The deposits at ≠gi, as well as the limited alluvial fills along the middle !Kangwa River valley are thin sedimentary veneers within a major Middle Pleistocene valleyway. These deposits apparently span the later Middle Pleistocene to the present. At the base of the ≠gi sequence is a calcreted, fluvial conglomerate, which "downstream" in the !Kangwa valley includes derived Early Stone Age artifacts. At ≠gi a layer of uncemented, fluvially cross-bedded sands is above the conglomerate; thus two separate, semi-humid episodes with stream flow are suggested. Above these alluvia is the ≠gi Middle Stone Age horizon, which consists of calcareous, textually diverse, valley floor colluvia. Apparently floodplain dessication led to discontinuous ponds, which were proto-types for the modern pans. Settlement around an ephmeral water resource seems likely. Gentle tectonism (decreasing the valley slope) during a geomorphic environment like the present is indicated. Capping the Middle Stone Age levels at ≠gi is a fresh-water limestone, referable to a valleywide lake and renewed geomorphic humidity. The first Late Stone Age horizon rests on this limestone, and consists of more valley floor colluvia. A return to a pan margin setting in a semi-arid landscape like present must be posited. In the middle of Late Stone Age time another valley-wide lake appeared as evidenced by a second freshwater limestone. When this lake disappeared pan margin colluvia with Late Stone Age settlement are again typical. Eventually the pan filled with dark organic muds, derived from soil erosion and deposited during limited alluviation of the ≠gi valley. Still later the pan basin was eroded (via deflation) and aeolian activity was widespread on the valley floor. Most recently the ≠gi margins have been re-colonized by vegetation. The alluvial fills in the !Kangwa valley provide a palaeo-geomorphological record compatible with the ≠gi horizons.

Geological and archaeological work on the ≠gi materials is continuing and full accounts of the research will be published subsequently.

5637

PHYTOGEOGRAPHY OF THE NAMIB DESERT OF SOUTH WEST AFRICA (NAMIBIA) AND ITS SIGNIFICANCE TO DISCUSSIONS OF THE AGE AND UNIQUENESS OF THIS DESERT

Ernest Richard Robinson

Department of Botany, University of Fort Hare, ALICE 7500, South Africa.

SUMMARY

Analysis of data on the distribution of plant species occurring in the Namib Desert showed that a large proportion (some 35%) of the desert flora consists of species which are either endemic or at least restricted to the desert. It was further shown that the majority (85%) of the endemic/restricted species occurs only in the winter rainfall area of the southern Namib. The low average number of species per genus seems to indicate that the high proportion of endemic/restricted species in the flora is not due to rapid phylogenetic speciation in recent times.

Although the large southern element supports the inclusion of the Namib flora in the Karoo - Namib phytogeographical region (Volk, 1966 and White, 1971), it is pointed out that the flora of the northern, or summer rainfall area has rather low floristic affinities with the Karoo and Namaqualand floras.

INTRODUCTION

The Namib Desert extends as a narrow strip (90 to 120 km wide) along the west coast of Africa from near Mossamedes in Angola southwards. The southern boundary is usually taken to be the Olifants River in the Cape Province (Wellington, 1955) although Léser (1977) maintains that the Namib does not extend further south than the Orange River. This paper deals with the part of the Namib between the Orange and Kunene Rivers (Fig. 1) and thus includes the greater part of this coastal desert. It is divisible into a number of bioclimatic sub-regions. From west to east there are three zones: along the coast is the fog desert zone (some 20 to 40 km wide); inland of this is an extremely arid zone of about 50 km wide which receives little fog and virtually no rain: and, a variable width transition zone where the desert merges into the arid steppe or bushveld of the escarpment. There are, in addition, two latitudinal zones of biogeographical significance. A winter rainfall climate occurs in the south, extending to somewhat north of Lüderitz Bay, while the remainder of the Namib receives its scanty rainfall in summer (Fig. 1).

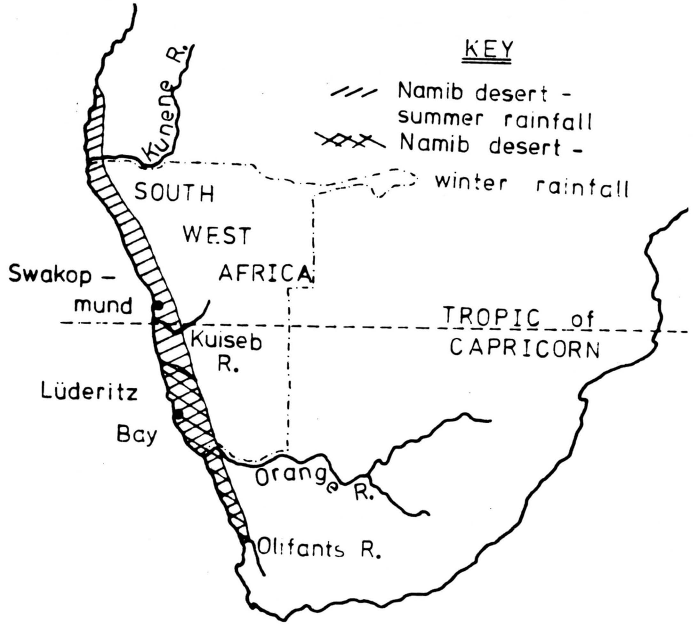

Fig. 1 Southern Africa, showing the Namib Desert and the summer and winter rainfall areas as well as the extent of the area covered in this study.

Of great significance to north- or southward migration is the Namib Erg. This vast dunefield extends from the Koichab River (at about the latitude of Lüderitz Bay) to the Kuiseb River (Fig. 1) and is up to 120 km wide (Besler, 1977). Geological evidence (Besler, 1977) indicates that there have been a number of series of dunes formed at different times.

Unusual elements of the flora (such as Welwitschia mirabilis Hook. fil. and Acanthosicyos horrida Welw. ex Benth. & Hook. fil. to mention but two species) have evoked much interest from the time of the earliest explorers (see Pearson, 1907 for instance) but the flora as a whole had not been analysed in terms of uniqueness, evolution etc. This paper sets out to achieve this and provide answers to the following questions:

1. Is the entire Namib flora clearly different from the remainder of the South West African flora as measured by the number of endemic or restricted species?

2. If so, is it possible to identify possible centres of speciation?

3. Is it possible to determine whether the restricted/endemic species are of ancient or relatively recent origin? The answer to this question might give some idea of how stable the Namib Desert system has been, since an unstable semi-arid environment seems to promote phylogenetic speciation (see Stebbins, 1972 for discussion of this point)

SOURCES OF DATA

Distribution data were obtained from observations and collections made during 1972-1975 while the author was resident at the Desert Ecological Research Station, Gobabeb, in the central Namib Desert. These data supplemented information from published papers, including Merxmueller's "Prodromus einer Flora von Südwestafrika", and herbarium records.

A major difficulty was the determination of what constituted a true desert species. Many plants utilized the many seasonally flooded rivers which cross the desert (particularly north of the Kuiseb) as migration routes. In this way many species (such as Eragrostis trichophora, Sporobolus nebulosus, S. consimilis, Chenopodium ambrosioides, Datura innoxia, D. stramonium and Nicotiana glauca to mention only a few of the most striking examples) penetrate deep into the desert although they are not true desert plants (Giess, 1962; Robinson, 1977). Still other species are opportunists, extending their ranges into the desert following good rains. In compiling the lists of species for the desert flora, all species recorded from the Namib Desert were included. This has undoubtedly resulted in the inclusion of some non-desert, and possibly some wholly alien species, but is considered preferable to the arbitrary exclusion of species. It is believed that naturalized exotics are as much a part of the flora of a region as opportunistic indigenous species.

Names of taxa are as given in Merxmueller (1966-1970).

RESULTS

1. Proportion of the flora restricted to the desert regions:

1.1 Families and genera (Table 1)

Some 104 families (101 spermatophytes and 3 ferns) and 496 genera (490 spermatophytes and 6 ferns) were recorded from the Namib Desert. This represents 63% and 71% of the families and genera respectively of the entire South West African flora. The largest families with taxa occurring in the desert are: Compositae (61 genera), Gramineae (46 genera), Aizoaceae (38 genera), Liliaceae (21 genera) and Fabaceae (19 genera).

Of the genera, 49 are restricted to the desert. These are not necessarily endemics (for example, genera such as Ficinia, Eleo-

	Total SWA No	Total Namib No.	Total Namib %	Taxa restricted to Namib No.	% Namib	% SWA
Family	166	104	63	49	47	28
Genus	703	496	71	210	42	30
Species	3168	1427	45	492	35	15

Table 1. Numbers of families, genera and species comprising the flora of South West Africa and the Namib Desert of South West Africa.

Zone	Total No. of Species	% Namib Flora	Species restricted to a single climatic zone No.	% Namib Flora	% Restricted Namib
Winter rainfall	880	62	418	29	85
Summer rainfall	365	26	55	15	3,9

Table 2. Numbers of species occurring in the summer and winter rainfall zones of the Namib Desert of South West Africa.

Category	Species/Genus
Total flora of S.W.A.	4,5
Total Namib Desert flora	2,9
Restricted Namib flora	2,3
Winter rainfall zone desert flora	2,9
Summer rainfall zone desert flora	1,1

Table 3. Mean numbers of species per genus for different categories of the South West African flora.

charis and Ruppia have only been recorded from the Namib in South West Africa, but they are, of course, not endemic to this area). Of the restricted genera, the majority (38) have either only one species or are truly monotypic.

1.2 Species (Table 1)

Some 3168 species have been recorded for South West Africa, and of this total, 1427 (45%) occur in the desert and thus comprise the Namib Desert flora. Of these species, a large proportion (492 or 34,5%) have only been recorded from the desert: they can be said to be restricted to the Namib Desert, at least in South West Africa.

2. DISTRIBUTION OF TAXA RESTRICTED TO THE DESERT

2.1 Species (Table 2)

Examination of the distribution of species found only in the desert indicated that there were more species (880) in the winter rainfall area of the south than in the northern, summer rainfall area (365 species). The remaining 182 Namib species occur throughout the desert. Furthermore, the winter rainfall area has 418 of the restricted species, while only 55 are found in the summer rainfall area: the remaining 19 restricted species are distributed independently of the season in which rain could be expected. The species restricted to the winter rainfall area comprised a large part (85%) of the "unique" element of the flora.

2.2 Genera

The larger genera having a winter rainfall distribution are given below in descending order of numbers of species in the winter rainfall area.

Crassula	Lessertia	Erharta
Ruschia	Andromischus	Kleinia
Adenogramma	Trachyandra	Zaluzianskya
Pelargonium	Lotononis	Arctotis
Juttadinteria	Anacampceros	Caralluma
Conophytum	Sarcocaulon	Duvalia
Pteronia	Stapelia	Polycarena
Cotyledon	Cephalophyllum	Euryops
Heliophila	Drosanthemum	Gazania
Lithops	Albuca	Delosperma
Othonna	Bulbine	Cheiridopsis
Zygophyllum	Lachenalia	Ursinia
Oxalis		

Genera with a predominantly northern distribution are:

Commiphora	Boscia	Rhynchosia
Dipcadi	Petalidium	Aerva
Aristida	Cardiospermum	Welwitschia
Tephrosia	Mercelliopsis	Moringa
Lebeckia	Chloris	Mentha
Merremia	Cucumella	Suaeda
Maerua	Engleria	

3. EVIDENCE FOR THE ARCHAIC (RELICT) OR MODERN NATURE OF THE ENDEMIC/RESTRICTED COMPONENTS OF THE FLORA

Such evidence may be gained from an assessment of how well the taxa of the flora meet the criteria for rapid evolution set out by Wright (1963)[1]. A measure which has been used to quantify this assessment is the mean number of species per genus (Stebbins, 1972). This indicates the number of related species in a particular area, and hence, the degree to which speciation has occurred.

The mean number of species per genus was calculated and results are given in Table 3. The mean of 4,5 species per genus is low throughout South West Africa and decreases still further to 2,3 for taxa restricted to the desert. Table 3 also shows that the summer rainfall area differs from the winter rainfall area in number of species per genus. In the summer rainfall area there is an average of 1,1 species per genus (most genera having one or at most a few species), while in the winter rainfall area the mean is higher, at 2,9 species per genus.

Not all genera comprising the restricted flora have such low numbers of species. For example: Crassula has 51 species in South West Africa and 32 are restricted to the Namib; Stipagrostis has 24 species of which 14 are only found in the desert; Ruschia is represented by 22 species and 14 are purely Namib in distribution; Juttadinteria which has 12 species has no extra-Namib members; and, Pelargonium with 17 species and 11 restricted to the Namib of South West Africa.

DISCUSSION AND CONCLUSION

The Namib Desert of South West Africa has a comparatively high proportion of restricted or endemic species (34,5% of the flora). This compares favourably with other regions of Africa which are considered to have significant numbers of endemics, and where these comprise from 5% (Wild, 1968 for the Chimanimani Mountains of Rhodesia) to 48% (Morton, 1972 for mountain systems in the Cameroons) of the flora. In this sense, the Namib flora is "unique", being clearly different to the surrounding areas. Data are still required from other areas, particularly Namaqualand, to determine which of the restricted species are truly endemic.

The greater part of the unique Namib flora occurs in the winter rainfall area of southern South West Africa. Comparisons between the genera of the southern Namib flora and lists given by Acocks

[1]See end of article

(1975) show clearly the strong similarities between this flora and those of Namaqualand and the Karoo. Inclusion of at least the southern Namib in the Karoo-Namib phytogeographical region, as done by Volk (1966) and White (1971) is obviously justified. The flora of the summer rainfall area does not, however have such strong affinities with the Karoo or Namaqualand flora. This may be because it has either a different centre or origin or as a result of climatic differences and the barrier formed by the Namib Erg. In short, the Namib Desert flora would, therefore, seem to either have a southern origin or to have two centres of origin.

The low average number of species per genus suggests that much of the restricted flora may be ancient, since, according to Stebbins (1972), values as low as those found in the Namib do not support an hypothesis that speciation is occurring. This therefore may be evidence that the environment has been stable for some time, at least for the summer rainfall region.

Despite the fact that most genera show little or no evidence of active phylogenetic speciation at present, this is not the case for all taxa (see 3 above). It is interesting to note that of the five genera having the largest numbers of species restricted to the Namib, four (Crassula, Ruschia, Juttadinteria and Pelargonium) are predominantly southern in distribution. This, together with the larger number of restricted species and higher average number of species per genus emphasises the difference between the summer and winter rainfall areas. It also suggests that the sand dunes have served as a barrier which has isolated the northern floral element and that the southern element may be of more recent origin than the northern.

[1]Evolution is most rapid in situations where a population is broken up into sub-units which are sufficiently isolated from one another to become differentiated by the actions of different processes, but where occasional migration between the local populations allows exchange of adaptive genes or gene complexes. Stebbins (1972) states: "If such a situation exists for long enough there will be the development of species complexes consisting of mosaics of allopatric species and narrowly endemic species and subspecies".

ACKNOWLEDGEMENTS

Discussions with Dr S. Endrödy-Younga (Transvaal Museum, Pretoria) pointed out the need to examine the whole Namib flora to obtain additional biological data about the age and uniqueness of the Namib. I am pleased to be able to acknowledge my debt to him for this stimulus.

The Desert Ecological Research Unit and the Department of Nature Conservation and Tourism of the South West African Administration made it possible for me to travel widely in the Namib during my stay at Gobabeb. These facilities are greatly appreciated.

Dr and Mrs Downing and Dr Gibbs Russell of the University of Fort Hare gave encouragement, assistance and very valuable criticism during preparation of the paper.

REFERENCES

Acocks, J.P.H. 1975, Veld types of South Africa, Mem. Bot. Surv. of S.A., 28, 128 pp.
Besler, H. 1977, Untersuchungen in der Dünen - Namib (Südwestafrika), J.S.W.A. Wissensch. Gesellsch. 31: 33-64.
Giess, W, 1962, Some notes on the vegetation of the Namib Desert with a list of plants collected in the area visited by the Carp - Transvaal Museum expedition during May 1959, Cimbebasia 2, 36 pp.
Leser, H. 1977, Zum Problem der Namib-Südgrenze in der südafrikanischen Kapprovinz, J.S.W.A. Wissensch. Gesellsch. 31: 7-31.
Merxmueller, H. (ed.) 1966-1970, Prodromus einer Flora von Südwestafrika, J. Cramer, Lehre, published as separate fascicles.
Morton, J.K. 1972, Phytogeography of the West African Mountains, In: D.H. Valentine (ed.) Taxonomy, Phytogeography and Evolution: 221-236, Academic Press, London.
Pearson, H.H.W. 1907, Some observations in the Welwitschia desert, S.A. Assoc. Sci. 5th Meeting Report: 116-117.
Robinson, E.R. 1977, Phytosociology of the Namib Desert Park, South West Africa. M.Sc. Thesis, Univ. of Natal, Pietermaritzburg, 220 pp.
Stebbins, G.L. 1972, Ecological distribution of centers of origin of major adaptive radiation in Angiosperms, In: D.H. Valentine (ed.) Taxonomy, Phytogeography and Evolution, p. 7-34, Academic Press, London.
Volk, O.H. 1966, Die Florengebiete von Südwestafrika, J.S.W.A. Wissensch. Gesellsch. 20: 25-58.
Wellington, J.H. 1955, Southern Africa: A geographical study, Vol. 1 Physical geography, Cambridge Univ. Press, 528 pp.
White, F. 1971, The taxonomic and ecological basis for chorology, Mitt. Staatsamml. München.10: 91-112.
Wild, H. 1968, Phytogeography in South Central Africa, Kirkia 6(2): 197-222.

PALAEONTOLOGICAL AND ARCHAEOLOGICAL INVESTIGATIONS IN THE LOWER ORANGE VALLEY FROM ARRISDRIFT TO OBIB (IN THE CONCESSION AREA OF THE CONSOLIDATED DIAMOND MINES OF SOUTH WEST AFRICA, (PROPRIETARY LIMITED)

Gudrun Corvinus

The Consolidated Diamond Mines of S.W.A. (Pty) Ltd
Geological Department, P.O. Box 253, Oranjemund 9015, South West Africa.

1. INTRODUCTION

This paper deals with the results of the first year's investigations into the palaeontological and archaeological resources of the Orange River valley after the author was employed as archaeologist to the mine. The investigations were used to clarify the problems in dating the Orange River deposits.

Palaeontological exploration led to the discovery of one of the richest and most important Tertiary fossil occurrences in southern Africa in river deposits at Arrisdrift,30 km inland from the mouth of the river and 40 m above present sea level. Excavations were undertaken during March to May 1976 and from November 1976 to January 1977. Basal gravels in a channel lag deposit yielded a large quantity of vertebrate and invertebrate as well as plant remains, indicating a Middle Miocene age for the Orange deposits at Arrisdrift. The vertebrates include at least 27 species of the orders Insectivora, Carnivora, Hyracoidea, Proboscidea, Perissodactyla, Artiodactyla and Rodentia. Three of the species are new while 8 genera have not hitherto been known in southern Africa. (Q.B. Hendey, in press).

The palaeontological findings established the age of the river deposits as Miocene, which is much older than they were at first thought to be. The archaeological findings so far may postdate the deposition of the Orange River gravels. They constitute mainly surface sites but also in situ sites in slopewash deposits and in the weathered residual rubble horizon overlying the terrace gravels. In the Middle Pleistocene, a long time after the formation of the Miocene Orange River deposits at Arrisdrift, Early Stone Age man occupied the river banks in the now abandoned channel between Terrace III (30m a.m.r.l.) and Terrace IV (20m a.m.r.l.). Artefacts of a slightly younger period were found embedded in slopewash deposits within the gullies which cut down through the terraces. An Acheulian industry was found in the red soil capping the 45 metre terrace at pit 11/AD7 at Arrisdrift. Early Middle Stone Age people inhabited the lower terrace. The latest arrivals were "Bushmen" who used the Orange River valley as one of their migration routes to the coast and were responsible for several "stop over" sites.