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POPULATION STRUCTURE OF SOME MANGROVE FORESTS OF PAKISTAN COAST

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Abstract

Twenty eight stands at six different sites *i.e*. Sandspit, Port Qasim, Kemari, Korangi Crossing, Ketti Bunder and Sonmiani were selected for qualitative measurements. 10 x10 m^2quadrats were made randomly at 25 meters intervals and small quadratS (1 X 1 m^2) were laid inside these quadrats for quantitative sampling of pneumatophores. Size class structure *of A. marina* and associated tree species, *Ceriops tagal* and *Rhizophora mucronata* were examined that reflect deteriorating and unstable condition due to anthropogenic disturbances. Size class structure of *A.marina* and associated tree species of some individual stands exhibited positive skewed with a few gaps. It is suggested that though stands deteriorating but could be saved by proper management plan. Tree density and basal area showed non significant relation. The overall density of *A.marina* (2960 trees/ha) and *R.mucronata (*3895.43 trees/ha) laid between basin and fringe mangrove forests while density of *C.tagal* (865 trees/ha) was lower than riverine forests. The basal area of all mangrove species was closed to dwarf mangrove forests however, tree height ranged between fringe and dwarf mangrove trees. The present study will help in the management and conservation planning of mangrove forests at the coastal areas of Pakistan. Some recommendations are outlined for future research and sustainable management of these forests species.

Introduction

Mangrove forests are distributed along the coast of the tropical and sub-tropical areas of the world. It propagates in most of the places to stabilize some of the land from erosion by wave action. Tropical coastal communities have utilized mangrove resources without upsetting the ecological balance in the area (IUCN, 2005). There is an impressive global literature that gives an overview of mangrove ecology and management i.e. Rollet, (1981); IUCN, (1983); Tomlinson, (1986); Hutching and Saenger, (1987); ISME,(1993); FAO, (1994). However, the use of mangrove forests has been a persistent danger to the existence of these forests along the coast of Pakistan. With the rapid urbanization and industrialization the mangroves have become major victims of exploitation as a source of building poles, fodder and firewood. No considerable work has been done on the management and maintenance of these forests. In order to achieve sustainable forest there is a need to evaluate the trends in forest conditions over time. The best way to characterize mangrove ecosystem and to monitor changes is through the assessment of forest structure (Holdridge *et al*., 1971 and Cintron and Schaeffer, 1984), according to Odum and Heald, (1975) these aspects being closely linked to forest productivity The structure of a plant community refers the distribution of biomass in forest. Several studies (Cintron and Schaeffer, 1984; Azariah *et al*., 1992) have been shown that various structural parameters like tree height, stem diameter, basal area, crown diameter and leaf area index are responsible to derive attributes like regeneration rates, distribution patterns and complexity index. The investigation of population structure has a paramount importance both for economically and environmentally stands point. Especially, the density and basal area have been particularly widely applied in phytosociology and ecology (Curtis and McIntosh, 1950).

Mangrove forests are of great interest to foresters, apiculturists, silviculturists, ecologists, environmentalists and biologists. Despite the importance of these forests a little attention is paid to describe the structure of different species of mangroves in Pakistan. Bearing these considerations in mind, the present study was conducted to investigate the population structure and regeneration characteristics of the most important and dominant mangrove tree species of Pakistan with its associated species**.** It is anticipated that present study will provide information to understand the current status and the future trends of the mangrove forests.

Materials and Methods

Quadrat method (Mueller-Dombois and Ellenberg, 1974) was applied for quantitative sampling. Six sites Sandspit, Port Qasim, Kemari, Korangi, Ketti Bunder and Sonmiani were studied. Twenty eight stands were sampled in a random manner having ten replicates of 10x10 m^2 quadrats. The interval was taken from the shoreline to the last mangrove stand following Mendoza and Danilo, (2001). All the trees within a quadrat with dbh more than 2cm for *A.marina*, *R.mucronata* and *C.tagal* were counted and measured for tree height, basal area and density following Ahmed and Shaukat (2012). Two hundred leaves were collected from each stand to measure the leaf area from each stand. 1x1 meter quadrat was laid inside the each quadrat for estimating the number and height of pneumatophores. Due to the monospecific nature of most of the stands, only absolute values (density and basal area) were calculated.

Size class structure: Individual stand size structure diagrams were prepared on the basis of dbh to determine the present and future of mangrove species at their particular site. The dbh size class structure of the study area were divided into five classes,

1. Juvenile size classes (2 to 10 cm dbh)
2. Small size classes (10.1 to 20 cm dbh)
3. Medium size classes (20.1 to 30 cm dbh)
4. Large size classes (30.1 to 40 cm dbh)
5. Mature size classes (40.1 to 50 cm dbh)

The series of size classes were subjected to excel spread sheet and graphs were constructed. Regression analyses were performed to check the relationship between leaf area, number, height of pneumatophores, tree height and absolute structural attributes (basal area and density).

Results

Structural attributes: The structural characteristics of the forest dominating mangrove species *Avicennia marina* and the other two associated species *R.mucronata and C.tagal* are given in Table 1. Twenty eight stands at six mangrove locations were encountered during the survey out of which twenty six stands were dominated by *A.marina.* The stand density of *A.marina* ranged from 1298 ha^{-1} to 4544 ha^{-1} at Phitti creek (stand 12) and Sukro creek (stand 18) respectively and the basal area ranging from 2.02 m^2ha^{-1} (Sandspit stand 3) to 21.22 m^2ha^{-1} at Dubbo creek 2 (stand 24). The basal area of the co-dominant species *R.mucronata* varied from 1.97 m^2/ha in Baloch Bhira (stand 26) to 3.78 m^2/ha in Kuppa Wali (stand 28). The other associated species *C. tagal* was only found in Baloch Bhira and occupied 3.14 m^2/ha basal area. The maximum height of the tree (5.3±0.19m) and number of pneumatophore (71±13) were found at Sandspit (stand 1) while no pneumatophores were recorded from Baloch Bhira (Stand 26). The minimum height (2.9±0.26m) of the tree was recorded from Chara creek (stand 7).The leaf area of each stand was also measured, the maximum leaf area of *A.marina* (34±7.23cm) was calculated from Dubbo creek 2 (stand 24) while the mean greatest leaf area of *R.mucronata* (33.5±6.25) was recoded from Baloch Bhira (stand 26). The minimum leaf area (16±2.25cm) of *A.marina* with the greatest height of pneumatophores (32.05±7.18 cm) was recorded from Mazhar point Chara creek (stand 9). The minimum height of pneumatophores (11.66±3.33 cm) were found at Kuppa Wali (stand 28).

Comparison among different types of mangrove forests elsewhere and Pakistan are given in Table 2. It is shown that large trees with higher basal area and height are reported from riverine mangrove forests and the highest density (25302 ha^1) with lowest basal area (0.6 m^2 ha^{-1}) was related with dwarf mangrove forests. Density of Pakistani mangrove was between riverine and basin but they occupied highest basal area among all types of mangrove forests. Density of *R.mucronata* lied between basin and fringe types of forests. The results of the overall Pakistani mangrove forests attained higher height than dwarf trees.

Table 1. Structural components of mangrove stands at different locations

Stands	Sites	LF (cm^2)	NP	HP (cm)	HT (m)	Absolute values	
						D (ha^{-1})	BA (m^2ha^{-1})
stand 1	Sandspit1	18.33±2.35	71±13	25.34±1.34	5.3±0.190	3895	6.59
stand 2	Sandspit2	19.02±1.36	38.64±14	28.14±3.24	4.38±0.172	2380	3.33
stand 3	Sandspit3	30.62±6.26	32.6±8	25.06±2.82	3.95±0.33	2596	2.02
stand 4	Sandspit4	30.62±5.36	29±7	24.2±2.83	4.57±0.20	3895	5.79
stand 5	Korangi creek	29.20±3.25	13.8±3	23.876±1.90	4±0.20	4111	4.82
stand 6	Gharo creek	26.91±3.25	18.4±4	24.7396±2.60	4±0.20	3462	3.94
Stand7	Chara creek	19.03±1.32	34.6±2	21.56±2.24	2.93±0.26	2813	9.72
stand 8	Chara creek (Aziz point)	28.51±3.58	30±4	15.6±1.32	3.95±0.15	4328	5.37
stand 9	Chara creek (Mazhar point)	16.50±2.25	25.5±1	32.05±7.18	4.96±0.26	3029	14.04

Table 1. Continue…

stand 10	Jhari creek	17.99±3.47	20±2	23.4±4.0	3.41±0.54	2596	4.53
stand 11	Kadeero creek	20.49±2.36	36±4	27.06±2.36	4.05±0.54	2164	9.61
stand 12	Phitti creek	21.10±2.35	26±2	30.84±3.54	4.33±0.70	1298	3.45
stand 13	Chann Nandi creek	23.08±3.56	24.8±3	29.24±4.54	3.76±0.22	2813	4.70
stand 14	Bakran creek	22.02±4.25	15±2	23.7±3.83	2.96±0.28	2596	2.54
stand 15	Rakhal creek	25.86±3.68	32.4±4	25.4±1.32	4.10±0.44	3029	2.08
stand 16	Ganglaro creek	28.50±3.65	19.2±3	18.6±1.12	3.47±0.28	3895	4.67
stand 17	Chann Waddo creek	31.57±4.26	20.6±1	24.4±1.59	3.34±0.37	3462	7.26
stand 18	Sukro creek	29.42±3.28	21.8±2	29.94±3.42	4.30±0.24	4544	10.08
stand 19	Chinna creek	32.83±1.65	36±3	25.68±1.18	5.07±0.58	1514	11.03
stand 20	Near Native jetty bridge	29.18±2.22	45.8±8	24.2±2.83	3.65±0.45	2164	3.81
stand 21	Korangi 1	30±3.21	24±5	31.94±3.28	3.11±0.13	3895	3.01
stand 22	Korangi 2	23±3.64	24.2±3	24.08±1.32	3.45±0.199	2596	3.99
stand 23	Dubbo creek 1	29±2.16	25.2±5	24.18±2.96	3.32±0.22	3246	7.79
stand 24	Dubbo creek 2	34±7.23	24.8±5	14.62±0.77	4.11±0.20	3895	21.2
stand 25	Dubbo creek 3	31.2±4.23	28.8±3	20.72 ±1.52	4.5 ±0.24	2380	14.12
***stand 26**	Baloch Bhira	33.5±6.25	-	-	2.37±0.20	1731	1.97
		16.2±1.45	-	-	1.32±	865	3.14
stand 27	Budgashi Channel	18±2.27	28.4±8.23	16±2.30	3.5±0.39	3246	4.36
****stand 28**	Kuppa Wali	21±3.25	-	-	3.4±	6059	3.78
		24.6±3.24	16±6.08	29.94	3.5±0.95	1298	4.99

Note: LF=mean leaf area, NP= mean number of pneumatophores, HP= mean height of pneumatophores, HT=mean height of tree, BA=basal area, D=density, - =not found, *=dominated by *R.mucronata* and *C.tagal, **=dominated by R.mucronata and A.marina*

Table 2. Compensative table for different types of mangrove forests.

Forest type		**Stem density** (ha^{-1})	**Basal area** (m^2/ha)	**Height** (m)
Riverine		1760	41.30	17.70
Basin		3580	18.50	9.0
Fringe		5930	17.90	8.20
Dwarf		25302	0.60	1.0
Pakistan	*A.marina*	2960	64.00	3.66
Present	*R.mucronata*	3895	2.87	2.88
Study	*C.tagal*	865	3.14	1.32

Source: Arreola-Lizárraga *et al*., (2004)

Correlation among variables: An attempt was made to explore the relation between density/ha, basal area m^2/ha and other parameters. Results of the overall stands were correlated in Table 3. The relationship between overall density/ha and basal area m^2/ha showed non significant correlation; though a wide variance was also associated with these two variables.

Table 3. Over all correlation between density/ha and basal area m^2/ha and other parameters:

Locations	**r-value**	**Significance level**
Density ha^{-1} / Basal area m^2 ha^{-1}	0. 242	ns
Basal area m^2 ha^{-1} / Tree height	0.087	ns
Density ha^{-1} / Number of pneumatophores	0.140	ns
Basal area m^2 ha^{-1} / Number of pneumatophores	0.022	ns
Density ha^{-1} / Height of pneumatophores	0.034	ns
Basal area m^2 ha^{-1} / Height of pneumatophores	0.01	ns

Size frequency distribution: Port Qasim, Ketti Bunder, Korangi crossing and Sonmiani composed of small size classes and in some stands many individuals were found in medium size classes with a gradual decrease in larger size classes. In Sandspit and Kemari this situation did not exist and small sized trees were frequently lacking. Fig. 1 shows the distribution of tree species in different size classes based on dbh (diameter breast height) in twenty eight stands. The results are summarized below,

Location 1. Sandspit:
Stand 1. Sandspit 1: This was a monospecific stand of *A.marina* with 3895 trees/ha. No trees were found in medium, large and mature size classes but juvenile and small size classes occupying 5.55% and 94.44 %, respectively.

Stand 2. Sandspit 2: This stand also showed the same situation as prevailed in stand 1. The two small size classes were found with an average value 2381 trees/ha. The juvenile size classes showed minimum number of individuals (9.09%) and the small size class occupied 90.90% of the total density. There was high degree of disturbance in this area.

Stand 3. Sandspit 3: Density size class structure of this stand showed the distribution of mangrove vegetation in two size classes with a total of 2597trees/ha. Mostly the trees were in juvenile size class (75%) and some in small size class (25%) of the total density. No trees were recorded in medium, large and mature size classes.

Stand 4. Sandspit 4: This stand occupied same number of trees (3895trees/ha) as in stand 1. Juveniles share 27.77% individuals, 61.11% in small size class and 11.11% in medium size classes. The form of the graph is more or less bell shaped absence of the trees in large and mature indicating high degree of disturbances.

Location 2. Port Qasim
Stand 5 Korangi creek: The size class structure described that this creek consists of 42.10 % juvenile size class, 52.63 % small size class and 5.26 % trees in medium size class. No tree was recorded in large and mature sized trees.

Stand 6. Gharo creek: This stand depicted the bell shaped structure of distribution and the large and mature size classes were absent from this site. The juveniles trees acquired 50% of the population, 43.75% trees were found in small size class with 1515 trees/ha and 6.25% trees were recorded in medium size class.

Stand 7. Chara creek: The structure of this stand was almost bell shaped which occupied 433 trees/ha (15.38%) in juvenile size class, 1298 individuals /ha with 46.15% in small size class, 649 trees/ha (23.08%) In medium size class and 433 trees/ha having 15.38% in large size class. The mature size class was absent from this stand. More than 44.59 dbh cm trees were absent in this forest.

Stand 8. Chara creek (Aziz point): This stand attained equal number of individuals 50% (2164/ha) in juvenile and small size classes. The medium, large and mature size classes were absent from this location. The structure was almost flat which showed that the future of this stand does not appear bright.

Stand 9. Chara creek (Mazhar point): In this stand no *A.marina* trees were found in juvenile and mature form while the small size class occupied 1212 trees/ha (40%). Medium size class occupied 1616 trees/ha (53.33%) and in large class this species acquired 202 trees/ha (6.67%) of the total population. The gaps in smaller size class and the absence of mature size class indicating possible diminishing of this species in future from this site.

Stand 10. Jhari creek: This forest was dominated by 50% juvenile trees. Due to positive skewed of this stand the future of this forest is indicating stable condition. Individuals of small and medium size classes occupied 33.33% and 16.67% respectively. But the large and mature sized trees were absent from this site.

Stand 11. Kadeero creek: The structure of this stand was almost flat, due to less or equal number of trees. The overall graph showed rectangular or equi-distribution, the individuals occupied equal number of trees 433/ha (20%) in juvenile, small and large size classes while medium size class contains 866 trees/ha (40%) of the total density. The individuals of mature size class were not recorded from this stand. Largest tree occupied 38.85cm dbh in this forest.

Stand 12. Phitti creek: This forest occupied 16.67% individuals in smaller size class, 50% in small size class and 33.33% in medium size class. The juvenile size class has minimum number of trees (216/ha) compared to other two classes. No trees were found in large and medium size classes. The shape of this forest indicating that the future of this forest is not promising.

Stand 13. Chann Nandi creek: In this stand *A.marina* attained 1082 trees/ha (38.46%) in juvenile form, 1298 trees/ha (46.15%) in small size class and 433 tress/ha (15.38%) were found in medium size class. Not more than 26.11 cm dbh trees were found in this forest, it shows great disturbance. The large and mature size classes were absent in this stand.

Stand 14. Bakran creek: The individuals of this stand were distributed in two size classes, the juvenile and small size classes with 41.67% and 58.33% respectively. The remaining size classes were not found which showed the awful future of this forest. The shape of this forest is negatively skewed; this makes the forest unstable and static. Maximum 15.29 cm dbh trees were found in this forest which suggests that this is a young and growing stand.

Stand 15. Rakhal creek: This forest was also monospecific stand covered with 3029 trees/ha of *Avicennia marina*. It 57.14% individuals occupied in juvenile size class and 42.85% in small size class. The stand showed inverse J-shape distribution which indicated good regeneration pattern and secure future, though the medium, large and mature size classes were not persisting.

Stand 16. Ganglaro creek: The structure of this stand attained J-shaped which showed positive skewed. Monospecific *Avicennia* forest occupied maximum individuals (2381/ha) in juvenile size class while small and medium size classes obtained 1082 (27.77%) and 433 (11.11%) trees/ha. No trees were found in other two classes. The occurrence of *Avicennia* trees in initial classes predict good future of this stand if it will protect well while the absence of the large size classes showing the huge degree of disturbances.

Stand 17 Chann Waddo creek: The shape of the forest is almost inverse J-shaped with a gap in large size class. However, the present size class showed the secure and regenerating future of this forest. This stand attained 3462 trees/ha. Its juvenile individual size class carried out 1979 trees/ha (57.14%), individual in small size class occupied 989 trees/ha (28.57%) while 247 trees/ha (7.14%) individuals were found in both medium and mature size classes.

Stand 18. Sukro creek: This stand attained 4545 tress/ha density, with almost bell-shaped structure. The large and mature size classes were absent from this site. Its 23.80% individuals occurred in both juvenile and medium sized classes while small size class attained 52.38% having 2381 trees/ha. Not more than 27.17 cm dbh trees were recorded in this forest which showed great disturbances.

Location 3. Kemari

Stand 19. Chinna creek: The small size classes showed gaps in this forest. The remaining size classes showed positive skewed. Maximum number of trees (57.14%) was found in medium size class while the large and mature size classes attained 28.57% and 14.28%respectively. This forest could be flourished if the seedlings and saplings will be introduced in this forest, otherwise this forest could be vanished in future.

Stand 20. Near Native jetty bridge: *A.marina* showing somewhat bell shaped structure having 2164 trees/ha. Its 20% trees were distributed in juvenile class, 70% individuals in small size class and 10% in medium size class. No plant was recorded in large and mature size classes. Though the medium size class individuals were lower in number but with large number of individuals in smaller and small size classes indicate the secure future of this stand.

Location 4. Korangi area

Stand 21. Korangi 1: Total density of this site was 3895 trees/ha. Its 72.22% individuals were found in juvenile size class and 27.78% individuals were recorded in small size class. No trees were found in other size classes. The shape of this graph is more or less negative exponential (inverse J), indicating the better regeneration pattern.

Stand 22. Korangi 2: This forest site was positively skewed having 2597 trees/ha. Its 50% individuals occupied small size class, 33.33% in medium size class and 16.66% in large size class. With the large number of individuals in small size class the future of this stand seems to be secured. The large and mature size classes were absent from this stand.

Location 5. Ketti Bunder

Stand 23. Dubbo creek 1: The shape of the structure is more or less uneven having 3246 trees/ha. This stand has backup from the seedlings and saplings of the same species. All size classes were presented in this stand. The maximum trees (38.88%) were found in small size class while juvenile and mature size classes acquired equal number of trees (11.11%). The remaining two classes, medium and large occupied 5.55% and 33.33% respectively.

Stand 24. Dubbo creek 2: This stand is represented by (36.36%) small and (45.45 %) large size classes of the total population. Juvenile and mature trees were entirely absent in this forest.

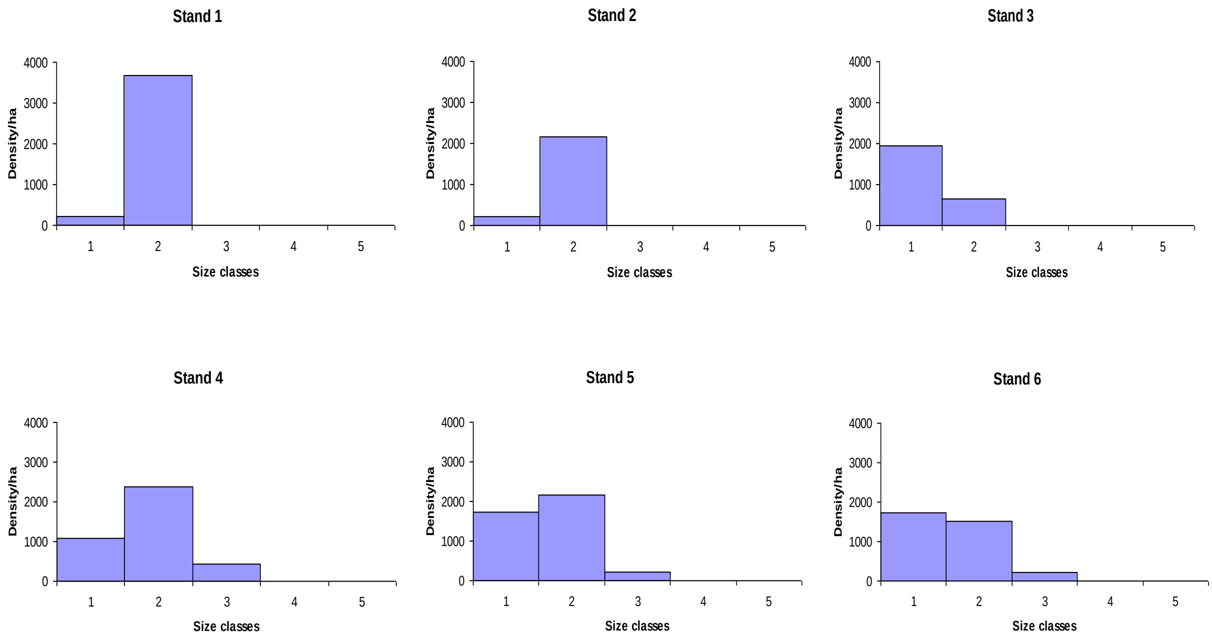
Stand 25. Dubbo creek 3: The structure of this stand was uneven. The higher number of trees were found in smaller size class 1111 trees/ha, while the least number of trees were found in large size class 159 trees/ha. The mature size class was absent from this site. The individual of juvenile and medium size class were found in 794 trees/ha and 317 trees/ha correspondingly.

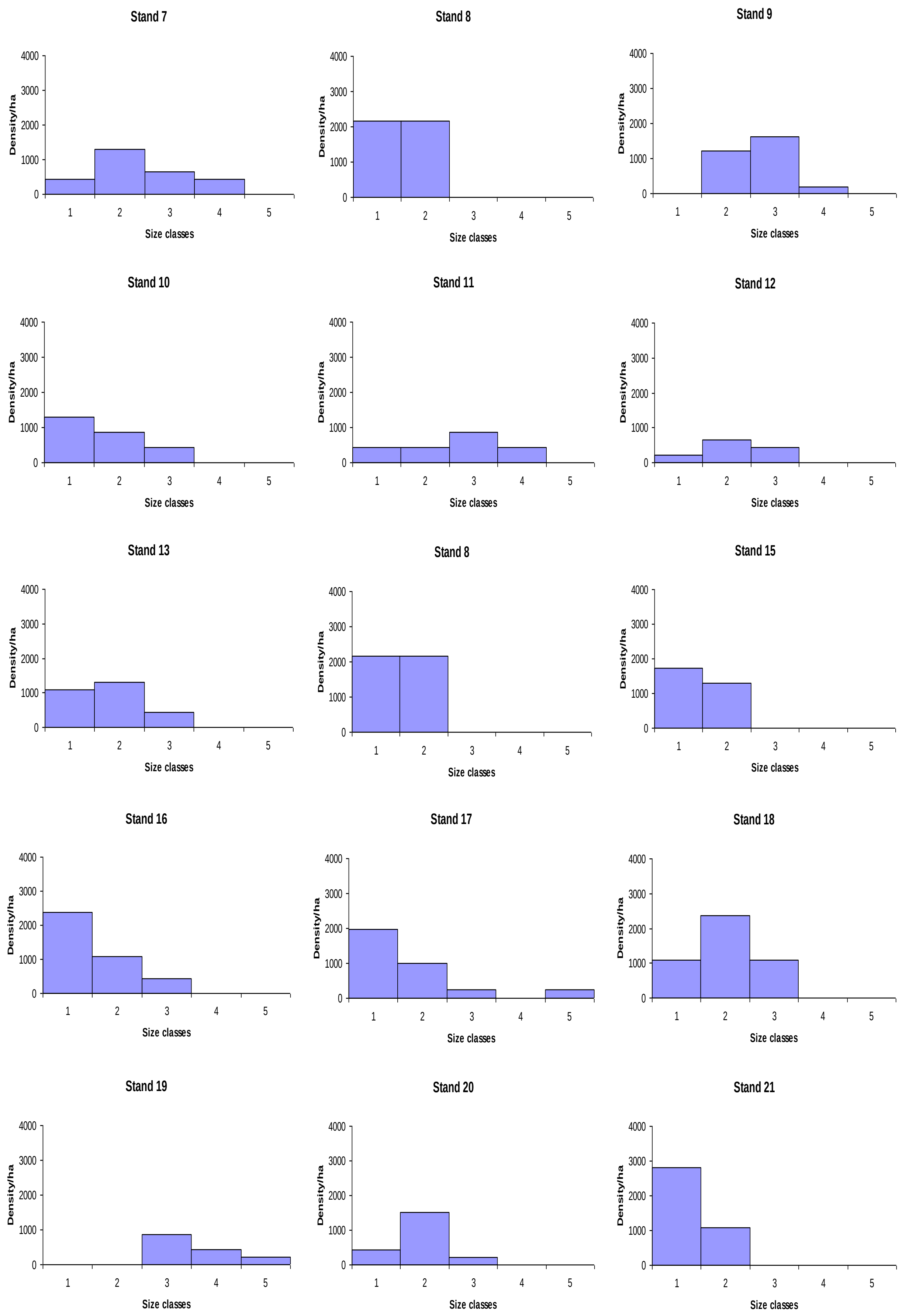
Location 6. Sonmiani

Stand 26. Baloch Bhira: Most common species of the study area i.e. *A. marina* was absent from this site. This was the only stand where two different mangrove species, *R. mucronata* and *C. tagal* were recorded. *R. mucronata was the* dominated species with 1731 trees ha^{-1} while *C. tagal* was co-dominated species having 865 trees/ha in this forest. Both thee species were found in juvenile size class, the other classes were not recorded from this site.

Stand 27. Budgashi Channel: This was a monospecific stand dominated by *A. marina*. Its 33.33% individuals were distributed in juvenile size class while 66.66% trees were recorded in small size class. Other three size classes were absent from this forest, which showed a high degree of disturbances. There is a need to plant more seedlings and saplings to manage this forest area.

Stand 28. Kuppa Wali: This stands was a mixed stand covered with *R.mucronata* and *A. marina*. The *R.mucronata* was dominant species with 6059 individuals/ha. It occupied 33.33% of the total stand density in both juvenile and small size classes. The large size class trees were absent from this stand showing a gap in this forest. Remaining two classes of this species attained 16.66% individuals in this particular forest. *A.marina* was the associated species having the 1298 trees/ha. *A.marina* was only found in smaller size class and medium size classes with 96.42% and 3.57% accordingly.




Stand 7
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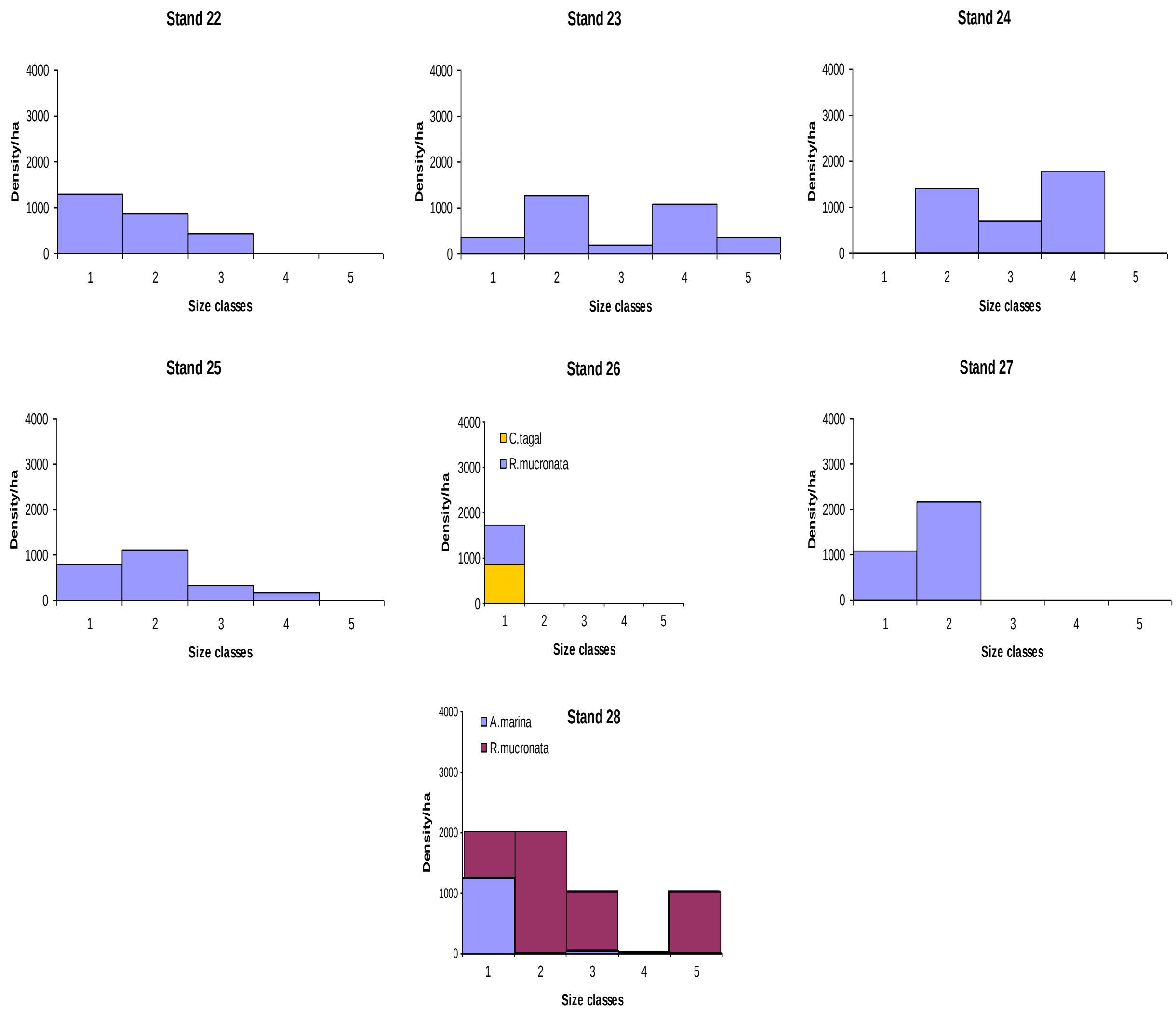

Fig 1. Size class distribution of mangrove tree species of Pakistan. Diameter classes are 10cm dbh intervals.

Discussion

Structural attributes: In present investigations the density and basal area showed large variation from site to site but they are within the range of the previous findings. Twillery *et al.,* (1995) stated that coastal geomorphology and topographic setting of the mangrove is an important descriptor in classifying mangrove forests. The results of the individual stands explained that the least tree basal area in Sandspit, Bakran creek and Rakhal creek may be due to the close proximity of human settlements which causes excessive pollution, harvesting and grazing. Many local people are involving in cutting trees, results in higher consumptive wood extraction from the forest, which in turn is reflected lowest basal area of mangrove trees. The logging of trees for fuel, charcoal making and construction materials are the only threat to mangrove destruction (IUCN, 2005). Kairo *et al.,* (2002) stated that anthropogenic activities have an accumulated effect on the current structure and the regeneration of the forest. Though, 32.13% density ha^{-1} of large and mature trees in the present investigation showed the cutting of the selective size classes, however if logging practice is continued and focused only on particular size classes than trees will be eliminated in particular size classes, which definitely create gaps in the forests. Amjad *et al*., (2007) explained that the use of mangroves has been reduced in this area due to provision of alternate source of fuel after the establishment of industrial units. The mangroves in Port Qasim showed great variations in all parameters, the dense mangroves in Sukro creek, Chara creek (Aziz point) and Korangi creek are due to strict protection from Sindh forest department. However the Korangi and Chara creeks received domestic and sewage wastes from Lyari and Malir rivers but away from the local inhabitants and was not directly exposed to the sea causes less utilization of mangroves trees. The number of trees was lesser than fringe type forests. In contrast Phitti creek possessed small number of trees/ha lesser than riverine forests possibly due to direct exposure of sea which eroded the mangrove sediments by strong wave. The area is mostly occupied by port operations and steel industries. The industrial pollution has now emerged as a problem that is primarily being directed towards immediate effect of the toxic substance, released by the industry. Human development around the forest, degrade the forest over time (Valiela *et al*., 2001). The Dubbo creek has maximum leaf area and basal area with low density below to riverine mangrove forest and the other semi-arid, sub humid and arid localities as reported by Pool *et al*., (1977) and Brown and Lugo, (1982). This suggests that the forest is composed of fewer but larger trees due to perennial fresh water supplies from the Indus delta and wave action along the Dubbo creeks results in fertile land.

Pneumatophores are the respiratory roots of mangroves and their density suggested the extent of pollution and anaerobic status of the sediments (Dick, 1986). This statement seems to be true in the present study as well. During study high density of pneumatophores was recorded from polluted sites compared to cleaned habitat. Khan, (1966) stated that the great variation in the density of pneumatophore was noticeably potentially owing to a distinct zonation in the monospecific stands of *A.marina.*

Size class distribution: It is shown that 92.85% of the total stands is covered with monospecific stands of *A.marina, 7.14%* with *R.mucronata* and only *3.57%* with *C. tagal*. Stand structure in mangrove forests is relatively simple due to frequent absence of understory species, which are usually found in other forest systems (Janzen, 1985). The overall structure of the forest at the coastal areas of Pakistan is substantial in some regards among the highest ever reported in the scientific literature. For simplicity of comparison only averages from the scientific literature are compared with the different mangrove forest in Pakistan. The dbh size class distribution in various mangrove locations showed a multimodal (reverse J-shaped, flat, bell shaped and uneven) structure. Size class structure of mangrove vegetation has not been frequently reported from disturbed or regenerating stands and never been studied on a wide scale.

Stands are composed of mosaics shape with mixed size classes in some stands while most of the individuals are found in small size classes with a gradual decrease of individuals in bigger size classes. This situation shows the better future of these forests. However, in mature forests the size class distribution is highly skewed. Some stands have similar number of *A.marina* trees/ha but showed different structure. Most of the individuals (67.85%) in small size classes (10 to 30 cm dbh) entailed a wave of recruitment in the stands, large number of *A.marina* juveniles/saplings indicating a balanced population structure. According to Manoj *et al.,* (2008) seedling and saplings are regarded as indicators of regeneration potential of species and the prevalence of good regeneration potential shows suitability of the species to the environment. It is stated that 3.87% of mangrove stands showed flat structure while 14.58% forest area is uneven in large size classes, an indictor of unbalanced population structure particularly when regeneration gaps occur. Therefore, it is recommended that the unbalanced population structure needs more attention in order to conserve and protect at seedling level**.**

During field sampling the evacuation of seedlings and trees was observed various times by erosion, strong waves actions, grazing, close canopy or logging practices (Fransworth and Ellison, 1996). Besides these factors the mortality of seedlings might be due to allelopathic effect of leaves and pneumatophores of *Avicennia marina* on its own germination and growth. It was observed that inside the forests there is high concentration of chemical discharge from the decomposing pneumatophores and leaves and low level of siltation compared to the edge where high rate of silt deposition was observed which might be reduces the rate of auto toxicity. No seedling survived in these gaps due to high allelopathic surface until long time despite the presence of light in these gaps. This may also be the one reason of natural gaps in mangrove forest (Nazim, 2011).

Dawson and Sneddon, (1969) stated that in unstable forests**,** dead trees of the various species do not get replaced by nearly equal number of younger trees but this is not in the case of Pakistan mangrove forests. *A.marina* is a fast growing and regenerating species which provides better chances of survival and could maintain the balance between death of old and birth of new trees but it requires a long time (Lacerda and Marins, 2002) and proper management**.** Thousands of seeds and seedlings produced every year while hundreds of trees and regenerating seedlings showed mortality by natural selection or anthropogenic activities (IUCN, 1994; IUCN, 1995 ; Vistro, 2000). Normal and balanced structure of forests show large number of small sized trees or seedlings in small size classes with a gradual decrease in large sized trees in larger classes (Ahmed, 1984 and Ogden *et al*, 1987). This situation does not exist in Pakistani mangrove forests; they are rapidly degrading day by day due to anthropogenic and other features. It is highly recommended that key priority should be given to manage and conserve unbalanced mangrove forests; therefore, seedling/ sapling should be properly introduced and monitored time to time.

References

Ahmed, M. (1984). Ecological and dendrochronological studies on *Agathis australis* Salisb, Kauri. Ph.D thesis. University of Auckland. New Zealand.

Ahmed, M. and Shaukat, S.S. (2012). A Text Book of Vegetation Ecology. Abrar Sons, New Urdu Bazar, Karachi.

Amjad, A., Shah. and Jusoff, K. (2007). Mangrove conservation through community participation in Pakistan: The case of Sonmiani bay. *International Journal of System Applications, Engineering and Development*. 5th WSEAS Int. Conf. on environment, ecosystems and development 14-16.

Arreola-Lizarraga, J.A., Flores-Verdugo, F.J. and Ortega-Rubio, A. (2004). Structure and litterfall of an arid mangrove stand on the Gulf of California, Mexico. *Aquatic Botany* 79: 137-143.

Azariah, J., Azariah, H.S., Gunasekaran and Selvam, V. (1992). Structure and species distribution in Coringa mangrove forest, Godavari Delta, Andhra Pradesh, India. *Hydrobiologia* 247: 11-16.

Brown, S and Lugo, A.E. (1982). A comparison of structural and functional characteristics of saltwater and freshwater forested wetlands: 109-130. In B. Gopal, R.E. Turner, R.G. Wetzel & D.E. Whigham (Eds.). *Wetlands ecology and management*. Proc. 1st Int. Wetlands Conf., New Delhi, India.

Cintron, G. and Schaeffer-Novelli, Y. (1984). Methods for studying mangrove structure.In: The Mangrove Ecosystem: Research Methods. Snedaker, S.C. and Snedaker, J.G. (Eds). UNESCO, Paris, France 91-113.

Curtis, J.T and McIntosh, R.P. (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology* 31: 434-455.

Dawson, J.W. and Sneddon, B.V. (1969). The New Zealand rainforest: A comparison with tropical rainforest. *Pacific Science* 23:131-147.

Dick, B. (1986). Oil and the black mangrove *Avicennia marina* in the Northern Red Sea. *Marine Pollution Bulletin* 17:500-503.

FAO. (1994). Mangrove Forest management Guidelines. Food and Agriculture Organization, Forestry Paper 117, Rome.

Farnsworth, E.J and Ellison, A.M. (1995). Scale dependent spatial and temporal - variability in biogeography of Mangrove-root epibiont Communities. *Ecological Monograph* 66: 45-66.

Holdridge, L.R., Greeke, W.C., Hatheway, W.H., Liang, T. and Tosi, J.A. (1971). Forest Environment in Tropical Life Zones. Pergamon Press, N.Y : 747.

Hutchings, P. and Saenger, P. (1987). Ecology of Mangroves. University of Queensland Press, Brisbane, Australia 388.

ISME. (l993). The World of Mangroves Part I. Japan 1-63

IUCN. (1995). *Rhizophora Plantations Korangi-Phitti Creek*. Karachi, Pakistan: IUCN. Khan, H.A., Bari, F., and Rafiq, M. (1997). *Forestry in NWFP*. Peshawar: Government of NWFP.

IUCN. (1994). Indus Delta Biosphere Reserve Workshop Report. Karachi, Pakistan :IUCN.

IUCN. (2005). Early observations of tsunami effects on mangroves and coastal forests. Gland: The World Conservation Union (IUCN). 4 p.

IUCN. (1983). Global Status of Mangrove Ecosystems. In Commission on Ecology Papers No. 3, eds. P. Saenger, E.J. Hegerl and J.D.S Davie. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland: 88.

Janzen, D.H. (1985). Mangroves: where's the understory. *Journal of Tropical Ecology* 1: 89-92

Kairo, J.G., Kivyatu B. and Koedam, N. (2002). Application of remote sensing and GIS in the management of mangrove forests within and adjacent to Kiunga Marine Protected Area, Lamu, Kenya. Environment, Development and Sustainability 4(2): 153-166.

Khan, S.A. (1966). Working plan of the coastal zone forestation division from 1963-64 to 1982-83, Karachi: 134. Pakistan Government press.

Lacerda, L.D. and Marins, R.M. (2002). River damaging and changes in mangrove distribution. ISME/GLOMIS. *Electronic Journal* 2: 1-4.

Manoj, D., Dobhal, A., Bhatt, S. and Kumar, M. (2008). Community structure and regeneration potential of natural forest site in Gangotri, India. *Journal of Basic and applied Sciences* 4(1): 49-52.

Mendoza, A.B. and Danilo, P.A. (2001). Mangrove structure on the eastern coast of Samar Island, Philippines. In: D.E stott. R.H. Mohtar and G.C. Stemhardt (eds): 423-425

Mueller-Dombois, D. and Ellenberg, H. (1974). Aims and Method of Vegetation Ecology. John Wiley and Sons, New York.

Nazim, K. (2011). Population Dynamics of mangrove forests from coastal areas of Sindh. Ph.D. thesis. Federal Urdu University of Arts, Science and Technology, Pakistan.

Odum,W.E and Heald, E.J. (1975). The detritus-based food web of an estuarine mangrove community. In Cronin, L. E. (ed.), Estuarine Research. Academic Press, New York: 265-286.

Ogden, J., Wardle, G. and Ahmed, M. (1987). Population dynamics of the emergent conifer *Agathis australis* in New Zealand. Seedling population size and gap phase regeneration. *New Zealand Journal of Botany* 25(2): 231-242.

Pool, D.J., Snedaker, S.C. and Lugo, A.E. (1977). Structure of mangrove forests in Florida, Puerto Rico, Mexico and Costa Rica. *Biotropica* 9: 195-212.

Rollet, B. (1981). Bibliography on mangrove research 1600-1975. UNESCO, U.K., 479

Tomlinson, P.B. (1986). The Botany of Mangroves. Cambridge University Press, Cambridge, United Kingdom.

Twilley, R.R. (1995). Properties of mangrove ecosystems and their relation to the energy signature of coastal environments. In: Hall, C. A. S. (ed.). Maximum power. pp. 43- 62. University of Colorado Press, Boulder, Colorado, USA.

Valiela, I., Bowen, J.L. and York, J.K. (2001). Mangrove forests: One of the worlds threatened major tropical environments. *BioScience* 51: 287-300.

Vistro, N. (2000). Mangrove forests-An Important Wood fuel Resource of the Coastal Belt. *Wood fuel Production and Marketing in Pakistan. Regional Wood Energy Development Programme in Asia.* National Workshop Faisalabad, Pakistan. pp: 103-106.