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Further data on the climate of the Alpine Vegetation Belt of eastern Lesotho

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ABSTRACT

Rainfall data from 31 stations in the Alpine Vegetation Belt of eastern Lesotho, together with temperature, relative humidity and evaporation data from Letšeng-la-Draai are presented and discussed, and comparisons, where possible, are made with data from Mokhotlong in the Subalpine Belt.

RÉSUMÉ

DONNÉES NOUVELLES SUR LE CLIMAT DE LA CEINTURE DE LESOTHO D'EST

Les données de la pluviosité de 31 postes dans la ceinture de vegetation alpine de Lesotho d'est, ensemble avec la température, la humidité relative et les données de l'evaporation de Letšeng-la-Draai, sont presentées et discutées, et des comparaisons sont fait, où c'est possible, avec les données de Mokhotlong de la ceinture sous-alpine.

INTRODUCTION

In 1963 the author pointed out that climatic data for the Alpine Vegetation Belt of the Drakensberg and Lesotho were meagre. This was certainly true of published data. However, today there exists a considerable amount of data, particularly rainfall data, much of it apparently still unpublished, which is derived chiefly from hydrological investigations in connection with the Oxbow Dam scheme. In 1955 the Government of Lesotho started on a programme of hydrographic data collection in the Oxbow and neighbouring catchments in the extreme north of the Upper Orange River Basin. A network of rain-gauges was established (35 in all) as well as two meteorological stations, one near the Tsehlanyane River and known as the Oxbow Meteorological Station and one at Letšeng-la-Draai† (lat. 28°58′S, long. 28′52′ E), 35 km south-east in the elevated central area of eastern Lesotho. Data from these stations are included and discussed in an unpublished M.Sc. (Eng.) thesis by Carter (1967) entitled, "A survey of the surface water resources of the Upper Orange Catchment". In addition to the data mentioned, rainfall data are available from Organ Pipes Pass summit (lat. 29°1′S, long. 29°11′E) and Sani Pass summit (lat. 29°36′S, long. 29°16′E), both stations situated near the edge of the Drakensberg escarpment further south.

These data fill a decided gap in our knowledge of the climate of the Alpine Belt and are particularly interesting in view of certain statements about the climate made by Van Zinderen Bakker & Werger (1974) in a paper on the bogs of the Oxbow area. The climatic factors will be discussed individually.

RAINFALL

Mean monthly and annual rainfall for 31 stations lying in the Alpine Belt are given in Table 1 (see page 568). Following Killick (1978b) the Alpine Belt is accepted as being above 2 740 m, but it is appreciated that the position of the lower limit of the Alpine Belt requires further study (Killick, 1978a). Stations B—X4 are situated in the catchments of the Tšehlanyane, Tlolohatse, Matšeng, Malibamatšo, Motete and Khubelu Rivers; the precise position of these rainfall stations in the Oxbow Region is given in Fig. 1, a reproduction of Fig. 1b in Carter (1967). It will be seen that mean annual rainfall varies from 633,9 mm at P1 to 1 609 mm at Organ Pipes Pass summit. Annual rainfall can vary considerably from year to year, for example at Sani Pass summit the mean annual rainfall for the hyetal year 1938/39 was 1441,6 mm and for 1944/45 only 439,3 mm, while at Station B the figures are 1 663 mm for 1956/57 and 701 mm for 1965/66.

Most of the rain (77%) falls between October and March. The percentage mean monthly rainfall as calculated by Carter for 16 rain-gauges (A–Oxbow Met. Stn.) over a 10-year period is given in Table 2.

Three of the stations are situated slightly below the lower limit of the Alpine Belt, but this should not significantly alter the figures given. It is interesting to note that in 21 of the 31 stations included in Table 1, December shows a lower rainfall than November.

Droughts occur periodically: at Sani Pass summit there were three chiefly winter droughts of 120 days duration between 1932 and 1947; May–August 1937 (rainfall 11 mm); May–August 1941 (rainfall 20,1 mm) and June–September 1945 (rainfall 6,1 mm). A drought of 210 days duration with only 45 mm of rainfall was recorded at Station K in 1966 between March and September i.e. autumn, winter and one month of spring.

Carter (1967) demonstrates convincingly in his Fig. 3a that rainfall in high mountains varies inversely with altitude. From Table 1 it can be seen that the higher-based stations such as P1, P2, P3, P5, P7 and P8 have the lowest mean annual rainfall. This is a well-known phenomenon of mountain climates.

Another observation made by Carter and reflected in Fig. 3b is that in the Oxbow area mean annual rainfall is high close to the north-western escarpment (e.g. gauges B, I, R, T and U), but decreases towards the east (e.g. gauges P1, P2, P5 and X4). A similar situation exists from west to east 90 km south of Oxbow (Fig. 3c). However, Carter states that along the Drakensberg escarpment the rainfall is high (e.g. Organ Pipes Pass summit, MAR 1 609 mm), but that this high rainfall effect does not extend more than 1,6–3,2 km into Lesotho.

It should be mentioned that Carter (Fig. 3d) has produced a isohyetal map of the Upper Orange River catchment, which should prove most useful to plant ecologists.

Van Zinderen Bakker & Werger (1974) claim that the rainfall in Lesotho "represents the highest precipitation in Southern Africa". This is not so. According to South African Weather Bureau data higher precipitation is recorded in the mountains of the south-western Cape and the eastern Transvaal. For example, the mean annual rainfall for Jonkersnek (Weather Station 22/30) at Jonkershoek in the south-western Cape is 3 539,2 mm (Weather Bureau, 1965) with a maximum annual rainfall of 3 874 mm in 1950 (Schulze, 1965). The mean annual rainfall for Broederstroom (Weather Station 678/858) in the eastern

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† Also spelt Letšeng-la-Terai.

TABLE 1.—Mean monthly rainfall in mm from 31 stations in eastern Lesotho

Station	B	D	E	F	G	H	J	K	L	R	S	T	U	I	N	O
Altitude in m..........	2 896	3 231	2 926	3 078	3 200	2 743	2 713	2 957	2 743	2 835	3 078	2 804	2 743	2 987	3 139	3 109
Period in years.........	10	10	10	9	9	9	9	9	9	9	9	9	9	6	6	6
January..............	198,2	169,9	184,5	173,9	181,1	181,9	156,9	173,4	186,3	182,7	219,8	197,6	199,6	210,2	161,7	200,0
February............	119,0	116,3	102,9	95,6	107,1	100,2	89,2	87,9	96,2	94,2	112,6	106,1	94,0	110,2	92,5	107,5
March...............	109,8	113,4	100,5	104,2	131,6	133,1	117,1	99,4	121,0	106,1	141,9	118,3	136,5	109,8	111,7	125,5
April................	99,0	74,3	90,1	83,0	76,2	99,2	82,0	88,3	115,2	100,0	98,3	109,4	107,0	72,7	63,8	82,0
May.................	44,2	33,3	38,3	37,4	29,7	55,4	42,1	41,7	64,9	46,4	44,0	54,4	58,7	30,7	23,2	27,8
June.................	15,3	9,7	12,0	14,1	9,0	23,1	17,2	12,7	22,3	17,0	23,1	24,6	22,4	13,8	12,5	14,5
July..................	20,0	13,5	16,6	13,1	11,4	20,9	19,0	12,6	24,0	19,6	23,7	23,1	22,1	7,7	5,3	9,3
August..............	22,6	13,5	15,7	14,2	8,8	23,1	14,7	12,5	23,4	18,4	18,2	21,1	21,1	15,7	10,3	16,2
September...........	51,2	41,9	54,1	34,1	27,9	40,9	36,1	29,8	34,3	28,7	40,8	31,3	31,7	18,7	21,2	27,5
October..............	142,8	104,4	128,8	107,3	79,6	118,8	136,7	108,7	134,8	120,1	135,9	128,7	138,4	78,5	88,7	88,8
November...........	182,1	161,7	162,5	162,6	151,2	164,3	163,6	161,9	181,7	170,0	183,6	184,6	174,1	159,8	151,2	171,0
December............	135,9	128,4	159,1	141,4	123,0	156,3	131,0	132,6	134,8	129,4	159,1	154,8	144,1	112,0	118,3	132,3
Total............	1 140,1	980,3	1 065,1	980,9	936,6	1 110,2	1 005,6	961,5	1 138,9	1 032,6	1 201,0	1 154,0	1 149,7	939,8	855,4	1 002,4

Station	P	P1	P2	P3	P5	P6	P7	P8	P9	Q	Q1	X4	Letšeng-la-Draai	Organ Pipes Pass summit	Sani Pass summit
Altitude in m................	3 048	3 292	3 170	3 231	3 170	3 170	3 170	3 261	2 987	3 109	3 018	2 652	3 050	2 927	2 865
Period in years...............	6	6	6	6	6	6	6	6	6	6	6	6	8	3	12
January.....................	169,0	143,0	169,0	174,3	166,8	163,5	156,7	181,3	156,5	228,7	222,0	130,3	114,6	342	163,7
February..................	101,7	76,5	96,8	90,3	81,7	110,7	87,7	85,3	87,3	108,0	105,7	70,0	86,3	295	159,6
March.....................	121,2	89,7	101,5	107,7	94,2	110,8	87,7	110,3	107,3	131,7	144,5	77,3	101,1	207	121,6
April......................	69,8	44,3	57,0	59,5	57,0	68,0	49,7	66,7	62,3	95,3	88,5	48,8	41,1	49	55,8
May.......................	27,3	8,8	18,7	22,3	17,0	33,0	7,5	28,3	18,5	32,5	35,2	16,7	21,4	46	36,9
June.......................	15,0	7,5	13,3	12,7	13,3	14,2	8,2	10,8	9,7	19,0	19,8	12,5	14,5	27	12,5
July........................	8,8	5,5	8,3	7,3	7,5	13,0	3,5	7,5	7,7	14,5	15,3	9,3	10,3	1	19,1
August.....................	14,2	6,2	11,7	11,5	10,8	25,0	4,8	9,3	9,7	13,0	12,8	9,3	11,7	16	16,0
September.................	34,5	13,5	24,2	23,8	22,0	36,2	17,2	24,5	21,3	22,3	31,7	22,2	23,6	61	35,9
October....................	86,7	48,0	70,5	76,3	67,3	85,2	52,0	75,2	67,2	89,8	97,7	69,5	73,5	109	89,5
November..................	134,2	95,2	115,5	116,8	102,7	127,7	101,0	122,3	116,3	161,5	175,8	109,5	88,9	226	136,3
December..................	122,8	95,7	115,0	122,3	110,8	147,3	113,0	127,0	102,3	127,0	149,2	116,7	126,6	230	148,9
Total.................	905,2	663,9	801,5	824,8	751,1	934,6	689,0	848,5	766,1	1 043,3	1 098,2	692,1	713,6	1 609	995,8

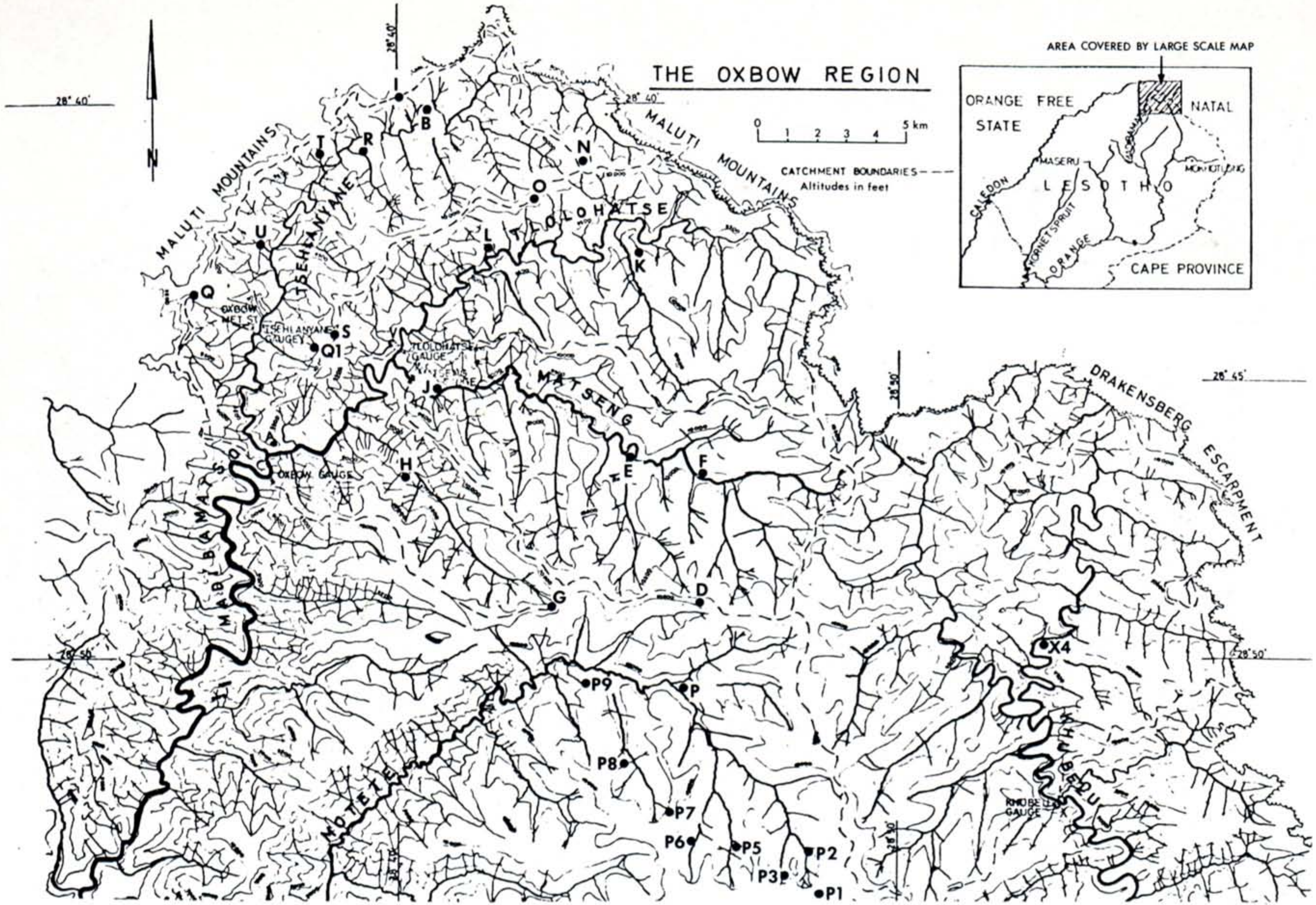

FIG. 1.—Map of Oxbow Region showing position of rain-gauges B–X4 included in Table 1. Map from Carter, 1967.

TABLE 2.—Percentage mean monthly rainfall for Oxbow Region (from Carter, 1967)

Month	Mean rainfall (%)	
October	11,2	
November	15,5	
December	13,1	
January	16,8	76,9
February	9,8	
March	10,8	
April	8,7	
May	4,0	
June	1,5	
July	1,9	
August	2,0	
September	5,0	

Transvaal is 2 150,4 mm (Weather Bureau, 1965). These figures are considerably higher than the figures cited for eastern Lesotho in Table 1.

TEMPERATURE

Air temperature data for Letšeng-la-Draai have been used to produce the Deasy temperature graph in Fig. 2. The curves for mean daily maximum (B) and mean daily minimum (C) with the hatched area between representing diurnal temperature range, show that air temperature is cool to mild in summer, but cold in winter. The absolute temperature curves A and D reach degrees of hot and frigid. Absolute minimum temperatures are below 0 °C throughout the year. The highest temperature recorded in 11 years is 31 °C on 29 January 1972 and the lowest −20 °C on 12 June 1967. Mean annual temperature is 5,7 °C. The estimated number of days per year with frost is 183. There are no data for grass level or soil.

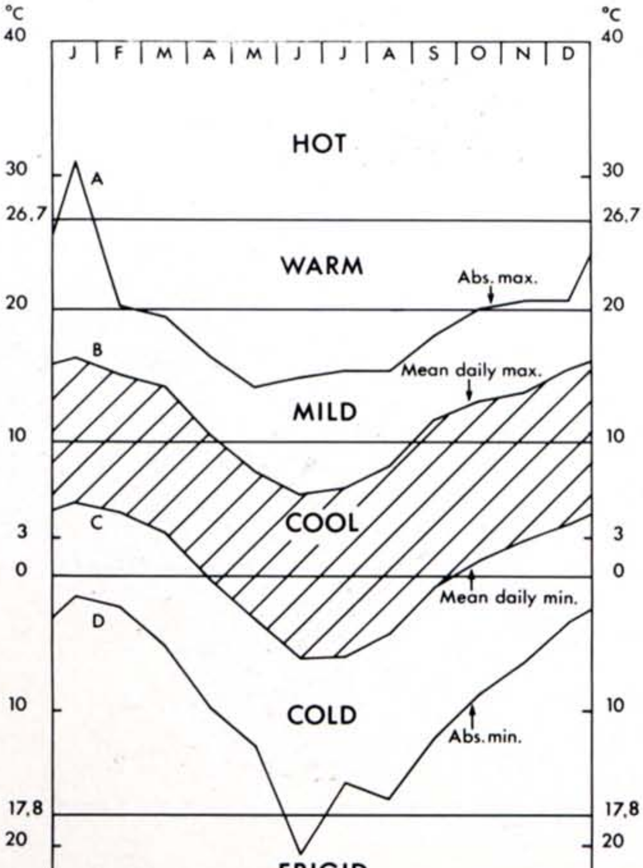

FIG. 2.—Deasy temperature graph for Letšeng-la-Draai.

Van Zinderen Bakker & Werger (*l.c.*) state that the maximum temperatures in summer do not exceed 16 °C, while the nightly minimum temperatures at soil level are below freezing point throughout the year. No supporting data were supplied. A glance at Fig. 2 reveals that maximum temperatures can certainly exceed 16 °C: the mean daily maximum temperature for January is 16,6 °C and the absolute maximum temperatures exceed 16 °C from September to April reaching 31 °C in January 1972. Unfortunately there are no data for temperature at soil level. However, if a screen minimum of 3 °C is employed as a criterion of light ground frost (as used by Schulze, 1965), it will be clear from Fig. 2, curve C, that only from March to November are ground level temperatures below freezing point likely to be a daily feature of the alpine climate—certainly not throughout the year as claimed by Van Zinderen Bakker & Werger. The present author has often been on the summit of the Drakensberg during summer and has only occasionally seen evidence of frost heaving and frozen bog pools even at dawn and at altitudes of above 3 000 m.

In plant ecological studies considerable use is made of "klimadiagramme" (Walter & Leith, 1960). With air temperature and rainfall data available for Letšeng-la-Draai, it is possible for the first time to produce such a diagram (Fig. 3.1) for the Alpine Belt. The chief conclusions to be drawn from this diagram are as follows: precipitation always exceeds temperature, therefore the climate is humid; and ecologically, winter is a time of stress, because of low rainfall coupled with low temperature.

The climatic diagram for Letšeng-la-Draai shows affinities with three of Walter & Leith's climatic classes, namely VI (cold, humid), VIII (Boreal) and X (mountain areas in other regions). It differs from VI in that the monthly summer rainfall exceeds 100 mm by a considerable amount (reaching 126,6 mm); the onset of the rainy season in October and its decline in April is much sharper; and the mean monthly summer temperatures are usually lower and persist for a longer time. It differs from VIII in the higher summer-rainfall, the sharper onset and decline of summer rain, the usually higher mean annual temperature and the lower mean monthly summer temperatures (in VIII these temperatures are rarely lower than 20 °C). The diagram approximates closest to some of the examples of X, the mountain climatic class, which is an extremely variable class.

A comparison of the climatic diagrams for Letšeng-la-Draai and Mokhotlong (lat. 29°17′S, long. 29°-05′E), 42 km south-east of Letšeng-la-Draai is interesting. Mokhotlong is situated in the Subalpine Belt at 2 377 m [according to Jacot Guillarmod (1971) the Subalpine Belt lies between 2 290–2 900 m] in the Lower Mountain Flats Region (Bawden & Carroll, 1968) of eastern Lesotho. Fig. 3.2 shows that Mokhotlong is drier than Letšeng-la-Draai and from the beginning of June to the end of August there is actually a brief period of aridity, when temperature exceeds rainfall. The author (1963) figured a profile through the Cathedral Peak area showing the variation of rainfall with altitude. This profile shows clearly the effectiveness of the scarp in creating a "rain-shadow" on the leeward side of the Drakensberg with resultant low rainfall at Mokhotlong. Mokhotlong is also warmer than Letšeng-la-Draai with a mean annual temperature of 11,5°C and with the mean monthly temperature never dropping below 0 °C. Moreover, the absolute minimum temperatures do not fall below 0 °C between December and March. The average number of frost days at Mokhotlong is 100.

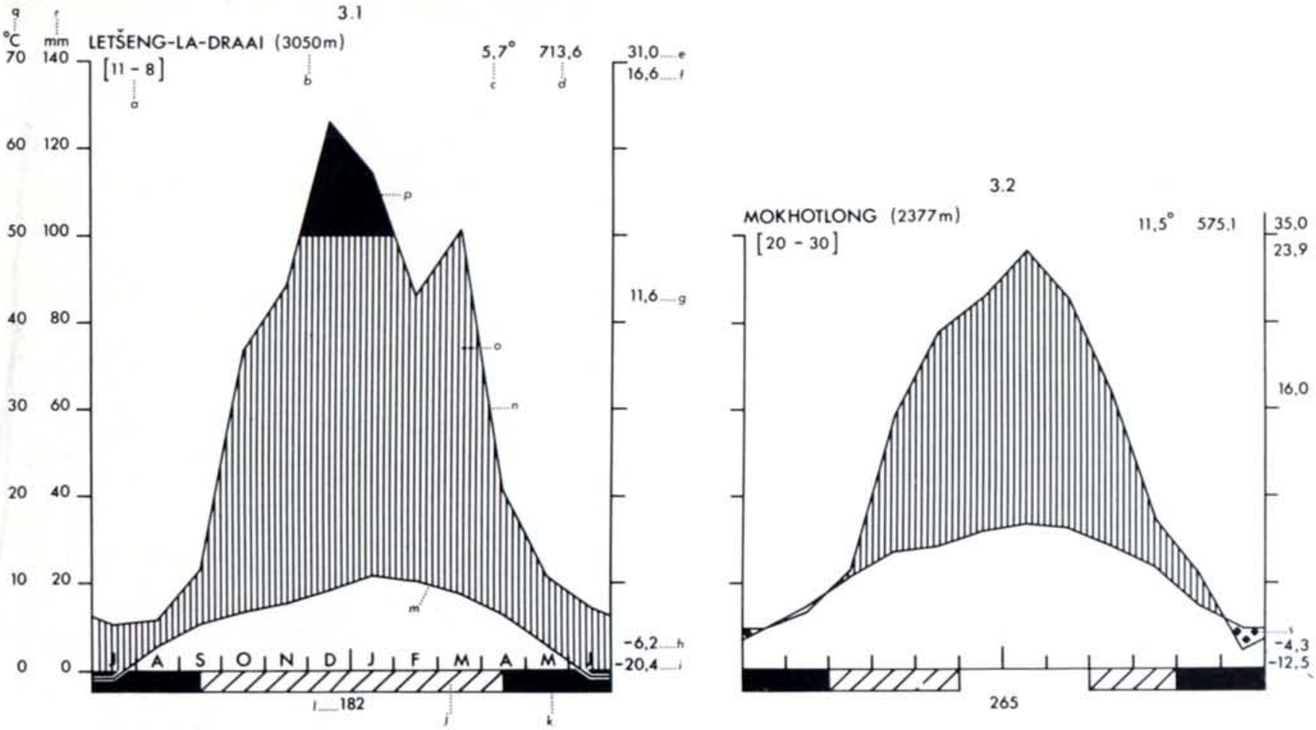

FIG. 3.—Climatic diagrams for Letšeng-la-Draai (3.1) and Mokhotlong (3.2). a, period of recording in years—temperature and precipitation; b, altitude; c, mean annual temperature; d, mean annual precipitation; e, absolute maximum temperature; f, mean daily maximum temperature of the hottest month; g, mean range of temperature; h, mean daily minimum temperature of the coldest month; i, absolute minimum temperature; j, months with absolute minimum temperature below 0°C; k, months with mean minimum below 0°C; l, mean duration of frost-free period in days; m, curve of mean monthly temperature; n, curve of mean monthly precipitation; o, humid period; p, mean monthly precipitation over 100 mm; q, temperature in 0°C; r, precipitation in mm; s, arid period.

TABLE 3.—Mean relative humidity data for Letšeng-la-Draai at 14h00

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966..........	70	62	38	46	45	42	26	23	28	38	48	56
1967..........	55	65	61	59	46	64	51	33	31	34	57	55
1968..........	47	44	64	48	51	54	48	37	26	29	51	39
1969..........	39	50	57	51	49	44	29	18	21	46	37	46
1970..........	52	50	36	37	37	31	39	43	31	50	37	42
1971..........	43	58	54	47	60	45	57	43	46	48	56	54
1972..........	64	52	68	56	43	51	—	29	52	42	50	35
1973..........	35	59	51	51	44	31	32	61	30	54	50	60
1974..........	72	66	62	55	47	50	40	43	36	35	62	45
1975..........	50	68	56	50	31	32	50	34	36	43	54	—
1976..........	70	70	68	54	51	67	55	44	40	58	48	52
Mean monthly	54	59	56	50	46	46	43	37	34	43	50	48
% range......	206	159	189	159	164	216	184	339	248	200	168	171

TABLE 4.—Mean monthly Class A pan evaporation in mm at Letšeng-la-Draai and Mokhotlong (from Carter, 1967)

Place	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
Letšeng-la-Draai...	14,48	16,31	19,31	17,48	15,98	14,15	8,59	8,18	4,90	6,02	8,59	15,96	149,73
Mokhotlong.......	19,20	20,27	23,55	21,49	18,49	19,05	12,47	10,77	7,70	9,60	14,53	17,42	194,54

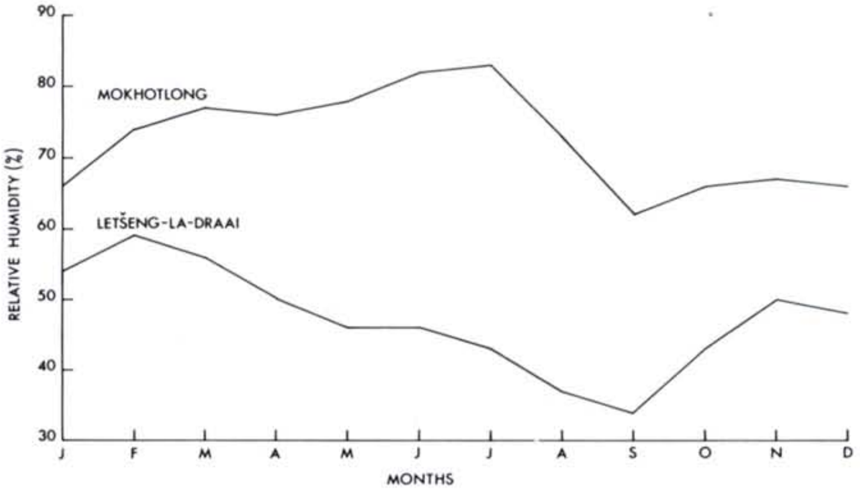

FIG. 4.—Annual march of relative humidity at Mokhotlong (08h00) and Letšeng-la-Draai (14h00).

HUMIDITY

Mean relative humidity data for Letšeng-la-Draai at 14h00 are given in Table 3. While not as significant ecologically as data for absolute relative humidity, these data do illustrate the variation in humidity from month to month, season to season and year to year. Tyson, Preston-Whyte & Schulze (1976) regard relative humidity as the least satisfactory way of measuring humidity, because of its high degree of dependence on temperature.

Relative humidities at Letšeng-la-Draai are high during summer, but low during winter and in early spring. The mean relative humidity for January is 54% with the highest monthly mean being 72% in January 1974. The mean relative humidity for August is 37% the lowest mean being 18% in August 1969; in September the corresponding figures are 34% and 21% in September 1969.

Tyson, Preston-Whyte and Schulze (*l.c.*) explain why there is low vapour pressure over the Drakensberg area in winter. "..... the winter intensification of the high pressure all over South Africa is accompanied by increased upper air subsidence with associated atmosphere drying. Under these conditions the moisture content of the air over the Drakensberg, which is already low due to elevation is further reduced. Onshore north-east winds are weak in this season and with the Drakensberg generally elevated to the level of the subsidence inversion, little moisture is advected over the area. This is reflected by low pressure over the Drakensberg area".

A further look at Table 3 reveals that the monthly mean relative humidity varies considerably from year to year, the percentage difference sometimes being as much as 339% (August). Mean annual range of relative humidity is 33%.

Unfortunately it is not possible to compare the relative humidity data for Letšeng-la-Draai with Mokhotlong, because the times of observation are different, viz. 14h00 and 08h00 respectively. However, there is a marked difference in the seasonal march of relative humidity at the two stations (Fig. 4). At Letšeng-la-Draai relative humidity is at a minimum during winter and early spring and at a maximum during summer, the wet season. This would be described by Schulze (1965) as a "monsoonal" type of variation. At Mokhotlong, on the other hand, the opposite situation prevails: relative humidity is at a minimum during spring and summer and at a maximum during winter, the dry season. This is apparently a "continental" type of variation. The reason for the seasonal difference in relative humidity is not clear and deserves study by climatologists.

EVAPORATION

Evaporation records from Class A pans are available for Letšeng-la-Draai (1962/63–1965/66) and Mokhotlong (1963/64–1965/66). The data in Table 4 show that total annual evaporation is higher at Mokhotlong than Letšeng-la-Draai. Evaporation at both stations is highest in summer and lowest in winter. Carter (1967) cites figures in his Table 4c to show that potential evapotranspiration (based on 70% of Class A pan evaporation) for Lesotho and its surrounds decreases rapidly with increasing altitude.

ACKNOWLEDGMENTS

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UITTREKSEL

Reenvalgegewens van 31 *stasies in die Alpine-Plantegroeigordel van oostelike Lesotho, tesame met temperatuur, relatiewe lugvogtigheid en verdampingsgegewens van Letšeng-la-Draai word aangebied en bespreek. Waar moontlik word vergelykings getref met gegewens van Mokhotlong in die Subalpine-gordel.*

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