

HYDROLOGY OF THE SABIE RIVER*

Manuel Pedro Romano

1. THE REGIME FACTORS

1.1. Physical and geological description of the Sabie basin.

The Sabie river, a tributary of the Incomati river, rises in the Republic of South Africa on the eastern side of the Mauch Berg and after flowing some 210 km. eastwards meets the Incomati 5 km. from Sabie village in Mozambique. The drainage basin, with a total area of some 6,800 sq. km., is embraced by latitudes 24° 35' and 25° 20' S. and longitudes 30° 37' and 32° 18' E.

As shown in fig. 1, the principal tributaries of the Sabie system are: the Sand (with Mutla Muli tributary), the North Sand (with White Waters tributary), the Metsemhlaba, the Umtsako, the Mutshidaka, the Matiwambo, the Matimiri, the Salipi and the Mlodozi in the territory of the Republic of South Africa, and the Maveane (with the Neuana tributary) and the Massicale (with the Cazebre tributary) in Mozambique territory.

The western part of the river system imbedded in the Drakensberg, in the complex Mauch Berg, is elevated over 2,100 metres above sea level.

From the planimetric and hypsometric standpoints, the Sabie river basin has the following characteristics:—

Table 1.—Mean altitudes of sub-basins of the Sabie catchment.

| Hydrographic basin | Area in square kilometres | mean altitude in metres |
|-----------------------------------|---------------------------|-------------------------|
| Upper Sabie | 368.65 | 1,125 |
| Buffels | 55.55 | 675 |
| Mac-Mac | 146.45 | 750 |
| Between Buffels and North Sand .. | 85.85 | 750 |
| North Sand | 292.90 | 725 |
| Maritsane | 459.55 | 900 |
| Between North Sand and Umtsabo | 111.10 | 675 |
| Between Maritsane and Bega .. | 35.35 | 600 |

*Presented at the Diamond Jubilee Congress of the Association, July, 1962. (Accepted for publication, November, 1962.)

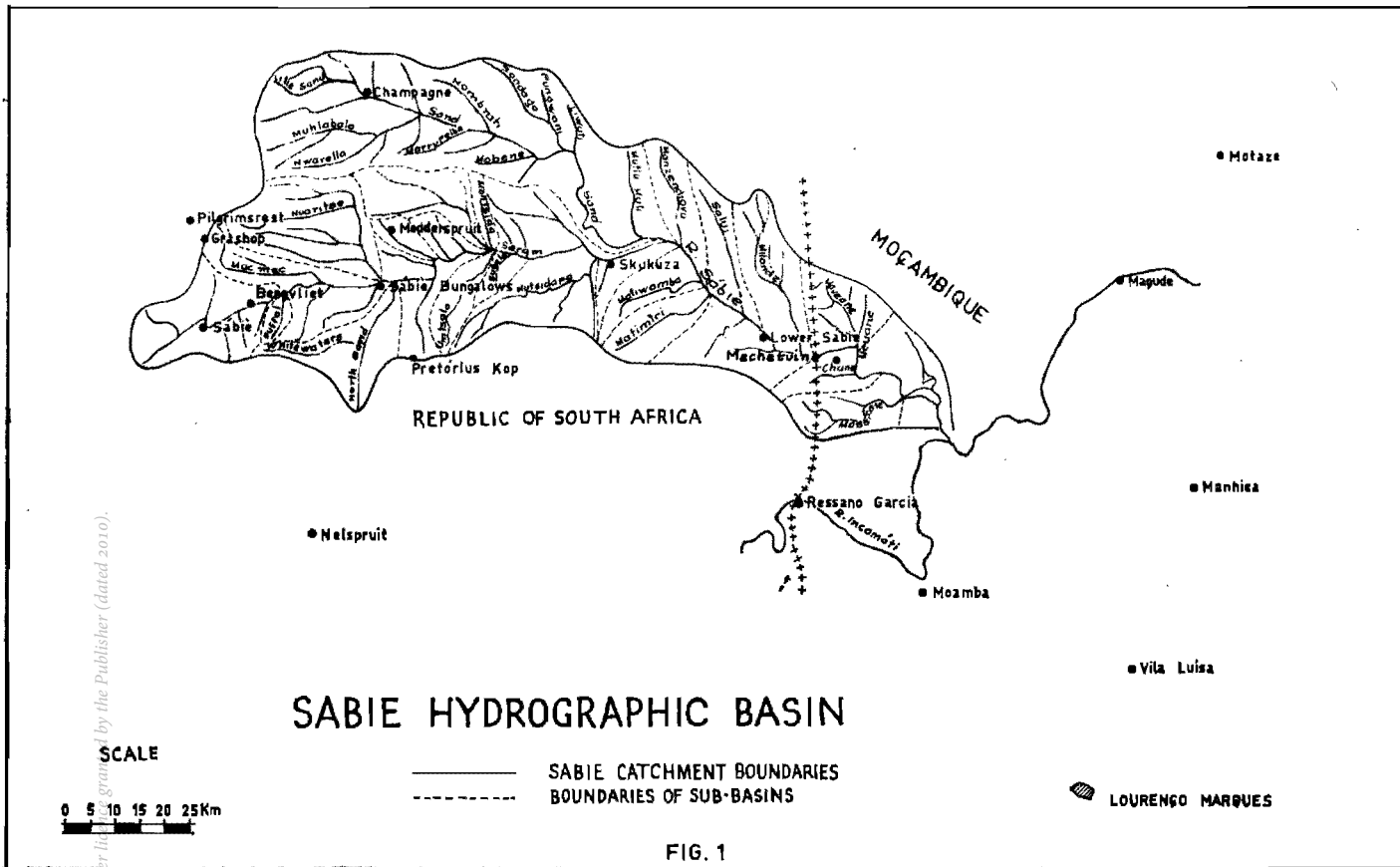
The relief falls towards the east, to rise again slightly on the Lebombo Mountains (Mozambique frontier) and again on the Corumana Sierra. After this mountain range, the altitude diminishes considerably towards the Incomati river valley, which lies 100 to 50 metres above sea level.

From the geologic standpoint, the river traverses: the Pre-Cambrian, the Archaic (granite and gneiss), the Karoo sediments, the Karoo lavas (riolite and basalts of the Lebombos), the Cretaceous (higher marine) and the Tertiary to Recent (resulting from the breakdown of very old formations, soft clays, sands and dunes). There are lime deposits of the post-basaltic period in which infiltration is appreciable.

Where vegetation is sparse, the terrain is susceptible to erosion which is serious in the sandy parts, where permeability is high and alluvial layers are many metres deep. In the upper regions, up to 600 metres above sea level, the profile is steep, attaining some 25% in the vicinity of Sabie village, in the Republic of South Africa. From source to mouth, the Sabie river profile has the following slopes: 50% over a 6 km. length between 1,500 and 1,200 metres above sea level; 20% over a 15 km. length between 1,200 and 900 metres; 30% over a 10 km. length between 900 and 600 metres; 6% over a 51 km. length between 600 and 300 metres; 4% over a 77 km. length between 300 and 100 metres (the frontier line passes near the 100 metre contour); and 1% over a 50 km. length between 100 metres and the river confluence which lies at an altitude of about 50 metres.

Below the 600-metre contour the river slope is small and gradual; the Skukuza camp site in the Kruger National Park is a characteristic example of this slope.

Floods do not cause great river rises except in such localities as the narrow gorge on the frontier line, known as *Pedra que Chora* (Weeping Stones). In the downstream regions, wide flood plains, stretching over some 75 sq. km. upstream of the Corumana



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Sierra, bring about gradual curbing of the flood crests.

1.2. *The Climate of the Basin.*

1.2.1. Temperature

Readings taken at stations in the Sabie basin show the annual distribution of temperature.

Table II.—Average annual temperature.

| Stations | Altitude in metres | Tempera- tures in OC., |
|---|-----------------------|------------------------------|
| Graskop | 1,478 | 15.1 |
| Sabie (Republic of South Africa) | 1,128 | 17.3 |
| Tweefontein | 1,152 | 17.1 |
| Bergvliet | 981 | 18.7 |
| Bosbokrand | 853 | 19.9 |
| Maboki | 853 | 20.8 |
| Emmett | 610 | 19.8 |
| Champagne | 610 | 21.1 |
| Skukuza | 277 | 21.7 |
| Sabie (Mozambique) | 80 | 23.5 |

Temperatures are generally very high and consequently evaporation is appreciable, not only in the hot season but also in the cool dry season (May-October).

1.2.2. Rainfall.

1.2.2.1. General remarks.

Data from the network of rainfall stations listed in Table III, and from the rainfall map of Southern Africa given in John H. Wellington's publication entitled *Southern Africa*, were considered. The emergence of the Corumana Sierra between a large part of the river basin and the sea seems hardly to influence the rainfall pattern. The rainfall diminishes gradually towards the interior as distance increases from the source of active evaporation—the sea. As altitudes increase, however, the interior regions of the river basin receive abundant and frequent rains, particularly the higher mountain regions on the eastern slopes of the Drakensberg, which enjoy more than 1,800 mm. per annum.

Apart from highly variable geographic distribution of rainfall, extreme droughts, on monthly, annual and secular basis, are suffered.

On the Portuguese side of the Sabie basin, at altitudes up to 100 metres, rains are of the frontal type somewhat similar to those

prevailing in Lourenco Marques. On the South African side of the basin, in the Drakensberg, the predominant rains are orographic.

1.2.2.2. Monthly distribution.

Rainfall distribution favours the summer season during which more than 75 per cent of the annual total falls.

The cold weather is marked by sparse rainfall. One does not find here that excellent river stabilizing factor—snow; it is non-existent even in the high regions of the basin.

1.2.2.3. Annual distribution.

Rainfall variations are indeed great: in 1939 a rainfall of 1,421 mm. was registered at Champagne, as contrasted with only 397 mm. in 1932.

The average value of the water film (run off expressed as average depth over the catchment) in the upstream regions of Sabie-Bungalows (lat. 25° 02' S. and long. 31° 07' 5 E.Gr.) with a drainage area of 725 sq. km. is 329 mm., while in the upstream regions of Machatuine (lat. 25° 10' and long. 32° 04' E with a drainage of 6,410 sq. km.) it is 123 mm. These figures indicate meagre annual average stream flows in the mid-basin regions.

2. THE REGIME ELEMENTS

2.1. *General remarks.*

One has to determine the regime elements from the sample results obtained from river flow measurements at Sabie-Bungalows and Machatuine, the only stations so far established. The hydrographs are somewhat uncertain for flows exceeding 120 cubic metres per second (m³/s) which must be determined by extrapolation. In spite of its sizeable river basin, the Sabie is not well fed, for its modulus is only 7.6 m³/s at Sabie-Bungalows and 25.2 m³/s at Machatuine. All the same, this meagre water flow is highly valuable for it traverses a region sadly lacking in water.

2.2. *Water loss.*

The mean rainfall readings for the years 1921-1950 for South African stations and corresponding readings for the years 1954-1960 for Machatuine (Mozambique) enable one to determine water losses of

COEFFICIENTS OF IRREGULARITY OF MONTHLY FLOW AND AVERAGE INTENSITY OF DISCHARGE ($l/s/km^2$) OF THE SABIE, AT SABIE BUNGALOWS (CATCHMENT $725 km^2$), COMPARED WITH PRECIPITATION AT MODDERSPRUIT

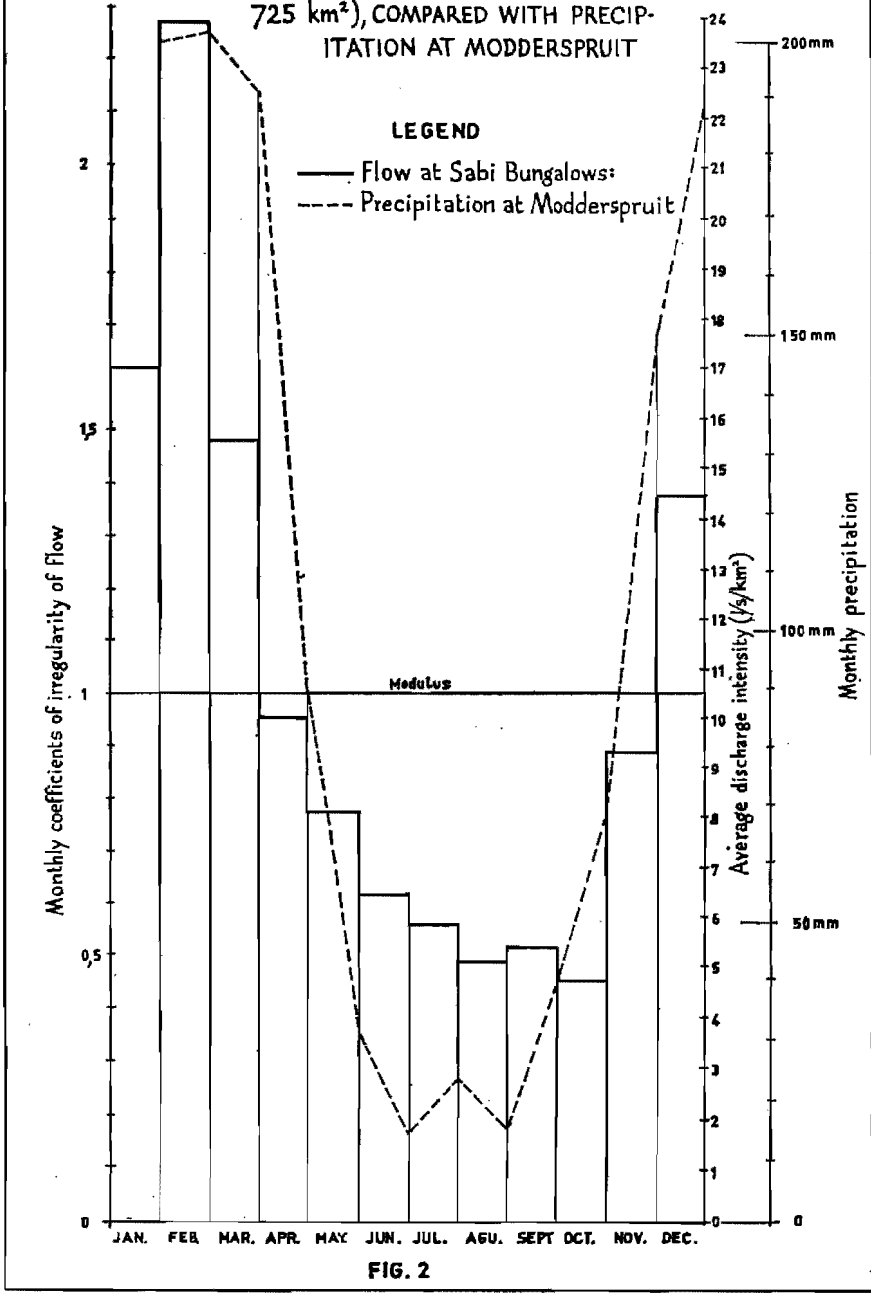
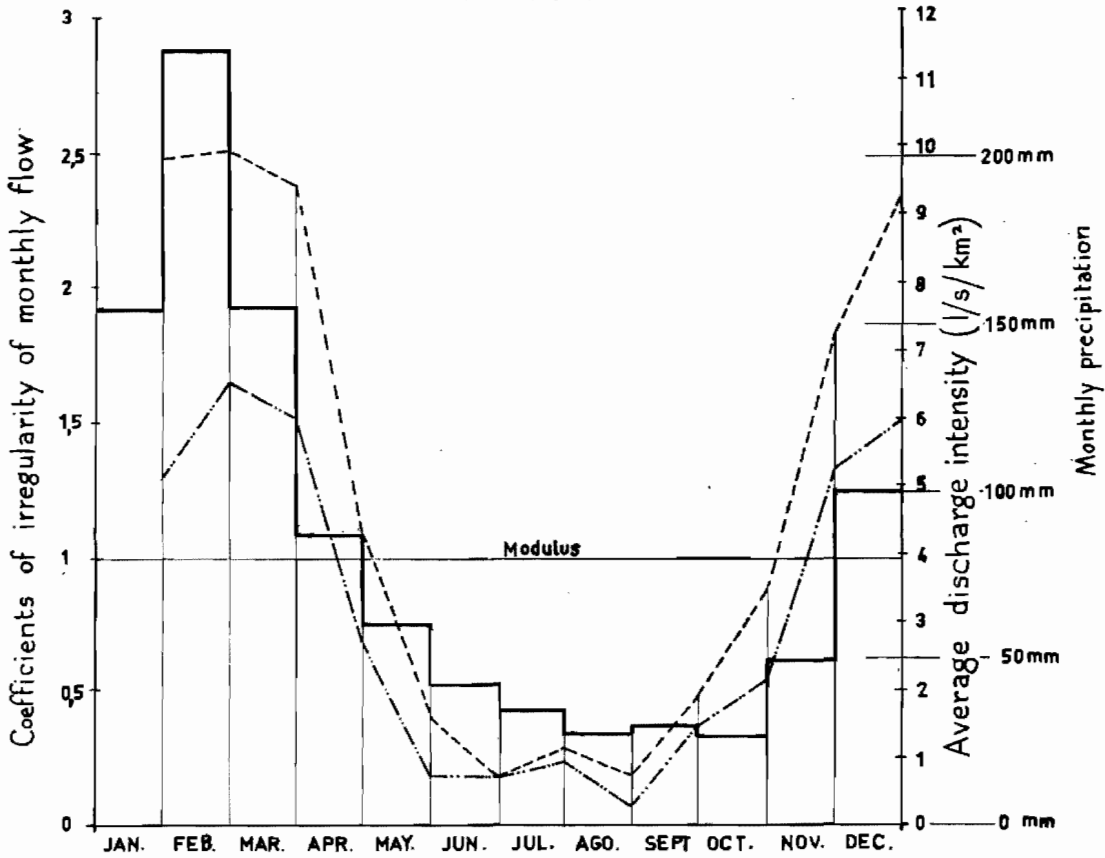


FIG. 2

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COEFFICIENTS OF IRREGULARITY OF MONTHLY FLOW AND AVERAGE INTENSITY OF DISCHARGE OF THE SABIE ($l/s/km^2$) AT MACHATUINE (CATCHMENT $6,410 km^2$) COMPARED WITH PRECIPITATION AT MODDERSPRUIT AND CHAMPAGNE



LEGEND

- Flow at Machatuine
- - - - - Precipitation at Modderspruit
- · - · - do do Champagne

FIG. 3

906 mm. (1,235-329 mm.) at Sabie-Bungalows and of 990 mm. (1,115-125 mm.) at Machatuine.

The coefficient of irregularity (i.e. the relationship between the extreme and mean values of annual river flow) is very low at Machatuine, showing thereby that the river variations are small from year to year. The corresponding coefficient for Sabie-Bungalows can not be determined as the available data cover only a 2-year period.

By the way of comparison, it may be remarked that the Seine river has, at Paris, a variability relationship of 8 to 10, and elsewhere, in the rivers of Europe, this relationship shows values above 5.

In any given year, the relationships between the mean river flows for the wettest and driest months at Machatuine fluctuate between 7.8 and 17, which is quite high on a world basis, though not for Africa.

Attention is drawn to the fact that the coefficients for the Sabie river at the Machatuine station were calculated over a 6-year period—far too short indeed. The coefficients of 3 to 4 and of 7.8 to 17, which are bound to rise when derived from longer records, leads us to suspect that lime beds and underground water reservoirs have a regulating influence on river flow.

2.3. Seasonal variations.

Maximum discharges occur well into the rainy season, generally in the month of February. Although rains are more abundant in January, river flows are not high then as the rain waters are largely absorbed by the parched soil.

Minimum river flows occur in the months August to November.

Poor distribution of river flow through the year is evidenced from an examination of Figs. 2 and 3. Based as they are on average values the graphs do not disclose fully the irregularity of year to year fluctuations.

The diagrams show also the monthly distribution of rainfall at the Modderspruit station—the most representative of the river basin stations upstream of Sabie-Bungalows—and at the Champagne station, both these stations being located in the Republic of South Africa.

The following data were gathered at the hydrographic gauging stations along the Sabie river, viz. Sabie-Bungalows (in South Africa) and Machatuine (in Mozambique):

| Elements | Sabie-Bungalows | Machatuine |
|--|-------------------------|---|
| Drainage area (km ²) | 725 sq. km. | 6,410 sq. km. |
| Average rainfall (P) | 1,235 mm | 1,115 mm |
| Average outflow (m ³) | 238.3 × 10 ⁶ | 3795.3 × 10 ⁶ m ³ |
| Usable rainfall (P ^u) | 329 mm | 124 mm |
| Water loss (P-P ^u) | 906 mm | 990 mm |
| Coefficient of outflow (P ^u /P) | 0.27 | 0.11 |
| Mean river flow (modulus) | 7.6 m ³ /s | 25.2 m ³ /s |

2.4. Classified water flows.

The average values of the characteristic flows of the Sabie river at Sabie-Bungalows and Machatuine are respectively as under:

| Classified river flows | Sabie-Bungalows | Machatuine |
|--------------------------------|------------------------|------------------------|
| C m (minimum flow) | 2.9 m ³ /s | 5.3 m ³ /s |
| CC 11 (excess flow in 11 mths) | 3.7 m ³ /s | 7.5 m ³ /s |
| CC 10 (excess flow in 10 mths) | 3.9 m ³ /s | 8.2 m ³ /s |
| CC 9 (excess flow in 9 mths) | 4.2 m ³ /s | 9.6 m ³ /s |
| CC 6 (excess flow in 6 mths) | 5.9 m ³ /s | 15.0 m ³ /s |
| CC 3 (excess flow in 3 mths) | 10.5 m ³ /s | 29.6 m ³ /s |
| CC 1 (excess flow in 1 mth) | 12.3 m ³ /s | 65.9 m ³ /s |

Note: Data for Sabie-Bungalows are approximate figures determined on the basis of average monthly flows; those for Machatuine were determined from a daily flow record.

3. FLOODS

3.1. General remarks.

The irregularity of the regime is emphasized chiefly, and in a striking manner, by the occurrence of great floods.

3.2. Rainfall.

The river floods are caused by the uncommon violence of the heavy rains, principally in November and February; at times, a rainfall of over 250 mm. is registered in 24 hours in the drainage basin of the Sabie river.

Whenever heavy rains persist for a long time, maximum river flows attain 30%-60% of the normal rainy season flows, and occasionally 90%-100%, at the exits from small drainage basins. In the downstream regions of the drainage basin, the tropical rains are always of the frontal type and therefore followed often by violent thunderstorms. In the upstream regions the rains are of the mountain type and very strong.

Table III.—Rainfall distribution. Monthly and annual averages in millimetres (1880-1956) at four stations.

| | J | F | M | A | M | J | J | A | S | O | N | D | year |
|-------------------|-----|-----|-----|----|----|----|----|----|----|----|-----|-----|-------|
| Modderspruit | 199 | 201 | 191 | 88 | 31 | 14 | 24 | 14 | 38 | 70 | 148 | 188 | 1,206 |
| Sabie (A. do Sul) | 194 | 163 | 159 | 64 | 23 | 14 | 21 | 15 | 45 | 77 | 157 | 183 | 1,114 |
| Champagne | 103 | 133 | 122 | 54 | 15 | 14 | 19 | 6 | 30 | 43 | 107 | 121 | 827 |
| Machatuine | 65 | 74 | 60 | 12 | 26 | 5 | 21 | 11 | 47 | 24 | 80 | 71 | 496 |

3.3. Flood mechanism.

The rises in the water level, of unequal intensity in keeping with the rhythm of rains, and the speed of propagation of the flood waves are usually extremely rapid and sudden: on January 21, 1958, the Sabie river at Machatuine became an impetuous stream with the level of waters rising 5.30 metres in 24 hours. In narrower stretches of the river bed, the surge of the flood waters undoubtedly goes much higher.

In the gorge of the Lebombo basalts, on the frontier between the Republic of South Africa and Mozambique, the swell of the flood in January 1958 must have far surpassed usual flood levels. Downstream of the Corumana Sierra, flood peaks are not very high because the waters spread over the low marginal plains and because there are no important tributaries to the Sabie in Mozambique territory.

3.4. Maximum river flows.

In those regions most affected by the floods, the maximum river flows may be considerable. For example: at Sabie-Bungalows the flood peak in November 1960 was 80 m³/s for a drainage area of 725 sq. km.; the flood peak on January 21, 1958 in Machatuine was 860 m³/s for a drainage area of 6,410 sq. km. or, say, 134 l/s/km² (litres per second per square kilometre)—quite a record for a river basin of this size, though this has been surpassed elsewhere in the Province. This apparently confirms the fact that the river basin in the upstream regions, where there is an abundance of lime deposits, stores much water after heavy rains, thus moderating the flood discharges and improving the dry weather flows.

The specific maximum river flows of the Sabie, though great, are definitely inferior

to those of the Pungue river; for instance, peak discharges of 7,000 to 8,000 m³/s were generated by a drainage area of 14,000 sq. km. or, say, 530 l/s/km².

The January 1958 flood was violent in the mountainous regions and in the upper middle Sabie basin, as was the case in almost the entire drainage area of both the Incomati and the Limpopo rivers.

4. CONCLUDING REMARKS

The Sabie river regime is characteristic of the eastern slope of the South African plateau. The floods, though violent because of the intense rainfall in this region, have their violence somewhat reduced as the flood waters spread over a vast river basin expansion downstream of the Lebombo Mountains; flow is further reduced by the permeability of the Sabie mid-basin regions, where groundwater has an appreciable regulatory effect.

The averages of median river flows are 5.7 m³/s and 17 m³/s for Sabie-Bungalows and Machatuine, far inferior to their respective moduli of 7.6 and 25.2, a fact which is not surprising since the rainfall in this part of Africa pours down in only four months of the year.

In exceptional years, however, the median river flow exceeds the modulus itself at Machatuine, although the stream is usually far more regular at Sabie-Bungalows.

Both the average flows and the discharges per unit area are low, chiefly at Machatuine, and they may even be much lower at the confluence on the Incomati river; yet these river flows are very useful to man as they traverse a very dry region.

In the mountainous regions of the Republic of South Africa, near the village of Sabie, flood intensities are likely to be very high.

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3. WELLINGTON, JOHN H. *Southern Africa*.
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MOZAMBIQUE POWER AGENCY SERVICES,
LOURENCO MARQUES.

AAN DIE REDAKSIE— —LETTER TO THE EDITOR

Note on an Engraving from the Northern Transvaal

In March, 1960, the author published an article in *The South African Archaeological Bulletin* entitled "Preliminary survey of the rock-art of the Limpopo valley" and noted that the furthest north that engravings of humans and animals had been found in the Republic was on the farm Rhodes Drift M.S. 15.

Subsequently the author has photographed this engraving which depicts a human on a horned mount and this is shown in Fig. 1.

MURRAY SCHOONRAAD.

1 CAISTER HOUSE,
635 PRETORIUS STREET,
PRETORIA.
7 February, 1963.



Fig. 1.

Physical Fitness

IN THE ARTICLE on Human Physical Fitness (January 1963) by Dr A. W. Sloan comparisons were made between South African Europeans, the British and the Americans. I was surprised to find no reference to an objective article published in *Manpower*, Vol. I, No. 1, September, 1942. Pretoria. The article was entitled "Comparison between Physical Efficiency Standards of Bantu, Chinese, Coloured, European and Indian school children." The tests were conducted by Drs. E. H. Cluver, T. W. de Jongh and E. Jokl under the aegis of the Medical Research Institute. The findings were chastening to the European's conceit.

M. D. W. JEFFREYS.

UNIVERSITY OF THE WITWATERSRAND,
MILNER PARK,
JOHANNESBURG.
19 February, 1963.

The Ubeidiya Fauna

Based on later work, I want to make the following amendments and corrections to my previous report on the Ubeidiya Fauna. The small Microtine rodent is not a *Pitymys*, but resembles strikingly the Central Asiatic genus *Phaiomys*. The biggest lower equine molars, previously determined as *Equus cf. suessenbornensis*, fall well into the size of very big *Equus stenorhinus* and should, therefore, better be referred to this species. Later and better finds of Suidae proved beyond any doubt that our remnants do not belong to the recent species *Sus scrofa*, but to *Sus strozzi*, an early pleistocene species.

The number of species found at the site could be substantially augmented, and, especially among the hamsters (Cricetinae) a considerable number of Villafranchian species could be added.

G. HAAS,

HEBREW UNIVERSITY,
JERUSALEM.
16 March, 1963.

re: Blue-eyed Africans

Since your *Journal* published my brief note requesting information about Bantu-speaking Africans with blue eyes, at least 17 informants have brought such instances to my notice. The replies have come from many parts of the Republic of South Africa and from Southern Rhodesia. Altogether, they have notified at least 31 cases, drawn from Zulu, Swazi, Xhosa, Sotho, Shangaan and Venda tribes.

The available data from such pedigrees as have so far been analysed do *not* support the views that the gene for blue eyes among these Africans behaves in the same way as the Caucasoid (European) gene for blue eyes. At this stage, it therefore seems unlikely that the blue-eye gene among Africans has been derived by hybridisation with Europeans; it is rather more likely that it has arisen as an independent mutation within the negroid gene pool.

Further investigations of this problem are being carried on by my research assistant, Miss J. Soussi B.Sc., and it would be appreciated if any readers of the *Journal* knowing of cases not already notified would bring them to our notice. We are interested not only in blue eyes among Africans, but also light eyes of other hues, such as light brown, grey and green eyes.

PHILLIP V. TOBIAS,

PROFESSOR OF ANATOMY,
UNIVERSITY OF THE WITWATERSRAND
HOSPITAL STREET,
JOHANNESBURG.
4 March, 1963.

Prehistory of the Transvaal*

This lavishly illustrated book with its 22 coloured pictures of paintings and engravings constitutes a landmark in South African archaeological progress. It has done for the Transvaal what was done for Southern Rhodesia by the late Neville Jones first in 1926 and later in 1949 and for Kenya by L. S. B. Leakey in 1931 and for Northern Rhodesia by J. Desmond Clark in 1950.

*A review of the book "Prehistory of the Transvaal: A Record of Human Activity" by Revil Mason. Johannesburg: Witwatersrand University Press, 1962. xxiv + 488 pp., 257 illus., Price R6.00 (£3.0.0, \$8.70)

It provides as accurate and critical a statement about the prehistory of this particular province of the Republic of South Africa as detailed knowledge of the facts at present allows, and furnishes thereby standards whereby future progress in unravelling our local story of the Stone ages can be measured.

We still await a book that will cover in similar detailed fashion the whole of the Republic, though the need for a general account has been met to some extent by the publication three years ago of J. Desmond Clark's *The Prehistory of Southern Africa*. But the student or enthusiastic amateur needs local descriptive works which enable him to identify the objects he encounters, to visit the actual sites that have provided the evidence and to appreciate the aspects and localities and thus the extent of the subject awaiting further investigation.

These are but some of the qualities that render Dr Mason's book especially valuable. We owe it primarily to its emergence from his doctoral thesis founded on his original work within the Transvaal but amplified and brought up to date by subsequent studies both official and voluntary.

The generosity of the Wilkie Brothers Foundation, Des Plaines, Illinois stimulated publication of the book by the Witwatersrand University Press, but it could not have seen the light in so opulent and attractive a form at so reasonable a price without supplementary interest-free loans from Mr. J. Scott and from the Anglo-American Corporation.

The first half of the book can be regarded as having two main sections.

The first section comprised in five chapters is introductory to the subject matter, to the Transvaal itself and preceding prehistoric research. It then faces the limitations of our stratigraphical records in river gravels and other open-air sites, illustrates the importance of sealed stratified deposits and emphasises the necessity for correlation between these two approaches by a rigid application of statistical techniques.

The second section (Chapters 6-8) carries us through at least half-a-million, possibly a million and a half years of prehistory from australopithecine culture to the end

of the Early Stone Age approximately 40,000 years ago.

While the book was in preparation various orthodox archaeological concepts were undergoing revision and even obliteration. The Australopithecines, previously deemed to be apes, were being accepted as human and as makers of tools. The Vaal river gravels, accepted as indicators of successive Pleistocene climatic fluctuations, were placed by the Yale geologist R. F. Flint in a suspense account "until systematic measurements have been made in selected drainage systems." He even questioned the value of alluvial deposits as a whole in this respect. Ferruginous and calcrete deposits have proven equally fallacious.

Carbon dating, that has been so useful because of its objectiveness, can be confounded by the mixing of strata or by the penetration of recent tree roots. Thus confidence can arrive only through the accumulation of data.

The ideal situation for the prehistorian is one like Olduvai Gorge. There a huge natural lake depression has been piling up hundreds of feet of horizontally-lying silt separated by strata of dateable volcanic soils. Then nature has kindly tilted the accumulation enough for rains to excavate its centre and leave the ancient shores exposed laterally for successive excavations.

Contrariwise the Transvaal is a succession of plateaus and Johannesburg is perched upon the Witwatersrand watershed between the Orange and Limpopo drainage systems. We have no helpful volcanic ashes and our landscape has been undergoing erosion for millions of years. So practically all our prehistoric records have rotted or worn away leaving only in nooks of upland vleis or in crannies of slumping dolomitic caverns the pathetic truncated records of that multi-millennial saga.

So, while the river gravels, especially when they happen to be fossil-bearing, have given us sequential information of considerable general value it is only those occurrences of stratified sequences in sealed deposits and containing artefacts in quantities of sufficient magnitude to provide statistical information for comparison with other stratified sequences that have been

regarded by the author as enabling us to reconstruct the prehistoric past with any approach to reliability.

Hence the definition of suitable categories of implemental forms susceptible of such comparative statistical application has dominated this enquiry into and interpretation of the stone artefact evidence especially in his analysis of the Early Stone Age. This occupies the first half of the book and prepares the stage for his review of the Middle and Late Stone ages. Nine valuable appendices to the volume amplify his findings by dealing with *The Faunal Material from the Cave of Hearths and Kalkbank* by H. B. S. Cooke; *The Kalkbank Suidae* by R. F. Ewer; *Analysis of Iron Age Metal and Slag* by W. Schneider and *Recording Soil Profiles* by A. B. A. Brink. They also include one by J. E. Kerrick on *Statistical Notes*, discussing the validity and limitations of the statistical method adopted by the author.

Perhaps the most novel feature of the book is its containing the first thoroughgoing public description of the earliest known stone culture, i.e. the so-called Earlier Acheulean pebble culture which was found accompanying australopithecine remains at Sterkfontein and replete already with handaxes, flakes, choppers, spheroids, cuboids, anvils, cores and irregular artefacts.

Astonished by the unexpected complexity of this tool assemblage and its comparison with those from other sites in the Vaal gravels Dr Mason is loath to believe that *Australopithecus* could have produced it and, despite the opinions of the late Professor C. van Riet Lowe, rejects the stone artefacts found at Makapansgat. Nor is he prepared to accept as australopithecine work the rather similar stone tools found by the Leakeys accompanying *Zinjanthropus* in Bed I of Olduvai Gorge. Yet he frankly accepts the bone artefacts discovered accompanying australopithecine remains at Makapansgat Limeworks as "the earliest artefacts at present known in the Transvaal." He prefers to regard the stone and perhaps even the bone artefacts as the tools made by the more advanced (? pithecanthropine) type of mankind that exterminated the Australo-

pithecines. Divergent deductions from the facts can of course only be resolved by the weight of evidence accumulating from further investigations.

The second half of the book covers the last 40,000 years and deals with the Middle and Later Stone Ages, Prehistoric Art and The Iron Age. It provides a much needed revelation to the modern inhabitants of the Transvaal of the wealth that still resides in our distant caves on our far-flung hill-crests of the Neanderthoid and Sapiens (or Boskop, Bush, Hottentot and Bantu) occupations that preceded the arrival of Europeans here during last century.

These four approximately equivalent sections of the book embrace very different periods of time. The Middle Stone Age extended over 30,000 years, the Later Stone Age (with which the Prehistoric Art is most closely affiliated) over less than 10,000 years and the Iron Age over little more than the last 1,000 years.

This division however corresponds approximately with our actual knowledge about the prehistory of the Transvaal; it is these more recent phases of our prehistory that are more familiar to the lay reader. So the author has been wise in his choice of suitable illustrations and has been immensely assisted therein by the reconstructional scenes pictured by his talented wife.

One cannot page through the book without being impressed firstly by the quality of the whole production and secondly by the aptness and opulence of its photographs, pictures, and coloured reproductions of paintings and engravings. These breathe collectively the very width, affluence and mystery of the veld as well as the seclusion and intimacy of its habitational recesses in rock shelters and caves. A whole new treasury of names has appeared like Kalkbank and Olieboompoort, Bosworth and Magabeng, Uitkomst and Olifantspoort, Rooiberg and Mapochstad, each clothed with fresh archaeological meaning and each but a foretaste of knowledge still to come.

RAYMOND A. DART.

REVIEWS

AGRONOMY

RESEARCH TECHNIQUES IN USE AT THE GRASSLAND RESEARCH INSTITUTE, HURLEY, being Bulletin No. 45 of the Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire, England by the Members of Staff of the Grassland Research Institute. *Published by Commonwealth Agricultural Bureaux, Farnham Royal, Bucks., England, 1961. 167 pp. plus 28 plates. Price 40s. (\$6.00).*

Here is a book containing the methods and techniques used by one of the large grassland research centres in Britain. It contains six main sections devoted to various aspects of grassland investigation each written by an expert in the field.

The first section is on experimental design and deals with problem definition, replication, errors in laboratory and field, as well as recording and computing results.

The chapters dealing with herbage plant investigation are concerned with preliminary selection of suitable plants and their physiology. Methods of pot culture environmental control, leaf area determinations, as well as analysis of pastures by point and clipped quadrats.

In the chapters dealing with animal studies, procedures for measuring live weight and carcass quality are described. There are parasitological techniques as well as methods for evaluating digestibility of herbage. No attention is given to the calculation of T.D.N. yield, however, a technique on which there is much controversy but which is useful nevertheless.

There is a section on soil/plant studies which discusses grass by evaluation, by crop yield and soil analysis. Techniques of incubation nitrogen and carbon analysis are described. There is also a chapter dealing with the irrigation of small experimental plots.

A short section on co-operative experiments deals with methods of marking plots and making measurements away from the laboratory. The final chapter deals with special laboratory equipment used in grassland investigations.

In the introduction it is pointed out that the methods described are not the only methods nor are they necessarily the best ones. They are, however, all tried and known to yield reproducible results. Pasture research workers will find many useful hints which may help them in their work. An extensive bibliography allows further reading on some of the techniques.

This is a useful book which should be accessible to all who are interested in herbage and pasture research.

P. GILLARD.