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Population Structure and a Pattern of the Gastropod *Potamides cingulatus* (Gmelin) in a Mangrove Habitat of Karachi, Pakistan

M. Atiqullah Khan, S.M. Saifullah✢, S.S. Shaukat✢
Naemullah Qureshi✧ and F. Chaghtai✦
Marine Reference Collection and Resource Centre, ♦Centre of Excellence in Marine Biology,
✢Department of Botany, University of Karachi, Karachi-75270
✧Federal Government Urdu Science College, University Road, Karachi, Pakistan

Abstract
The study was conducted for one year on population structure and dispersion pattern of the common gastropod species *Potamides cingulatus* was conducted in a mangrove habitat of Karachi. Population diversity levels were moderate in summer but maximum in late autumn and winter. It was also revealed that the species consisted of two groups of individuals, which differed from each other in their colour, size-class structure, population diversity and dispersion pattern. It is, therefore, suggested, they may be considered for two different varieties or forms of the species.

Introduction
Potamides cingulatus is a very common gastropod species of the polluted mangrove habitats of Pakistan and also of other countries (Macnae, 1968; Saifullah, 1982, 1996; Jones, 1986, Dybdahl, 1995; Jacobsen, 1996). It predominately occurs on soft mud in mangrove habitat at low tide. *P. cingulatus* consists of a small (up to 30 mm) elongate robust shell sculptured with rows of spiral beads, the anterior canal is prominent and the columella very much twisted. There appear to be two types of individuals in this species, one large and black and the other small and brown in colour.
Inspite of its abundance in the country, there is no information available on the population density and its seasonal variation which is very important for understanding the dynamics of the mangrove ecosystem. Tirmizi and Barkati (1983) studied allometric growth of this species. The present work, therefore, takes into account the population structure and pattern of this species in a mangrove habitat of Sandspit area at Karachi coast.

Materials and Methods
Sampling: Individuals of *P. cingulatus* were counted in 10 quadrates (50×50 cm) in the intertidal zone of mangrove stands of Sandspit area, δ Karachi on each sampling occasion. Such observations were made in the area fortnightly for a period of 12 months. Simultaneous observation on temperature and salinity of sea water of the channels located within the sampling area were also recorded using a thermometer and refractometer respectively. Soil samples were collected and studied for (observations were made on) soil texture. The shells after being brought to the laboratory were washed thoroughly with detergent to study the structure and colour. Their length was measured to the nearest 0.1 mm from apex to the siphnoid canal tip.

Pattern Detection: An index of pattern detection that is relatively insensitive to changes in density is required to detect spatial pattern (Myers, 1978). Accordingly, Lloyd (1967) index of patchiness© and Morisita (1971) index (1δ) that are unaffected by changes in density caused by random thinning, were used. First mean crowding (m) (Lloyd, 1967) was calculated as:

$$m = \frac{1}{N} \sum_{i-1}^{Q} Xi\,(Xi-1)$$

where Xi is the number of individuals in the ith quadrate, Q is the number of quadrats and

$$N = \sum_{i-1}^{Q} Xi$$

Index of patchiness C is then calculated as $c = m/\lambda$ where λ equals the mean density per quadrate. Morisita's index which is close to Lloyd's index of patchiness is:

$$I\delta = \frac{\sum_{i-1}^{Q} Xi\,(Xi-1)}{N\,(N-1)}$$

Estimates of the pattern detection indices in literature are invariably reported without any indication of sampling variance. The Jackknife method (Tukey, 1958) not only allows estimation of variance from one sample but also permits bias reduction. The variance/mean ratio was also computed. Aggregation pattern was also explored by using Taylor's power law (Taylor, 1971; Taylor *et al.*, 1978). This approach involves relating variance to mean by a power equation as follows:

$$S^2 = a\,X^{-b}\,am^b$$

and, therefore,

$$\log S^2 = \log a + b \log m$$

where S^2 and m are the sample variance and mean density per quadrate respectively at successive time intervals. The parameter b is a measure of aggregation that is generally regarded as characteristic and constant for a species (Taylor *et al*., 1978).

Results and Discussion

Environmental variation: The seasonal variation in temperature and salinity of sea water in the channels occurring at the sampling sites is shown in Fig. 1. It is evident that high temperature as well as high salinity prevailed in summer.

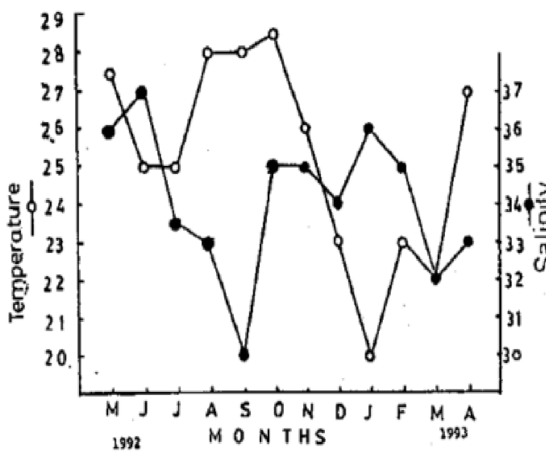

Fig. 1: Changes in water temperature and salinity at Sandspit mangrove site during 1992-93

The grain size distribution of the soil shows it to be mainly muddy in texture, that is consisting mostly of silt and clay particles (Saifullah and Elahi, 1992). It was black in colour as a result of accumulation of dead organic matter, which was very high as compared to other normal soil and, therefore, may be termed as organic soil (Snedaker and Snedaker, 1984).

Size Class Structure: Observation on the individuals of *P. cingulatus* revealed that there are two different morphological types of populations co-occurring in the area. One consisted of individual that were relatively larger in size (11 to 32 mm in length, 'X = 22.462 mm) and black in colour whereas the individuals of the other population were smaller (11 to 26 mm in length, 'X = 20.472 mm) and brown in colour (Fig. 2).

Population Density: In general, there was considerable seasonal change in the density levels of both black and brown populations and the density of black population was considerably higher than that of brown population. Density of black population was moderate during May to mid-August (monsoon season} but, thereafter, declined (September to October). Density levels of black population again increased from mid-October 1992 to early February 1993 (northeast monsoon season). Subsequently, the population !, remained at a lower level up to mid-April. Density level of brown population showed a similar trend to that of black (population. From May to early August the brown population density was moderate; it declined from mid-August and remained so up to mid-September. The density of brown population again increased from early October and remained at a low level during January and February, thereafter, it showed fluctuations.

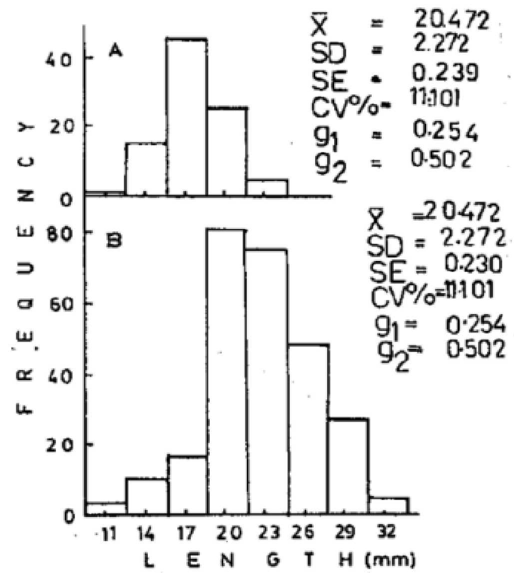

Fig. 2: Size-class structure of brown (A) and black (B) populations of *P. cingulatus* at Sandspit, Karachi. $\bar{x}$ = mean, SD = standard deviation, SE = standard error, CV% = coefficient of variation, g_1 = skewness, g_2 = kurtosis.

Population dispersion pattern: Dispersion pattern of black, brown and total population as measured by Lloyd's index of mean crowding (m), Morisita's index (Id), patchiness© and variance/mean ratio ($S^2/\bar{x}$) is presented in Table 1. In general, the dispersion pattern of both black and brown populations was aggregated as evidenced by all the four measures of dispersion. Higher degree of aggregation for black population was recorded for May to early October, 1992 and April, 1993 as shown by Morisita's index of patchiness, while relatively lower level of aggregation occurred during late October, 1992 to March, 1993. Brown population showed a somewhat similar trend of dispersion.

Table 1: Jackknife estimates of Lloyd's index. Morisita's index and ptchiness and the variance mean ratio

	Lloyd's		Morisita's		Patchiness			
Black	Index	Variance	Index	Variance	Index	Variance	V/m	t
1992								
May	54.656	111.168	1.358	0.02	1.350	0.020	17.071	34.092
May	71.151	47.576	1.096	1.823	1.094	1.809	8.034	14.921
June	58.584	169.356	1.290	0.013	1.286	0.013	15.927	31.665
June	81.107	481.087	1.330	0.036	1.327	0.036	23.934	48.650
July	27.697	30.563	1.198	6.874	1.193	6.885	16.214	11.060
July	64.780	75.797	1.277	0.021	1.274	0.020	16.679	32.260
August	84.161	95.718	1.228	0.013	1.226	0.013	18.447	37.010
August	119.468	600.595	1.364	0.012	1.362	0.012	36.979	76.323
September	24.472	21.820	1.317	0.014	1.309	0.013	7.629	14.062
September	28.801	62.185	1.541	0.056	1.532	0.055	12.432	24.251
.October	40.713	126.408	1.531	0.036	1.524	0.035	16.995	33.930
October	103.968	256.482	1.144	4.643	1.143	4.643	15.874	31.552
November	91.580	31.453	1.049	1.316	1.048	1.307	5.807	10.197
November	100.113	40.873	1.080	2.110	1.079	2.095	9.312	17.632
December	57.833	38.525	1.345	0.033	1.342	0.032	17.483	34.966
1993								
January	121.021	298.367	1.127	2.591	1.126	2.591	16.499	32.878
January	151.960	1221.223	1.208	0.018	1.207	0.018	30.920	63.470
February	111.689	193.395	1.101	2.238	1.100	2.236	12.613	24.635
March	46.357		1.162	4.366	1.159	4.327	8.277	15.437
March	71.821	65.073	1.212	0.013	1.210	0.013	15.032	29.766
April	50.153	32.983	1.601	0.098	1.595	0.097	21.857	44.244
April	57.516	151.903	1.322	0.030	1.319	0.030	16.815	33.549
1992								
May	28.708	12.316	1.314	0.023	1.307	0.022	8.630	16.185
May	32.502	84.398	1.419	0.058	1.412	0.057	11.884	23.088
June	38.153	210.495	1.789	0.189	1.780	0.188	20.178	40.683
June	43.354	62.091	1.454	0.054	1.448	0.053	16.111	32.055
July	21.882	99.851	1.554	0.206	1.542	0.205	10.062	19.223
July	37.050	96.278	1.259	0.037	1.254	0.037	9.689	18.432
July	5.173	6.134	2.931	1.850	2.750	1.530	4.847	8.161
August	4.789	3.818	1,601	0.243	1.543	0.228	3.043	4.334
September	24.472	21.820	1.317	0.014	1.309	0.013	7.629	14.062
September	11.327	11.407	1.452	0.018	1.432	0.019	5.019	8.525
October	45.856	84.516	1.899	0.148	1.890	0.145	25.247	51.436
October	23.366	18.149	1.224	0.023	1.217	0.023	5.807	10.197
November	39.828	27.427	1.212	9.991	1.207	9.854	8.787	16.519
November	15.385	5.559	1.176	7.302	1.166	7.094	3.582	5.477
December	29.959	61.723	1.982	0.169	1.968	0.164	17.662	35.345
1993								
January	11.224	52.330	2.860	1.712	2.779	1.663	9.500	18.031
February	9.975	7.894	1.388	0.084	1.367	0.081	4.141	6.663
February	11.365	1.335	1.116	0.013	1.104	0.012	2.309	2.777
March	29.767	6.485	1.233	0.021	1.227	0.210	7.224	13.203
April	15.163	-	1.673	0.091	1.652	0.088	7.845	14.520
April	21.143	27.449	1.214	0.026	1.206	0.026	5.260	9.037
1992								
May	81.601	179.692	1.309	0.017	1.306	0.017,	22.600	45.821
May	95.566	56.058	1.087	2.002	1.086	1.988	9.608	18.260
June	88.833	235.679	1.331	6.671	1.328	6.613	25.834	52.681
June	1120.701	980.164	1.326	0.032	1.324	0.032	34.786	71.671
JUly	41.132	29.680	1.105	2.966	1.102	2.954	5.440	9.418
July	95.430	115.549	1.189	7.760	1.187	7.711	17.982	36.024
August	84.316	88.595	1.197	0.010	1.195	0.010	16.494	32.868

August	122.899	637.151	1.355	0.011	1.353	0.011	37.361	77.133
September	35.839	49.514	1.249	0.012	1.244	0.012	9.972	6.950
September	40.713	126.408	1.531	0.036	1.524	0.035	16.995	33.930
October	64.471	233.063	1.947	0.162	1.940	0.159	36.129	74.520
October	121.816	210.433	1.107	1.781	1.106	1.778	14.323	28.262
November	127.621	114.189	1.061	1.231	1.060	1.228	9.241	17.482
November	112.426	55.319	1.061	7.884	1.060	7.821	8.331	15.551
December	81.056	114.009	1.391	0.039	1.389	0.038	26.375	53.828
1993								
January	125.429	281.036	1.126	2.017	1.125	2.015	16.944	33.822
January	152.467	-	1.208	0.018	1.207	0.018	31.034	63.711
February	118.927	214.795	1.094	1.600	1.092	1.601	12.550	24.501
March	57.780	55.997	1.151	4.183	1.149	4.152	9.538	18.111
March	98.455	99.666	1.179	0.011	1.177	0.011	17.637	35.292
April	64.719	81.896	1.598	0.090	1.593	0.089	27.891	57.044
April	78.817	311.919	1.292	0.028	1.289	0.028	21.136	42.715

For brown population greater degree of population aggregation was found during early May to early October, 1992 and lower level of aggregation was recorded for late October to late November, 1992 and March, 1993.

The equations of Taylor's power law for black, brown and total populations calculated were as follows:

$S^2 = 7.082\ m^{1.169}\ R^2 = 0.6619$ black population

$S^2 = 2.329\ m^{1.1447}\ R^2 = 0.7970$ brown population

$S^2 = 23.42\ m^{0.907}\ R^2 = 0.4206$ total population

The brown population showed greater aggregation than did the black population. Differential aggregation patterns could be the result of differential mortality and/or differential predation by predators such as sea-gulls and crabs. The total population, however, showed a tendency towards random distribution. Once b is estimated a common transformation can be applied to the original counts (Healy and Taylor, 1962). The appropriate transformation for black and brown *P. cingulatus* populations are $X^{0.415}$ and $X^{0.206}$ respectively.

The differences in colour, size class structure and distribution pattern between the two groups of individuals of *P. cingulatus* mentioned above, suggest that they may be considered for its two different varieties or forms. However, further work especially cytogenetic studies are needed to establish this proposition.

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