BULL. BOT. SURV. INDIA
Vol. 4, Nos. 1-4 : pp. 141-146, 1962

ECOLOGY AS AN AID TO FLORISTICS. I: ADAPTATION AND ECOTYPES

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ABSTRACT

The paper aims to demonstrate the role of the biological environment in shaping a plant species. Genetically and physiologically controlled demands and range of tolerance and their interactions produce a mosaic of populations. It is in these populations that 'ecads' and 'ecotypes' are distinguished.

The paper gives suitable examples of adaptations, ecads and ecotypes.

This has opened a new line of work in taxonomic studies. Slight differences in morphological or even physiological characters of otherwise similar species should not be taken to separate the species taxonomically. Only ecological experimentation will provide the final answer.

INTRODUCTION

The paper aims to demonstrate the role of the biological environment in shaping a plant species. Actually individual demands and range of tolerance and their interactions (as also interbreeding between genetical races) produce a mosaic of population, whether edaphic, zonal, altitudinal or regional. It is in this context that ecological study is of significance in many taxonomic problems.

Environment and organisms, both animals and plants, is a diphase system. A species can be pictured as a crystal of solute immersed in the solvent of its biological environment. If the solvent is suitable the species is dispersed homogenously and widely or otherwise precipitates and is discarded. The demands of the solute are according to its genetic and physiological characteristics. The environment in which a species grows is not a simple physical system but a biological complex. With this complex a species is intimately connected making an "inter-related whole" (according to the 'ecosystem' concept of Tansley, 1935).

Environment is galaxy of factors each with temporal and spatial aspects ; and a species grows in one or more media of soil, water and atmosphere. Temperature is also of great importance since it regulates metabolism. As pointed out by Misra and Puri (1954) photo-thermal requirements actually control the periodicity in plants, such as sequence of dormancy, germination and sprouting of buds, leaf fall and flowering and fruiting, as also thermal zonation of plants. The role of temperature in absorption and translocation of water and minerals is well known. Rainfall directly controls the moisture requirements in plants. In monsoonic country like ours the complete pattern and periodicity of plants is different from the temperate world. It has been shown by Went (1957) that the frequency of rains has a direct effect upon the growth of some plants in contrast to its general effects of humidity and soil-water supply. However, the periodicity of gain and loss of water in a terrain actually governs the distribution of types of vegetation.

Soils including soil-biota constitute the underground environment of a plant and are responsible for the supply of moisture and mineral nutrients.

The biotic factors, which are independent variables of the environment, not only disturb the physical surroundings but also affect the plant life directly.

Actually the components of the environment act and interact in various ways and degrees to produce a large variety of habitats for plant growth which is conditioned by temporal variations in their elements during the ontogenic phases of the plants. Putting it in terms of Weaver and Clements (1938) a species undergoes action, reactions and coactions amongst the elements of the environment and amongst themselves to present the existing mosaic of population.

ADAPTATION

Unlike a physical solute a species on its part also adapts itself to various degrees to be able to grow in the existing environmental complex. The adaptation may be purely physiological or any morphological characteristics may change, or both. Daubenmire (1959) opines that such features may ensure a degree of success either by allowing the plant to make especially full use of the amounts of nutrients, water, heat, or light available to it or by bestowing a significant amount of protection against some adverse factors.

The range of demands or range of tolerance may be narrow (with low ecological amplitude) or broad (with high ecological amplitude). Species with high ecological amplitude are adapted to greater fluctuations in the components of the environment. When genetically similar plants are grown in different habitats they show different features of growth, and to a certain extent, the characteristics of an individual develop according to the particular habitat. Sometimes the differences in the adapted structures are so large that a casual observer may mistake them, to be two different species. Thus for example *Marselia* grows right from the water to the dry margins of a pond. It shows broad leaflets with entire margins, long petioles and internodes when in water in contrast to highly serrated leaflets, short petioles and compact internodes when growing on dry margins (Pandeya, 1952).

Similarly, grasses *Bothriochloa pertusa* (Linn.) A. Camus and *Dichanthium caricosum* A. Camus have been shown (Pandeya, 1950-51, 53) to have large variations in their morphological characters under different habitats. In both the cases variations have been noted in habit form, number of culms, number of spikes per culms, number of spikelets per spike and total seed output. The variations which are found to be largely governed by intensity of grazing and soil moisture are

(i) The species under protection show 'basket form' habit, whereas in over-grazed areas they acquire 'Saucer shape' (text fig. 1).

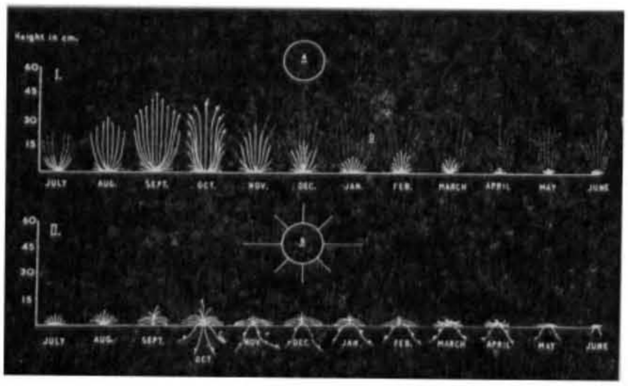

Fig. 1. Monthly variations in the growth form (habit), height and cover of *Bothriochloa pertusa* (Linn.) A. Camus and/or *Dicanthium annulatum* Stapf. under (I) moderate grazing and (II) intense grazing. A & B are the surface view of the spread of the grass.

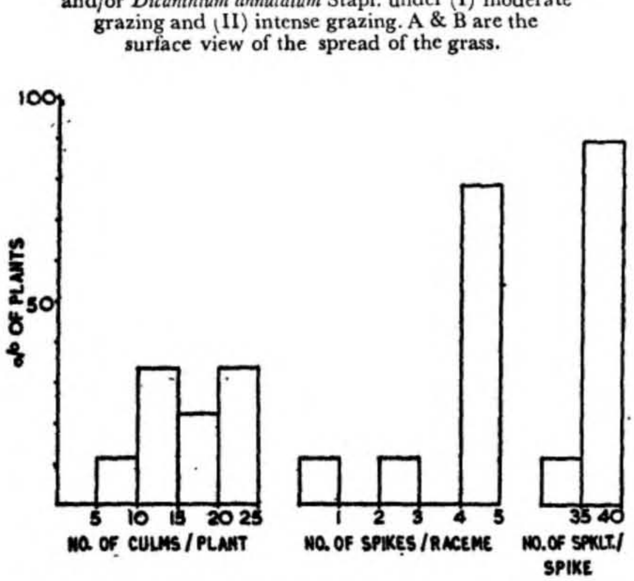

Fig. 2. Frequency of occurrence of the various morphological characters of *Bothriochloa pertusa* (Linn.) A. Camus as adapted under the various ecological conditions.

(ii) Variations in the other morphological characters of *B. pertusa* in relation to soil moisture and intensity of grazing are presented graphically in text fig. 2.

The variations in the morphological characters of the plants of *Dichanthium caricosum* are given in table 1 (also *see* plate 1).

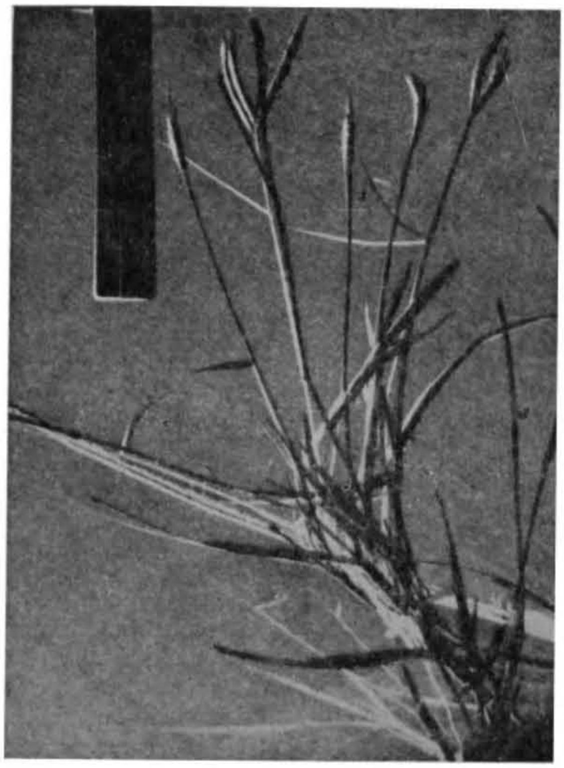

Plate 1. Plants of *Dicanthium caricosum* A. Camus with one, two and three spikes varies directly with the soil moisture.

From the figures and the table the effects of grazing and drought upon the plants can be summarized as:

Morphological features: The two species show reduced size of erect stem; reduction in the number of spikes per receme; reduction in the number of spikelets per spike; and reduction in the length and breadth of lower glume of spikelets.

Physiological: Development of red pigments, and initiation of early flowering.

In the above two examples of environmentally induced variations the fate of adaptation is rather paradoxical. The measurements of the morphological characters are less under drier situations as well as in moist places, exhibiting the same type of variations under diverse habitats.

The adaptations cited above are temporary features and are reversible.

A number of culture experiments were undertaken to confirm the variabilities of *Dichanthium caricosum* (See Pandeya, 1953). Plants with stunted growth having little foliage and mostly with one

TABLE I

MORPHOLOGICAL CHARACTERS OF THE PLANTS OF *DICHANTHIUM CARICOSUM* A. CAMUS FROM DIFFERENT LOCALITIES OF SAGAR (M.P.)

Locality	Soil moisture in % of dry wt. on March, 1952	Aver. height of plants in cm.	Aver. No. of spikes per raceme	Aver. No. of spikelets per spike	Length of Gl. i. of Sessile spikelets in mm.	Breadth of Gl. i. Sessile spikelets in mm.	Colour of spikes	Remarks
1	2	3	4	5	6	7	8	9
1 Along water drains supplying water to crop fields in University Gardens and farms	27.42	52.0	2 3 4 2 3	34 46 46 32 38	3.5 4.0 4.0 3.7 3.7	1.7 1.8 1.8 1.8 1.8	Greenish brown	No grazing
2. Crop fields, University Gardens and farm	9.64	75.0	2 3 3 2 4	32 40 30 34 40	3.7 3.9 3.6 3.6 3.8	1.8 1.8 1.7 1.7 1.8	Purplish green	No grazing
3. Crop fields Makronia village	8.30	75.0	4 3 2 1 2	64 48 36 28 32	4.2 4.0 3.8 3.7 3.7	2.0 2.0 1.8 1.7 1.7	Purplish green	Very mild grazing
4. University Botanical Gardens	8.05	75.0	3 3 3 4 4	36 36 44 44 40	3.7 3.7 3.9 4.0 3.8	1.7 1.7 1.9 1.9 1.8	Purplish green	No grazing and no cutting
5. Lime-rich soil on open slope	2.55	20.0	1 2 2 1 1	18 20 22 18 18	3.4 3.4 3.4 3.5 3.4	1.6 1.6 1.6 1.7 1.7	Purple	Severe grazing
6. Enclosure area in University Botanical Gardens	11.83	105.0	4 4 3 3 3	48 50 54 48 48	4.0 4.0 4.2 4.0 3.9	1.8 1.8 2.0 1.8 1.8	Greenish brown	No grazing and no cutting
7. Along high hedges in the University Botanical Gardens	10.23	200.0	4 4 3 3 3	60 60 54 54 52	4.2 4.2 4.0 4.0 4.0	2.0 2.0 1.9 2.0 2.0	Greenish brown	Severe grazing
8. University grounds (open plateau)	3.79	24.0	1 2 1 1 1	30 36 44 34 28	3.5 3.7 3.7 3.7 3.5	1.7 1.8 1.8 1.8 1.7	Purple	Severe grazing
9. Plateau of Gambheria Village	5.66	32.0	2 2 2 2 2	36 36 38 32 36	3.7 3.7 3.7 3.5 3.7	1.8 1.8 1.8 1.7 1.8	Greenish purple	Severe grazing
10. University grounds-open slopes	6.45	32.0	4 1 2 3 2	42 36 38 40 38	3.8 3.7 3.7 3.8 3.7	1.8 1.7 1.8 1.8 1.8	Greenish purple	Occasional grazing

spiked racemes were brought from grazed areas and having heavy interspecific competition. These plants were put in plots of sandy loam, and watered alternate days with no fertilizer or manure supplied to it.

Initial readings of the plants from various localities are given in table 2. The plants were allowed to grow thus for one year. After this period all the transplanted plants looked almost alike (data in table 2). This concludes that the variations were only somatic (or temporary).

In addition to the morphological characters the physiological characters are also adapted. Thus it has been observed by Pandeya and Goswami (1962) that the osmotic pressure of *Acanthospermum hispidum* DC. varies inversely with the soil moisture. The results were confirmed by growing the plants in a large variety of soils and with different intensities of watering. The data confirm each other. (*See*—text fig. 3) Levitt (1956) is of the opinion that this characteristic does not enable xerophytes to extract more water from the soil, nor is it believed to play a significant role in reducing transpiration. Possibly the high osmotic pressure (Daubenmire, 1959) of plants in dry regions is no more than a development necessitated by the high solute content of the unleached soils.

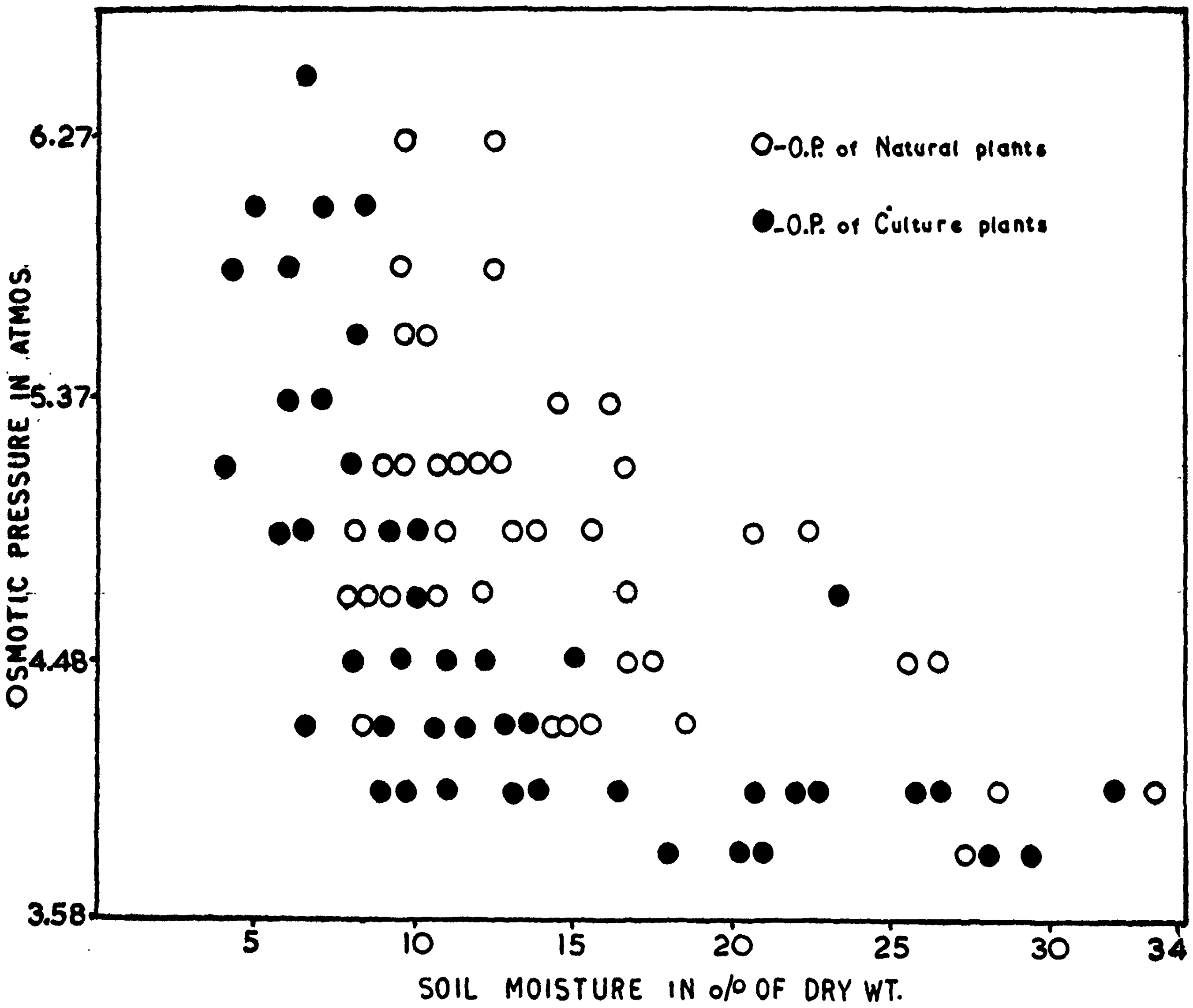

Fig. 3. Variations in the Osmotic Pressure of *Acanthospermum hispidum* DC. (both natural and culture plants) with soil moisture.

Such plants with somatic variations in their morphological and physiological characters are called as 'ecads' or 'ecophenes'.

ECOTYPES

In many other cases the adaptations become irreversible or genetically fixed variations. Daubenmire

(1959) concludes that such variations arise only by changes in the structure of genes within chromosomes, recombinations of genes through hybridization, or irregularities during mitosis or meiosis that change the number of chromosomes per cell. Such adaptations are now believed to have arisen by the selective action of environment operating as a sieve or genetic variations, the origin of which are

TABLE II

(1) MORPHOLOGICAL CHARACTERS OF *DICHANTHIUM CARICOSUM* A. CAMUS PLANTS BEFORE TRANSPLANTING

Locality	Condition of growth	Height of plants in cm.	Length of inter-nodes in cm.	No. of racemes	Aver. No. of spikes per raceme	Length of spikes in cm.	No. of sessile spike-lets	Length of GL.i. of Sessile-spikelets in mm.	Breadth of GL.i. of Sessile spikelets in mm.	Aver. length of leaf in. cm.
1. Crop fields, University grounds	Under heavy inter-specific competition	80	15.8	21	1	4.1	26	3.7	1.6	11.5
2. Botanical Gardens	Occasional cutting	35	10.5	8	2	6.4	34	3.8	1.8	17.5
3. Open limerich slope	Under severe grazing	15	4.6	1	1	3.1	18	3.4	1.6	5.4
4. University plateau	Under severe grazing	20	4.4	1	2	3.8	26	3.7	1.7	6.5
5. -do-	-do-	15	4.0	2	1	3.6	22	3.5	1.7	6.3
(2) MEASUREMENTS OF AN AVERAGE PLANT AFTER ONE YEAR OF CONTROLLED GROWTH										
Culture plants. No cutting, no grazing and no manuring. Watered on alternate days		95	11.5	16	3	7.6	56	4.0	1.8	19.0

strictly matters of chance. Thus many species have mosaic of populations, each of which is distinguishable in genetically based physiologic (and sometimes morphologic) features having survival value. This has been designated as an "ecotype. It was Turesson (1922) who found that the differences recognisable in the field between populations of the same species occupying diverse habitats were maintained in the experimental garden, even when they were grown starting from seeds.

In India, Misra and Siva Rao (1948) first established the ecotypic differences in *Lindenbergia polyantha* Royle. Ramakrishnan (1958, '60 & '61) has established ecotypic differences in some plants of Varanasi.

Of the two ecotypes recognised in *Euphorbia hirta* Linn. by Ramakrishnan (1960) one is the 'erect type' occurring in moist localities and the other 'prostrate type' in dry hard soils. According to him the prostrate compact type is a product of the prostrate type under the influence of trampling and other biotic influences on footpaths. The distribution of these two forms appears to be controlled according to their ability to withstand drought and survive in dry hard situations. In another communication, Ramakrishnan (1961) describes two inter-breeding ecotypes of *Euphorbia thymifolia* Linn.: (i) red form, having a red colour throughout the plant body and (ii) the green form. Upon hybridization, the F^2 plants segregate in the ratio 15:1 in which 15 represent different grades of red colour of the plant body and the one being pure green form. Thus, altogether five forms have been recognised. These are found in nature also. It is found that first two forms mentioned above can grow in calcium-rich soils and calcium-poor soils while the latter 3 forms can thrive only in non-calcareous soils. The first two hybrids have been called as facultative calcicole and the other 3 as obligate calcifuge. The obligate calcifuges are very sensitive to calcium with regard to their germination and seedling growth. It has been discussed that the calcifuge habit of plants in the tropics is not necessarily accompanied by acidity of the substratum. Thus, two ecotypes have been established in *E. thymifolia*: (a) The red form and (b) the green form, the former being tolerant of calcareous as well as non-calcareous soils and the latter thriving only in non-calcareous soils.

Ecotype is not only differentiated by edaphic, microclimatic or biotic factors but also where a species extends across several climatic zones it may evolve a distinct climatic ecotype in each. Further, a single ecotype may, under suitable stimulus, be represented in several habitats by many ecads, and for this reason the critical delimitation of ecotypes within a species requires experimentation.

DISCUSSION

A species gets adapted to variations in the biological environment in which it grows. These adaptations may be just environmentally induced variations in which case they are called as 'ecads' or they may become genetically fixed giving rise to 'ecotypes'. It was only in the times of Turesson (1922) that genetically distinct races of a species (or ecotypes) became established.

Persistent differences among ecotypes growing in the same environment verified earlier conclusions that a taxonomic species is not a single ecologic unit but is composed of numerous genetic races which exhibit inherent differences in physiological as well as often in morphological characters. The ecotypes were observed to differ in earliness of flowering, height, erectness, thickness and colour of leaves, etc. But the differences were not sufficient to warrant taxonomic recognition and often showed intergradation.

It is these observations which have given new line of work in taxonomic studies. Slight differences in morphological or even physiological characters of otherwise similar species should not be taken to separate the species taxonomically. Only ecological experimentation will provide the final answer.

There is also a necessity of revision of any such taxonomic nomenclature which is based on morphology alone.

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