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ECOLOGY AS AN AID TO FLORISTICS. II—AUTECOLOGY

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ABSTRACT

Paper describes how autecology can, (i) distinguish between species which are genetically different but otherwise look similar, (ii) species which have been given different latin names on the basis of morphology alone and which are only ecological variants of a particular species ; and (iii) the distribution of a species.

Suitable examples have been described for each study.

A tentative scheme has also been given for Biological Flora studies for unification of the work.

In the first paper of this series has been described the role of the environment moulding a plant species both morphologically and physiologically giving rise to mosaic of populations which may be somatically and/or ecotypically different. The various adaptations can best be recorded by compiling 'Biological Flora' of a region. Biological flora is an account of species of a region in which each species is realised as a growing, reproducing and dispersing unit within a biological environment. This is against the conventional flora based on mere collection of plants and building herbaria. The British Ecological Society who has adopted the concept of Biological flora has investigated the same on autecological basis.

Autecological study essentially deals with those phases of the structure, function and evolution of a species which are directly or indirectly related to its biological and physical environment. Or, as pointed out by Misra and Puri (1954) autecological studies give an assessment of potential and real aggressiveness and susceptibilities of a species under varying conditions of environment ; the means of regeneration, dispersal, growth and development of plants and their effectiveness are also studied.

Such studies have been only recently initiated in this country. Nevertheless, the work of the last decade has amply illustrated the significance of characterising a species by their biological potentialities within an ecosystem.

In the present paper will be described how autecology can distinguish between species which are genetically different but otherwise look similar ; species which have been given different latin names on the basis of morphology alone and which are only ecological variants ; and lastly the distribution of species.

I

Pandeya (1950-51) has ecologically differentiated the grasses *Bothriochloa pertusa* (Linn.) A. Camus and *Dichanthium annulatum* Stapf. The two plants are much alike. The plasticity of the two grasses, as regards the nature of substratum (soil), seems to be responsible for their wide distribution. Light grazing seems to favour their growth but in intensely grazed areas they grow into depauperate form. Ecological variabilities of the two grasses seem to be mainly due to grazing, moisture content and lime content of soil (*cf.* table 1). There is shown a quantitative correlation between exchangeable calcium and sesquioxides and fresh weight of the plants.

Spectro-graphic Analysis : Spectrographic analysis of healthy plants of the two grasses was done in order to examine the differences between the chemical constituents of the two grasses. From the same stand at two different spots plants of the two species were collected. Two samples of each plant were taken. Soil of the two spots was also collected. Plants were oven-dried at 110°C. Next they were ashed at 500°C in a muffle furnace. The ash so obtained was examined spectrographically. Soil samples were treated similarly. The spectrographic bands obtained were converted into approximate quantitative value. For each grass, bands of the two samples are put together with the respective soil band in the middle (*see* table 2). The table gives approximate amounts of only 10 major mineral elements.

Table 2 reveals that chemically the two species are very much similar. The 10 elements reported have almost the same amount in both the cases.

It can be said from the present study that the two species, viz., *Bothriochloa pertusa* and *Dichanthium annulatum* are ecologically much similar.

A comparison in the morphological and ecological characters of the two grasses are given in table 3.

II

In another communication Pandeya (1953) has given the morphology and ecology of 3 species of the genus *Dichanthium* Willemet. The genus belongs to the tribe Andropogoneae of sub-family Panicoideae. Haines (1924) has described 3 species of this genus. To this Blatter and McCann (1935) have added four more species. Linnaeus (as quoted

TABLE 1

VARIATIONS IN THE MORPHOLOGICAL CHARACTERS OF *BOTHRIOCHLOA PERTUSA* (LINN.) A. CAMUS (B) AND *DICHANTHIUM ANNULATUM* STAPF. (D) ANALYSIS OF THE CORRESPONDING SOIL SAMPLES AND INTENSITY OF GRAZING

Localities	Plant measurements: No. of culms per plant		No. of spikes/ culm		Aver. No. of spikelets/ spike		Seed output		Soil Characters (In % Dry. Wt.): Water content (Sept)	pH	Organic Carbon in mgm./ 100 gm. soil	Total Nitrogen	Exch. Calcium	Exch. Sesquioxides	Intensity of Grazing
	B	D	B	D	B	D	B	D	SOIL						
Along Hedges in Univ. Gardens	30	24	5	6	40	34	6,000	4,896	22.12	7.5	425	0.136	0.2010	1.2000	Occassional to nil
Vill. Makroni Slopes	25	15	5	6	40	32	5,000	2,880	14.46	6.7	575	0.112	0.0856	0.0845	Moderate
University Farm	25	14	5	6	40	32	5,000	2,688	20.28	7.0	Above 600	0.132	0.6650	0.1650	Moderate
Vill Makronie N. Slopes	20	10	5	6	40	32	4,000	1,920	13.61	6.5	575	0.106	0.0521	0.0052	Intense to Moderate
Patharia Forests	20	15	5	5	40	32	4,000	2,400	9.70	6.9	Above 600	0.224	1.0080	0.0920	Moderate to Nil
Along Sonar River	16	20	5	6	40	32	3,200	3,840	15.62	7.2	475	0.106	0.5750	0.1200	Moderate
University Grounds, down slopes	15	10	5	6	40	32	3,000	1,920	17.20	7.6	300	0.091	1.3740	0.1200	Moderate
Botanical Gardens	15	12	5	6	40	32	3,000	2,304	19.30	7.2	Above 600	0.177	0.6200	0.2350	Occassional clipping
University Grounds, Along Streams	15	10	3	6	40	32	1,800	1,920	36.20	7.3	Above 600	0.120	0.5960	0.1560	Intense
University Grounds, Forming association	12	15	1	5	35	32	420	2,400	19.31	7.2	Above 600	0.117	0.6200	0.2350	Intense

TABLE 2

SPECTROGRAPHIC ANALYSIS OF THE PLANTS OF *BOTHRIOCHLOA PERTUSA* AND *DICHANTHIUM ANNULATUM* AND THE CORRESPONDING SOIL SAMPLES

Elements	*Bothriochloa pertusa*			*Dichanthium annulatum*		
	Plant sample No. 1	Soil	Plant sample No. 2	Plant sample No. 1	Soil	Plant sample No. 2
Calcium	40	100	30	40	90	40
Magnesium	30	50	30	30	40	30
Sodium	Absent	15	Absent	Absent	10	Absent
Potassium	10	25	15	10	20	15
Silicon	35	10	40	30	45	30
Aluminium	10	20	15	15	20	15
Manganese	10	30	5	10	15	10
Iron	15	30	20	15	20	15
Litanium	10	20	10	15	25	10
Barium	5	20	5	5	15	5

TABLE 3

MORPHOLOGICAL DIFFERENCES AND ECOLOGICAL BEHAVIOUR OF *BOTHRIOCHLOA PERTUSA* (WILLD.) A. CAMUS AND *DICHANTHIUM ANNULATUM* STAPF.

1. Morphological Differences :

Characters	*Bothriochloa pertusa*	*Dichanthium annulatum*
(*i*) Root Stock	Thin, small and buiged	Thick and paddy
(*ii*) Stems & Culms	Sub-erect	Erect
(*iii*) Leaf	Ligule truncate, round and ciliate	Ligule oblong and non-ciliate
(*v*) Spikelets : Sessile		
(*a*)	Eliptical compressed and dorsally awned	Ovate, dorsally compressed, callus small, shortly bearded
(*b*)	Lower glume flat on back, hairy below middle, keels ciliate upwards	Lower glume papyraceous, margins narrowly keeled, upper glume depressed
(*c*)	Pit present in lower glume	No pit in lower glume
Pedicelled	Mostly reduced. Pit in lower glume	No pit in lower glume

2. Ecological behaviour :

(*i*) Habit	Perennial	Perennial
(*ii*) Phenology	Flowers : Sept. to Nov.	Flowers : Oct. to Dec.
(*iii*) Seed studies :		
(*a*) seed output	Average : 3, 505	Average : 2, 795
(*b*) % germination	43.3%	45.6%
(*iv*) Optimum growth conditions : SOIL CHARACTERS :		
(*a*) pH-value	7.2	7.0
(*b*) Org. Carbon	Above 600 mgm.	Above 600 mgm.
(*c*) Soil Moisture	19.3% (In % dry wt.)	20.28% (In % dry wt.)
(*d*) Total Nitrogen	0.117%	0.132%
(*e*) Exch. Calcium	0.235%	0.665%
(*f*) Exch. Sesquioxides	0.235%	0.165%
(*v*) Plant Analysis		
(*a*) Fresh wt.	27 gms.	75 gms.
(*b*) Dry wt.	15.7 gms.	19.2 gms.
(*c*) Ash Content	10.5% (in % dry wt.)	11.5%
(*vi*) Ash Analysis		
(*a*) SiO_2	3.26% of dry wt.	4.40%
(*b*) Fe_2O_3	1.63%	1.70%
(*c*) CaO	1.01%	1.54%
(*d*) Al_2O_3	2.17%	1.85%
(*vii*) Total Nitrogen	4.15%	5.12%

by Haines, 1924) described *Andropogon caricosum* Linn. (Syn. *D. caricosum*)—with solitary spike; and Willdenow has said 'leaves with sparse hairs and sheaths hirsute at bases'. Haines has further described a robust variety of *D. caricosum*, viz., var. *mollicomus*. The variety is considered to be the same as *Dichanthium nodosum* Will. by Fischer in Gamble's Flora of the Presidency of Madras (1934).

The description of Haines for *D. caricosum* tallies with the stunted plants of the species, at least in Madhya Pradesh, where the studies were made. The plants of this species have 1 or 2 spikes in over-grazed and dry areas. The species grows in robust form in reserved grasslands, and in association with scrubs in gardens and cultivated fields where they get regular supply of water all the year round. Detailed autecological study of *D. caricosum* was, therefore, undertaken on experimental basis. From the culture experiments a polygraph (text fig. 1) has been drawn to designate the initial measurements of the plants before transplanting—(3 plants were chosen: i—under heavy inter-specific competition, ii—under severe grazing and in lime-rich soil, and iii—under severe grazing but on black cotton soil) and the resultant growth after one year of controlled and similar conditions.

It is seen that diagrams 'HLSGH' and 'hlsgh' are much similar in shape.

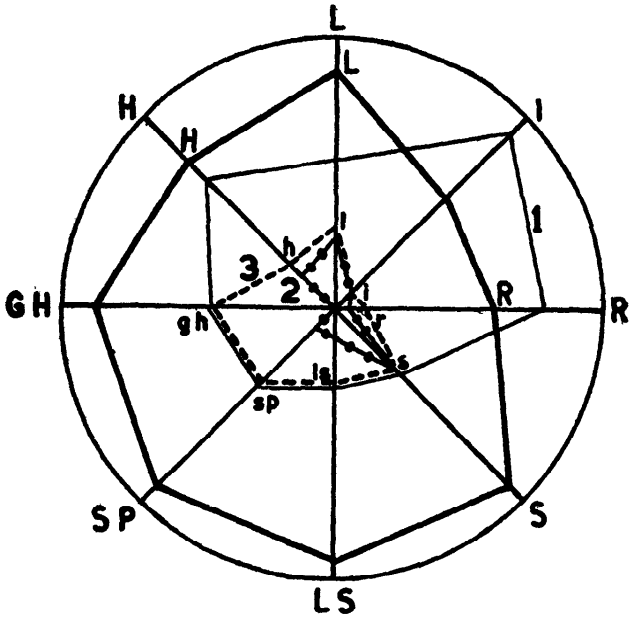

Fig. 1. Polygraph for the size and shape of the plants of *Dicanthium caricosum* A. Camus from three localities (numbered 1, 2 & 3 and with details in the text) before transplanting and of the plant after one year of controlled growth. (H, Height of plants; L. Average number of leaves; I, Length of internode; R. number of racemes; S, Average number of spikes per Raceme; LS, Length of spikes; SP, number of sessile spikelets; GA, Length of glume *i* of the sessile spikelet; and GB, Breadth of glume *i* of sessile spikelet.)

It is further found that the lengths of the leaf and the spike have correlated in growth as shown in text fig. 2. The data are taken from the culture plants for points 'A' at the time of transplanting and 'B' (after one year of controlled growth). Points 'C' have been put for the spike-leaf relation of a number of robust plants, (hitherto called as *D. nodosum* or *D. caricosum* var. *mollicomus*) as found in nature. The variations are, therefore, continuous and belong to a uniform population of the species.

From the study it has been concluded that probably *D. caricosum* var. *mollicomus* (or *D. nodosum*) is just an ecad of *Dichanthium caricosum* A. Camus.

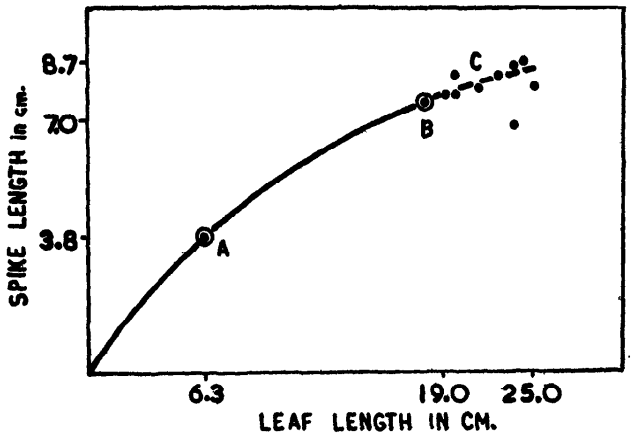

Fig. 2. Leaf-spike relation of *Dicanthium caricosum* A. Camus.

III

Autecology also helps in exploring the reasons for the pattern of distribution of a species.

Thus Pandeya and Awasthi (1959) and Pandeya and Goswami (1962) have examined the wide distribution of *Acanthospermum hispidum* DC. on autecological basis.

The species, an annual herb, belonging to the family Compositeae is new to India. During 1948-49 we observed its accidental occurrence at Sagar and Pachmari in Madhya Pradesh. Rev. Fr. Santapau first noted it in Bombay and published a small note on it. After this, in a private communication, he observes as follows: "I have seen the plant covering enormous areas near Junagadh in Saurashtra, certainly an area about 20 miles long and more or less 4-5 miles wide, at a place from which the forest has been recently removed. On the slopes below Purandhar Hills, Poona Dist. I first noted one or two plants at the very base; some two years later (1950) I saw several plants about half way up the hill". Since 1949, within our observations the plant got widely distributed in thick colonies in Madhya Pradesh. With the help of extensive culture experiments it has been shown that the species grows in a wide variety of habitats with respect to physical and chemical nature of the soil. However, the plants have best growth in well aerated soils which are neither water-logged nor dry. No correlation could be established between the growth measurements

(taken as a function of the environment) and soil chemical characters. Further, the plant produces a large number of seeds which do not require any dormancy. These factors have contributed to the wide-spread distribution of *Acanthospermum hispidum* DC.

Pandeya and Jain (1960) and Pandeya (1962) have accounted for the limited distribution of tree species, as well, on autecological basis (also *see* Jain, 1958, 60 & 61 and Joshi, 1958 & 59). They have studied the autecology of *Shorea robusta* Gaertn.f. (sal) with special reference to Madhya Pradesh.

Sal has a very restricted distribution and occurs

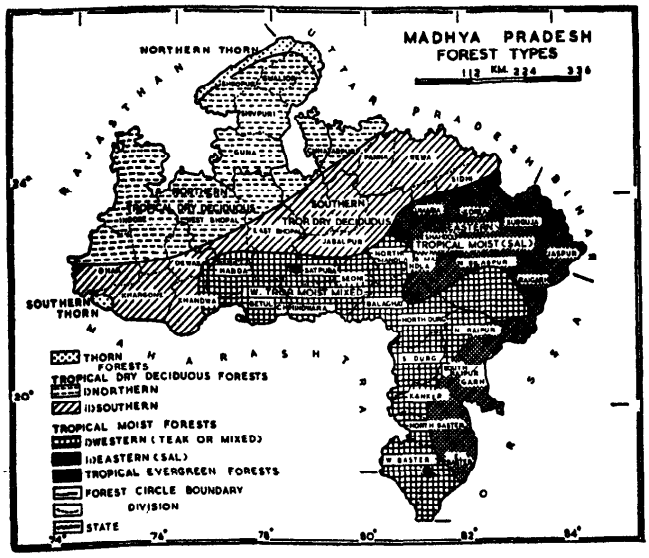

Fig. 3. Vegetational Map of Madhya Pradesh.

in India in two belts, viz., the northern belt of sub-Himalayan zone and the other in eastern parts of Madhya Pradesh interrupted by Chattisgarh plains (*cf.* text fig. 3).

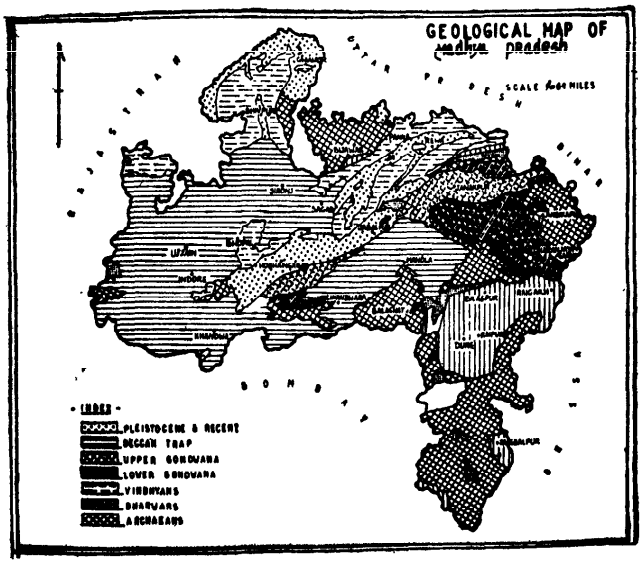

Fig. 4. Geology of Madhya Pradesh.

The autecological studies on sal included a phyto-sociological analysis of all the forest types of Madhya Pradesh (viz., sal, teak and mixed forests) by belt transect method, analysis of top soils and soil profiles for the physical and exchangeable elements, seed studies, leaf analysis and lastly climatic considerations of the sal and non-sal zones of the state. The field observations were also confirmed by culture experiments.

From text fig. 4 it can be said that trying to correlate the distribution sal forests with geological formations will be just a futile attempt since the forests are found on all types of lithology ranging from the oldest to recent deposit including basalt (Deccan trap). The study of soils and soil-profiles reveals that in mixed forests the profiles are neutral to alkaline (*cf.* text fig. 5) with varying amounts of

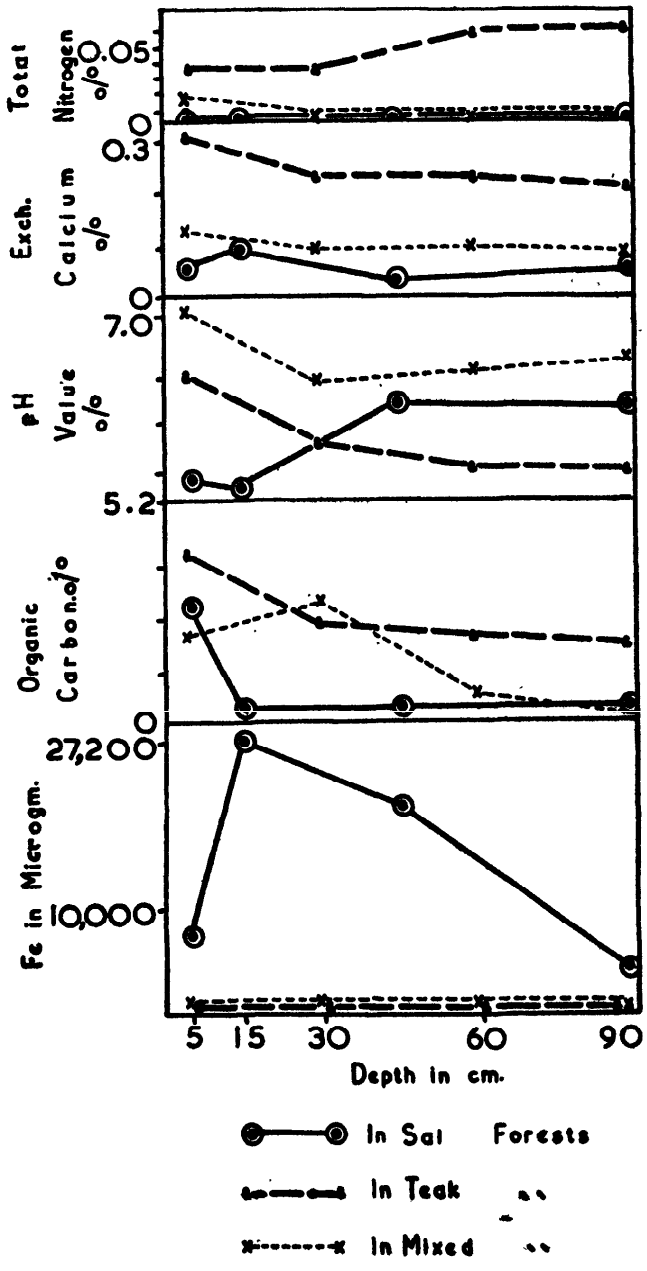

Fig. 5. Soil-Profile characters of the three forest types of Madhya Pradesh.

calcium depending upon the parent rocks. The teak (*Tectona grandis* Linn.) forests have almost neutral, immature and base rich soils, although the bases are poorer in comparison to those of mixed forests.

Sal soil profiles studied in C.P. quality I forests of S. Raipur (Karka) and E. Jagdalpur (Machkot) are similar although the former is on alluvium and the later on Cuddappah lime [*cf.* Plate 1 (A & B)]. The sal soils, in general, are leached down ones and are slightly acidic, poor in bases and rich in iron. Since good quality sal growing on different rocks has almost similar soils it may be said that leached soils probably have no bearing on the parent rock. Accordingly, under certain limits, all the soils under sal were found similar irrespective of underlying rock. On this basis the soils, which are dependent variables (depending for their formation on climate, vegetation and lastly lithology) can not be taken as a governing factor for the distribution of a species.

Attention was, therefore, drawn on climatic factor. It was found that sal grows in areas with heavy rainfall; teak in good to moderate rainfall and

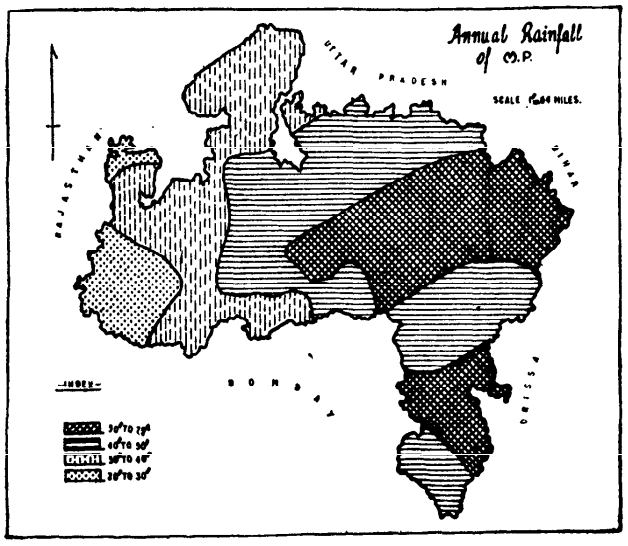

Fig. 6. Rainfall Map of Madhya Pradesh.

mixed forests in moderate rains. (*cf.* text fig. 6). Details of mean maximum and minimum temperatures and annual rainfall of the various districts of the state for the year 1957 are presented in table 4. The climo-vegetational relationship is noted as follows:

Forest	*Mean max. temp. °C.*	*Mean min. temp. °C.*	*Annual Rainfall mm.*
Sal	31.4	19.07	1,229,09
Teak	32.1	19.20	1,226,90
Mixed	32.5	19.80	10,411,70

Variations in monthly rainfall, local or monsoon, are to some extent governed by altitude also. Thus sal is generally concentrated on hilly areas where the humidity is high all the year round, temperature is mild and lastly the monsoon breaks by the start of June which should coincide with the 14 days viability period (here critical period) of sal seeds.

TABLE 4

MEAN MONTHLY TEMPERATURE AND RAINFALL OF SAL AND NON-SAL ZONES OF MADHYA PRADESH FOR 1957

Months	Mean Temperature °C		Aver. Monthly Rainfall in mm.	
	Sal	Non-sal	Sal	Non-Sal
January	19.39	21.00	31.23	163.10
February	20.14	31.60	2.70	3.14
March	22.33	25.13	66.45	46.58
April	29.16	30.33	16.69	36.74
May	32.95	33.25	17.53	14.44
June	31.62	32.16	86.20	109.54
July	26.13	27.17	420.32	275.44
August	26.53	26.00	446.59	327.98
September	26.53	26.61	128.53	128.86
October	23.26	26.00	14.15	21.24
November	21.87	22.89	0.66	—
December	19.94	22.54	0.91	—

All those points converge on the continuous and higher moisture, mild temperature and consequently altitudinal requirements of sal which appears to account for its limited and restricted distribution.

DISCUSSION

In the paper, examples have been described which attempt to solve some of the taxonomic problems with the aid of autecological studies.

Such autecological studies can be profitably employed to explore the Biological flora of a region.

For the unification of Biological Flora studies, a tentative scheme is drawn here subject to modification with experience.

1. Systematic position and taxonomy of the species
2. Morphology and range of variations in structures
3. Distinguishing of ecads and ecotypes, if any
4. Geographical distribution
5. Associates of the species
6. Habit:
   (a) Variations in habit or growth from
   (b) Stomatal index and its variation
   (c) Osmotic pressure and its range
   (d) Root system
7. Genetic features: Chromosome number and its variation.

8. Seed and its germination:
   (i) Seed studies
   (ii) Seed output
   (iii) % germination
   (iv) Viability and seedling mortality
   (v) Reproductive capacity.
9. Phenology
10. Pollination and dispersal of seeds
11. Environmental factors (Habitat):
   (a) Climatic and plant growth
   (b) Soil and plant growth
   (c) Biota and plant growth
12. Culture experiments to confirm field observations and growth behaviour.

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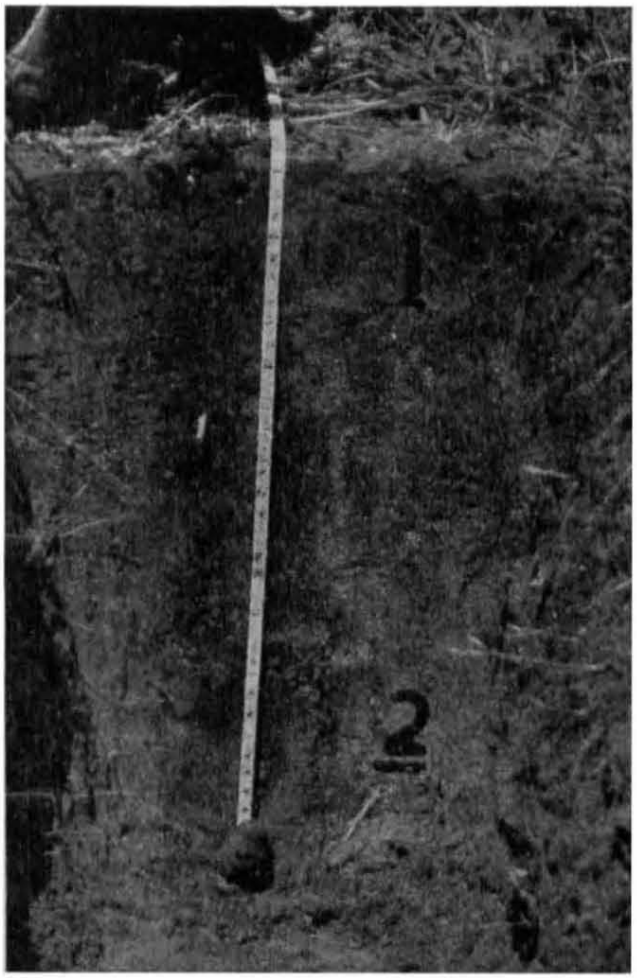
PLATE 1



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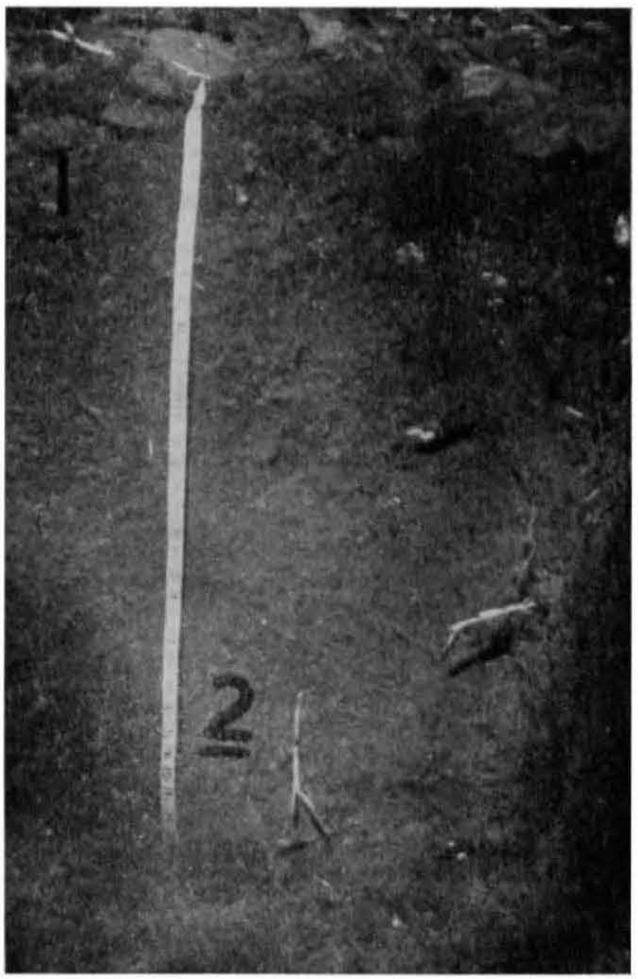

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