Demographic studies on the grey mangrove

(*Avicennia marina*) of the Arabian Gulf coast, Saudi Arabia

Awad F.Farah[1]and Abdulaziz M.AL-Bahrany[2]

Abstract:

Several excursions were carried out during 2000-2002 to study the occurrence and the distribution of the grey mangrove [*Avicennia marina* (Forssk.) Vierch.] along the western coast of the Arabian Gulf, Saudi Arabia. Based on their densities, the stands of the grey mangrove were classified visually into three groups, namely high density stands at Anak and AL-Zower areas; medium density stands at Anak, Sanabis and Juaymah areas; and low density stands at AL-Nasira, Ramis and Ras Tannurah areas.

Demographic studies of the grey mangrove were conducted at two selected sites, namely Sanabis (S1) supporting medium density stands and Anak (S2) supporting high density stands.

It has been shown that the average growth rates of the grey mangrove with respect to height of shrubs, canopy width and seedling height were lower in S1 than in S2.The studies showed that the rate of transfer from seedling stage to sapling stage was greater in S2 than in S1.Moreover, densities of saplings and shrubs, seedlings and pneumatophores in S2 exceeded those in S1.

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[1] Department of Botany, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan.

[2]Department of Horticulture, College of Agricultural and Food Sciences, King Faisal University, Al-Ahsa, Saudi Arabia.

The annual increase in shoot height and canopy width demonstrated that active growth of the plants occurred during summer rarher than in winter.

The results of this study indicate that the grey mangrove is in a state of active dynamic growth, which recommend its successful utilization for afforestation of the western coast of the Arabian Gulf in Saudi Arabia .

Key word: Afforestation, *Avicennia marina*, density, growth rate, pneumatophores, saplings and shrubs , seedlings.

Introduction

Mangrove forests comprise taxonomically diverse, salt tolerant trees and shrubs which thrive in inter-tidal zones of sheltered tropical shores and islands. Mangroves may be defined as tropical trees restricted to inter-tidal and adjacent communities (Tomlinson,1994). They have especially modified aerial salt filtering roots and salt excreting leaves; therefore, they are adapted to live in salt wetlands where other plant life cannot survive.

exclusive to the mangrove habitat, dominates approximately 75% of the world's coastline between latitudes 25°N and 25°S (Lugo and Snedekar, 1974).

Mangroves may extent to higher latitudes e.g. the mangroves in New Zealand extent as far as 37°S, and to about 31°N in Southern Japan (Tomlinson, 1994).

Although mangroves of the Arabian region were the first mangroves to be reported in the world literature by Nearchus and Theophrastus over 2000 years ago (Baker and Dicks, 1982), the number of mangroves and associated species in the Arabian countries is low compared to the Indian ocean mangles, (Price *et al*. , 1987). However, Sheppard *et al*. (1992) reported that the low species diversity in Arabia is attributed to the severe climatic and environmental conditions within the limited range of suitable habitats and niches.

Avicennia marina (Forssk) Vierch. Which belongs to the family Avicenniaceae (End.) Schnizl, is the main species among the mangroves that occur in the Arabian peninsula. However *Rhizophora mucronata* was reported to occur in the eastern coast of the Red Sea (Migahid, 1978) and Zifzaf Island (Mandura *et al*., 1987, 1988). *Rhizopra stylosa* in Hoodida, North of Yemen (Kogo,1986), and *Burguiera gymnorrhiza* in the isolated islands offshore from Hoodida (Zahran, 1974). In the Hanak offshore islands, the presence of *Avicennia marina* extends northwards along the eastern coast of the Red Sea and the Gulf of Agaba facing Al-Wagh (Lat, 26°N), where it forms a dense vegetation; the same vegetation was observed along the western shoreline of the Red Sea (Kassas and Zahran, 1967; Zahran, 1983). The distribution of mangroves extends southwards along the eastern coast of the Red Sea till Jizan where it forms a dense vegetation reaching the height of 5.0 m (Zahran, 1983). Along the western coast of the Arabian Gulf, *A. marnia* occurs in the most southern part in Qatif area (Lat. 26°30'N), where it forms an extensive stand in Tarout Bay and Ad-dafi Bay including Gumrah Island (KFUPM, 1994).

Socioeconomic wise, mangroves have many uses. However in Saudi Arabia, they are used for camels grazing, firewood, and creation of favourable conditions for fish and prawn reproduction. Likewise, in Tanzania and East Africa, the main use of mangrove is for extaction of wood for charcoal production, firewood, in addition to the creation of sauitable environment for macrobenthic fauna (Vannini *et al.,* 2000). In Malaysia, mangroves are important nursery grounds for commercially important fish and prawn species (Khoon *et al*. , 2005), while in Venezuela, mangrove woodlands can offer exceptional opportunities for resting, feeding, sheltering and nursing to faunal elements (McGinleuy, 2007).

In Saudi Arabia, as in other parts of the world, over exploitation and destruction of mangroves threaten the sustainability of mangal ecosystems. Moreover, the mangrove ecosystem in the western coast of the Arabian Gulf was subjected to stresses and is nowadays threatened by the rapid human development activities, namely land reclamation, dumping of solid wastes, oil spills, in addition to the traditional stresses e.g. grazing by animals and cutting (KFUPM,1994). It is generally accepted that mangrove forests have their important ecological roles with respect to coastal stabilization and their protection against winds and storms, and provision of forest resources, production of nutrients for water fauna of economical importance like fishes and prawns. Thus, proper utilization and management of mangroves are needed for their conservation. Because mangroves provide many ecosystem services, their loss in many countries and regions results in fisheries decline, degradation of clean water supplies, salinization of coastal soils, erosion and land subsidence, as well as release of carbon dioxide into the atmosphere (Barbier *et al*.,2005).

In mangrove ecosystems, demographic studies are essential tools to gather information about the population of mangroves, and to study the population dynamics.

As far as demographic studies of mangroves concerned, the present study may be the first report in Saudi Arabia.

The present study was undertaken to investigate the occurrence and the distribution, and to study the demography of the grey mangrove along the western coast of the Arabian Gulf in Saudi Arabia.

Materials and Methods

Occurrence and Distribution

The fieldwork was carried out between March, 2000 and April, 2002. The study involved surveying the grey mangrove along the western coastline of the Arabian Gulf in Qatif area (Lat. 26°30'N), Saudi Arabia. During this period several excursions were carried out to a number of sites (Anak, Al-Zowr, Sanabis, AL-Nasira, Juaymah, Ramis , Ras Tannurah) (Figure 1). Photographs were taken by a kanon F-50 Camera; and visual ratings were used to classify the grey mangrove stands along the western coastline of the Arabian.

Demographic Studies on Grey Mangrove Populations

Two sites namely Sanabis (S1) and Anak (S2) were chosen for field studies:

1.at each site, a permanent sample plot (PSP) of a fixed area (50m x 100 m) was marked to cover the populations of the grey mangrove extending from landwards to seawards.

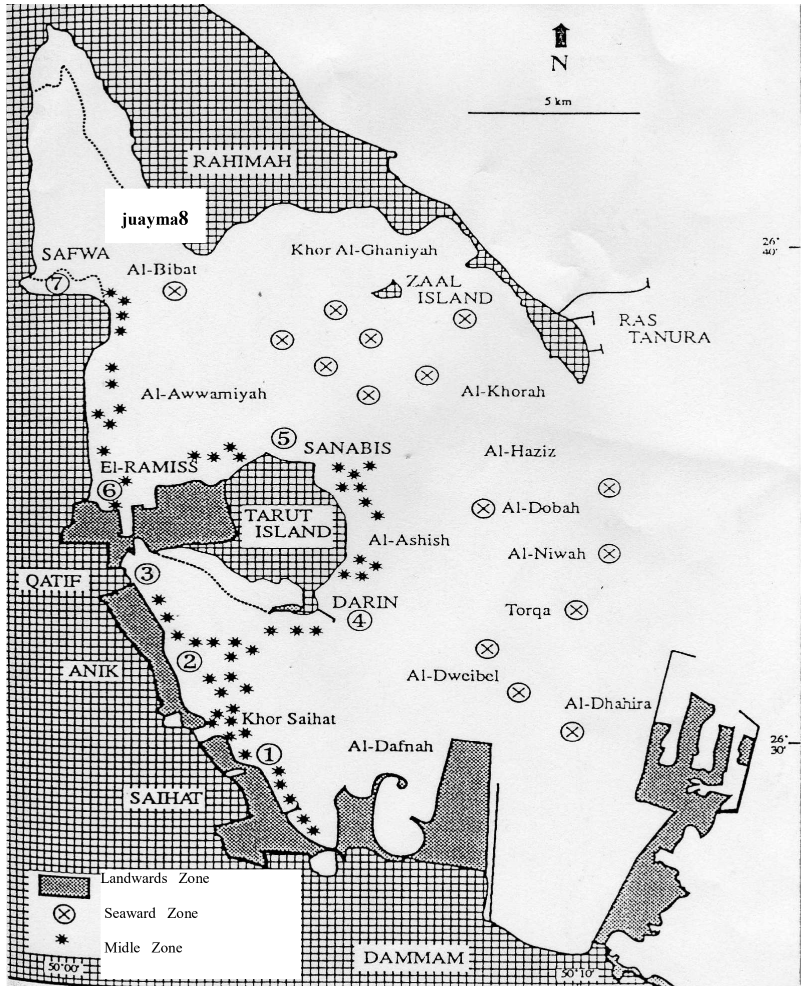

Fig.1. Sites of the grey mangrove stands at the Arabian Gulf coast, Saudi Arabia.

Within each PSP, along a 100-m transect, three quadrats of 5 m x 5m, made of coloured plastic rope, were laid down at random, one at landwards, the second one in the middle and the third one at seawards. In each quadrat, all the plants (adult shrubs, saplings and seedlings) and pneumatophores were counted and their numbers recorded.

2.Within each PSP, twenty plants (saplings and young shrubs), selected randomly within the three quadrats, were tagged, using red-coloured rectangular pieces of copper. Their heights and canopy widths were measured in cm. with a measuring tape, at 6- month intervals (viz 5 periods) during the course of this study.

3.Within each PSP twenty 1.5m x 1.5m sample quadrats (made of hard plastic) were fixed at randomly selected places. Within those quadrats, all seedlings and pneumatophores, were counted annually, for three seasons, during the present course of the study. Also, pneumatophores under old shrubs of the dense stand (closed canopy) at Anak were counted. Heights and diameters of both young and old pneumotophores were measured. In addition, twenty seedlings ,chosen at random, were tagged, using labeled coloured pieces of stiff paper, and their heights measured with a measuring tape at six month intervals (viz 5 periods).The following measurements were obtained from the gathered field data of saplings and shrubs, seedlings and pneumatophores: height (H) (cm), canopy width (W) (cm), density (D), abundance (A), frequency (F), A/F ratio, growth rate, transfer between classes, transition probability, survivorship and mortality rate.

The analysis of the measurements were performed according to Curtis (1959) and Clarke (1995).

Results and Discussion

It was found that the populations of the mangrove along the western coast of the Arabian Gulf in Saudi Arabia consists of the grey mangrove (*Avicennia marina*) growing in pure mono-specific stands of varying densities, high density, medium density, and stands of low density. The high density stands represented the vegetation in Anak (Fig.2) and AL-Zowr areas. The medium density stands were observed at Sanabis, Al-Nasira, Juayamh (Fig.3), and Anak. The low density stands were observed at certain locations in Ramis and at a number of isolated places near Ras Tannurah (Fig.4), where they formed scattered patches of bushes. However, the unprotected areas of the shoreline North of Qatif and South of Dammam did not support mangrove plants.

Depending on the data obtained, concerning the field distribution of the mangroves, two sites, namely Sanabis (S1) and Anak (S2), were selected for demographic studies.

Comparing the two selected sites, (S1) (the total area ca.11 ha) and (S2) (the total area ca. 42 ha), the latter was found to exceed the former in density of shrubs and saplings, seedlings and pneumatophores (Table 1). This may be attributed to the fact that, S2 was subjected to the positive favourable effect of treated discharges dumped from the nearby sewerage station which enriched the mangrove swamps with mineral nutrients and hence salinity mitigation, which in turn lead to enhance the growth of the grey mangrove. Similar observations were reported by Clough *et al*. (1993) and Cooke *et al*. (1990). However, at both sites zone 1 (the landwards zone) was found to accommodate more shrubs and saplings than both zone 2 (the middle zone) and zone 3 (seawards zone) (Table 1). In fact at both sites the original landwards zone was lost as a result of land reclamation. So the part considered as zone 1 (the landwards zone) in the present study is actually a part of the original landwards zone and a part of the middle zone. At both sites, the populations of mangrove were found to expand landwards and seawards.

Shoot height and canopy width of the shrubs and saplings at S1 and S2 are presented in Fig.5 and Fig.6. Significant differences ($P<0.05$) were obtained between the means of shoot height in all periods of study, at the two sites of study, with the exception of period three. Likewise, significant differences ($P<0.05$) in canopy width were manifested between the plants at the two sites in all periods of study. Both the shoot height and the canopy width increased with time as growth progressed during the five periods of study. These results are in agreement with those of Clarke (1995) who reported that mangroves are in a state of dynamic growth.

Table 2 shows the transfer of individuals between height classes. The rate of transfer of individuals could be assessed by measuring growth rates of individuals in different height classes. The average growth rate of shoot height (shoot height extension) was estimated as 32.3 ± 11.0 cm y^{-1} and 34.6 ± 8.3 cm y^{-1} at S1 and S2 , respectively. With this growth rate, at a period of two years, 4 of the 5 individuals, and the five individuals of the height class <100 cm moved out (shifted) to the second height class (100 – 200 cm) at S1 and S2, respectively. The transition probability is thus 4/5 = 0.8 at S1 and 5/5 = 1.0 at S2 . With the same growth rates and at a period of 2 years ; 9/13 and 8/10 individuals of the height class 100-200 cm shifted to the height class > 200 cm, with a transition probability of 0.70 and 0.80 at site 1 and site2, respectively. Likewise, the growth rates of canopy width were found to be 55.3 $\pm$ 44.0 cm y^{-1} and 57.4 $\pm$ 7.30 cm y^{-1} at S1 and S2, respectively. The growth of the canopy width was greater than that of the shoot height, hence, the Shrubby shape of the grey mangrove. However, the shruppy shape of the grey mangrove in the Gulf coast of Saudi Arabia may be attributed to the fact that those plants were not subjected to heavy grazing or cuttings, hence they obtained their natural shape.

The annual increase in shoot height demonstrated that active shoot growth occurred during the summer months (May – September) with growth rates of 17.5cm and 20.0cm compared to the growth rates (15.0cm and 14.5cm) of winter months (November – March) at S1 and S2, respectively. Likewise, the annual increase of shoot canopy width with growth rates of 38.0 cm and 35.5 cm during summer months, compared to 17.0 cm and 21.8 cm during winter months at S1 and S2, respectively, corroborates that finding. Similar results were reported by Chen *et al*. (1995) who stated that" the ambient temperature is one of the most important factors affecting the growth of mangrove plants". Moreover, the distribution of mangles is closely related to high temperatures as they can only be found in tropical and subtropical regions, at altitudes between 25° N and 25° S (Lugo and Snedeker, 1974).

Table 3 shows inconsistent results of density (D), abundance (A), frequency (F) and A/F ratio of the seedlings at both sites of the study in season 1 and season 2. However, in season 3 , both sites of the study scored the maximum value of frequency (i.e. 100%) and 0.065 and 0.070 average A/F ratio for S1 and S2, respectively.

The average growth rates of the seedling□s height were found to be 13.8 cm y^{-1} and 29.7 cm y^{-1} at S1 and S2, respectively (Fig.7). With these growth rates, 19 out of the 20 seedlings at S1 and 18 out of the 20 seedlings at S2 were shifted from new seedling class to old seedling class in the third season. The transition probability is thus 19/20 = 0.95 and 18/20 = 0.90 at S1 and S2, respectively. So, the probability of remaining as new seedlings after 3 years is thus 1-0.95 = 0.05 and 1-0.9 = 0.10 at S1 and S2, respectively. Moreover, in season 3, two seedlings (height ≥ 80 cm, with branches) and 16 seedlings (height ranged between 103-152 cm) shifted out of old seedling class to sapling class at S1 and S2, respectively. Their transition probability is thus 0.10 and 0.80 at S1 and S2, respectively. In general, S1 was characterized by having more young seedlings (height < 30 cm) and less old seedlings (height ≥ 30 cm) than S2, throughout the three seasons of the study. This may be attributed to the fact that seedlings of S1 were growing under the medium density stands of the grey mangrove, thus they were subjected to more light intensity compared to S2, where seedlings were growing under high density stands of the gey mangrove, (the closed canopy), hence receiving less light intensity. Conversely, S2 exceeded S1 in total number of individuals of old seedlings **($\geq$ 30),** this may be accredited to the fact that, S2 seedlings were subjected to relatively less competition, thus they manifested comparatively less dead seedlings while, S1 seedlings were subjected to both ineraspecific competition, and inerspecific competition with adjacent flora like *Salsola* , *Salicornia* and *Sueada,* a situation which resulted in more dead seedlings.

Table 4a shows density (D), abundance (A), frequency (F) and A/F ratio of the grey mangrove pneumatophores at the two sites of study. At both sites, the number of pneumatophores increased with time as growth of plants progressed. Thus, at season 3 both sites (S1 and S2) scored the maximum frequency, i.e. 1.0 (100%), and 0.41 and 0.47 A/F ratio, respectively. However, the A/F ratio of the old pneumatophores under the high density stand of Anak was found to be 6.34. A/F ratio is known as Whiteford □s index and its values higher than 0.05 indicate aggregation. The old pneumatophores of Anak were projecting from old trees and shrubs which were furnished with more cable roots than the young trees and saplings, thus they were highly crowded and taller than the young pneumatophores.

Table 4b shows the parameters taken in season 3, including density, height and diameter of young pneumatophores at S1 and S2, and old pneumatophores of the dense stand of S2 (Anak). No remarkable differences were realized between young pneumatopores at S1 and S2 with respect to density and diameter. However, a remarkable difference was realized in height between the two sites, where at S2 pneumatophores with an average height of 21.7 cm showed 88.8% increase over those of S1 (average height = 11.5 cm). The difference between old pneumatophores at site 2, and young pneumatophores at S1 and S2 was highly remarkable with respect to all characteristics, particularly density and height .

Pneumatophores, being a special type of roots, are characterized by being negatively geotropic and are furnished with abundant lenticels. The lenticels communicate via arenchymatous tissue with the underground roots thus providing a system of gaseous exchange (Chapman, 1976).

The presence of mangrove plants and the existence of their mass of pneumatophores hasten silt deposition, causing rapid land elevation. Once established with seed parents, slow seawards migration of the mangroves takes place and so it can be said that mangroves do produce new land (Chapaman, 1976).

Conclusion

It could be concluded that ,the grey mangrove (*Avicennia marina*) along the western coast of the Arabian Gulf, Saudi Arabia is in a state of dynamic growth, thus mangrove afforestation could be successfully practiced to conserve the coastal ecosystem, protect the fragile coastlines, enhance biodiversity and fisheries productivity, and to provide employment to local population.

The mangrove ecosystem was found to be constantly under - going changes due to its dynamic nature. Thus, an accurate and up to date information base on the status of mangrove vegetation, continually overtime , is a prerequisite for the sustainable management of mangrove forests (Kannan,2005) . The required information cannot be obtained with traditional field surveys to be made inside the mangrove swamps as they are extremely difficult. Therefore, remote sensing and geographic information system serve as valuable aids in providing fast, efficient and accurate information to detect the changes. Thus, the information gained can be utilized for the effective planning and management of mangrove forests , besides it could be implemented in afforestation of the grey mangrove in the Arabian Gulf to compensate for the lack of forests in Eastern Saudi Arabia.

Fig.2. A Stand of a high population density of the grey mangrove growing at Anak.

Fig.3. A Stand of a medium population density of the grey mangrove growing at Juaymah.

Fig.4. A Stand of a low population density of the grey mangrove growing at Ras Tannurah.

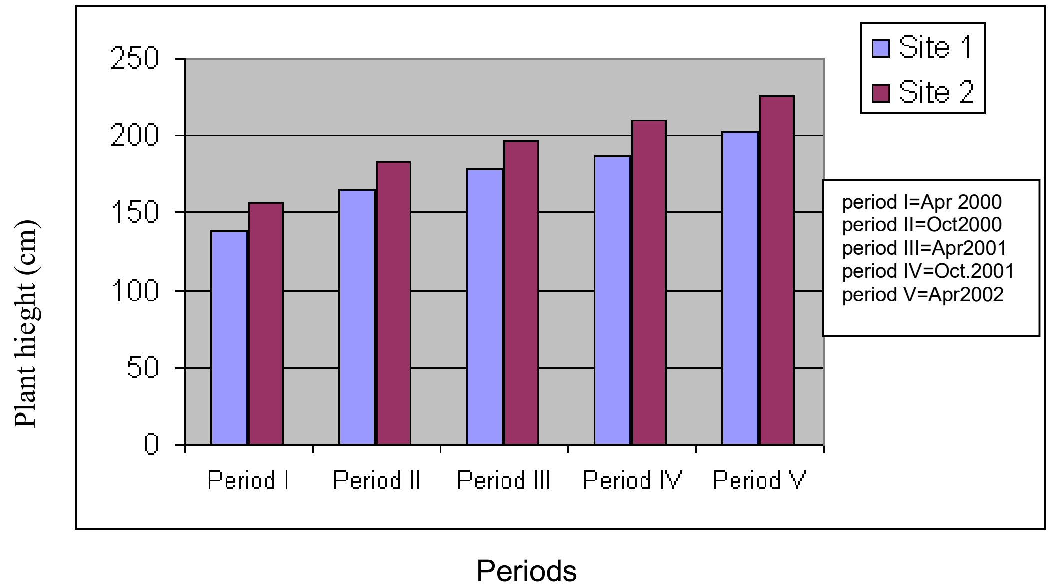

Fig. 5. Plant hieght (cm) of the grey mangrove of five periods at site 1(Snabis) and site 2 (Anak).

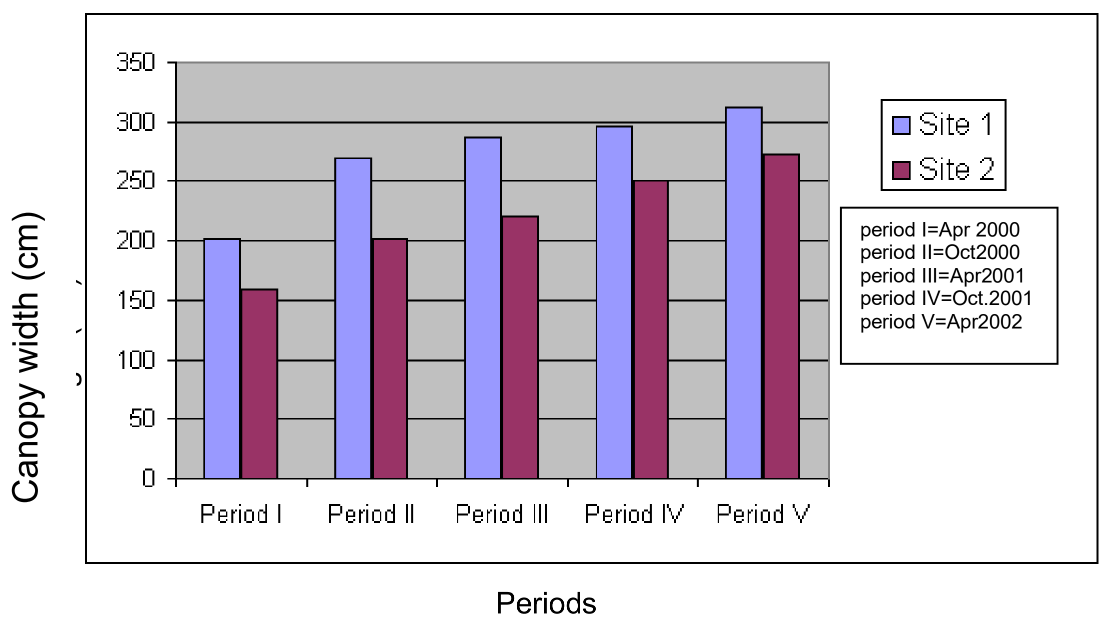

Fig. 6. Canopy width (cm) of the grey mangrove of five periods at site 1(Snabis) and site 2 (Anak).

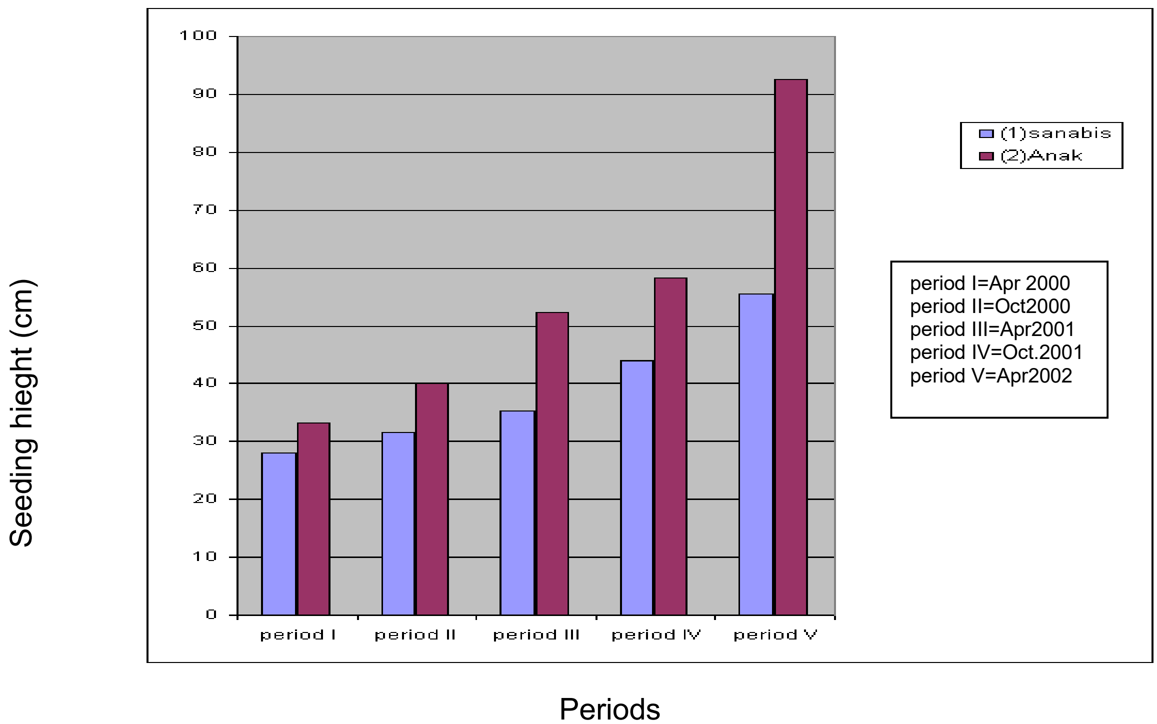

Fig .7. Seedling hieght (cm) of the grey mangrove stands at Sanabis and Anak. sites

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دراسات ديموقرافية عن نبات المانقروف (الشورة) (أفيسينيا مارينا) النامي على شاطئ الخليج العربي بالمملكة العربية السعودية

عوض فقير فرح [1] وعبد العزيز م. البحراني [2]

تمت رحلات علمية متعددة خلال الفترة 2000م - 2002م , لإجراء مسح عام لدراسة وجود وتوزيع مجموعات نباتات المانقروف (الشورة) النامية على طول الشاطئ الغربي للخليج العربي , بالمملكة العربية السعودية . وتم تقسيم المجموعات النباتية لنباتات الشورة وفقاً لكثافتها إلى ثلاث مجموعات هي : المجموعة ذات الكثافة العالية في منطقتي عنك والزور , والمجموعة ذات الكثافة المتوسطة في مناطق عنك وسنابس وجعيمة , والمجموعة ذات الكثافة المنخفضة في مناطق الناصرة ورامس ورأس تنورة.

ومن ثم تم إختيار منطقتين من تلك المناطق لإجراء دراسات ديموقرافية عن نباتات الشورة هما منطقة سنابس (S1) ذات الكثافة المتوسطة، ومنطقة عنك (S2) ذات الكثافة العالية لنباتات الشورة .

وجد أن المعدل السنوي: للنمو الطولي لكل من النمو الطولي للجنبات (الصغيرة والكبيرة), والنمو في قطر الظلة التاجية, والنمو في طول البادرات أقل في منطقة S1 مقارنة بمنطقة S2. كما أوضحت الدراسة أن معدل الإنتقال من مرحلة البادرة إلى مرحلة الجنبة الصغيرة كان أعلى في S2 مقارنة بـ S1. كما أن S2 تفوقت على S1 في كثافة كل من الجنبات والبادرات والجذور التنفسية . كما وجد أن النمو الطولي والعرضي لنباتات الشورة يكون بمعدل أعلى في الشهور الصيفية مقارنة بالشهور الشتوية.

أشارت الدراسة أن نباتات الشورة في حالة نمو ديناميكي , وبالتالي يمكن إستخدامها بنجاح في التشجير الغابي (أي تكوين غابة) للشاطئ الغربي للخليج العربي, بالمملكة العربية السعودية.

[1] قسم النبات – كلية العلوم والتقانة – جامعة أم درمان الإسلامية – أم درمان – السودان .

[2] قسم البساتين – كلية العلوم الزراعية والأغذية – جامعة الملك فيصل – الأحساء – المملكة العربية السعودية.