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POPULATION DYNAMICS OF *EUPATORIUM ODORATUM* IN SUCCESSIONAL ENVIRONMENTS FOLLOWING SLASH AND BURN AGRICULTURE

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SUMMARY

(1) Studies on the population dynamics of *Eupatorium odoratum* with particular respect to recruitment, mortality, population flux and reproductive efficiency in successional plant communities following slash and burn agriculture (jhum) are reported.

(2) The recruitment and mortality patterns of individuals in 1-, 3-, 5-, 10- and 20-yr-old fallows showed that the seedling population experienced more severe mortality in older fallows than in newer fallows. No recruitment occurred in 10- and 20-yr-old fallows. The mortality of adult shoots was greatest in a 5-yr-old fallow.

(3) The changes in population size and reproductive output are discussed in the light of changing ecological conditions and the implications of the results are discussed in relation to the jhum cycle.

INTRODUCTION

Eupatorium odoratum L. is a noxious perennial weed in many parts of the world. It was introduced to India from tropical America during the Second World War and since then it has spread widely and has become a dominant weed of wastelands, roadsides and other exposed areas.

The aim of the present study was to identify the various factors governing the population size and reproductive behaviour of *E. odoratum* at different successional stages of community development following slash and burn agriculture (jhum) which is extensively practised by the local tribal population of Meghalaya in north-eastern India.

Eupatorium odoratum possesses most of the characteristics necessary for rapid spread and establishment. The seeds (cypsellas) are effectively dispersed by wind during April and early May and new areas are colonized every year. Seed set is completed before the rains and germination starts in May–June with their onset. From June to October active growth occurs, after which the plants start flowering. Maximum fruiting takes place in January and by March the seeds are mature.

METHODS

The experimental sites were situated at Burnihat in Meghalaya (26°02′N; 91°52′E) at an altitude of about 100 m. Five fallows of different ages (1, 3, 5, 10 and 20 yr) were selected as the study sites. Age was calculated from the time the fields were left fallow after slash and burn agriculture. Density, frequency, cover and vegetation were recorded using 1 × 1 m quadrats for herbaceous species and 10 × 10 m quadrats for shrubs and trees. The importance value index was calculated using relative frequency, relative density and

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relative basal area of the species. The values are based on twenty quadrats at each site (Misra 1968; Kershaw 1973).

Demographic studies were carried out in permanent quadrats of 1 m^2 with three replicates in each of the fallows. The fates of seedlings and shoots of established plants were followed from May 1978 to May 1979. The seedlings were marked, using colour paints, by putting a dot on cotyledons to differentiate seedlings from two cohorts, one appearing in May and the other in June. Adult shoots present at the time of first recording were assumed to be more than 1-yr-old. Shoots were tagged with aluminium labels. Maximum and minimum temperatures and rainfall were recorded.

Seed production m^{-2} was estimated by counting the numbers of seeds produced in three replicate quadrats each of 1 m^2.

RESULTS

Climate

The climate at Burnihat shows three distinct seasons. The dry and windy summer runs from mid-February to May with an average maximum temperature of 37 °C and a minimum of 7 °C. The rainy season extends from May to September (average annual rainfall, 2220 mm). This is a warm period with high humidity. The mild winter with an average maximum temperature of 25 °C and an average minimum of 5 °C extends from November to mid-February. This period is practically rainless except for a few winter showers (Fig. 1).

Vegetation

The early stages of succession are characterized by a number of weedy grasses like *Imperata cylindrica*, *Thysanolaena maxima* and *Arundinella bengalensis* and by *Grewia elastica*. *Dendrocalamus hamiltonii* dominates older fallows along with some tree species (present as seedlings, stem or root sprouts) and a few shrubs and climbers. The importance value indices for different species are given in Table 1.

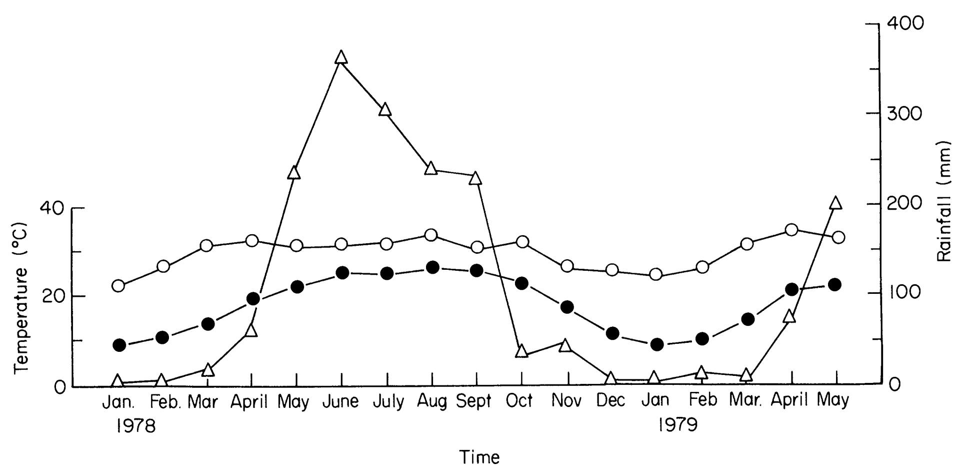

FIG. 1. Some climatic data for the study area. Monthly maximum (O) and minimum (●) temperatures; monthly rainfall (△)

TABLE 1. Importance value indices of associated plant species in different fallows. Partly from Ramakrishnan *et al.* (in press)

Species	Age of fallow (yr) 1	3	5	10	20
Arundinella bengalensis (Spreng) Druce	19·7	23·9	28·5	–	–
Grewia elastica Royle	71·2	80·3	–	–	–
Imperata cylindrica Beauv.	23·9	34·1	48·8	–	–
Thysanolaena maxima Kunze.	35·9	42·5	–	–	–
Panicum khasianum Munro.	10·3	11·0	12·1	–	–
Panicum maximum Jacq.	9·6	9·9	11·2	11·0	–
Ensete superba L.	9·3	–	–	–	–
Eupatorium odoratum L.	30·8	171·2	53·3	8·1	5·4
Carex cruciata Nees.	–	–	11·3	–	–
Setaria glauca Beauv.	–	2·6	10·3	–	–
Cymbopogon khasianum Stapf ex Bor	–	3·4	9·2	–	–
Dendrocalamus hamiltonii Nees.	–	–	1·0	33·8	53·8
Ficus hispida L.	11·5	12·1	20·8	26·1	16·7
Cyperus globosus Allioni.	–	–	–	28·8	–
Litsaea assamica Hk.f.	–	–	–	11·4	–
Maesa indica Wall.	–	–	–	6·9	–
Combretum decandrum Roxb.	–	–	–	6·6	–
Macaranga denticulata Muell.	–	–	–	6·4	–
Gmelina arborea Roxb.	–	–	–	6·5	–
Machillus khasyana Meissn.	–	–	–	5·4	–
Vitex peduncularis Wall.	–	–	–	–	38·5
Vitex glabrata Br.	–	–	–	–	28·3
Schima wallichii Chois.	–	–	–	–	35·3
Terminalia bellerica Bedd.	–	–	–	–	33·8
Bauhinia variegata L.	–	–	–	–	27·8
Dillenia indica L.	–	–	–	–	27·8

Dash indicates species absence.

Population flux of E. odoratum

In 1- and 3-yr-old jhum fallows, populations of *E. odoratum* increased by 5 and 148 individuals m^{-2} over the study period but in older fallows no increases were observed (Table 2). Seedling mortality was high but adults generally survived. The fallow with

TABLE 2. Population flux of *Eupatorium odoratum* in different fallows

	Age of fallow (yr) 1	3	5	10	20
(a) No. of plants m^{-2}, May 1978	0·0	5	35	3·3	2
(b) No. of plants m^{-2}, May 1979	5·3	153·6	35	2·6	2
(c) Net change (b–a)	5·3	148·6	0·0	−0·7	0
(d) Rate of increase (b/a)	–	30·7	1·0	8·7	1
(e) No. of plants m^{-2} arrived between May 1978 and May 1979	15·7	1469·2	2351·8	0·0	0
(f) Total no. of plants m^{-2} lost between May 1978 and May 1979	10·4	1320·6	2531·8	0·7	0
(g) Plants present May 1978, alive by May 1979	–	5	35	2·6	2
(h) Percentage survival of plants in (a) (g/a × 100)	–	100	100	78	100
(i) Total no. plants m^{-2} recorded during study	15·7	1474·2	2566·2	3·3	2
(j) % annual mortality of all individuals (f/i × 100)	66·2	89·5	98·6	21·2	0
(k) Mortality (%) of arrivals between May 1978 and May 1979	66·2	89·8	100	0·0	0

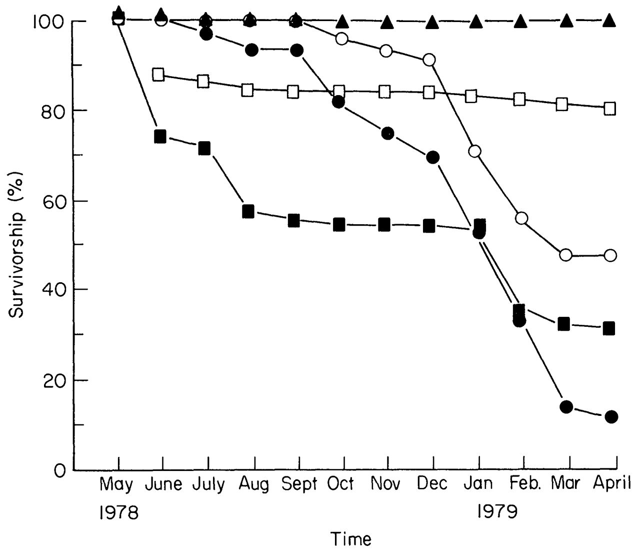

FIG. 2. Survivorship curves of shoots of *Eupatorium odoratum* in different fallows. 1-yr-old fallow (▲); 3-yr-old fallow (□ ■); 5-yr-old fallow (○ ●). Unfilled symbols, shoots > 1-yr-old; filled symbols, shoots < 1-yr-old.

maximum recruitment also showed maximum mortality. In 10- and 20-yr-old fallows the adult populations did not show any significant change.

Survivorship of shoots

Shoots in the 1-yr-old fallow showed no mortality throughout the study period (Fig. 2). In the 3-yr-old and 5-yr-old fallows mortality of the older shoots was comparatively low but younger shoots survived less well. In 5-yr-old fallow, older shoots showed greater

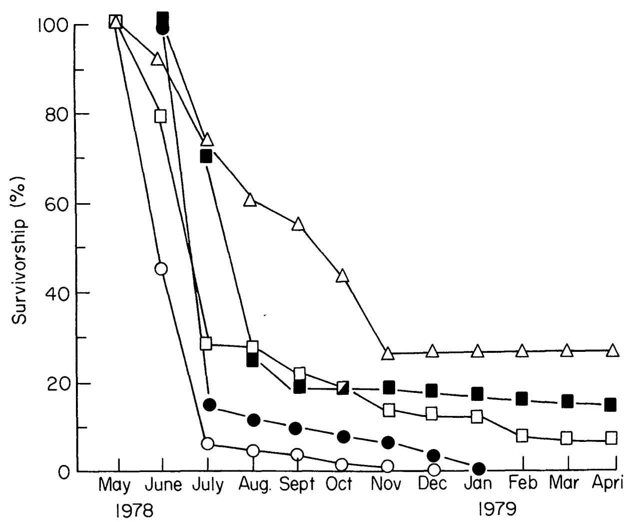

FIG. 3. Survivorship curves of *Eupatorium odoratum* seedlings in different fallows. 1-yr-old fallow (△); 3-yr-old fallow (□ ■); 5-yr-old fallow (○ ●). Unfilled symbols, first seedling cohort; filled symbols, second seedling cohort

mortality than they did in the 3-yr-old fallow. The 10- and 20-yr-old fallows had no new shoot recruitment during the study period and mortality of the existing shoots was insignificant.

Survivorship of seedlings

Highest seedling mortality occurred in the 5-yr-old fallow where all seedlings were dead by January 1979 (Fig. 3). In the 3-yr-old fallow, seedlings did survive. Mortality was highest during May and June with further losses during the winter. In the 1-yr-old fallow the rate of mortality was less but the period was extended from May to November.

If 50% seedling mortality is used to express relative incidence of mortality, this occurred within the first 30 and 45 days for cohorts one and two respectively in the 5-yr-old fallow, within 45 and 60 days for cohorts one and two respectively in the 3-yr-old fallow, but not until 135 days in the 1-yr-old fallow.

Reproductive performance

The reproductive performance of individuals was inversely proportional to the fallow age (Table 3). All plants in the 1- and 3-yr-old fallows were fertile but only about 50% of the plants in the 5-yr-old fallow produced seeds and none did so in the 10- and 20-yr-old fallows. Seed numbers plant^{-1} reflected the differences in fertility and, since the germinability of seeds from all the populations was the same (39%), the reproductive capacity (*sensu* Salisbury 1942) was greatest for plants in the 3-yr-old fallow.

TABLE 3. Reproductive output of *Eupatorium odoratum* in relation to the age of the fallow

	Age of fallow (yr)				
	1	3	5	10	20
(a) Plants m^{-2}*	2	5	35	3·3	2
(b) % fertile plants m^{-2}	100	100	51·4	–	–
(c) % sterile shoots m^{-2}	–	4	53	100	100
(d) Capitula fertile plant^{-1}	214	2927	26	–	–
(3) Seeds fertile plant^{-1}	6409	87 237	780	–	–
(f) Seeds m^{-2}	12 818	436 185	13 975	–	–
(g) Reproductive capacity plant^{-1}	943	1107	155	–	–

* Excluding seedlings.

DISCUSSION

During succession in plant communities edaphic and micro-environmental changes occur. Mineral nutrient and soil moisture status may improve and changes in the pH occur as litter accumulates and decomposition develops. An open community changes into a closed one with a more complete canopy and increased potential evapo-transpiration. *Eupatorium odoratum*, present in such seral communities is exposed to these changes during its establishment and development. Light may be one of the major factors regulating the population size of *E. odoratum* during secondary succession (Bennett & Rao 1968; Cruttwell 1968).

The present results show that seedling survival was markedly reduced with the increase in the age of the fallow. Recruitment of new individuals to the population reached its peak in the 3-yr-old fallow and in older fallows hardly any new recruitment occurred. The size of existing populations declined sharply after 5 yr. Reproductive output was less in older fallows to the extent that the few plants that survived in the 10- and 20-yr-old fallows had only sterile shoots. The higher seed production in 3-yr-old fallow compared with 1-yr-old fallow may have been due partly to the improved fertility status of the soil in the former situation and partly to the increased age of the plants.

Only some of the individuals of *E. odoratum* in the 1-yr-old fallow flowered and these individuals occurred where the population density of this and other species was comparatively low and the light conditions were more favourable. Similarly, the mean values for seed output plant^{-1} in 3- and 5-yr-old fallows are derived from a mixture of uneven-aged plants, all of which were at least a year old. The marked decrease in the seed output in 5-yr-old fallow compared to that in 3-yr-old fallow was indicative of the unfavourable conditions created by increased intra- and inter-specific competition for the available resources (Harper & White 1974; Hawthorn & Cavers 1976).

The heavy seedling mortality during June and July in 3- and 5-yr-old fallows may be attributed to intra-specific competition (Ramakrishnan & Jeet 1972) and to the high density of other species that emerged during the monsoon. The high mortality during June and July is not unexpected for seedling mortality in its severest form, expresses itself during the first few weeks of the growth of a plant (Ramakrishnan & Kumar 1971).

Mortality of seedlings and shoots during the winter indicates the importance of soil moisture in the survivorship of *E. odoratum.* As is evident from the climatological data, this is a comparatively dry period. The dryness of the soil is further accentuated due to steep slopes, high infiltration losses as well as fairly thin soil cover. The higher mortality, during winter, of younger shoots recruited during the preceding monsoon, shows them to be more susceptible than older shoots. This is again in conformity with the general belief that mortality is most severe in the early stages of growth of a plant.

Eupatorium odoratum is a noxious weed appearing in fallows after slash and burn agriculture (jhum) which is prevalent in the north-eastern hill region of India. As is evident from the present study, the vigour of this weed is drastically curtailed after about 5 yr during secondary succession. This would imply that the weed would be controlled naturally when the jhum cycle (the intervening fallow period after which the same forested land is again cultivated) is long enough. In the past, the jhum cycle was about 20–30 years which was ideal not only for the recovery of soil fertility under a forested fallow but also for keeping noxious weeds like *E. odoratum* under control. However, in recent times, there has been considerable shortening of the cycle to about 4–5 years due to increased population pressure, reduction in available land for cultivation following changed land tenure practices and the consequent changes in the man/land ratio. As a result not only is the recovery of the soil fertility affected but large tracts of land have been taken over by weeds like *E. odoratum.* The weed community is presently being maintained in a permanent state of arrested succession.

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