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POPULATION DYNAMICS OF *PERISTROPHE PANICULATA* (FORSSK.) BRUMMITT, A DESERT ANNUAL HERB

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ABSTRACT

The present study highlights the different aspects of population dynamics of herbaceous desert annual *Peristrophe paniculata* (Forssk.) Brummitt, for two consecutive years (2012 and 2013). Demographic analysis was carried out by systematic sampling. The survivorship curves obtained for both the years followed Deevey type I pattern, which is a salient feature of annuals. Increased age specific mortality and decreased life expectancy, was mainly due to the environmental conditions prevailed in the study area. Plants completed their life span within ten weeks in 2012 and in eleven weeks in 2013. Plant height increased with time as well. Reproductive effort of plants was found to be started from second week of growth in both the years. Biomass allocation was highest for shoots in the early stages of life, but with the onset of flowering biomass allocated to reproductive organs increased considerably. Significant differences in the population size were observed in both the years. Relatively, higher plant density and greater vegetative and reproductive performance of *P. paniculata* individuals was noted in 2013. It might be due to prolong monsoon period with relatively greater rainfall in 2013. Varying precipitation in both the years affects the population dynamics of *P. paniculata* individuals. Temporal variability in precipitation seems to drive fluctuations in seedling emergence, plant growth and competitive ability.

KEYWORDS: *Peristrophe paniculata*, Demography, Survivorship curve, Biomass distribution, Reproductive effort.

INTRODUCTION

Demographic studies are crucial for better understanding of plants with their surroundings (Silvertown & Franco, 1993). Many attempts have been made to illustrate the population dynamics of plant species in specific territory and to obtain insight about the microevolutionary progressions that influence the life history factors (Bradshaw, 1965). Demographic parameters such as survival, life expectancy and life span are essential for understanding life-history evolution and forecasting population dynamics (Lauenroth & Adler, 2008). They are more valuable and meaningful when carried out on temporal and spatial scale (Symonides, 1987; Oostermeijer *et al.*, 1996). Therefore, understanding of plant population responses to spatial and temporal environmental variation is an important aim of plant ecological research (Jongejans & de Kroon, 2005; Aziz & Shaukat, 2011).

Annual plants are the main vegetation in arid and semi-arid regions (Li *et al.*, 2008). Studies on annual plants are very useful for not only the conservation, restoration and management of local vegetation but also for the stabilization and sustained development of ecosystems. Karachi being a maritime subtropical desert has dominant vegetation of annual plants after monsoon precipitation. These summer annuals are short-lived and are the optimal experimental subjects for ecological studies. Annual plants have their unique traits, and it is relatively easy to monitor multiple generations during the course of a single long-term project. *Peristrophe paniculata* (Forssk.) Brummitt, is the most common summer annual in Karachi. Large stands of *P. paniculata* emerge after monsoon showers and are widely distributed in maritime subtropical desert of Karachi. *P. paniculata* is up to 60-180 cm in height. It is also economically and pharmaceutically important. The present study is designed to evaluate the temporal variability in the population dynamics of *P. paniculata* for two consecutive years.

MATERIALS AND METHODS

Study site: The site chosen for the study is situated in Karachi University Campus, Sindh (Lat. 24° 48′ N., Long. 65° 55′E.). The climate of Karachi is semi-arid. The city enjoys a tropical climate encompassing mild winters and warm summers. Summer season persists for longest period during the year, while spring and autumn are very short and not that much distinct. Karachi receives the monsoon rains from July to September. The level of precipitation is low for most of the year, with an average of 220 cm of rain per year. The summer temperatures vary between 30^0C to 36^0C. The dry air and moisture deficiency after monsoon season may create drought conditions. As the environmental conditions are dry, xerophytic vegetation dominates the area.

Demography and biomass distribution: Data was recorded for two years i.e., in 2012 and 2013, after the monsoon showers. Demographic data was collected by placing ten permanent quadrats (10 x10 inch) per year. Sampling was done systematically, and started soon after the emergence of plants. Population size was measured at weekly intervals, from germination till death of plants. Using demographic data, life table and survivorship curves were constructed.

At every sampling date two plants were randomly collected from the outside of each quadrat. Plants were taken to the laboratory where their root and shoot lengths were measured. Plants were then dried (80°C for 72 hours) and their dry weights were also recorded. Quadrats were harvested at the last sampling date prior to seed loss.

RESULTS

According to the data collected from the "Pakistan Meterological Department" in Karachi, the amount of monsoon precipitation received during 2012 is 133.9 mm for 2013 is 179.1 mm. Considerably higher amounts of monsoon showers were recorded in 2013.

P. paniculata populations took ten weeks in 2012 and eleven in 2013 to complete their entire life cycle. Life tables of both the years showed decrease in the life expectancy (ex) of plants with an increase in age specific mortality (qx.) (Tables1 & 2). Survivorship curves of individuals follow Deevey type I survivorship pattern (Deevey, 1947) in both the years (Fig. 1), which is a characteristic feature of annuals. Number of individuals decreased with the passage of time and their numbers also varied at different sampling dates. Significantly, higher number of individual were recorded in 2013 ($F = 24.22$, $p<0.001$).

Table 1. Life table of *Peristrophe paniculata* (Forssk.) Brummitt for the year 2012.

Age (weeks)	No. of individuals alive (lx)	No. of individuals dying (dx)	Stationary population (Lx)	Residual life (Tx)	Age specific mortality (qx)	Life expectancy (ex)
1	1000	62.5	968.75	5781.25	0.06	5.97
2	937.50	62.5	906.25	4812.5	0.07	5.31
3	875.00	62.5	843.75	3906.25	0.07	4.63
4	812.50	31.25	796.88	3062.5	0.04	3.84
5	781.25	0	781.25	2265.63	0	2.90
6	781.25	187.5	687.5	1484.38	0.24	2.16
7	593.75	250	468.75	796.88	0.42	1.70
8	343.75	218.75	234.38	328.12	0.64	1.40
9	125	93.75	78.13	93.75	0.75	1.20
10	31.25	31.25	15.63	15.63	1.00	1.00
11	0	0	0	0	0	0

Table 2. Life table of *Peristrophe paniculata* (Forssk.) Brummitt for the year 2013.

Age (weeks)	No. of individuals alive (lx)	No. of individuals dying (dx)	Stationary population (Lx)	Residual life (Tx)	Age specific mortality (qx)	Life expectancy (ex)
1	1000	0.1	999.95	7165.48	0.0001	7.165
2	999.9	0	999.9	6165.53	0	6.166
3	999.9	30.3	984.75	5165.63	0.03	5.245
4	969.6	76.25	931.47	4180.88	0.078	4.488
5	893.35	135.85	825.42	3249.41	0.152	3.936
6	757.5	30.3	742.35	2432.99	0.04	3.277
7	727.2	212.1	621.15	1681.64	0.291	2.707
8	515.1	60.6	287.85	1060.49	0.117	3.684
9	454.5	136.35	386.32	772.64	0.3	1.999
10	318.15	90.9	272.7	386.32	0.285	1.416
11	227.25	227.25	113.7	113.62	1	1
12	0	0	0	0	0	0

Plant size enhanced with time. Typical sigmoid curve was obtained when plotted against time. In the first three weeks of life, plants exhibited greater increase in size and become stable after seventh weeks of life in 2012 whereas, in 2013 gradual increase in plant size was observed till eighth week of life (Fig. 2).

Figs. 3 and 4 represents the biomass distribution to the component organs of *P. paniculata* in the year 2012 and 2013 respectively. Plants started reproductive effort from the second week of life in both the years. In the early stages of life, plants allocate greater biomass to roots and shoots, but with the commencement of flowering biomass allocated to vegetative organs decrease. Significant differences ($F = 13.02$, $p<0.001$) were observed in the biomass allocated to vegetative and reproductive structures in both the years. Plants of both the years started allocating maximum biomass towards reproduction in the later stages of life. It was also observed that the individuals of year 2013 survived a week more as compared to those of 2012 and allocates greater biomass to reproductive organs.

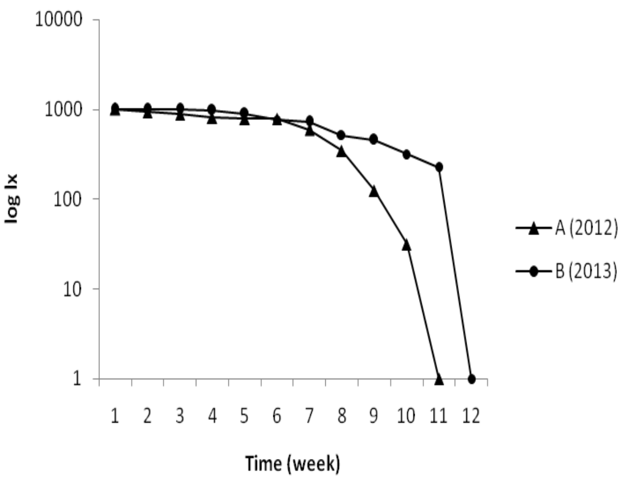

Fig. 1. Survivorship curve of *P. paniculata* individuals for the year 2012 and 2013.

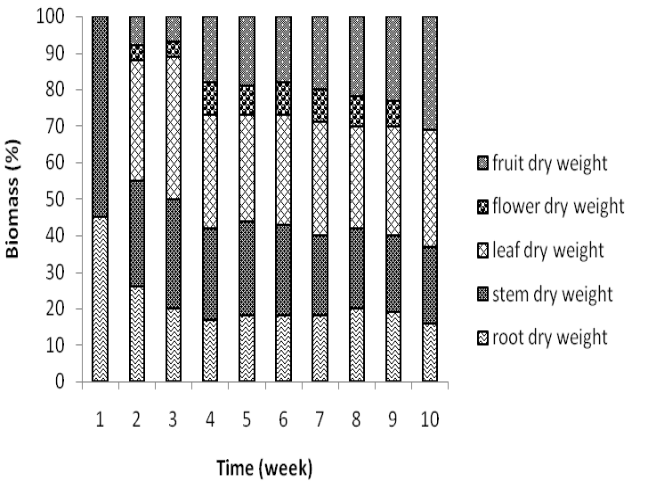

Fig. 3. Biomass allocation (%) to component organs of *P. paniculata* individuals for the year 2012.

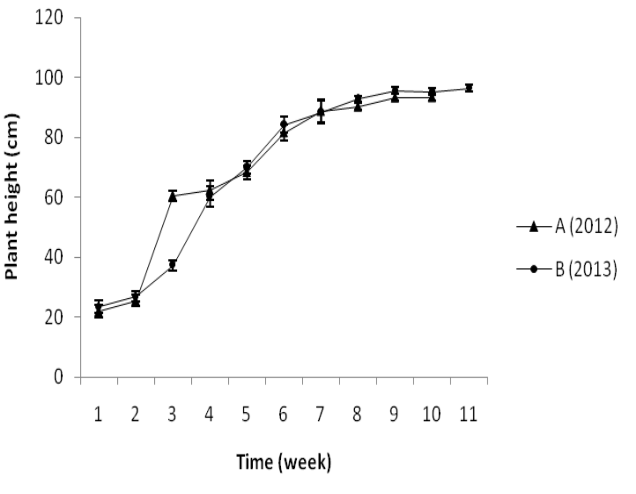

Fig. 2. Plant height of *P. paniculata* individuals for the year 2012 and 2013.

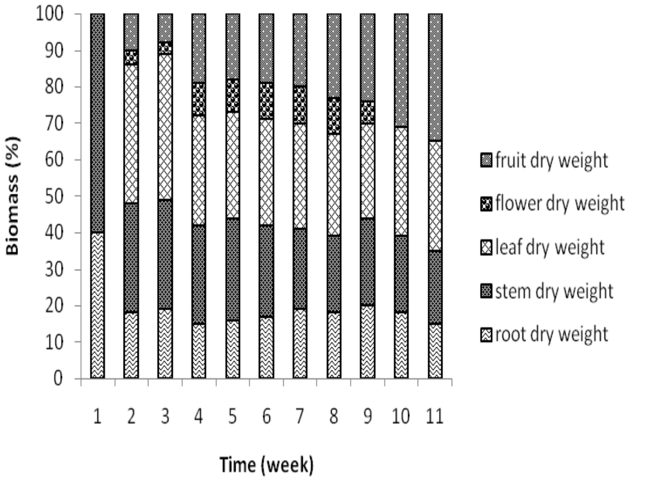

Fig. 4. Biomass allocation (%) to component organs of *P. paniculata* individuals for the year 2013.

DISCUSSION

Peristrophe paniculata populations showed decline in the number of survivors with time in both the years and followed Deevey type I (Deevey, 1947) survivorship pattern, which is a characteristic feature of annual species and also reported in *Vulpia fasciculata* (Watkinson & Harper, 1978), *Ipomea sindica* (Aziz & Shaukat, 2011) and *Cleome viscosa* (Aziz & Shaukat, 2012). Numbers of individuals were higher in 2013, mainly due to relatively higher precipitation rates for somewhat longer periods in 2013. Gonzalez-Astorga and Farfan (2000), also considered the pattern of precipitation as the main factor of temporal variability in seedling emergence of an annual plant population *Tagetes micrantha*. Similarly, Klemow and Raynal (1983), reported different survival rates of cohorts on temporal scale mainly due to variability in seasonal rainfall pattern. Mortality rates of *P. paniculata* populations were greater in the later stages of life. It might be due to increase in competition or density dependant factors. One of the main reasons is the lowering of moisture levels after monsoon rains and high temperature and evapotranspiration. Seedling survival of the annuals *Prognostics poaeoides* and *Bassia dasyphylla* were also found to be positively correlated with the water content of the upper soil (Long and Li, 2003). Similarly, Chesson *et al*. (2004) also suggested that low precipitation of arid and semi arid regions exert strong influence over life histories, physiological characteristics and species composition.

The plant size of *P. paniculata* enhanced with time. Silvertown and Charlesworth (2001), suggested that the growth of individual plants positively affects population growth, because the probability of survival and reproduction of plants, increase with plant size. However, populations of 2013, showed relatively higher plant sizes and greater reproductive growth. *P. paniculata* individuals started reproduction from the second week of life in both the years. Harper and White (1974) reported that a number of annuals start flowering and set their first seed when very young and this process continues throughout the growing season. Considerably, greater reproductive output in 2013 might be due to relatively higher and longer period of precipitation in 2013. According to Evans *et al*. (2007) fecundity is positively associated with rainfall and drought usually results in absolute reproductive malfunction.

Optimal partitioning of biomass among various plant organs helps to effectively capture resources to maximize plant growth rate (Dewar, 1993). In the early stages of growth, *P. paniculata* populations allocated most of its biomass to shoots thus giving the plants good photosynthetic form. Tilman (1988) suggested that annuals are better competitors because of fast growth resulting from the high proportion of their biomass allocated to leaves in the early stages of life. Such an allocation is helpful for plant to its reproductive development. However, at the onset of flowering, plants started allocating more biomass towards their reproductive effort and the percentage production of flowers and fruits increased with time period. This shows that plants are preparing for recruitment in next congenial season.

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