Evolution of phenological plasticity in *Parthenium hysterophorus* in response to air pollution stress and unordered environmental variation

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SUMMARY

Strong phenotypic plasticity in *Parthenium hysterophorus* regarding life span, height of plant, flowering time, under pollutant stress, particularly air pollution stress were observed. Environment might be more important in determining genetic and phenotypic changes. There was also increasing evidence that the amount and pattern of expressing genetic variation itself was environment dependence. *Parthenium hysterophorus* showed adaptive phenotypic evolution within range of environments.

Key words : Phenotypic plasticity, *Parthenium*, Ecotype, Environmental variation.

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With the tremendous scientific and technological advancement, man has to a large extent succeeded in controlling and dominating nature. Plant species contain a tremendous amount of genetic variation, both within and between populations. This genetic variation shows up in the morphological and physiological traits of plants adapted to survive in different climates. Turreson (1922a) defined an ecotype as a population of plants that is genetically differentiated in response to the conditions of a particular habitat. An ecotype reflects the elevation, precipitation, temperature, growing season, soil and site characteristics where the population is found (Turreson, 1922b).

Sessile modular organisms, such as plants, which cannot migrate when environmental conditions change and whose modules may experience different environments, benefit from mechanisms to cope with environmental heterogeneity. Because most organisms, and certainly plants, change their phenotype in response to environmental change. It is often assumed that phenotypic plasticity has frequently evolved as an adaptation to environmental heterogeneity. Many phenotypic responses to environmental stress, however, may be the consequence of passive reductions in growth due to resource limitation. Moreover, phenotypic plasticity does not necessarily evolve as an adaptation but alternatively can evolve due to genetic correlations with other traits that are under selection or due to genetic drift. Therefore, plasticity of a trait does not necessarily imply that it is adaptive (Clausen *et al.*, 1940).

Organisms can respond to environmental stress in such a way that their tolerance zones may change. Each species is fairly well adapted or fit, if it has been in its particular environment for many generations. The range of tolerance of a species may be narrow (*i.e.* species has a low ecological amplitude) or broad (*i.e.* species has a high ecological amplitude). Thus, organisms are "Slaves" to the physical environment, they adopt themselves and modify the physical environment so as to reduce the limiting effect of temperature, light, water and other physical conditions of existence. Species have wide geographical distribution, almost always develop locally adapted populations called ecotypes, that have optima and limits of tolerances adjusted to local conditions (Clausen *et al.*, 1939).

In this context the present work was undertaken for serval purpose, first to compare samples taken from the same natural population, but in different years and thus analyse, the genetic stability of a local population not only for its characters, but also for its plasticity. Second to provide a precise comparison of the different responses norms according to different ecological niches. Studies on flowering and leafing phenology have dramatically increased during the last few decades because changes in plant phenology can be indicative of possible effect of climate change at multiple scale.

MATERIALS AND METHODS

The performance of *Parthenium hysterophorus* was evaluated for responses to air pollution stress. Phenological variables such as relative growth rates in height Rh were measured in every season. Based on data of chlorophyll content, ascorbic acid content, pH, relative water content the APTI were determined. The monitoring of pollutant at study site was done by using high volume air sampler equipped with four impingers. Investigations have been undertaken to assess the ability of *Parthenium* to accumulate air pollutant on the basis of air pollution tolerance index (APTI).

RESULTS AND DISCUSSION

Population responses of species to various ecological factors are such as density-increase, herbivory, inter-specific competition, allelopathy and density-independent factors including microsite-characteristics with a view to discerning the mechanism of plant population regulation (Turesson, 1922a). Most of the ecological research findings are based on short-term observations without adequate emphasis on year to year variability. Phytosociology of roadside vegetation is important aspect to ascertain responses. Most changes in vegetation were limited to nonpalatable aggressive annuals with very little change in palatable grasses. One interesting change observed was initial rapid colonization and later replacement of *Parthenium hysterophorus*, a noxious invader, by other species along the roadside. The need for investigating pollutant tolerant phonological plasticity arises form two reasons. Firs the likely selective role of pollutant as evidenced from observation and second a need of comparative data concerning the phonological plasticity of different quantitative traits. At a given pollutant concentration a significant variability among parthenium population exists.

Ambient air quality data (Table 1) revealed deterioration in air quality at traffic intersections and relative height of plant decreased as compared to residential site. In each season plant showed bushy, rosette habit (Table 3). APTI made *Parthenium hystorophorus* more and more resistant, as it accumulated the pollutant (Table 2).

Table 1 : Monitoring of pollutant at study site

Sr. No.	Pramaters ($\mu g/m^3$)	Heavy traffic site			Residential site		
		1	2	3	1	2	3
1.	NO_2	67	54	52	44	21	25
2.	SO_2	44	58	53	32	25	27

(mean values 2002-2004)

Table 2 : APTI of *Parthenium hysterophorus*

Sr. No.	Plant	Heavy traffic site			Residential site		
		1	2	3	1	2	3
1.	*P. hysterophorus*	6.3	7.2	6.3	6.2	5	6.3

(mean values 2002-2004)

Table 3 : Mean values of plant height at different site in different season

Sr. No.	Season	Height of plant in cm.			Height of plant in cm.		
		Heavy traffic site			Residential site		
		1	2	3	1	2	3
1.	Summer	60	40	45	75	82	90
2.	Monsoon	25	15	20	85	90	95
3.	Winter	30	20	40	75	90	90

(mean values 2002-2004)

Environmental extremes and pollution stress create ecotypes in *Parthenium hystorophorus* as

– Plants are dwarfed and set seed quickly.

– Plants prostate to keep soil stable around roots, soil dry out quickly so plants set seed quickly.

– High SO_2 and NO_2 concentration make extreme dwarf population.

– 100 % defoliation.

– Defoliation at pre-flowering and formation of rosette.

– Defoliation at flowering and formation of rosette.

There was survival of 75 % individuals in heaving traffic density. This appars to be one of the most important findings that certainly has a major bearing on the range of adaptation of the weed. This information suggests that variation in fundamental functional trait would enable *Parthenium hysterophorus* to adjust to a variety of habitat conditions. In summer, if plants are stressed (due to lack of water), parthenium weed can complete its life cycle in four weeks.

Similar ecotypic characteristics can and do evolve independently in geographically separated populations. These similar phenotypic characteristics may, or may not, be mediated by similar genetic differences from other populations of the species (Turesson, 1925). Further, gene flow between different ecotypes is relatively common (Gregor, 1944). If there is sufficient selective pressure to maintain the genetic differences associated with the different adaptive phenotypes, other genes, not so associated, may flow freely between the populations.

The high potential fitness benefit of phenotypic plasticity tempts us to expect phenotypic plasticity as a frequent adaptation to environmental heterogeneity. Here are outlined requirements and potential constraints for the evolution of adaptive phenotypic plasticity. Studying plasticity along the pathway from gene expression to the phenotype and its relationship with fitness will help for better understanding why adaptive plasticity is not more universal, and to more realistically predict the evolution of plastic responses to environmental change. These experiments suggest that Parthenium weed may become more competitive in the future, as the level of carbon dioxide in the atmosphere continues to rise.

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