Seed Bank Strategies of Coastal Populations at the Arabian Sea Coast

M. Ajmal Khan
Bilquees Gul

Abstract—Pure populations of halophytic shrubs (*Suaeda fruticosa, Cressa cretica, Arthrocnemum macrostachyum, Atriplex griffithii,* etc.) and perennial grasses (*Halopyrum mucronatum, Aeluropus lagopoides,* etc.) dominate the vegetation of the Arabian Sea coast at Karachi, Pakistan. The coastal populations maintained a persistent seed bank. There is a close relationship between seed bank flora and existing vegetation. The size of the seed bank varies with the species dominating the population. *Arthrocnemum macrostachyum,* which dominated the coastal swamps, had the highest seed density, 940,000 seed m^{-2}, followed by *Halopyrum mucronatum*, which showed 75,000 seed m^{-2}. For all other species (*Suaeda fruticosa*, *Cressa cretica*, *Atriplex griffithii,* and *Aeluropus lagopoides*), seed bank varies from 20,000 to 35,000 seed m^{-2}. Seed bank of all species substantially reduced a few months after dispersal.

The desert littoral salt marshes near Karachi, Pakistan, are characterized by a simplicity of structure and composition (Chaudhri 1961). Monospecific patches of vegetation are common with occasional stands dominated by a single species with or without minor associates (Khan, unpublished data). The vegetation from seaward to landward is mangrove (*Avicennia marina*) followed by muddy coastal swamp with *A. macrostachyum* (Karim and Qadir 1979) and then other communities like *Atriplex griffithii* Moq. var. *stocksii* Boiss. (Chenopodiaceae), *Suaeda fruticosa* (L.) Forssk. (Chenopodiaceae), *Halopyrum mucronatum* (L.) Stapf. (Poaceae), *Aeluropus lagopoides* (L.) Trine. Ex Thwarts (Poaceae) *and Cressa cretica L.* (Convolvulaceae) were present on adjacent low dunes.

There are few studies on the seed bank of coastal communities and little information is available on the seed bank of subtropical shrub-dominated coastal communities. The coastal shrubs and grasses produce a large number of seeds and most of them disappear a few months after dispersal. Such marshes maintain a persistent seed bank despite a significant loss of seed. The size of coastal salt marsh seed banks varies from a 0 to 140,000 seed m^{-2} (Jefferies and others 1981; Jerling 1984; Hartman 1988; Ungar and Woodell 1993, 1996), but are usually small. Similar low densities have been encountered in several Arabian Sea coastal communities near Karachi. Seed bank studies from Karachi, Pakistan, have demonstrated that dominant perennial halophytic shrubs and grasses maintain a persistent seed bank (Gulzar and Khan 1994; Aziz and Khan 1996). Six different coastal dune communities showed a very small seed bank (30-260 seed m^{-2}, Gulzar and Khan 1994), while coastal swamp communities had a larger seed bank (11,000 seed m^{-2}). The *Cressa cretica* seed bank at Karachi showed a persistent seed bank (Aziz and Khan 1996), with the number of seeds reaching its maximum (2,500 seed m^{-2}) after dispersal and dropping down to 500 seed m^{-2} a few months later. Gul and Khan (1998) reported that coastal swamps dominated by *Arthrocnemum macrostachyum* showed a great deal of variation from upper to lower marsh. Upper marsh had the highest number of seeds with higher species diversity. A number of hypotheses have been suggested to explain this relatively small number of seeds. These include: loss of seeds because of coastal abrasion (Hutching and Russell 1989), environmental extremes beyond the range of tolerance (Ungar 1995a,b), and composition of aboveground vegetation and its seed production (Milton 1939; Hutchings and Russell 1989). Factors that contribute to the distribution and maintenance of seeds in wetland soils include burial, inundation pattern (depth, duration, and timing of water fluctuation), physical and chemical characteristics of the substrate, and disturbance (Leck 1989).

The role of the seed banks in coastal salt marsh communities of arid subtropical regions dominated by perennial halophytic shrubs is poorly understood. Although a large number of seeds is produced (Gul 1993; Khan and Ungar 1996; Noor and Khan 1994; Aziz and Khan 1996) recruitment from seeds is rare (Gul 1993). The size of the seed bank varies widely, temporally, and spatially. The role of population characteristics in maintaining this distribution is largely ignored. We are reporting here the temporal dynamics of seed bank of Arabian Sea coast communities, and their size and its relationship with vegetation.

Materials and Methods

Study Site

The study site is located in Manora creek, near Sands pit at the Karachi coast (24° 48' N, 65° 55' E), Pakistan. Mean ambient summer temperature is 36 °C and mean winter temperature is 25 °C. Rains are received during monsoon season extending from June to September. *Avicennia marina* dominated the area submersed with seawater, and from the *Avicennia marina* edge to mean high tide line, the area (110 meters) is dominated by *Arthrocnemum macrostachyum*. Toward the landward side there are various

In: McArthur, E. Durant; Ostler, W. Kent; Wambolt, Carl L., comps. 1999. Proceedings: shrubland ecotones; 1998 August 12–14; Ephraim, UT. Proc. RMRS-P-11. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

M. Ajmal Khan is a Professor of Plant Ecology at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. Bilquees Gul is a Plant Ecologist at the Department of Botany, University of Karachi, Pakistan. Corresponding author and address: P.O. Box 8452, University of Karachi, Karachi-75270, Pakistan, e-mail: ajmal@www.fascom.com

communities dominated by *Atriplex griffithii, Suaeda fruticosa, Aeluropus lagopoides, Halopyrum mucronatum, Urochondra setulosa,* and *Cressa cretica*.

The vegetation in each community was sampled 20 times using the point-centered quarter method (Cottam and Curtis 1956), which places grids randomly. Density, frequency, and cover were measured and importance value index was calculated. To assess the seed bank, 20 random soil cores were collected using a 1.5-cm diameter corer to a depth of 15 cm and placed into plastic bags. Samples were collected at regular monthly intervals over a period of 12 months from June 1994 to May 1995. Seeds were manually sorted after collection with the help of a binocular microscope, identified from using a reference collection, and counted. Germination of seed method does not work with perennial sub-tropical halophytic shrub seed banks (Khan 1991).

Results

Vegetation analysis showed that there were pure stands of *Arthrocnemum macrostachyum, Aeluropus lagopoides, Atriplex griffithii, Cressa cretica, Halopyrum mucronatum,* and *Suaeda fruticosa.* The size of *Arthrocnemum macrostachyum* seed bank was large. The maximum density of 917,135 seed m^{-2} of *A. macrostachyum* seeds occurred after dispersal (fig. 1). The number declined to 61,136 seed m^{-2} after 2-3 months.

The seed bank of *Suaeda fruticosa* reached to about 28,000 seed m^{-2} after the dispersal (fig. 2) and after 4 months of dispersal the size of the seed bank was reduced to about 5,000 seed m^{-2}. The seed of *Cressa cretica* also increased substantially after dispersal reaching 35,000 seed m^{-2} (fig. 3) and their number decrease substantially only after 1 month of dispersal to about 4,000 seed m^{-2}.

Seeds of *Atriplex griffithii* also increased substantially after the dispersal reaching a size of 20,000 seed m^{-2} (fig. 4) and then declined abruptly after a month of dispersal to only 5,000 seed m^{-2}. Seeds of *Halopyrum mucronatum* gradually decreased and went down to 10,000 seed m^{-2} from 70,000 seed m^{-2} after the dispersal (fig. 5). Seeds of *Aeluropus lagopoides* increased substantially after dispersal and decreased immediately to less than 5,000 seed m^{-2} (fig. 6).

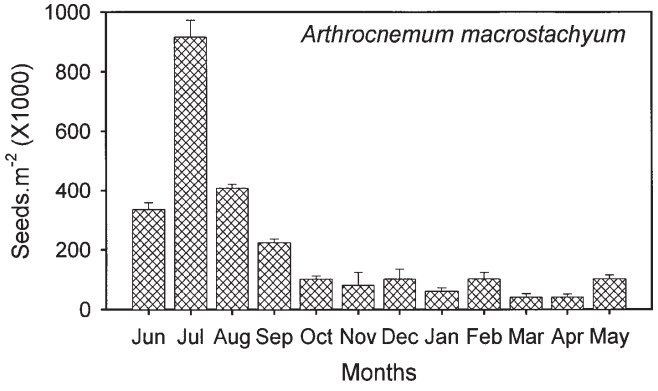

Figure 1—Seasonal distribution of *Arthrocnemum macrostachyum* seeds in an Arabian seashore .

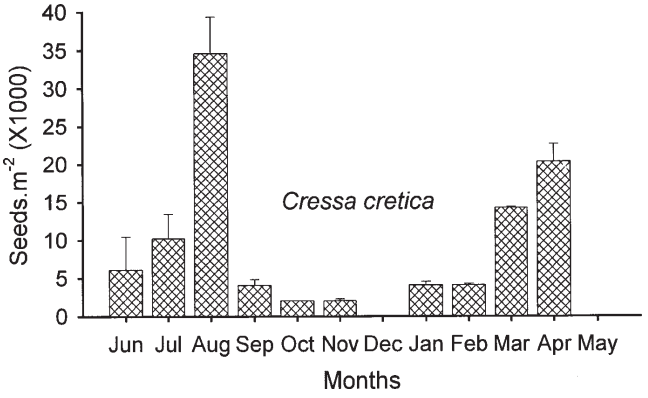

Figure 3—Seasonal distribution of *Cressa cretica* seeds in an Arabian seashore.

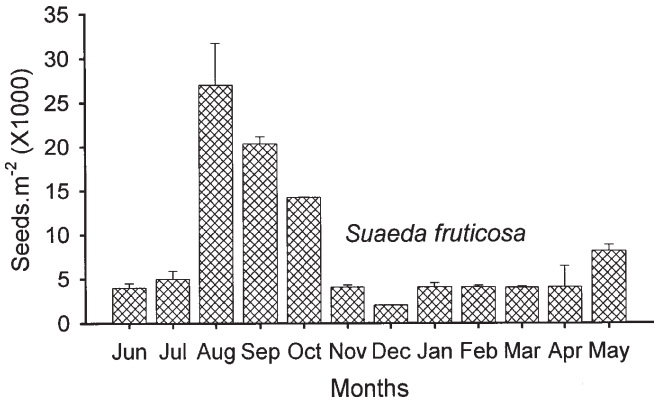

Figure 2—Seasonal distribution of *Suaeda fruticosa* seeds in an Arabian seashore.

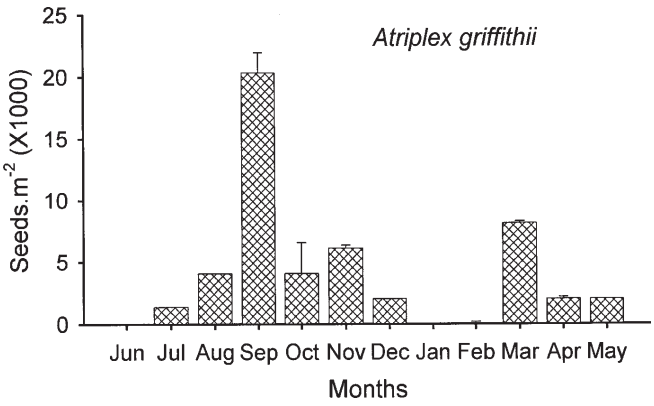

Figure 4—Seasonal distribution of *Atriplex griffithii* seeds in an Arabian seashore.

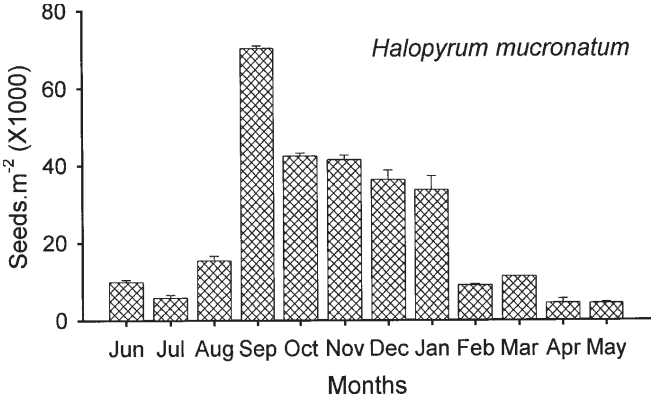

Figure 5—Seasonal distribution of *Halopyrum mucronatum* seeds in an Arabian seashore.

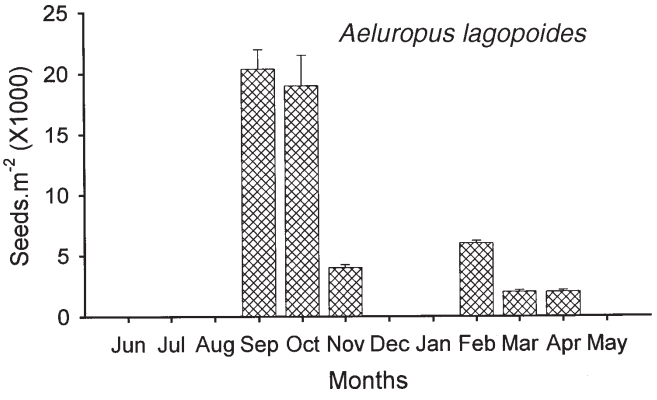

Figure 6—Seasonal distribution of *Aeluropus lagopoides* seeds in an Arabian seashore.

Discussion

The vegetation of the Arabian Sea coast is characterized by low diversity and usually found in the form of pure communities. Seed bank is also characterized by low diversity. The densities of seeds in the seed bank vary from 20,000 seed m^{-2} to 940,000 seed m^{-2}.

Six different communities from sand dunes to coastal swamps were studied. Size of the seed bank showed a great deal of variation ranging from 10,000 seed m^{-2} to 900,000 seed m^{-2}. Gul and Khan (1998) studied the five zones of coastal swamps at an Arabian Sea coast marsh and reported a substantial decrease in seed bank size with a corresponding increase in inundation frequency. Low species diversity could be attributed to high soil salinity (Aziz and Khan 1996) and increased degree of inundation (Zahran 1973; Leck 1989), coastal abaration (Hutchings and Russell 1972), environment beyond the range of salt tolerance (Ungar 1995), or composition of vegetation and seed production (Hutchings and Russell 1989). Coastal communities differ widely in seed bank size (Gulzar and Khan 1994; Ungar 1995a; Aziz and Khan 1996). Aziz and Khan (1996) studied the seed bank of a community dominated by *Cressa cretica,* which occupied dry elevated sandy areas at the Karachi coast and is seasonally inundated with seawater. The size of the seed bank reached its maximum (2,500 seed m^{-2}) after dispersal. Gulzar and Khan (1994) surveyed various communities at the Karachi coast and reported sizes from 50 to 11,000 seed m^{-2}. In addition, size of the seed bank (in coastal communities) varied significantly from the time of dispersal to a few months after dispersal (Aziz and Khan 1996). As noted by Harper (1977) seed bank composition varied, one species often making up an overwhelming proportion of the seed bank. The size of the seed bank in coastal salt marshes elsewhere varied from 47 seeds m^{-2} to 130,000 seeds m^{-2} (Jerling 1984; Hartmann 1988; Ungar and Woodell 1993, 1996). British coastal marshes have no seed bank or only a small seed bank in the zonal communities (Milton 1939; Jefferies and others 1991; Hutching and Russell 1989). Investigations of Pacific coastal marshes indicate that some communities may have large seed banks, with either temporary or persistent seed banks (Josselyn and Perez 1981; Hopkins and Parker 1984). In a Pacific zonal community dominated by *Salicornia virginica* the seed bank in October contained 700 to 3,174 seed m^{-2} (Hopkins and Parker 1984). The dominants made up 96.7% of the seed bank and there was a high correlation between the seed bank and the species within the plant community. Other Arabian Sea coast communities also showed a close relationship between vegetation and seed bank flora (Gulzar and Khan 1994; Aziz and Khan 1996). The number of seeds in various *A. machrostachyum* zones declined substantially 2 months after the dispersal but they maintained a sizeable seed bank (≥61,113 seed m^{-2}). Similar results were reported on *H. mucronatum, A. lagopoides, A. griffithii, S. fruticosa,* and *C. cretica* by (Gulzar and Khan 1994; Aziz and Khan 1996). Our data showed a great deal of spatial and temporal variation in the size of the seed bank. The number of seed banks could substantially change with the change in time or place of the sample taken. A large variation that was reported in the size of the coastal seed banks may not be a real representation of actual dynamics of the seed banks unless they are studied for extended periods and include all the coastal zones.

References

Aziz, S.; Khan, M.A. 1996. Seed bank dynamics of a semi-arid coastal shrub community in Pakistan. J. Arid Environ. 34: 81-87.

Chaudhri, I.I. 1961. The vegetation of Karachi. Vegetatio. 10: 229-246.

Chaudhri, I.I.; Qadir, S. A. 1958. Sand dune vegetation of coastal regions of Karachi. Pak. J. For. 8: 337-341.

Cottam, G.; Curtis, J.T. 1956. The use of distance measurements in phytosociology sampling. Ecology. 37: 451-460.

Gul, B. 1993. Demography, ecophysiology and seed bank dynamics of *Arthrocnemum indicum*. M.Sc. Thesis, University of Karachi, Karachi. 143 p.

Gul, B.; Khan, M.A. 1994. Growth, osmoregulation, and ion accumulation in the coastal halophyte *Arthrocnemum indicum* under saline conditions. Pak. J. Mar. Sci. 3: 115-123.

Gulzar, S.; Khan, M.A. 1994. Seed banks of coastal shrub communities. Ecoprint. 1: 1-6.

Harper, J.L. 1977. Population biology of plants. Academic Press, New York.

Hartman, J.M. 1988. Recolonization of small disturbance patches in a New England salt marsh. Am. J. Bot. 75: 1625-1631.

Hopkins, D.R.; Parker, V.T. 1984. A study of the seed bank of a salt marsh in northern San Francisco Bay. Am. J. Bot. 71: 348-355.

Hutchings, M.J.; Russell, P. J. 1989. The seed regeneration dynamics of an emergent salt marsh. J. Ecol. 77: 615-637.
Jefferies, R.L.; Davy, A. J.; Rudmick, J. 1981. Population biology of the salt-marsh annual *Salicornia europaea* agg. J. Ecol. 69: 17-31.
Jerling, L. 1984. Composition and viability of the seed bank along a successional gradient on a Baltic Sea shore meadow. Holarctic Ecol. 6: 150-156.
Josselyn, M.N.; Perez, R.J. 1981. Sediment characteristics and vegetation colonization. In: Niessen. T.; Perez, R.J., eds. The Hayward regional shoreline marsh restoration: biological succession during the first year of dike removal. Technical report 1. Tiburon Center for Environmental Studies, Tiburon: 7-34.
Karim, A.; Qadir, S.A. 1979. Phytosociological studies of the coastal swamps of Karachi. Bangladesh. J. Bot. 4: 89-98.
Khan, M.A.; Gul, B. 1998. High salinity tolerance of germinating dimorphic seeds of *Arthrocnemum indicum.* Int. J. Pl. Sci. 159: 826-832.
Khan, M.A.; Ungar, I.A.; Gul, B. 1998. Action of compatible osmotica and growth regulators in alleviating the effect of salinity on the germination of dimorphic seeds of *Arthrocnemum indicum* L. Int. J. Pl. Sci. 159: 313-317.
Leck, M.A. 1989. Wetland seed banks. In: Leck, M.A.; Parker, V.T.; Simpson, R.L., eds. Ecology of soil seed banks. Academic Press, New York: 283-305.
Milton, W.E.J. 1939. Occurrence of buried viable seeds in soils at different elevations on a salt marsh. J. Ecol. 27: 149-159.
Ungar, I.A. 1995a. Seed germination and seed-bank ecology in halophytes. In: Kigel, J.; Galili, G., eds. Seed development and germination. Marcel and Dekker, Inc. New York: 599-628.
Ungar, I.A. 1995b. Seed bank ecology of halophytes. In: Khan, M.A.; Ungar, I.A., eds. Biology of salt tolerant plants. University of Karachi, Pakistan: 65-79.
Ungar, I.A.; Woodell, S.R.J. 1993. The relationship between the seed bank and species composition of plant communities in two British salt marshes. J. Veg. Sci. 4: 531-536.
Ungar, I.A.; Woodell, S.R.J. 1996. Similarity of seed bank to the aboveground vegetation in grazed and ungrazed salt marsh communities on the Gower Peninsula, South Wales. Int. J. Pl. Sci. 157: 746-749.
Zahran, M.A. 1973. Comparative eco-physiological studies on *Puccinellia maritima* and *Festuca rubra*. Bull. Fac. Sci. Man. Uni. 1: 43-66.