ECO-PHYSIOLOGICAL INVESTIGATIONS ON THE WATER BALANCE OF THREE IMPORTANT SPECIES OF JUNIPER FOREST TRACT AT ZIARAT (BALUCHISTAN)

by

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Introduction. *Dry juniper forest of Baluchistan is an open type of forest with* Juniperus excelsa *M. Bieb as the principle tree species and a plenty of shrub growth in much open spaces (TROUP*, 1921; *CHAMPION et al.*, 1965). *The average number of juniper trees per hectare have been estimated at hardly twenty eight (KHATTAK*, 1976) *and* Caragana ambigua *and* Pervoskia abrotenoides *are amongst the most frequent of the shrubs. Caragana is a medium sized bush growing on gritty sites while Pervoskia is a herb with bulbous thick tap root, lush green and a dominant colonizer of river beds and leaves (ZELLAR and BEG*, 1969).

The climate of this tract is cool but extremely dry because of limited rainfall. In the absence of good meteorological records in the past the climatic statistics of this area are scanty and nothing definite could be said. The loose information indicates (TROUP, 1921) 12 *in. of rainfall, which is erratic and about half of it is in the form of snow. Recently this institute has established an observatory at Ziarat and the data collected during the year* 1976 *is reproduced in Appendix.*

The tract is hilly and rugged, the main rocks being Siwalik—conglomerate, sandstone, Phar limestone and Ghazij shales. The soil is poorly developed with a shallow profile.

Under such conditions where water is the most critical climatic element an investigation was conducted to compare the water relations of juniper with those of its two common associated plants in respect of their rates of transpiration, stomatal behaviour, plant water contents and water deficit so as to have an understanding about their capacity to exhaust soil moisture or resist desiccation.

Material and methods. The experiment was conducted on September 16, 1976 on a single plant of each of three species growing around Forest—Rest House at Ziarat; Longitude 67°-44′ E, Latitude 30.23 N and at an altitude of 2450 m above sea level. The candidate tree was about 5 m in height and 20 cm in diameter at breast height; the bush of Caragana was moderate in size and unbrowsed while plant of Perovskia was lush green and flowering. The soil was shaley and rich in moisture as unusual heavy rain had occured a week before (79 mm). To determine different factors, observations were taken by three workers observing simultaneously at three hours intervals starting from 6 a.m., till 6 p.m.

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Transpiration measurements were made by rapid weighing of detached shoots with the help of a torsion balance (HUBER balance). Details of the technique can befound in our recent publication (1977). All values are calculated on fresh weight basis and expressed as mg transpiration/g fresh weight/minute.

The method employed to establish the form of curves representing stomatal reaction in shoots without regular supply of water was as follows: the shoot was cut from the respective plant, hung on one arm of the balance and its initial weight determined within seconds. Further measurements were made at successive time interval: 15 minutes, 30 min., 45 min., one hour, tow hours and so on. Later these specimens were oven-dried at 105°C and the water contents for respective reading was expressed as percent of oven dry weight. The difference between the two successive readings divided by time elapsed, gave the rate of water loss during that time interval.

The behaviour of stomatal opening and closing was determined by examining the freshly pealed off strips of epidermis under microscope without fixing. An average vale of ten stomata was calculated to represent the state of stomatal opening.

The water contents of the shoots were determined by the following formula and expressed as percent of oven dry weight:

$$\% \text{ water content} : \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Oven dry weight}} \times 100$$

Water deficit was determined by WEATHERLEY's method of relative turgidity as described by SLATYER and MCLLROY (1961).

Temperature and relative humidity were measured by a mechanically operated psychrometer, while evaporation was determined by Piche evaporimeter by suspending it with the stem of the tree and protecting it from solar radiation. (plotted in Figure 1-c).

Results. *Daily march of transpiration:* The data in respect of each of the three species is plotted in Figure 1-a. The transpiration curve of Perovskia differs from rest of the two species in being highly rated during whole of the day and the rate of transpiration is about 2.5 mg/g fresh weight/min. The curve of Caragana took a smooth start in the morning steadily ascending to a value of about 2 mg/g/min., by noon and finally touched the maximum value in the evening. The curve of juniper occupies lowest orientation in the graph, is low rated intranspiration and the peak value is about 1.3 mg/g/min.

Stomatal reaction in cut shoots: The stomatal behaviour in cut shoots is plotted in Figure 2-a; -b; -c. The stomatal reaction, in general are of the usual pattern as noticed by many workers (QURAISHI and KRAMER, 1970; FERRI, 1960) in such investigations and the physiological state of the tissues has been atributed to the pronounced fluctuations

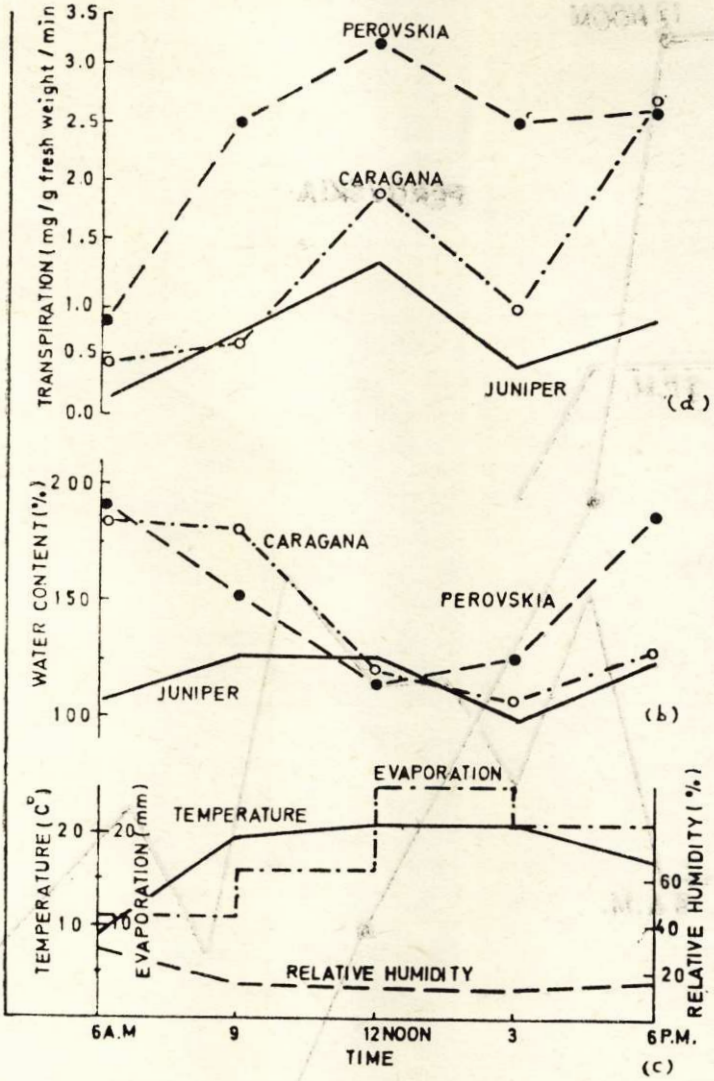

Figure 1. Daily march of Transpiration, Water Contents and Physical factor Date 16-9-1976.

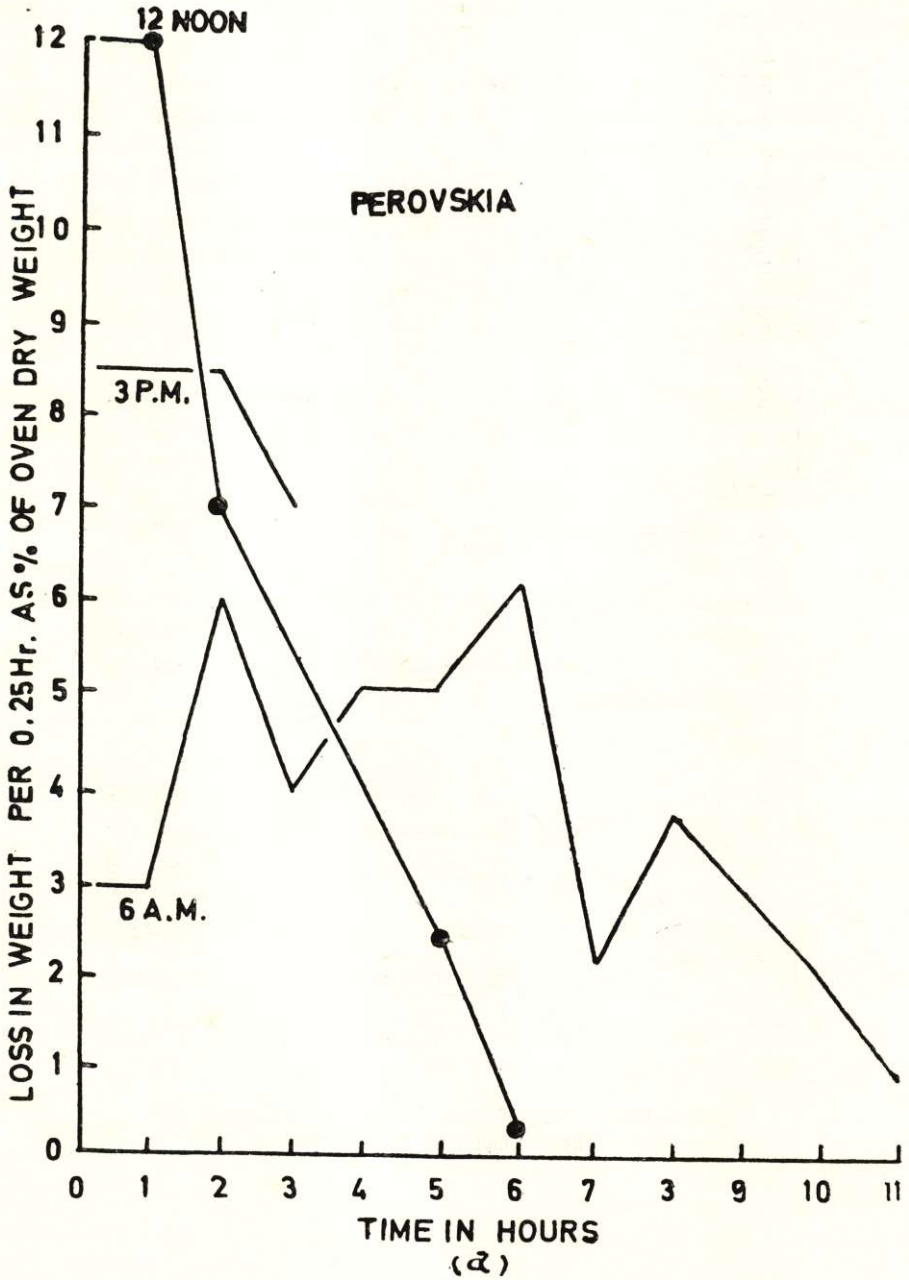

Figure 2 (*a*) Showing stomatic reaction in cut-Shoot and water loss in *Perovskia.*

observed in opening and closing behaviour during different times of the day. The behaviour of stomates in controlling water loss under severe moisture stress is described below, respectively taking the curve of 12 noon as representative one:

(*i*) In Figure 2-a, the 12 noon curve indicate that Pervoskia lost almost all of its initial water contents within six hours. This shows lack of any control on water loss—stomatal or cuticular.

(*ii*) In Figure 2-b, the 12 noon curve of Caragana follows a step wise decend and the rate of water loss is low (6.25%) and each step indicates closing of stomates associated with cutting down water loss followed by reopening and increase in water loss. This type of stomatal mechanism is better than that of Pervoskia.

(*iii*) In Figure 2-c, the 12 noon curve of juniper follows a steep descend associated with closing of stomates within 2 hours and the rate of water loss is just 2.75% of the total water contents during the first hour with further decrease later on. This indicate efficient control over water loss by quick closing of stomates and minimum cuticular transpiration than rest of the two species described above.

Degree of stomatal opening during day time: In Pervoskia, the stomates remained wide open during the whole of the day, while this state was observed at about noon in both Caragana and juniper. In Caragana, the stomates partially closed in after noon followed by wide reopening at about evening.

Plant water content: The plant water contents in respect of each species is plotted in Figure 1-b. The value of water contents in both Caragana and Perovskia is of highest order in the morning in the range of about 185% of their oven dry weight followed by a substantial decrease in this quantity (120%) which persisted till 3 p.m. Later, the water contents started increasing as the climatic conditions became favourable. In the case of juniper, the water contents were comparatively much lower than those of the above mentioned species and fluctuations were inbetween 110 to 125%.

Water deficit: The state of water deficit is plotted in Figure 3. Except the curve of juniper, the curves of both, Caragana and Perovskia occupy a higher order of water deficit during most of the day. In Perovskia, the water deficit was of the highest order and fell mostly in the range of about 30%, next is Caragana, where the value was about 20%, the juniper had the lowest waterdeficit during the whole of the day and was about 13%.

Discussion. It is evident from the results that *Juniperus excelsa* is physiologically the most highly adapted species to the habitat and its locality factors as compared to *Caragana ambigua* and *Perovskia abrotenoides* because of its lower rate of transpiration lower water contents, lower water deficit, and better control on stomatal behaviour under normal as well as abnormal conditions.

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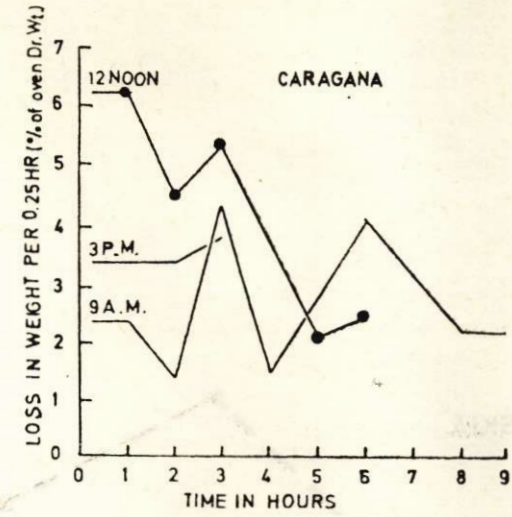
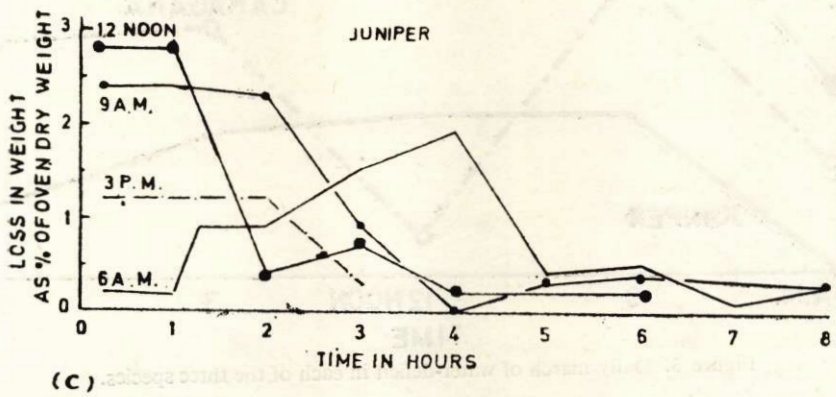
Appendix

Meteorological data collected during the year 1976-77, *by the Watershed Management observatory of Pakistan Forest Institute at Ziarat*

Months	Temperature		Rainfall mm.	No. of Rainy days	Snow fall depth (cm)	No. of snowy days	Mean relative humidity (%)
	Mean Max. (C°)	Mean Min. (C°)					
August, 1976	26.1	11.2	5.33	3	—	—	31.7
Sept., ,,	22.5	7.9	14.40	9	—	—	30.0
Oct., ,,	21.8	2.7	0.51	1	—	—	25.0
Nov., ,,	15.2	3.3	—	—	—	—	22.0
Dec., ,,	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Jan., ,,	6.3	9.5	—	—	93	6	81.0
Feb., ,,	11.0	4.2	—	—	—	—	42.0
March, ,,	15.3	1.9	1.52	3	—	—	27.0
April, ,,	18.0	4.8	12.7	8	—	—	38.0



(b)



(C)

Figure 2 (*b*) & (*c*) showing stomatic reaction in the cut shoots & water loss respectively in *Caragana & Juniper*

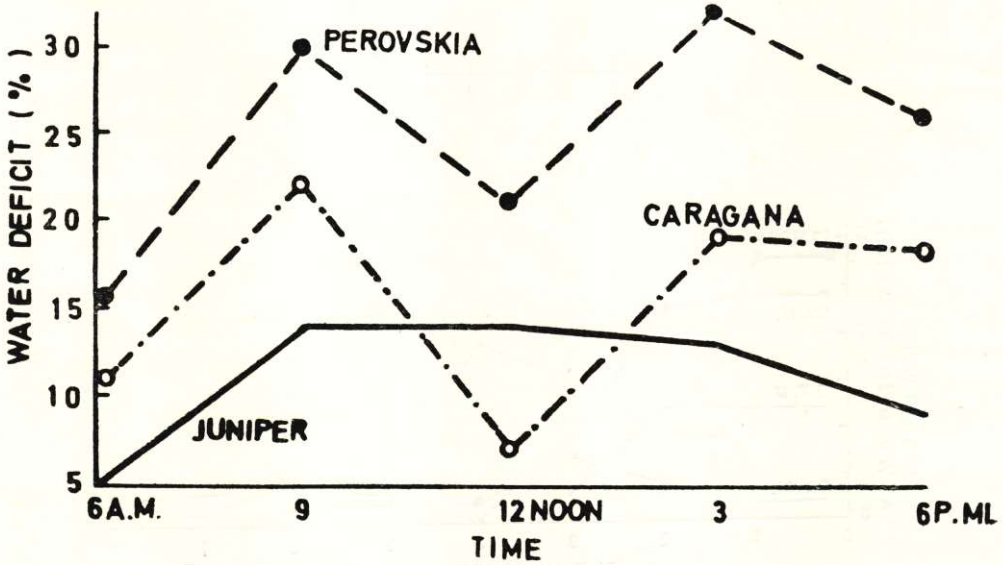


Figure 3. Daily march of water-deficit in each of the three species.