J. Phytol. Res. 23(2) : 367-372, 2010

POPULATION DYNAMICS OF *EVOLVULUS ALSINOIDES* (L.) L. AND *E. NUMMULARIUS* (L.) L. IN A TROPICAL DRY DECIDUOUS FOREST IN ALWAR, RAJASTHAN

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Population dynamics of indigenous species, *Evolvulus alsinoides* (L.) L. and an alien species, *E. nummularius* (L.) L. was evaluated in a tropical dry deciduous forest in Alwar, Rajasthan (27°4' to 28°4' N and 76°7' to 77°13'E). The population density of *E. alsinoides* was 3 plants m^{-2} in August 2006 which increased to 3.4 plants m^{-2} while that of *E. nummularius* was 7 plants m^{-2} in August 2006 which increased to 10.5 plants m^{-2} in a year. In both the species, established plants exhibited 100 percent survivorship whereas seedling cohorts experienced above 90 percent mortality. Similar observations were made in the second year, although the seedling recruitment and seed production was higher than the preceding year. The results obtained suggest that *E. nummularius* prefers high soil moisture conditions whereas *E. alsinoides* can grow in dry as well as moist places. *E. alsinoides* completes its life cycle twice a year whereas *E. nummularius* completes only once in a year. These differences in the growth behaviour of the two species explains the wide spread distribution of former whereas the limited distribution of the latter to moist situations in Alwar district of Rajasthan.

Keywords : Established plants; Mortality; Seedlings; Survivorship.

Introduction

Evolvulus alsinoides (L.) L. and *E. nummularius* (L.) L. (Convolvulaceae) are perennial herbs which grow in forest and degraded forest areas in Alwar district of Rajasthan. The former is an indigenous plant of enormous medicinal importance while the latter is an alien species native to South America. With the increase in biotic pressure on forest vegetation, the population of these species may be adversely affected in this region. It is, therefore, imperative to understand the population dynamics of these species in their natural environment which may be useful in the their conservation. The population dynamics of several herbaceous species have been evaluated[1-8]. Harper and White[9] have described the schematic model of successive stages involved in the regulation of the number and mass in plant populations. In the present study, an attempt has been made to evaluate the natality, mortality, survivorship and reproductive potential of *Evolvulus alsinoides* and *E. nummularius* in a tropical dry deciduous forest in Alwar district of Rajasthan.

Material and Method

The study site : The demographic study of *Evolvulus alsinoides* and *E.nummularius* was carried in R.R. college campus Alwar (27°4′ to 28°4′ north latitude and 76°7' to 77°13′east longitudes) which is located in north-eastern Rajasthan about 150 Km from Jaipur. Previously this site was an orchard surrounding the palace of Maharaja of Alwar, which has now been used to house R.R. college for the last 75 years. Since then the orchard has been abandoned and in the last two decades it has developed in a tropical dry deciduous thorn forest dominated by *Holoptelea integrifolia* and *Prosopis juliflora.* The vegetation of this site is subjected to moderate grazing by about 30 goats and a few cows. The common herbaceous species of this site are listed in Table 1. The soil is sandy loam with pH 7.8 , organic carbon 0.34 %, phosphorus 62 kg ha^{-1} and potassium 810 kg ha^{-1} according to Dey[10]. The climate is semiarid, monsoonal type characterized by three seasons. The summer season extends from mid March to June is externally hot and dry with maximum temperature rising to 45°C. The rainy season is from July to September which receives 90% of the annual rainfall (620 mm). The winter commences from November and extends up to February with temperature dropping to 4°C in December-January.

The demographic study of *E. alsinoides* and *E. nummularius* was carried out by laying five permanent quadrats of one m^2 randomly in the study site. Individuals

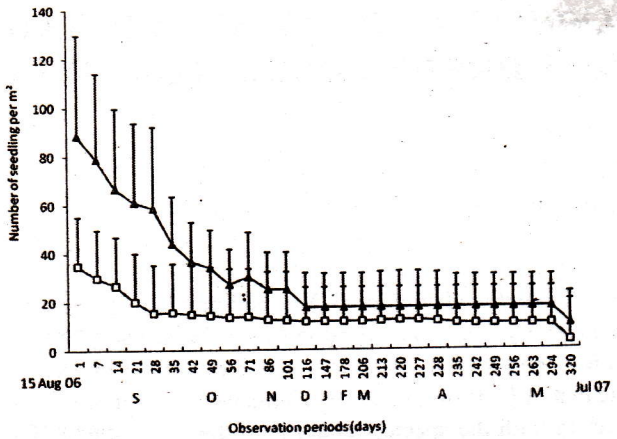

Fig.1. Survivorship of seedling population in first year (Aug. 2006-July 2007); (-□-) *E. alsinoides* (-▲-) *E. nummularius* at R.R. college campus.

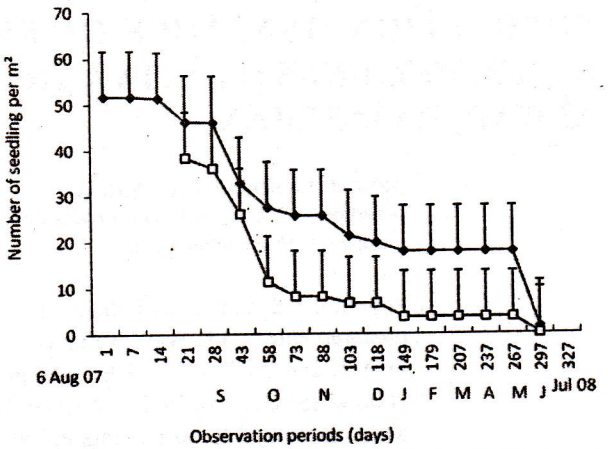

Fig.2. Survivorship of seedling population in first year (Aug. 2007-July 2008); (-●-) *E. alsinoides* (-▲-) *E. nummularius* at R.R. college campus.

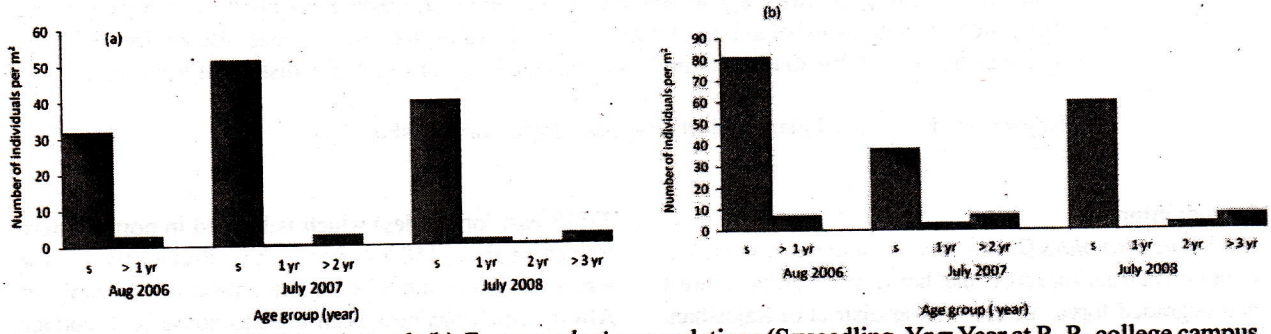

Fig.3. Age structure of (a) *E. alsinoids* (b) *E. nummularius* populations (S=seedling, Yr = Year at R. R. college campus.

of both the species were tagged and mapped, and then their fate was followed at short and regular intervals. The population census was done at weekly intervals from July to August, at fortnightly intervals from September to November and at monthly intervals from December to June. Cohorts of seedling of both the species were marked in August 2006 and July 2007 when there was the highest recruitment in permanent quadrats. In permanent quadrats each seedling was tagged by tying a coloured thread at its base. The fate of each cohort was followed at regular intervals until July 2008. A new seedling was treated as seedling for one year and if it has survived more than one year , then it was designated as established plant. The soil moisture content was determined by taking five soil samples, each from 10 cm×10 cm×10 cm volume of soil, at a random near the permanent quadrats in the study site at regular intervals following Misra[11] (Table 2). The climatic characteristics, *i.e.* air temperature and soil surface temperature were measured at different places in the site at regular intervals (Table 3). The soil surface temperature was measured up to 2 cm depth of soil while the air temperature was measured 2 feet above the soil surface by using simple thermometer. The available light intensity was measured by lux meter. These observations were taken from 11 am to 12 pm in R.R. College Campus.

Result and Discussion

Population flux : The population size of *Evolvulus alsinoides* was 3 plants m^{-2} in the tropical dry deciduous forest at R.R. college campus in August 2006 (Table 4). Thirty two new seedling m^{-2} were added in August 2006 out which 0.4 m^{-2} survived over a one year period. The population increased to 3.4 m^{-2} by July 2007 exhibiting a growth rate of 1.13. Established plants exhibited 100 percent survivorship whereas the newly recruited seedling experienced 90.2 percent mortality. In the second year the population increased to 4.8 m^{-2} with growth rate of 1.29 (Table 2). The comparatively higher survivorship in the second year may be attributed to higher rainfall. The population density of *E.nummularius* was 7 plants m^{-2} in August 2006 which increased to 10.5 plants m^{-2} over a

Table 1. Density and frequency of herbaceous species at R.R. College campus in August, 2007 (± SE).

	Species	Density (m^2)	Frequency (%)
1.	*Evolvulus alsinoides* (L.) L.	18.75 ± 6.63	100
2.	*Evolvulus nummularius* (L.) L.	30.5 ± 6.98	65
3.	*Peristrophe bicalyculata* (Retz.) Nees	8.3 ± 1.98	65
4.	*Brachiaria ramosa* (L.) Stapf.	24.35 ± 4.82	75
5.	*Cassia tora* L.	4.15 ± 1.20	50
6.	*Achyranthes aspera* L.	0.9 ± 0.44	25
7.	*Capparis sepiaria* L.	0.3 ± 0.10	30
8.	*Sida cordifolia* L.	3.95 ± 0.85	65

Table 2. Soil moisture (%) in the tropical dry deciduous forest at R.R. College campus, Alwar.

Observation periods	2006 - 2007	2007 - 2008
Jun	12.0 ± 0.5	14.6 ± 1.0
Jul	16.4 ± 0.7	11.8 ± 1.1
Aug	12 ± 0.5	10.3 ± 0.3
Sep	3.25 ± 0.4	6.9 ± 0.5
Oct	0.18 ± 0.01	0.3 ± 0.04
Nov	0.16 ± 0.01	0.4 ± 0.1
Dec	0.14 ± 0.01	0.15 ± 0.02
Jan	0.9 ± 0.01	0.14 ± 0.02
Feb	0.2 ± 0.01	0.3 ± 0.01

Table 3. Air temperature, soil surface temperature (°C) and light intensity (100 lux) available to the herbaceous layer of the tropical dry deciduous forest at R.R. College campus, Alwar.

Observation periods	Air temperature		Soil surface temperature		Light intensity	
	2006-2007	2007-2008	2006-2007	2007-2008	2006-2007	2007-2008
July	43	44	45	46	70180 ± 17028	58840 ± 15258
Aug	44	43	47	46	59120 ± 17172	37080 ± 10396
Sep	43	36	46	40	47480 ± 17622	51900 ± 13706
Oct	39	32	42	34	44920 ± 16174	48500 ± 11118
Nov	29.6	30	32	32	39980 ± 14494	32040 ± 6394
Dec	29	27	32	29	26640 ± 9827.7	36140 ± 6500
Jan	27	24	28	25	39100 ± 10184	32940 ± 5564
Feb	24	19	25	22	28240 ± 9832	45520 ± 7430
Mar	24	29	26	26	30660 ± 11114	43140 ± 7000
Apr	25	40	29	42	*	*
May	43	43	39	45	*	*
Jun	47	47	48	48	*	*

* Observations were not recorded.

Table 4. Population flux of *Evolvulus alsinoides* in the tropical dry deciduous forest of of R.R. College campus Alwar.

Parameter		First year (1.8.2006-2.7.2007)	Second year (2.7.2007-2.7.2008)
a)	Number of plants present in the Beginning of the year	3	3.4
b)	Number of plants present after one year period	3.4	4.8
c)	Net change over one year period (b-a)	0.4	1.4
d)	Rate of increase (b/a)	1.13	1.29
e)	Number of plants arrived in one year period	32	51.6
f)	Total number of plants lost in one year period	31.6	50.2
g)	Plants present in the beginning alive after one year period	3	3.4
h)	Percentage survival of plants in (a), (g/a×100)	100	100
i)	Total number of plants recorded during the one year period	35	55
j)	Percentage annual mortality of all individuals (f/I × 100)	90.2	91.2

Table 5. Population flux of *Evolvulus nummularius* in the tropical dry deciduous forest of of R.R. College campus Alwar.

Parameter		First year (1.8.2006-2.7.2007)	Second year (2.7.2007-2.7.2008)
a)	Number of plants present in the Beginning of the year	7	10.5
b)	Number of plants present after one year period	10.5	10.5
c)	Net change over one year period (b-a)	3.5	0
d)	Rate of increase (b/a)	1.5	0
e)	Number of plants arrived in one year period	81.5	38.3
f)	Total number of plants lost in one year period	78	38.3
g)	Plants present in the beginning alive after one year period	7	10.5
h)	Percentage survival of plants in (a), (g/a×100)	100	100
i)	Total number of plants recorded during the one year period	85	48.8
j)	Percentage annual mortality of all individuals (f/I × 100)	91.7	78.4

Table 6. Reproductive potential of *Evolvulus alsinoides* and *Evolvulus nummularius* in 2006-2008 at R.R. College, Alwar.

Parameters	*E. alsinoides*			*E. nummularius*		
Year	2006	2007	April 2008	2006	2007	April 2008
1. Number of fertile plant / m²	6.4 ± 1.8	12.2 ± 3.9	2.2±0.6	122 ± 5	32 ± 2	*
2. Number of fruit /m²	81.2	57.2	65.5	140.3	825	*
3. Number of seed / m²	325 ± 115	293 ± 34	262	137±66	357 ± 136	*

*There was no growth in *E. nummularius* during February-April 2008.

one year period (Table 5). The net increase in population size was 3.5 plants m^{-2} with a growth rate of 1.5. Although the established plants showed no mortality 91.7 percent of new recruited individuals died by the end of one year period. In August 2007, 38.3 seedlings m^{-2} were recruited as compared to 81.5 seedling m^{-2} in the preceding year. All the seedling of 2007 cohort died by July 2008. Hence, the population density of established plants remained unchanged (10.5 m^{-2}) in the second year. The cause of low recruitment of seedlings in this species in the second year is obscure. The comparison of the population flux of *E. alsinoides* and *E. nummularius* populations growing at R.R. college campus over two year period indicates that the population density of the latter is twice that of the former species. Although both species exhibited almost equal population growth rate, the recruitment of new individuals was 120 m^{-2} in *E. nummularius* and 84 m^{-2} in *E. alsinoides*. The slightly higher survivorship of seedling of the former than the latter may be the cause of higher population density of *E. nummularius* in this habitat.

Survivorship of seedlings: The survivorship of seedling cohorts of August 2006 of both the species of *Evolvulus* declined continuously until November 2006, then remained unchanged till May 2007 and again declined in June 2007 (Fig. 1). Seedling cohort of 2007 of both the species showed high survivorship in July and August with a decline from September to March 2008, and again declined in June 2008 (Fig. 2). Similar seedling mortality pattern have been observed in *Indigofera trita*[10]. These observations suggest that seedling mortality in these species occurred chiefly with the decline in soil moisture content and extreme hot climatic conditions (Table 2,3). This in conformity with Fisher and Compbell[12], Yadav and Tripathi[15], Jones and Sharitz[13] and Yadav[14] who reported seedling mortality in plant species due to drought. Knipe and Herbel[15] also observed adverse effect of drought, heat and disease on the seedlings of *Larrea* in California. The tree canopy of the dominant tree species, *Holoptelea integrifolia* and *Prosopis juliflora* may also have caused seedling mortality in both the species by reducing the intensity of incoming radiation under the canopy (Table 3). The role of tree canopy in seedling mortality has been reported[10,14,16,17]. Some seedlings of both the species might have been died due to trampling by cattle and goats. Seedling cohorts of *E. nummularius* exhibited higher survivorship than that of *E. alsinoides*. This may be due to the better growth of the former in sandy loam soil of the study site as compared to that of the latter which prefers sandy or coarse hill soil. However, only a few seedlings of this species got established at the end of one year study period. This may be the reason for the low population density of established plant of both the species in nature. Most of the seedling of *E. nummularius* also died due to low soil moisture, high temperature in summer season (Table 2,3) and some presumably due to trampling by cattle. As both the species are not palatable, the impact of grazing may not be a limiting factor for the population of these species.

Survivorship of established plants: The established plants of *E. alsinoides* and *E. nummularius* exhibited 100 percent survivorship in the study site over a two year period. This suggests that the established plants of both species can tolerate harsh climatic situations and competition stress caused due to associated species. Hawthorn and Cavers[2] and Yadav and Tripathi[3] also suggested that the survivorship of mature plants was not affected by moisture stress. Sarukhan and Harper[1] also reported that the established plants of *Ranunculus* species may not die due to harsh climatic conditions, and the major risk is during active growing season. However, the established plants of many species may die due to competition for resources in the active growing season[3]. During the dry cold winter season and dry hot summer season the aerial branches of the plants of both species died and the subterranean root - stock remained viable until the following rainy season when it sprouts to give rise to aerial branches. The perennial root- stock being subterranean provides the individual plants protection against trampling and grazing, and resistance to soil moisture stress and extreme temperature conditions. The well established root system confers the established plants an advantage in utilizing below ground resources more efficiently as compared to other associated herbs. The established plants of both the species were observed to survive under the tree canopy although they exhibited very slow growth rate. These may be the reasons for 100 percent survival of established plant of these species over a two year period.

Age structure: The population size of *E. alsinoides* is smaller as compared to *E. nummularius* (Fig 3). One new age groups was added to population of *E. alsinoides* every year which indicates that the population size is gradually increasing. The large seedling population and successively increasing number of individual in older age groups suggests that the population of *E. alsinoides* is stable. A new age group was added to the population of *E. nummularius* in the first year (2006-2007), however, no new age group was added in the second year (2007-2008) as seedling population experienced 100 percent mortality. These observations indicate that the population of *E. nummularius* is unstable in this region.

Reproductive potential: Evolvulus alsinoides produced 325 seeds m^{-2} whereas *E. nummularius* produced 136 seeds m^{-2} in 2006, however, in 2007 *E. nummularius* produced 357 seed m^{-2} as compared to former which produced 229 seeds m^{-2} in R.R. college campus (Table 6). The seed production seems to be not affected by the increased rainfall in *E. alsinoides* in 2007 whereas *E. nummularius* produced higher number of seeds in 2007 when the rainfall was higher and for longer duration. This suggests that *E. nummularius* prefers moist habitats whereas *E. alsinoides* grows in dry as well as moist environmental situations. Hence, the later is more wide spread in distribution in Alwar district than the former. In *E. alsinoides* almost all fruits produced seeds whereas in *E. nummularius* during the 2007, the seed production was very low (357 m^{-2}) as compared to the fruit production 825 m^{-2}. The high vegetative growth, attributed to longer duration of rainfall in 2007 initiated enormous production of flowers and fruits in the later species, however, the seed setting was low. This suggests that *E. nummularius* allocates higher amount of resources to vegetative parts than to the seed production. *E. alsinoides* exhibited higher initiation of flower and fruit production in response to higher rain fall, however, the number of seed m^{-2} remained almost constant. Hence, there is a difference in the growth behavior of both the species in response to increased soil moisture content. This also suggest that both the *Evolvulus* species growing in Alwar district of Rajasthan may be k-strategists, as they allocated more resources to vegetative parts rather than to seed production. *E. alsinoides* also completes a second life cycle from February to May if there is rainfall in the month of February. It produced 66 fruits m^{-2} and 262 seeds m^{-2} in May 2008 at R.R. college campus whereas there is no growth in *E. nummularius* during the same period. Thus, *E. alsinoides* has the advantage of completing the life cycle twice a year which helps it in increasing the longevity of its established plants as well as augment the reproductive potential.

Acknowledgements

The authors are grateful to Dr. Ramdhan, Principal, R.R. Autonomous College, Alwar for encouragement and providing necessary facilities for completing this work.

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