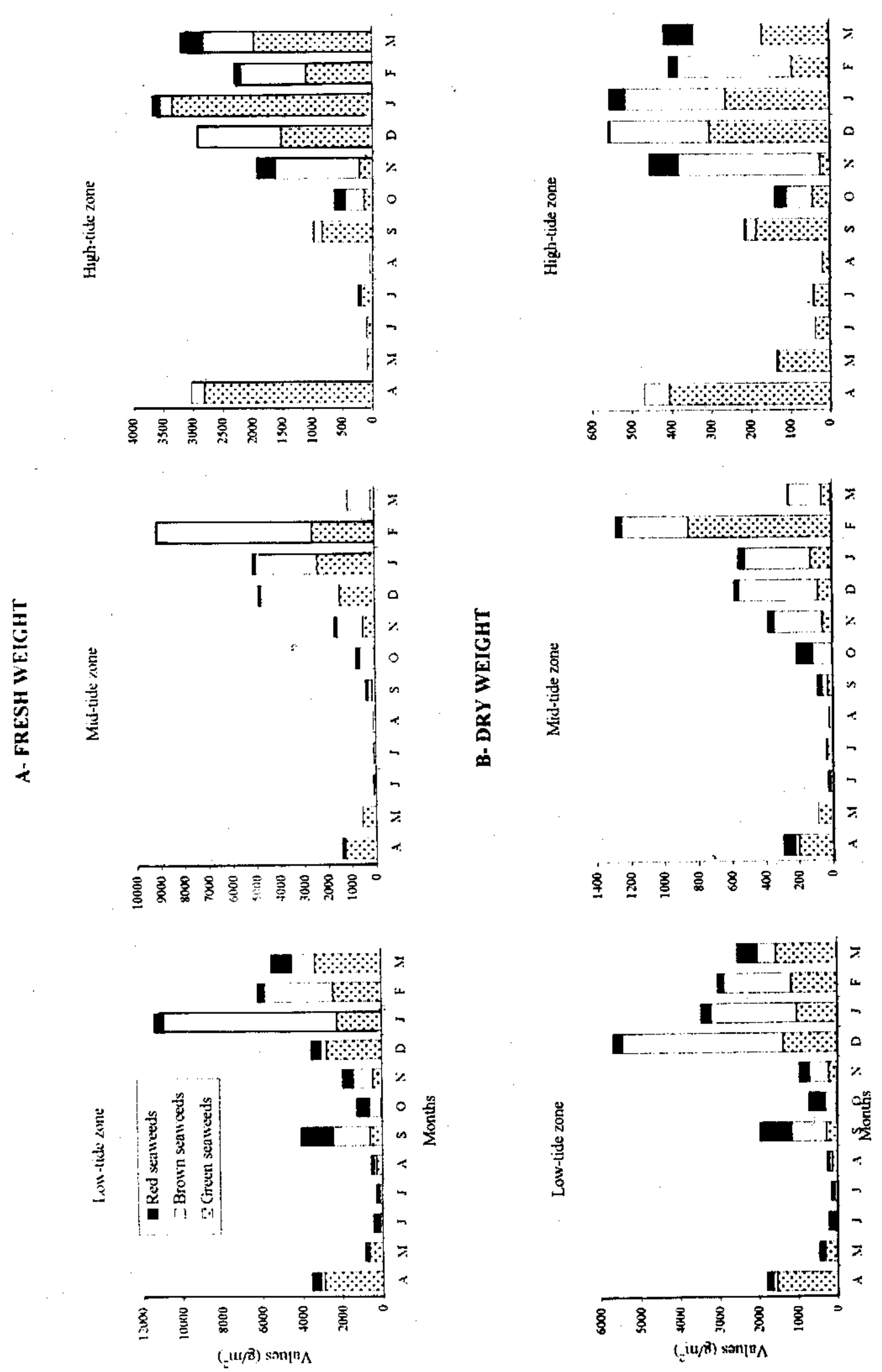
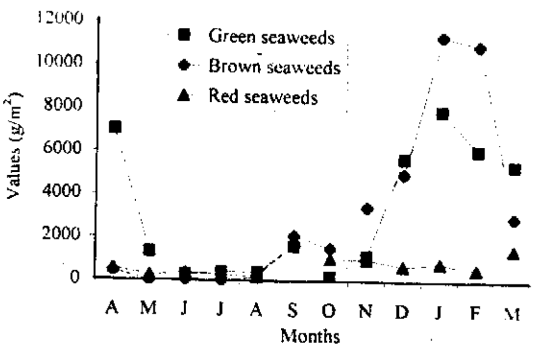


Fig. 2: Histograms show seasonal variation in biomasses of seaweeds at Pacha in different tide zones

during this period probably occurred due to increase in the duration of exposure (-0.4 m, tidal height) of the tidal zone.

Period V (November and December, post-monsoon): During this period lowest values of air (24.75 °C) and water temperatures (23.35 °C) but relatively short sunshine hours (10:49 hours) were observed. The duration of immersion (-0.35 m; tidal height) was higher than in periods I, II, and III. Another important climatic feature was the arrival of a hurricane in November. But no changes in algal growth were observed due to the hurricane. In this period gradual increase in relative humidity (32.5%), highest values of pH (8.05), salinity (39 l) and medium high dissolved oxygen (5.69 ml/l) were noted, so that gradual increase of the fresh weight of seaweeds (16878.4 g/m^2) occurred. The meteorological and hydrographical parameters had thus important effect on algal production. Highest growth of algae was observed in pre-monoon season (January to March) and lowest values of algal growth were recorded in the monsoon season (May to September).



ig. 3: Monthly variation in the fresh weight of seaweeds at Pacha

lonthly variation in the total dry weight of abundant eaweeds:

uring the study period the brown seaweeds had the ghest total dry biomass of 13598.4 g/m^2, the green eaweeds 11001.9 g/m^2 and the red seaweeds 4045.98 'm^2 (Table 1).

gures 2B represent seasonal variation in dry weight of eaweeds in different tide zones. Highest (51%) dry weight seaweeds was recorded in low-tide zone, 28 per cent in id-tide zone and 21 per cent in high-tide zone.

pre-monsoon season the highest biomasses, 10833.7 m^2, 2395.7 g/m^2 and 1851.6 g/m^2, were recorded in low, d and high-tide zones, respectively. Fig. 2B presents percentage incidences in different tidal levels.

There were seasonal variation in biomasses showing that high fresh weight 156.1 m^2/month of seaweeds was found in February, when the dry weight was also high (26.5 m^2/month) in February (Table 2).

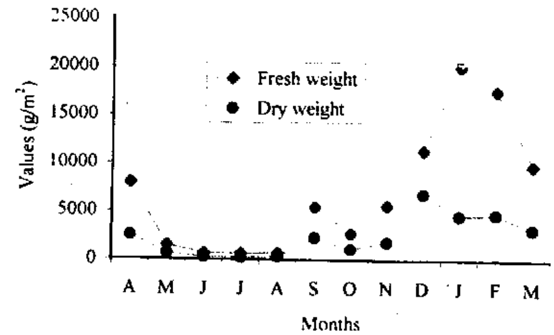


Fig. 4: Seasonal variation in fresh and dry weights of abundant seaweeds found at Pacha

Statistical Analyses: For species richness Morisita Index (I) was computed. Green and brown seaweeds represented aggregated distribution throughout the year. Brown seaweeds also showed aggregated distribution except in June when the distribution was uniform. The species diversity (Shannon-Weiner index; H) of red, green and brown seaweeds is given in Table 3.

Degeneration of seaweeds: Many green algae, such as *Codium iyengarii, Caulerpa scalpelliformis, C. racemosa, C. peltata* and *Chaetomorpha antennina* and some red algae such as *Melanothamnus somaliensis, Laurencia pinnatifida, Botryocladia leptopoda* and *Acanthophora spicifera* usually persisted in these habitats for few months only. In most exposed habitats several algal species are dislodged and swept away by water movements.

Discussions

It is one of the findings of this study that seasonal changes have a profound effect on algal abundance in the intertidal zone at Pacha. Here abundance of algae seemed to coincide with moderate temperature, maximum growth occurring in the early N.E. monsoon season (57211.3 g/m^2). In July (S.W. monsoon) very small amounts of seaweeds flourished on the ledge. According to Saifullah (1973) however, the minimum growth of seaweeds at Buleji, a rocky bench nearby, was found during the period of May to September (S.W. monsoon season) but high during the N.E. (December to February). Recently Hameed and Ahmed (1999) noted that N.E. monsoon season was favourable for the growth of seaweeds as compared to S.W. monsoon season at the rocky ledge of Buleji. In the present study it was noted that the abundance of algae followed tidal fluctuations and decrease or increase of temperature in air and water. According to Matheison *et al.* (1981) wide ranges of temperatures cause pronounced seasonal differences in flora. Payri (1987) stated that tidal variations affect the growth of the species which inhibit the intertidal zone. Similarly Nasr and Aleem (1948) have emphasized that light intensity also affects the growth form of certain species. Varma (1959) stressed that the maximum vegetation and algal growth are seen during the months when the salinity of the sea water was moderate at Palk Bay, India.

Eighty-five species of seaweeds were collected from Pacha during the whole study period out of which 19 were green, 23 brown and 43 red. Anand (1943, 1940) recorded collectively, 79 species of red and 46 species of green seaweeds from Manora, Keamari harbour, Sandspit and Baba Island. Saifullah (1973) recorded 48 species of attached and drift algae from the Buleji. Recently, after a quarter century of Saifullah's (1973) work at Buleji, Hameed and Ahmed (1999) reported 66 species of brown, red and green seaweeds from the same rocky shore. They recorded 17 species of green, 29 species of red and 20 species of brown seaweeds. Qari (1988) recorded 21 edible species of red, green and brown seaweeds from the rocky shore of Buleji.

In present study the smallest number of species was observed in the high-tide zone. Hameed and Ahmed (1999) observed that high-tide zone of Buleji possessed high fresh algal biomass because this zone receives high wave action. Red seaweeds had high number compared to brown and green seaweeds. Hameed and Ahmed (1999) noted highest number (29) of red seaweeds as compared to brown (20) and green (17) at Buleji. At Pacha brown seaweeds possessed highest fresh weight (2944.2 g/m^2) as compared to red and green seaweeds. During the study highest biomass of brown seaweeds was contributed by the following seaweeds: *Colpomenia sinuosa, Dictyota* sp., *Iyengeria stellata, Jolyna laminarioides, Padina pavonia, P. tetrastromatica, Sargassum binderi, S. boveanum, S. tenerrimum, S. latifolium, Stoechospermum marginatum* and *Stokeyia indica*. Saifullah (1973) reported the following seaweeds to dominate the wet weights at the rocky beach of Buleji: *Sargassum* sp., *Taonia* sp., *I. stellata, P. tetrastromatica* and *D. divericata*.

Hameed and Ahmed (1999) reported that highest (41313.5 g/m^2) fresh weight of seaweeds was contributed by the brown algae; which were mainly comprised of *Sargassum filiformis, S. tenerrimum, S. crassifolium, C. sinuosa, Dictyota* sp., *D. dichotoma, P. tetrastromatica, S. indica, I. stellata* and *S. marginatum* at the rocky beach of Buleji near Pacha.

At the rocky shore of Pacha a majority of the green seaweeds like *Codium* spp. and *Caulerpa* spp. live in the shallow and protected water pools. *Codium iyengarii* was dominated among green algae which was found in greater abundance than on other rocky beaches of Karachi. This may be due to the topographical features of the rocky ledge of Pacha. Which becomes exposed at very low tides so that the habitat (TLA, TLB, TLC and TLD) remains submerged in water for much of the time and results in the luxuriant growth of *C. iyengarii*. Miller *et al.* (1983) pointed out that dominant green macro-algae were generally most abundant in the shallower waters of lagoons at Rhode Island, U.S.A. It was also found by Underwood and Kennelly (1990) that the densities of macro-algae were the greatest toward the bottom of the shore (low-tide zone) in Australia. During the present study it was found that low-tide zone had heaviest algal growth (47.25%), whereas mid-tide zone (28.41%) and high-tide zone lowest fresh algal vegetation (24.34%). Hameed and Ahmed (1999) reported fresh algal biomass of 35 percent from high-tide zone, 34 percent from low-tide zone and 31 percent from mid-tide zone at the rocky shore of Buleji.

At Pacha most seaweeds live in low-tide zones of wave action and formed greatest biomass as compared to mid and high-tide zones. Miller *et al.* (1983) had pointed out that low-tide zone is a better location for algal growth. Underwood and Kennelly (1990) have also pointed out that algal vegetation is more abundant on slopes and flats.

In the present study biomass of various seaweeds were examined for correlations with several environmental factors. In winter 58976.5 g/m^2 and in summer 12474.6 g/m^2 of seaweeds were recorded from Pacha. According to Saifullah (1973) abundance of algae generally declined during the warmer parts of the year but increased in winter at the rocky shore of Buleji. Similarly Hameed and Ahmed (1999) noted higher algal biomass (26956.9 g/m^2) in winter at Buleji. In the present study in the winter month of January the highest (21855 g/m^2) algal population was recorded. Hameed and Ahmed (1999) also pointed out that in January highest (13833.4 g/m^2) and May the lowest (104.8 g/m^2) fresh weight of seaweeds was recorded at Buleji. Qari (1985) found maximum growth of algae in February, in the nearby rocky beach at Buleji.

In general the algal biomass was found to have an invers relationship with the tidal height, high temperature and a exposure at Pacha. The peak growth of green seawee occurred in January. In August the smallest biomass of r seaweeds was found, but in September it sudden increased. This sudden change must have been due to th availability of nutrients, suitability of the environment conditions and owing to the sudden appearance of seve red algal species on the Pacha the rocky ledge.

The present study showed the perennial algae of the roc beach of Pacha to be *Gelidium usmanghani* and *Ja capillacea,* whereas *C. iyengarii, E. procera, Dictyota* sp., *stellata, P. pavonia, S. binderi, S. tenerrimum, S. latifolium, G. usmanghani, M. somaliensis, S. marginatum* and *S. indica* were the major contributors to the fresh weight of seaweeds. According to Qari (1985) and Qari and Qasim (1988) the four species which were collected from Buleji during most of the year were *C. racemosa, C. iyengarii, E. procera* and *I. stellata*. Saifullah (1973) observed that *U. fasciata, C. tenuissima, Sargassum* spp., *Cystoseira* spp. and *V. pachynema* formed very high biomasses at the rocky ledge of Buleji which is located close to Pacha.

In the present study the highest value of seaweeds dry weight was noted in the pre-monsoon season. Qari (1985) noted that the highest dry weight of seaweeds at Buleji was found in the pre-monsoon season, and that the dry weight of seaweeds was directly proportional to their fresh weight. Hameed and Ahmed (1999) observed highest dry weight of seaweeds in the pre-monsoon season at Buleji. The present study at Pacha showed that the major contributor to dry weight was made by *Codium iyengarii*. However, according to Saifullah (1973) and Qari (1988) *Ulva fasciata* was the most abundant green seaweed in dry weight at Buleji. Saifullah (1973) found that low-tide zone of Buleji possessed highest biomass than other tidal zones and was more productive in respect of dry weight (42230.3 g/m^2) of seaweeds. This great increase was found by him in February owing to the fast growth of algae in winter. The decline observed during June to July were attributed by him both to decrease in algal numbers and to individual weight losses. In favourable conditions all algal vegetation showed high biomass, while in unfavourable conditions they showed degeneration and decay, which affected the dry weights of the weeds. In April and May *Codium iyengarii, Botryocladia leptopoda, Calliblepharis fimbriata, Scinaea* spp. etc. were dislodged and deposited on the shore. Misra (1966) reported that high temperatures and exposure to sun were responsible for maxima or minima in the development of the Phaeophyta population on the Indian coast. Doty (1971) has pointed out the importance of the unpredictable storm turbulences which affect the large algal standing crop on the Hawaiian open reef flats. Payri (1987) reported that in the end of October the plants of *Hydroclathrus clathrus* and *Chnoospora implexa* begin to decay and are swept away by tidal water. Moreover, the rainfall which began in the later months of the year had a drastic effect on most of the algae which became detached with the change of season at Tiahura reef, French Polynesia. According to Tsuda (1974) desiccation is a factor influencing the degeneration of the algae. Rao and Sreeramulu (1964) suggested that degeneration of the algae may be attributed to the prevalence of unfavourable environmental conditions, especially increase in the duration of exposure. At Buleji Ahmed (1992) first noted that in the end of September the thick green carpet of *Ulva* sp. and *Enteromorpha* sp. was transformed into a snow-white covering indicating decay of seaweeds. Hameed and Ahmed (1999) reported a complete decay of *C. anteninna* and *U. fasciata* (from September to November) on the exposed rocky ledge of Buleji.

Water contents also affect the biomass fluctuations. Many of the thick seaweeds hold high amount of water as compared to thin and delicate algae. The green and brown seaweeds possess high water contents compared to reds. During the observation period it was noted that red, brown and green seaweeds had their peak growths in summer, late summer and in early winter, respectively. It was also noted that the red seaweeds require the high intensity of sunlight and long sunshine hours or "long-day illumination", brown algae moderate light intensity, while green seaweeds require dim light intensity and minimum sunshine hours or "short-day illumination" as compared to red algae.

This is the first study made at Pacha and reveals the richness of its flora. It would be worthwhile to extend the study further to acquire more data about the marine communities of this secluded site to serve as a base-line study for further comparisons.

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