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CLIMATIC DISCOMFORT IN THE KIMBERLEYS

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Abstract: Mean monthly dry and wet bulb temperatures for several localities in the Kimberleys are tabulated. A climatic discomfort diagram is then constructed based on a plot of mean dry bulb against mean wet bulb. These temperature values for the Kimberley stations are then plotted graphically on the diagram to show relative degrees of discomfort throughout the year.

Mean monthly dry and wet bulb temperatures together with appropriate mean monthly wind speeds are applied to the effective temperature nomogram in order to derive mean monthly effective temperatures for the Kimberley stations. The effective temperatures are plotted to indicate graphically the actual and relative changes in climatic discomfort during the year. Since effective temperatures makes allowance for the effect of mean wind speed, it is considered to be more satisfactory than previous measurements of discomfort based solely on air temperature and humidity.

1. INTRODUCTION

Climatic discomfort lowers the efficiency of the work force thereby reducing output per head. Moreover, the tropical climate raises production costs by its effects on the industries. In the Kimberleys, these effects are evident in problems of beef processing, breeding, animal nutrition, wool discoloration, diseases and pests. This paper however is primarily concerned with the effects of the climate on human workers.

Monotony of climate is an important subjective factor influencing discomfort, and therefore human efficiency. If the weather is similar day after day, boredom, lassitude or depression may result and these effects can be enhanced by isolation. Human comfort is increased by variability of the weather, i.e. alternating fine and wet periods, wind changes, and cloud movements with their corresponding changes in air temperature and humidity.

In the Kimberleys, particularly away from the coasts, the dry mild winters have recuperative influences on health. Moreover, the tropical disturbances which bring the summer rains provide some measure of weather variability at the most uncomfortable time of the year. The inland areas have the additional advantage of appreciable diurnal and annual temperature ranges, which are factors stimulating activity.

2. DISCUSSION OF TEMPERATURE AND HUMIDITY DATA

Figures representative of mean temperatures for selected stations in the Kimberleys are tabulated in Table 1, the corresponding figures for Perth being included for comparison. These average monthly figures were obtained by taking the mean of the average monthly maximum and minimum temperatures. It can be seen that the annual range between the mean of the coldest month (July) and the hottest month (November or December) is 14.0°F for the coastal station Wyndham; but at the inland station, Halls Creek, the range is 23.3°F.

Average index of mean relative humidity figures are included in Table 1. The average index of mean relative humidity has been derived from the ratio of the average 9 a.m. vapour pressure to the saturation vapour pressure at the mean temperature. Being thus related to mean temperature this value of relative humidity is a good approximation to the daily mean (Climatic Averages Australia). A notable feature is the comparatively high figures for the wet season, particularly on the coast, where Broome has a mean humidity of 76% in February. In the dry season, the humidities are low, the figure for Halls Creek being only 35% in September. It will be seen that these low humidities during the dry season have an important bearing on the climatic discomfort in the region.

3. WET BULB TEMPERATURES AS DISCOMFORT INDICATORS

Wet bulb temperatures are useful indicators of the physiological effects of climate. Vigorous physical work becomes increasingly difficult as the wet bulb temperature rises above about 75°F. A wet bulb of 78°F is sometimes quoted as being the limit for white workers working in the open (Brooks 1950). This limit could probably be raised to 80°F for acclimatised white residents in tropical localities.

Wet bulb temperatures for selected stations in the Kimberleys are included in Table 1. Since the diurnal range of wet bulb temperature is small, being only of the order of 0-8°F, the average of the 9a.m. and 3p.m. mean figures may be taken to represent the mean daily wet bulb temperature.

Table 1 - Climatic Averages

Means	No. of Years.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Wyndham													
Mean Temperature	43	88.3	87.6	87.3	86.1	81.4	77.1	75.8	79.1	84.3	88.4	89.8	89.3
Relative Humidity *	30	66	67	63	46	41	40	38	40	44	52	55	60
Wet Bulb	42	79.8	79.4	77.9	73.2	68.4	65.2	63.6	67.1	72.2	77.1	79.1	79.8
Wind Speed +	5	600	600	500	500	600	600	600	500	600	700	600	500
Effective Temperature	-	82	81	81	78	73	69	68	70	76	80	82	83
Halls Creek													
Mean Temperature	42	86.5	85.7	83.1	77.7	70.9	65.7	64.1	69.0	75.9	83.7	87.2	87.4
Relative Humidity *	30	54	54	50	40	41	44	42	39	35	38	38	46
Wet Bulb	41	74.7	74.4	71.9	66.7	62.1	59.0	57.4	60.8	60.8	70.1	72.4	73.7
Wind Speed +	-	700	700	500	600	700	1000	1000	900	800	1000	800	700
Effective Temperature	-	78	77	76	71	66	60	57	63	69	75	78	78
Broome													
Mean Temperature	44	85.5	85.4	85.4	82.7	76.3	71.2	69.7	72.5	77.0	81.2	84.7	86.2
Relative Humidity *	30	75	76	73	56	54	53	52	54	56	64	66	70
Wet Bulb	44	80.2	80.2	79.1	73.6	68.1	64.0	62.3	65.1	68.8	73.5	77.3	79.5
Wind Speed +	5	700	700	600	600	600	700	600	700	800	800	800	800
Effective Temperature	-	80	80	80	77	71	66	65	66	71	76	79	81
Perth													
Mean Temperature	62	74.7	74.5	71.7	66.7	60.8	57.0	55.3	56.1	58.4	61.0	66.4	70.8
Relative Humidity *	30	53	52	57	60	68	72	73	71	64	64	57	54
Wet Bulb	59	65.0	65.1	53.6	60.5	56.6	53.8	52.3	53.0	55.0	56.8	60.2	63.1
Wind Speed +	10	1500	1500	1400	1200	1100	1100	1100	1200	1300	1400	1500	1500
Effective Temperature	-	66	66	64	60	54	49	47	47	49	52	58	63

* Relative Humidity is the average index of mean relative humidity

+ Wind Speeds are expressed in ft per min.

As is to be expected, Table 1 shows that wet bulb temperatures for the coastal stations are appreciably higher than those for the inland station. If a wet bulb temperature of 70°F is taken as a mean critical temperature above which physical work becomes uncomfortable, then it may be seen that Wyndham is above this limit for eight months of the year, Broome for seven months, and Halls Creek for six months. However, this criterion is somewhat arbitrary and does not take account of diurnal or annual temperature ranges or mean wind speeds.

In Fig. 1 mean monthly dry bulb temperatures are plotted against mean monthly wet bulb temperatures for selected stations, Perth being included for comparison. Berry, Bollay and Beers (1945) illustrate a discomfort scale which is the result of experimental work of the American Society of Heating and Ventilating Engineers (A.S.H.V.E). An adaptation of this scale has been included in Fig. 1.

The positions of the plots for the selected stations define the relative orders of climatic discomfort for the various months of the year. On this scale, it is evident that Halls Creek is more comfortable than Wyndham for each month of the year, particularly in the dry season, when conditions at the former are fairly comfortable for about four or five months.

4. EFFECTIVE TEMPERATURE DATA

The concept of effective temperature has come into use as a more accurate measure of climatic discomfort. The effective temperature is the temperature of a still saturated atmosphere, which would on the average produce the same general effect of comfort or discomfort as the actual atmosphere in which the subject is situated. The concept has been used to define discomfort zones.

A nomogram relating dry and wet bulb temperatures and wind speeds to ascertain effective temperatures was published (Yaglou 1926, 1927) by the American Society of Heating and Ventilating Engineers (A.S.H.V.E). This nomogram has been used by the Commonwealth Bureau of Meteorology to derive 9a.m. effective temperatures for January (Commonwealth Year Books). Gentilli (1951) also used the nomogram to derive mean monthly effective temperatures for the working day.

The A.S.H.V.E effective temperature scale applies to normally clothed sedentary workers for indoor conditions taking account of wind speeds. It has not been fully tested under Australian conditions due to lack of indoor wind data, but the concept has been widely used in the U.S.A.

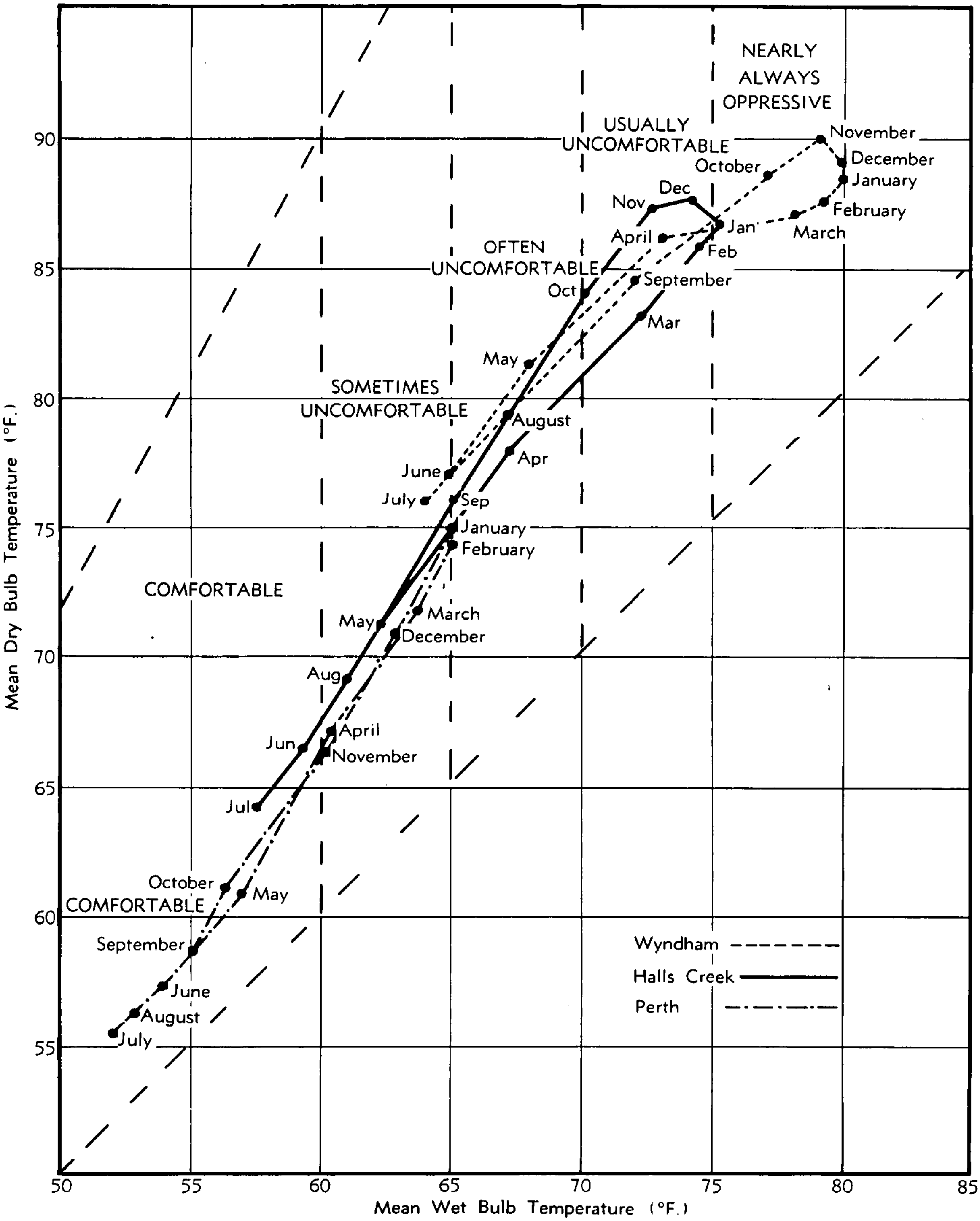

Fig. 1. Discomfort diagram based on mean monthly Dry and Wet Bulb temperatures.

There is a tendency in the tropics for white settlements to be established on windward coasts, slopes, or windy points; and housing is designed to allow reasonably free air movement. In this way, maximum benefit can be gained from the drying power of the winds.

The wind corrections on the A.S.H.V.E. effective temperature scale were derived for indoor conditions, but no such data are available in Australia. Lee (1940 and 1944) considers that 150 ft per minute is about the maximum speed of practical use for increasing comfort since greater speeds result in papers being disturbed, the raising of dust etc. This irritating effect of indoor air movements cannot be neglected, but when oppressive conditions are being experienced in the tropics the general tendency is to take full advantage of winds. For the purposes of this study it was decided to use the mean monthly wind data applying to outdoor conditions, taking 20% of the outdoor mean wind speed. This is considered to be a reasonable approximation for wind speeds in a tropical dwelling designed to allow free air movements. In the case of sub-tropical localities such as Perth, this percentage would be too great. However, for purposes of uniformity and comparison this value was also used for Perth in obtaining effective temperature data.

The effective temperature nomogram was used to derive mean monthly effective temperatures from the mean monthly dry and wet bulb temperatures and mean monthly wind speeds. The mean wind speeds for Hall's Creek were estimated from mean monthly pressure and gradient wind charts and wind frequency data. The results are tabulated in Table 1 and plotted in Fig. 2.

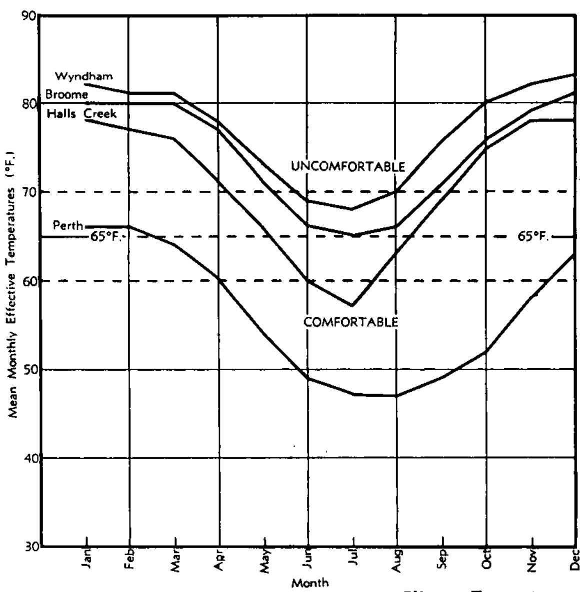

Fig. 2. Discomfort diagram based on mean monthly Effective Temperatures.

The Sub-Committee on district allowances appointed by the Joint Council of the Commonwealth Public Service has expressed the view in post World War II years, that effective temperature provides the only available satisfactory measure of climatic discomfort. In its second interim report, the Sub-Committee stated that the normal sedentary worker does not feel any degree of discomfort unless the effective temperature is greater than 65°F. Gentilli (1951) takes 69°F mean monthly effective temperature as the criterion for measuring climatic discomfort when deriving effective temperature data for the working day. In Fig. 2 a relative comfort scale is included, taking 65°F as a critical temperature.

The effective temperatures plotted in Fig. 2 take into account the three variables, temperature, humidity, and wind. A marked feature of the results is the higher effective temperatures for the coastal stations in comparison with the inland station, Halls Creek. Wyndham's figures are never below 65°F, although they approach this level in July. Broome's figures descend to 65°F in July and approach this level during three months (June - August inclusive). Halls Creek is below 65°F for three months (June - August inclusive) and approach this level during about five months (May - September inclusive).

In terms of annual range of effective temperature, Wyndham's range is 15°F, Broome's is 16°F, while Halls Creek's is 21°F (Perth 19°F). The high annual range at Halls Creek, extending to a lower limit of only 57°F in July is a significant recuperative characteristic of the environment of this inland station.

5. CONCLUSION

The results show that with respect to human comfort, conditions on the inland pastoral stations are significantly better than in the coastal towns. This is a pertinent point to be considered in the selection of sites for developmental projects with their associated housing settlements.

The proposed site of the Ord River Scheme is located well inland, about sixty miles southeast of Wyndham and nearly one hundred miles from the open ocean. A reasonable assumption from the analysis is that effective temperatures in this locality will be between those of Wyndham and Halls Creek. Furthermore, in view of the distance of the locality from the sea, it is possible that the effective temperatures will be closer to those of Hall's Creek in the dry season. Thus advantage should be gained of the stimulating influence of an appreciable annual range of effective temperature.

In the past, the low standard of living conditions has added to the difficulties of the climatic environment. There is no doubt that by appropriate housing design, air conditioning, refrigeration, and social amenities, the unpleasant effects of the climate can be reduced to more tolerable standards. An example is the settlement at Cockatoo Island.

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