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Environmental changes in the Kaokoland Namib Desert during the present millennium

(with 7 figures, 6 plates, and 2 tables)

by

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KEY WORDS

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Radiocarbon chronology

ABSTRACT

Some fluvial forms and sediments in the valleys of the Hoanib and Hoarusib Rivers in the Kaokoveld Namib are described. Radiocarbon dates of plant remains from some of the younger deposits suggest a sequence of climatic fluctuations during the present millennium. Thus a relatively wet phase of autochthonous valley formation which occurred in both river systems came to an end in the 12/13th centuries AD in the Hoarusib valley. Arid conditions with low energy floods probably prevailed until after the 16th century AD in the Hoanib valley. Active incision set in after this, and still prevails, suggesting a recent increase of precipitation in the hinterland. The dated sediments are defined informally as the youngest members of two new lithostratigraphic units: the Hoanib Alluvium formation and the Hoarusib Alluvium formation. Palaeoenvironmental changes in terms of 'wetter' and 'drier' on a time-scale of centuries rather than millenia have now been recognized in the landforms of the region.

ZUSAMMENFASSUNG

Es werden einige fluviale Formen und Sedimente der Hoanib- und Hoarusibriviere (Rivier = Trockenfluß) in der Kaokoveld/Namib beschrieben. 'Feuchtere' und 'trocknere' Klimaschwankungen in der Zeitskala von Jahrhunderten statt Jahrtausenden lassen sich aufgrund geomorphologischer Beobachtungen und 14C-Daten an Pflanzenresten erschließen. Demnach endete eine relativ feuchte Phase autochthoner Talbildung, die in beiden Riviersystemen vorkam, im Falle des Hoarusibriviers im 12./13. Jh.n.C. Im Hoanibrivier scheinen hingegen bis nach dem 16.Jh. aride Verhältnisse mit energiearmen Fluten geherrscht zu haben. Danach begann wieder eine Phase aktiver Einschneidung, die bis heute fortdauert und auf eine neuerliche Zunahme der Niederschläge im Hinterland verweist. Die datierten Formen und Sedimente werden informell als jüngste Glieder zweier neuer lithographischer Formationen, die 'Hoanib Alluvium formation' und die 'Hoarusib Alluvium formation', definiert.

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1 INTRODUCTION

In the Kuiseb River valley, upstream of the research station at Gobabeb, landforms and sediments bear evidence of climatic change during the Quaternary. The relative ages of these features were established in 1972 and correlated with the sequence previously derived mainly in the coastal area (Rust and Wieneke, 1974). Further work on, and discussions of, the geomorphology of this river valley have since been published by various authors (Ollier, 1977; Marker, 1977; Marker and Muller, 1978; Rust and Wieneke, 1980; Marker, 1983; Ward, 1984).

One of the prominent sedimentary features in the Kuiseb canyon is the 'Ossewater lake deposits' (Rust and Wieneke, 1974) or 'Homeb silts' (Marker, 1977; Ollier, 1977). These have been absolutely dated by radiocarbon to 23 000 to 19 000 BP (Vogel, 1982). The dating provides at least one useful fixed point in the chronological sequence of past climatic events in the region. The palaeoenvironmental interpretation of these and other geomorphic relics is not always uncontroversial, but there is no doubt that they do reflect palaeoclimatic conditions in one way or another. Eventually they may provide a reliable chronological framework of local environmental change during that geologic period which is still relevant to the present. This may then be used to predict the effects that future global climatic changes can be expected to have on the southern African subcontinent.

In order to investigate whether comparable landforms and sediments are represented in the dry valleys of the rivers to the north of the Kuiseb River and, if possible,

to date them, the area between the Ugab and the Kunene Rivers was visited in July/August 1984 (Fig. 1, 2).

In the course of the fieldwork geomorphologic-stratigraphic evidence of climatic fluctuations was observed that obviously related to the more recent past. Radiocarbon dates indicate that these phenomena pertain to the present millennium and are relevant in that they reflect the variability of the present climate.

As is well known, radiocarbon dates, particularly for the past 500 years, are somewhat distorted (cf. de Vries, 1958; Stuiver and Suess, 1966; Lerman et al., 1970; Vogel, 1970, 1971), and it is necessary to convert such results to true historical dates in order to provide a realistic chronological sequence. This is done for the radiocarbon measurements presented here by using the most recent calibration curve for the southern hemisphere (see forthcoming issue of *Radiocarbon*, 1986, and Vogel et al., therein).

2 HOANIB RIVER

The Hoanib River derives from the Great Escarpment beyond the Namib desert and has a length of 238 km, and an average gradient of 0.48% (Topographical Map SWA 1 : 250 000). It normally ends in an extensive floodplain on the inland side of a ca. 10 km broad dune belt that runs parallel to the coast (Fig. 3). In exceptional rain years such as 1982 and 1984 the river breaks through the dunes and reaches the Atlantic Ocean. On the first of these occasions the floodwater built up in front of the dune barrier until it started to filter through on the other side. Once this happened the dune sand was rapidly eroded away on the downstream side until a passage through the dune was created (pers. comm. of the local rangers).

Within the dune belt remnants of sandy silts occur 7 m above the river bed, and driftwood was found at

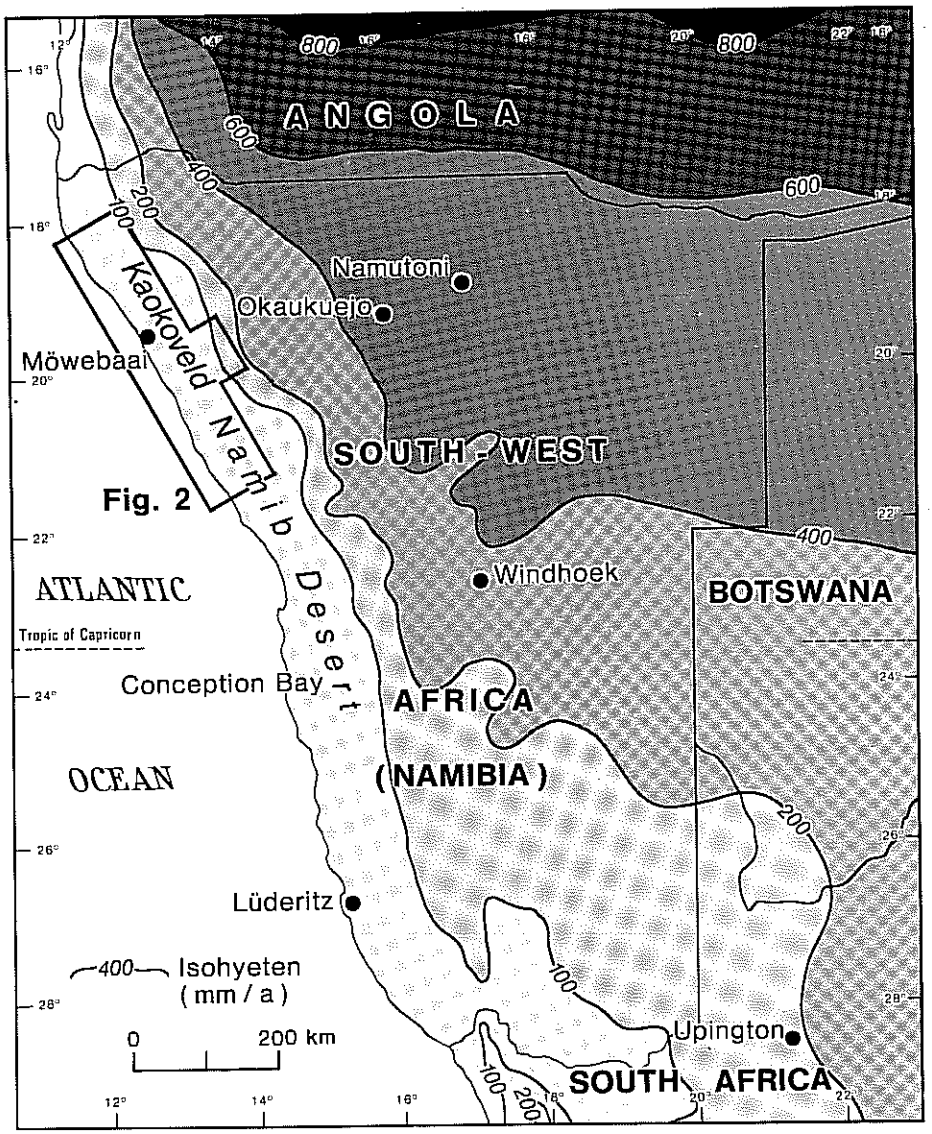


FIGURE 1: Locality of the investigated area in South West Africa/Namibia.

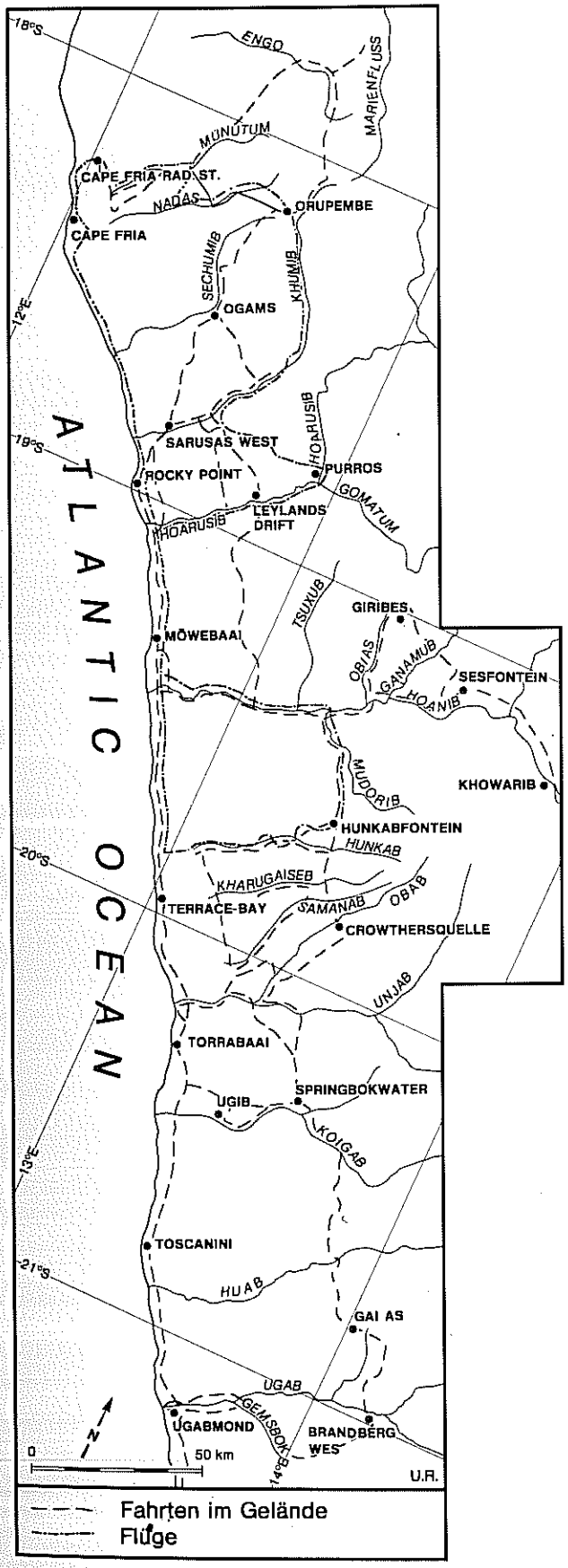


FIGURE 2: Enlargement of study area shown in Fig. 1 with the routes travelled.

various levels up to 13 m above the present river bed. Two of these logs (Fig. 3) were dated with the following results:

Pta-3882. Hoanib log + 7m 40 ± 30 BP
Outer annual rings of driftwood log 7 m above present river bed in Hoanib river course in dunefield ca. 10 km from coast. Most probable calibrated date: AD 1900.

Pta-3884. Hoanib log + 13 m 200 ± 70 BP
Outer annual rings of driftwood log 13 m above present river bed in Hoanib river course in dunefield ca. 10 km from coast. Most probable calibrated date: AD 1670 or AD 1770.

These datings confirm that considerable floods have passed through the dunefield during the last centuries to spill into the Atlantic.

As stated above, the river normally terminates in an extensive 'internal delta' or floodplain on the landward side of the dunes (Fig. 3). The floodplain extends for 16 km from 170 m above sea level to 200 m a.s.l., with a gradient of 1.9 o/oo. The sediment (HOM 3 in Fig. 6) consists of fine-grained river-end deposits which are in the process of accumulation.

From about 30 km inland to Amspoort (260 m a.s.l.) the meandering Hoanib is cutting into its own alluvial sediments (Plate 1). Geomorphologically the internal delta in this section forms a terrace of the Hoanib. We term the sediments that form this terrace as the 'Amspoort silt member' of the 'Hoanib Alluvium formation'. It consists predominantly of fine-grained fluvial silt (HOM 4, 10, 4211, II, IV in Fig. 6). The stratification is mainly horizontal, indicating low flow velocities (Picard and High jr, 1973).

In this tract of the river two buried trees have recently been exposed in the right-hand river bank, probably by the 1982 or 1984 floods. Radiocarbon analysis of samples from these trees gave the following results:

Pta-3880. Hoanib trunk 350 ± 40 BP
Outer annual rings of upright trunk of dead tree completely buried *in situ* by 9 m river silts and now exposed by lateral erosion of river bed (Plate 2) at site of profile 42 (Fig. 3) some 38 km from the coast. Most probable calibrated age: between AD 1490 and AD 1640.

Pta-3879. Hoanib tree (105.3 ± 0.6)‰
Inner wood of dead branch of still living tree some 3 km downstream of Pta-3880, buried 2 m in silt and recently exposed in bank of river channel some 7 m above river bed. Most probable calibrated date: AD 1958.

The first of these dates, Pta-3880, shows that some 9 m of silt has accumulated to cover the still upright standing dead tree since the 16th century. The second

date, Pta-3879, suggests that the incision of the present river channel must be a fairly recent event. Even if the 2 m of silt covering the trunk of the tree is overbank deposit, the adjacent river channel was probably not as deep at this point as it is today when the tree was partially buried. The evidence therefore indicates that active erosion of the Amspoort silts is taking place in the present century.

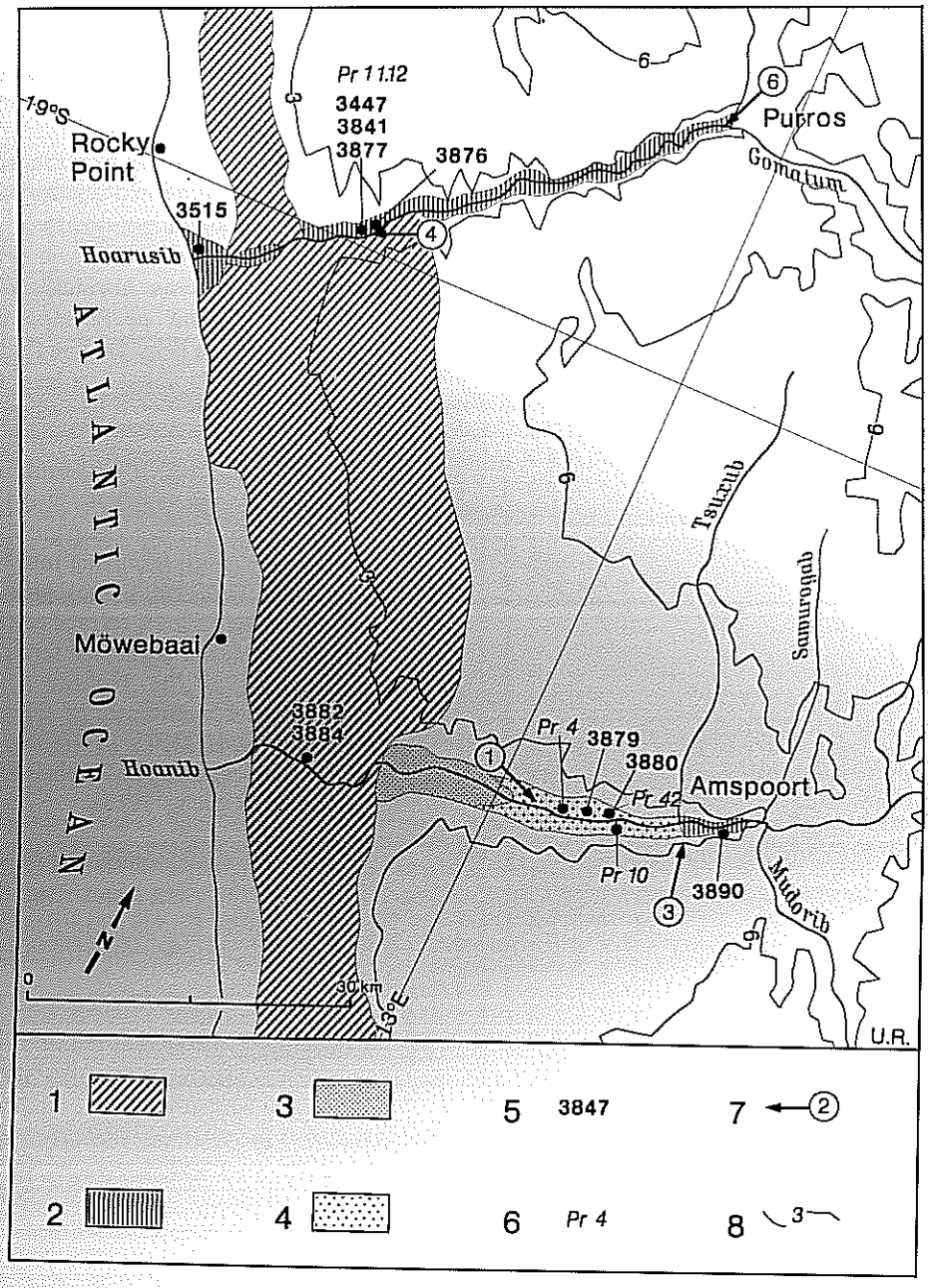
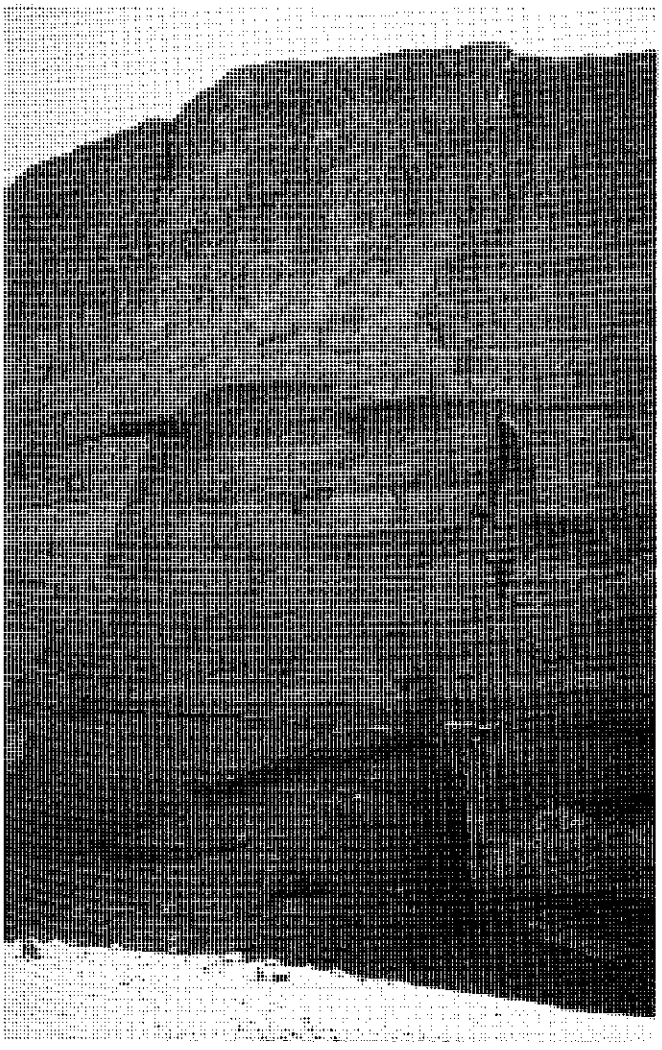


FIGURE 3: Late Holocene sediments and landforms along the Hoanib and Hoarusib Rivers.
1: Dune belt
2: Yount Terrace members (jT) of the Hoanib Alluvium formation and of the Hoarusib Alluvium formation
3: Floodplain of the Hoanib River
4: Amspoort Silts
5: Analysis number (Pta-) of the 14C dates
6: Number of field profile
7: Photo/**Plate** with direction of sight
8: Isohypse (x 100 m)

PLATE 1: 'Amspoort Silts' of the Hoanib River towards the SE. The Hoanib in the mid-distance is incised into its own former river-end deposits (the Amspoort silts member of the Hoanib Alluvium formation). These sediments bury a pre-existing relief which is visible in the background and on the right. (Air photo U. Rust 29.8.1984)



At Amspoort (poort = defile) the Hoanib cuts through bedrock to enter the previous floodplain area. At this point the Tsuxub tributary joins the Hoanib River from the north. The terrain is seen on Plate 3, and in Fig. 5 the sedimentary situation at the mouth of the Tsuxub is depicted schematically. The sequence of events here was as follows:

- accumulation and calcification of the basal conglomerate
- deposition of the gravels of the Lower Terrace (uT)+ from the Tsuxub valley up to level a

+ oT = obere Terrasse = Upper Terrace
  uT = untere Terrasse = Lower Terrace
  jT = junge Terrasse = Young Terrace

- incision of the Young Terrace (jT) to the base level b
- accumulation of the 'Amspoort silts' up to level c
- incision of the present Hoanib River course and formation of Tsuxub gully

PLATE 2: Profile 42 in the Hoanib River (cf. Fig. 3). *In sita* tree which grew from a level at or below the present river bed and was covered by 9 m of Amspoort silt while still upright. The tree ceased growing about AD 1565 ± 75 and was subsequently buried. When the silt build-up had reached a height of + 1.5 m, fire produced a charcoal level (below, left) but still left branches standing. (Photo U. Rust 22.8.1984).

The situation below, at and above Amspoort, must be considered together. The levels a and c in Fig. 5 cross each other downstream of Amspoort and the basal calcified gravel dips below the surface and is not exposed again. Above Amspoort the Hoanib is incised 1 to 2 m deep into fluvial sediment. This deposit is a typical channel-fill sequence consisting of fine and coarse fluvial sediment (Picard and High jr. 1973). An exposed log buried in this fill sequence (Fig. 3) gave the following date:

Pta-3890. Hoanib log 1120 ± 50 BP

Log protruding from Hoanib Young Terrace deposit above Amspoort in Hoanib river. Calibrated date: AD 920.

This fluvial deposit is designated the Hoanib Young Terrace (jT) of the Hoanib Alluvium formation. The

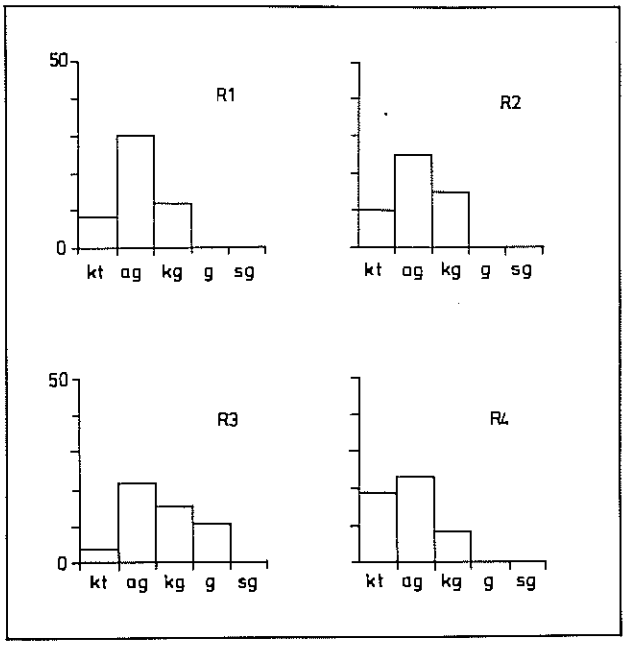


FIGURE 4: Histograms of the frequency distributions of the degree of roundness for selected samples of gravels (after RUST and WIENEKE, 1973).
R 1: Sawurogab Lower Terrace (uT)
R 2: Sawurogab river bed
R 3: Hoanib river bed
R 4: Hoarusib Young Terrace (jT)
kt = kantig/angular, ag = angerundet/subangular,
kg = kantengerundet/subrounded, g = gerundet/rounded,
sg = sehr gut gerundet/well-rounded

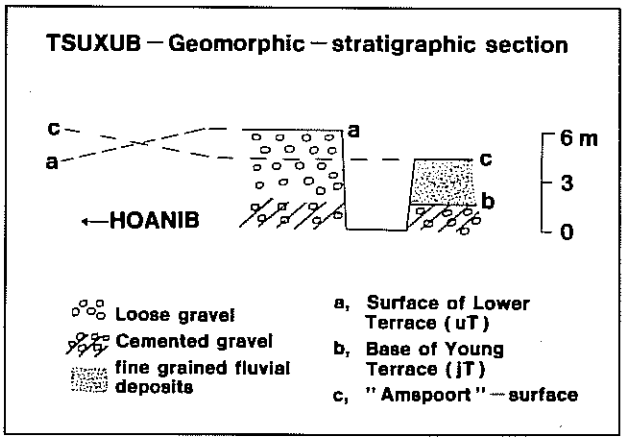
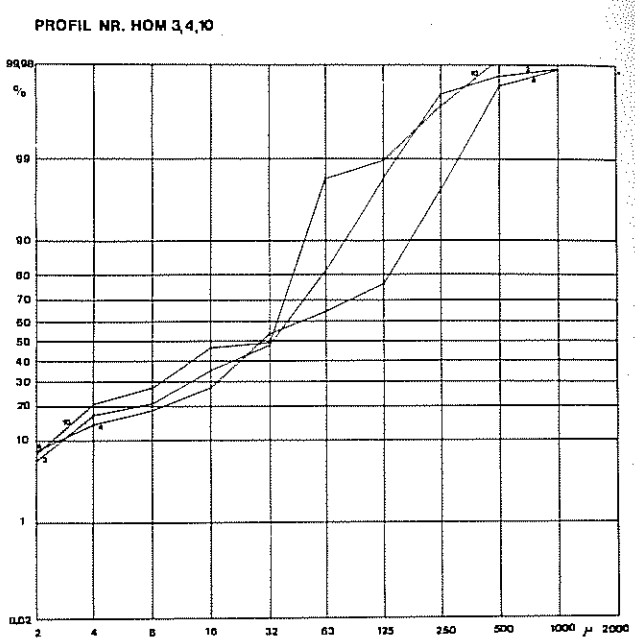


FIGURE 5: Schematic section through Tsuxub River at junction with the Hoanib River at Amspoort (see **Plate** 3).



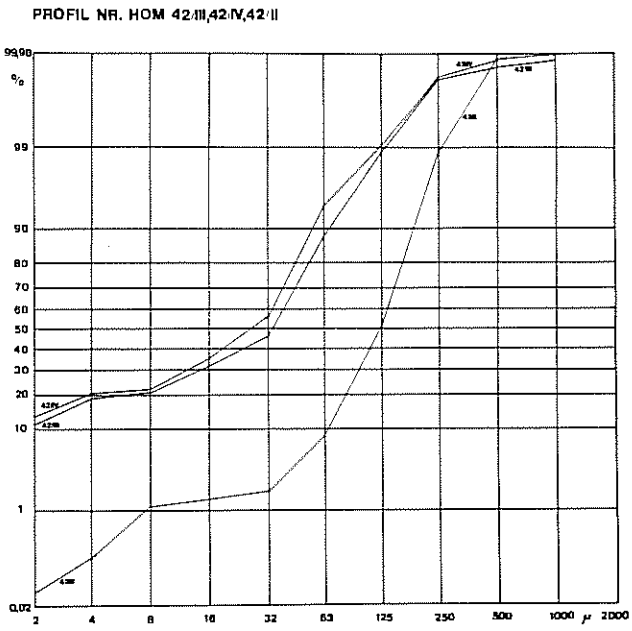


FIGURE 6: Cumulative frequency curves of grain size distributions of selected sediment samples from the Hoanib system, plotted on probability paper with a logarithmic ordinate.

basal part of the Hoanib Young Terrace was also accumulated from the Tsuxub side valley (Fig. 5) and thus documents autochthonous valley formation (RUST, 1980). The date Pta-3890 suggests that the Hoanib Young Terrace already started accumulating some thousand years ago and continued to do so at least until the 16th century (Pta-3880). In fact the dates indicate a gradual progression of the aggradation downstream during the present millennium.

At present deposition is still taking place on the floodplain (internal delta) east of the dunes, but incision has started upstream of this, thus eroding the 'Amspoort silts'. Lithostratigraphically the Hoanib Young Terrace upstream of Amspoort and the Amspoort silts downstream of Amspoort (Fig. 3) may be only one unit but geomorphologically they document two different palaeoenvironments (par. 4., Table 1.).

3 HOARUSIB RIVER

The Hoarusib River also originates in the more humid hinterland (Fig. 1, 2) along the Great Escarpment. It has a length of 240 km and an average gradient of 0.47% (Topographical Map of SWA 1: 250 000). Except in years of low rainfall it often reaches the Atlantic Ocean at least once during the season.

Between Purros at 300 m a.s.l. (Fig. 2, 3) and 'the Poort' at 80 m a.s.l. the river runs along a channel in bedrock with numerous, relatively short, ruggedly incised side-valleys or 'gramadullas' (in the sense used for the similar landscape in the Kuiseb River Canyon by Rust and Wieneke, 1974). From just above the final poort some 11 km from the sea, remnants of massive silt deposits occur, mainly in protected localities in the northern side-valleys. These silts rise to at least 70 m above the river bed and can be traced upstream to well beyond Leyland's Drift (200 ma.s.l.). They reflect extensive choking of the valley system by the river itself. The fine-grained (Hom 12 III, IV in Fig. 7) horizontally stratified sediments are similar to, but more extensive than, the 'Homeb silts' in the Kuiseb valley (Vogel, 1982) and may also document shortening of the river for an extended period during the Pleistocene. Radiocarbon dates (unpublished) show that these silts are considerably older than those at Homeb, but their chronostratigraphic position is still uncertain.

The type locality of the silts is in the Clay Castles Valley (Plate 4) ca. 17 km upstream from the river mouth. We therefore call these silts the 'Clay Castles Silts member' of the fluvial sedimentary sequence in the Hoarusib river, which we term the 'Hoarusib Alluvium formation'.

At its mouth the Hoarusib River has deposited an extensive fan some 7 km across which is at present being abraded by the sea. Radiocarbon dates (unpublished) suggest that these silts were laid down in mid-Holocene times. The present river has cut a bed some 8 m deep through the delta to spill directly into the Atlantic Ocean. This sedimentary body would constitute another member of the Hoarusib Alluvium forma-

TABLE 1: Environmental changes during the present millennium in the Kaokoveld Namib Desert

	Evidence		Interpretation		
	Time (AD)	Geomorphology	Morphodynamics	Climate	HELGREN's (1979) Model
HOARUSIB VALLEY	present	present river bed gullies in tributaries	river lengthening	as present	arid incision
	12/13th centuries	accumulation of jT Hoarusib Young Terrace)	autochthonous valley formation	more humid than present	arid aggradation
	before 12/13th centuries	base of jT			humid incision
HOANIB VALLEY	present	presen river bed present floodplain gullies in tributaries	river lengthening	as present	arid incision
	after 16th century	Amspoort silts	river shortening	more arid than present	arid aggradation
	before 10th century	accumulation of jT (Hoanib Young Terrace)	autochtonous valley formation	more humid than present	
		incision of jT (level 'b' in Fig. 5)			humid incision

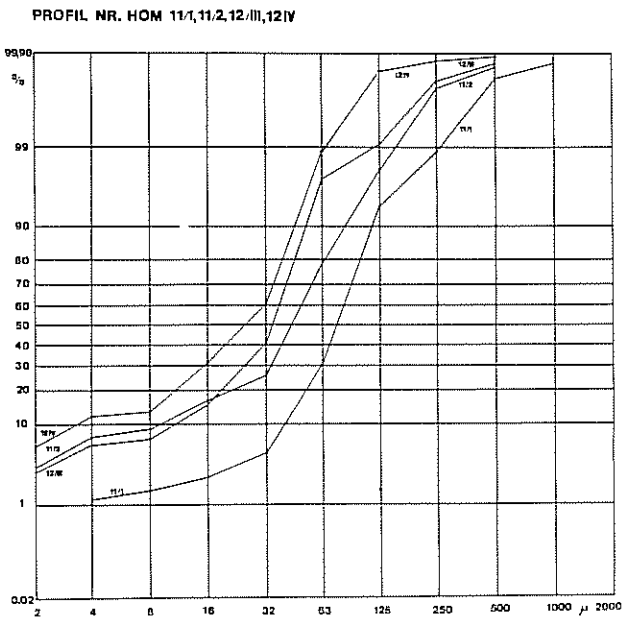


FIGURE 7: Cumulative frequency cures of grain size distributions of selected sediment samples from the Hoarusib system plotted on probability paper with a logarithmic ordinate.

tion. Along the river a lower terrace of silty material is visible at the mouth (see below).

In the Clay Castles Valley a Young Terrace is also prominently exposed (Plate 4). It consists of fluvial sediments (HOM 11/1, 11/2; Fig. 7) with only moderate rounding (R 4 in Fig. 4). The high proportion of angular gravels (kt-fraction) indicates the presence of slope rubble that has been transported for a short distance only (Rust and Wieneke, 1973). In addition the terrace incorporates reworked sediment and blocks of Clay Castles silt (Plate 5). Geomorphologically this Hoarusib Young Terrace (jT) can be intermittently traced all the way up to Purros (Plate 6) and downstream to the river mouth (Fig. 3). The Hoarusib River has removed most of this terrace deposit and often only a bench mark of silt remains clinging to bedrock on the river bank. In the gramadullas the terrace is, however, still mainly intact with relatively minor gullies extending up the side valleys (Plate 4). At Leyland's Drift (Fig. 2) there are also two older terraces (uT and oT) which will, however, not be discussed here.

Several samples of plant material were recovered from the Hoarusib jT-sediments at and near the Clay Castles Valley. Radiocarbon dates of these samples are as follows:

Pta-3447. Hoarusib jT plant 890 ± 20 BP
Scattered plant fragments stratified 2 m below surface of Hoarusib Young Terrace near entrance of Clay Castles Valley. Most probable calibrated date: AD 1170.

Pta-3841. Hoarusib jT reed root 860 ± 50 BP
Reed root in same level as above sample. Most probable calibrated date: AD 1200.

Pta-3877. Hoarusib jT log 1120 ± 50 BP
Outer wood of 20 cm log buried 0.4 m below surface of terrace at same locality. Calibrated date: AD 920.

Pta-3876. Hoarusib jT branch 720 ± 40 BP
Branch buried 1.5 m below top of 5 m terrace fragment clinging to bedrock in main river channel 2 km upstream from Clay Castles junction. Calibrated date: AD 1270.

Pta-3515. Hoarusib jT charcoal 900 ± 50 BP
Charcoal eroding from the Young Terrace 2 km upstream from the river mouth. Calibrated date: AD 1160.

Except for the log (Pta-3877) the calibrated ages of the samples all fall between ca. AD 1160 and 1270. That of the log is ca. AD 920, but this need not represent a discrepancy since it may already have had a considerable age when embedded. In this arid environment hard wood does not decay readily, and the possibility of finding redeposited old logs always exists. On the basis of these results we may conclude that the aggradation of the Hoarusib Young Terrace took place during the 12th and 13th centuries.

TABLE 2: Fundamental environmental tendencies during the present millennium in the Kaokoveld Namib Desert

Time (AD)	Geomorphology	Climate
present	river lengthening	as present
12/13th centuries to after 16th century	river shortening	drier than present
before 12/13th centuries	autochthonous valley formation	more humid than present

4 INTERPRETATION

As has been pointed out most recently by Mensching (1984), the palaeclimatic interpretation of terraces and deposits of ephemeral rivers poses specific problems. He came to the conclusion that palaeoenvironments can only be reconstructed by considering the interrelationship of the forms and sediments in both the main and side valleys. We agree with this view and, as has been shown for the Kuiseb River (Rust and Wieneke, 1980), the side valleys are in fact more important, because allochthonous influences need also to be taken into account in the main channel. Helgren (1979, pp 317-326) has developed a geo-ecological 'environmental scenario for alluvial fills' which can be applied to the features investigated here (Table 1).

The alluvial fills in the gramadullas or side valleys are locally controlled. The degrading of the slopes and material transport in the washes indicate that a period of active formation was terminated by a phase of accumulation. The Young Terrace (jT) of the Hoarusib River documents this situation: A period of active incision in the gramadullas, representing wetter conditions in the Namib itself, ended with 'arid aggradation' (Helgren, 1979), thus producing the sediment body of the Young Terrace. Subsequently the runoff

PLATE 3: Junction of the Tsuxub River with the Hoanib River at Amspoort from the S. In the middle and background the Lower Terrace (uT) of the Tsuxub is seen to grade into the talus on the hill slopes. In the mid-distance on the right an erosion gully of the Tsuxub cuts into the Amspoort silts while the Hoanib in the mid-foreground dissects the lower calcified gravels (compare Fig. 5) (Air photo U. Rust 29.8.1984)

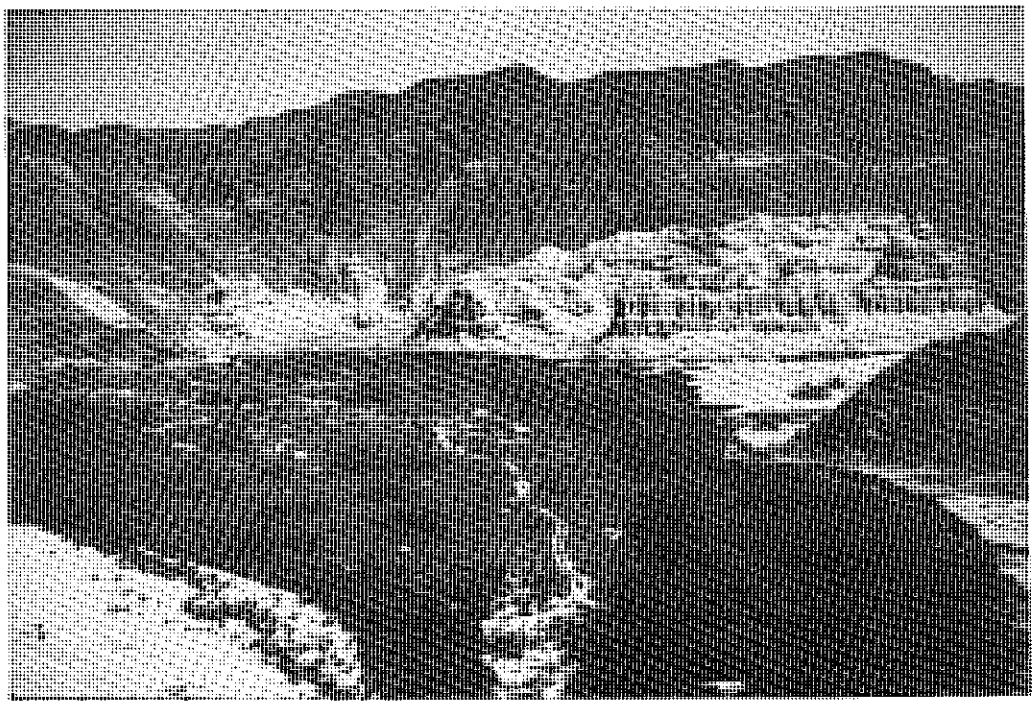


PLATE 4: Type locality of the 'Clay Castles Silts' in the Hoarusib grammadullas 130 m a.s.l. from the E (Fig. 3). In the left foreground is the Hoarusib river-bed with its overgrown high-water bed. In mid-distance the white erosion remnant, 25 m thick, of the 'Clay Castles Silts' which filled the pre-existing valley relief. The Young Terrace (jT) of the Hoarusib in mid-distance and right foreground is present in the main channel and the local tributary (Clay Castles Valley), and is currently being eroded in both (Air photo U. Rust 28.8.1984).

from the hinterland resulted in the removal of the sediments from the main channel and the cutting of small gullies into some of the tributary valleys. This erosional phase that continues to the present can be classified in Helgren's (1979) terminology as a period of 'arid incision'.

The situation in the Hoanib River valley reflects a similar sequence of events: After a phase of active incision into older gravels (level 'b' in Fig. 5), also along the Tsuxub valley, showing local runoff and wetter conditions, the region became drier and flooding less intense and 'arid aggradation' set in, to produce the Hoanib Young Terrace (jT) sediments above Amspoort and later (?) the Amspoort silts below Amspoort. In the past few centuries downcutting has again set in, suggesting intensification of floods derived from the inland.

From a geomorphological point of view the manner in which the Hoanib River is dissecting the Amspoort silts is of interest: Upstream of Amspoort the river follows a straight course, while below Amspoort it is braided into shallow meanders, eroding both sideways and downwards, until it merges onto the present floodplain. This fluvial morphodynamic situation, inciden-

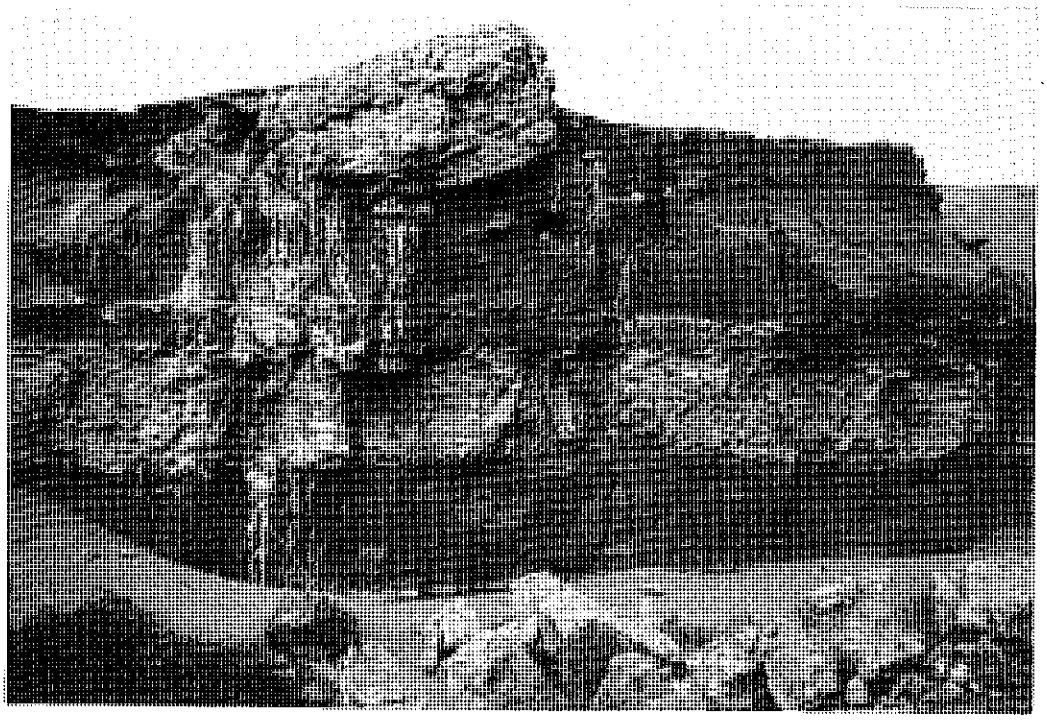


PLATE 5: Sediment body of the Young Terrace (jT) at the type locality in the Clay Castles Valley. The exposure of 2.5 m shows a block of re-deposited 'Clay Castles Silts' sediment in the top. Such blocks and stones document slope erosion in the side valley itself (Photo U. Rust 21.8.1984).

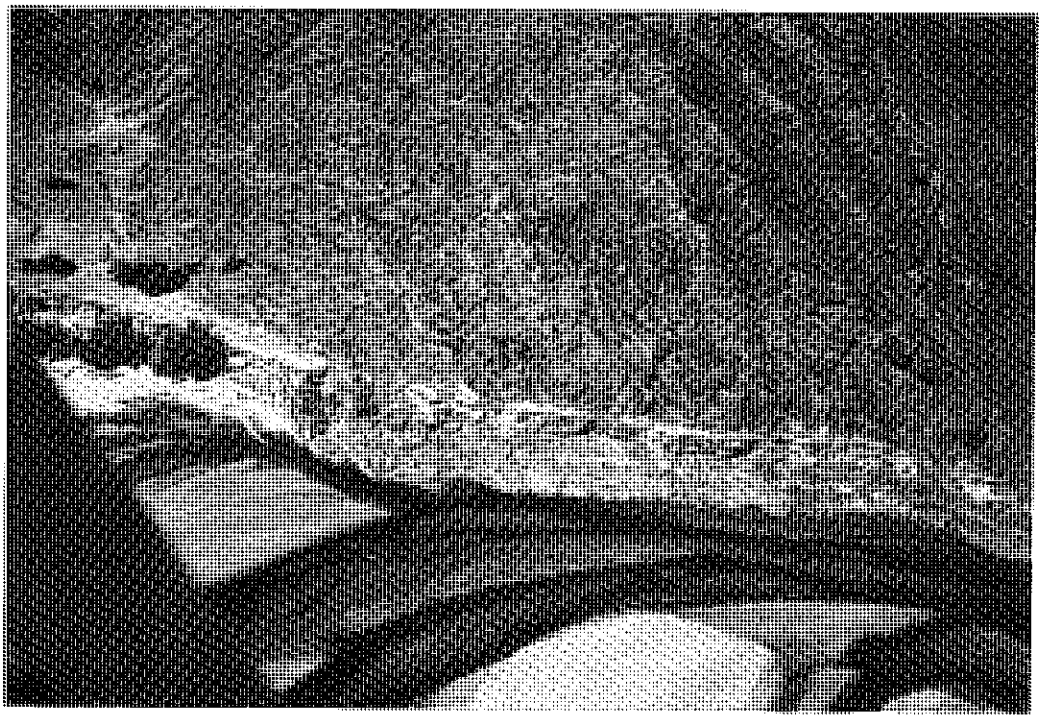


PLATE 6: At the entrance to the Hoarusib gramadullas near Purros (300 m a.s.l.). Looking S over the water-bearing river in foreground it can be seen that the Young Terrace (jT) fills the side valley (left background) and follows the main course down stream (to the right) as a bench mark (Air photo U. Rust 28.8.1984).

tally, is also observed in the periglacial transition from the Würm Glacial icemargin to the adjacent gravel plains in the Northern Alpine region ('Trompetentalbildung', Troll, 1954). This coincidence of forms and processes (Priesnitz, 1980) in two extremely different environments is remarkable.

In the Hoarusib valley we did not observe the equivalent of the Amspoort silts. It may be present on the alluvial fan at the river mouth, although the main body of this fan pre-dates the Hoarusib Young Terrace (unpublished radiocarbon dates).

It may be mentioned here that remnants of apparently young silt deposits (river-end deposits) were also found in other river systems to the south. In the Hunkab, Kharugaiseb and Samanab river beds (Fig. 2) these silts indicate shortening of the streams which could well be contemperaneous with the Amspoort silts of the Hoanib. They have, however, not been dated as yet. Another general observation that applied to virtually all the rivers along the Skeleton Coast is that they are at present all actively eroding their own sediments, suggesting that the increase in runoff deduced for the Hoanib and Hoarusib systems is the result of

an increase in precipitation in the catchment area. Overgrazing on the upland plateau could, however, also be contributing to the increased runoff at present.

5 CONCLUSIONS

The findings described here document rather drastic geomorphologically active, environmental changes in the Kaokoveld Namib Desert and the adjacent hinterland during the present millennium (Tables 1, 2). That this part of the Namib Desert has been subject to changes of such magnitude in the recent past, has hitherto not been recognized (cf. Ward et al., 1983). We ourselves had not anticipated finding evidence of change on a time-scale of centuries rather than millennia. The realization of the geomorphic sensitivity of the region is a new result (cf. van Zinderen Bakker, 1975; Rust et al., 1984). It is of fundamental importance to Quarternary research for the ultimate reconstruction of the succession of changes in climate on the subcontinent in general.

The point of departure of this investigation was the recurring discussion of the features and sediments in the Kuiseb River system, and particularly of the Homeb silts (cf. par. 1). We undertook to search for corresponding silt bodies in the river courses to the north. What we found, was a profusion of silt deposits, but of obviously widely divergent ages. The mere existence of silts in different river systems therefore does not justify the assumption of synchronism and the independent dating of each such feature is essential before any valid conclusions can be drawn. Thus, for instance, the Clay Castles Silts in the Hoarusib River valley are phenotypically similar to the Homeb silts in the Kuiseb River valley, but we know already that they are actually much older and hence belong to a different climatological phase. It has furthermore become clear that the various sediment bodies encountered may reflect different palaeoenvironmental conditions, the main problem being whether the alluvial deposits are due to more or less runoff, and whether this was of a local or an allochtonous nature.

6 ACKNOWLEDGEMENTS

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Archaeological sites in the Fish River Canyon, southern SWA/Namibia

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ABSTRACT

Twenty-seven archaeological sites were located in the Fish River Canyon during a survey in June 1981. The presence of Pleistocene (Early and Middle Stone Age) artefacts was noted at nine locations and more recent settlement remains at a further eighteen. The location of these sites is indicated and their associations and distribution are discussed.

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1 INTRODUCTION

The archaeological content of areas managed by the Department of Agriculture and Nature Conservation in South West Africa is not well known. In most cases these areas comprise large tacts of land that are relatively undisturbed and are maintained in a state that probably approximates the conditions of recent prehistoric settlement.

Although management and development strategies pose little threat to the archaeological resources of most park areas, the existence of a popular hiking trail in the Fish River Canyon Reserve provides an exceptional case in which valuable prehistoric materials may be easily and inadvertently disturbed.

The route of the hiking trail follows the deeply incised and meandering course of the canyon from below the Northern Lookout Point (Fig 1 N.L.P.), for 83 km to the rest-camp and mineral spa at Ai-Ais (27°35′ S., 17°30′E.). Arid open countryside with a subdued topography dominated by Dwarf Shrub Savanna (GEISS 1971: 12) surrounds the approaches to the canyon. Yet, the extended catchment of the Fish River and frequent artesian springs within the canyon provide a well-watered and, in places, densely vegetated environment that is in marked contrast to the surrounding area. Small antelope, gamebirds, waterfowl and other resources such as fish are concentrated within this linear oasis and it is possible that larger game species also frequented the canyon in the past. Evidence from an extensive survey of archaeological sites within the Konkeip drainage to the west of the Fish River and along the adjacent Southern Namib border (WENDT 1980: 41) suggests that a mobile prehistoric population exploited resources concentrated mainly within the dry river valleys of the region. No reliable data on the archaeology of the Fish River Canyon were available at the time of the survey reported here, but the unusual abundance of resources within an otherwise arid region supported the expectation that some evidence of prehistoric settlement would be found in the canyon.

2 ARCHAEOLOGICAL SURVEY

The survey was timed to co-incide with the mid-winter peak in the use of the canyon by hikers in 1981. Hiking activity is mostly limited to the Fish River bed between N.L.P. and Ai-Ais; the area of highest potential impact by hikers lies along the shortest passable route between these two points. Archaeological sites approached or crossed by the well-beaten trails developed during that season were recorded with photographs and descriptions; no material was collected from the sites and little attention was paid to areas out of sight of the trail during the five day survey.

In Fig 1, the distribution of archaeological sites recorded during the survey is shown. The sites, all open-stations, were of two distinct varieties with independent distributions. In the first of these, reworked Pleistocene-age artefacts were associated with the gravels of the present river-course and the lower parts of some scree slopes. The second variety consisted of relatively recent and well-preserved open station settlements with stone hut circles and cairns. These were unevenly distributed on alluvial fans and along the banks of the river throughout the length of the surveyed portion of the canyon. Isolated Early Stone Age artefacts appeared to occur only in the active gravels and showed traces of heavy abrasion and rolling. Somewhat larger numbers of Middle Stone Age artefacts, such as blade-forms with prepared platforms, occurred in the scree gravel. It was unclear whether or not these artefacts were in primary contexts and their numbers were insufficient to warrant detailed examination.

In Fig 1 the eighteen recent open station settlements are grouped into three broad categories, namely single-feature sites, sites with up to five features and those with up to ten, the largest observed concentration. In all except three cases these sites were situated on the inside of bends in the river; the distribution of open pools and jetsam indicated that the most vigorous development of the bends was towards the outside, away from the sites. The few exceptional locations were embayments formed at the confluence of a minor tributary with the Fish River (Sites 10, 13) and a dune field several hundred metres away from the present course of the river (Site 11).

Although three of these sites consisted only of single cairns (Sites 5, 6, 8), the remainder showed traces of hut foundations. In all except one case (Site 9), these were semi-circles and open arcs with diameters of between 1.5 m and 3.0 m. In addition, the single hut feature at Site 9 showed a secondary lobe added to the one side. Cairns were associated with the hut at Site 10 and a more elaborate and enigmatic structure — with an upright slab at each end and enclosed by a circle of smaller stones — on Site 16, may mark a burial. The same site was also associated with a small enclosure of stone, with an internal diameter of 60 cm. Similar features in the Zerrissene Mountains of Damaraland have been interpreted as pens for young small stock or as storage cairns (CARR *et. al.*, 1978: 251, 253).

Few surface associations were found on any of these sites; irregularly flaked quartz cobbles and stone mortars were the only evidence of stone tools and no relia-

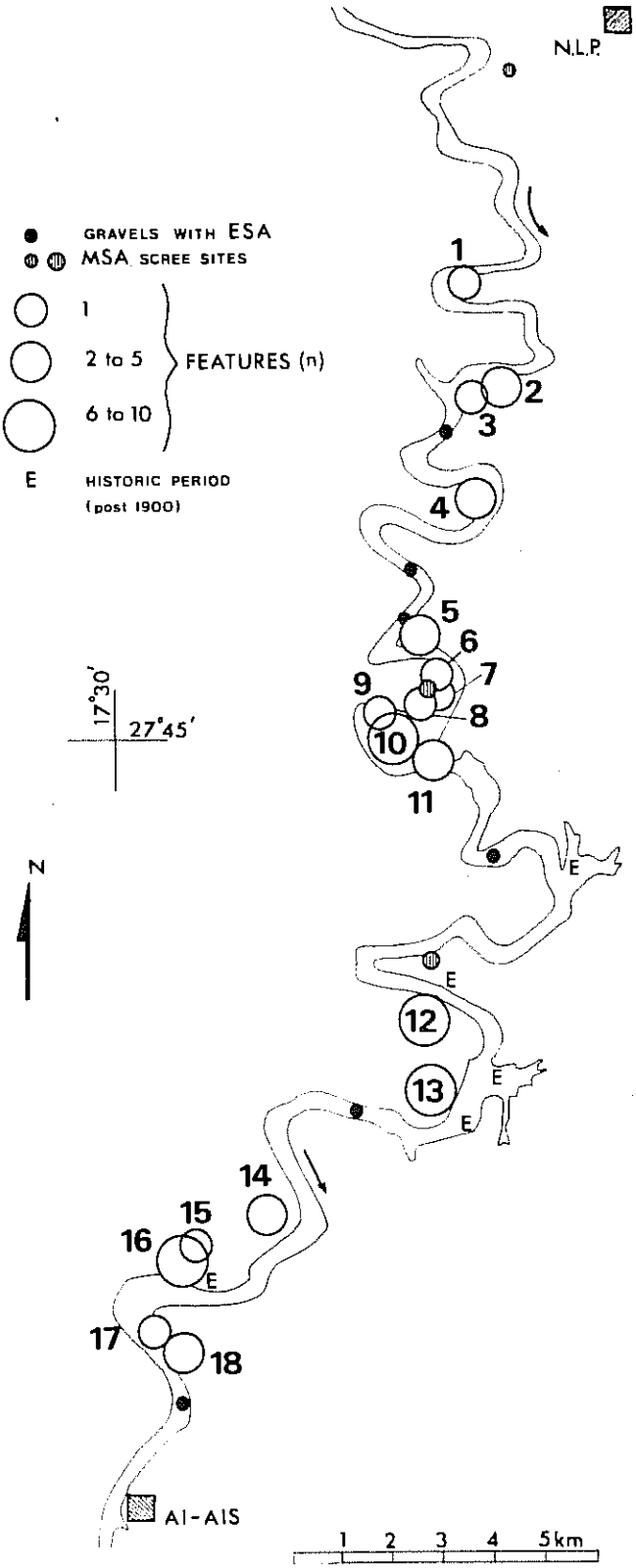

FIGURE 1: The distribution of archaeological sites in the Fish River Canyon, southern Namibia.

bly associated bone was noted from any of the open station sites. The five historic period European sites in the lower parts of the canyon were similarly lacking in surface materials, although no evidence of vandalism was apparent at these or any of the archaeological sites.

3 DISCUSSION

The brief survey reported here covered most of the possible site locations within the confines of the Fish River Canyon. Access to the canyon floor and its potential area for settlement is limited by the precipitous cliffs. Consequently, there is an apparent decrease in the size of settlements as the canyon becomes progressively narrower up-stream from Ai-Ais. Although there is only a weakly negative correlation ($r = -0.37$) between distance up-stream and the decreasing number of features per site, it appears that access to up-stream sites was limited by space and topography and that down-stream locations were favoured. The five features at Site 2, well within the confines of the canyon, and the occurrence of small and single-feature sites far down-stream suggest that more complex factors may have influenced site selection strategies. This somewhat unstructured distribution is partly due to a lack of chronological control: although it appears from the associations and preservation of the open sites that most are attributable to pre-colonial herders, discoloured soil from within the features of Site 14 may contain dung of a more recent date. The absence of ceramics from these sites may be due to the mobile surface of terraces above the river bends but ceramics and other surface remains are not always associated with residential features on similar sites where some activities are spatially segregated (Kinahan 1984).

The archaeological remains of pastoral settlement are notoriously scant (SMITH 1983: 79) and even relatively recent occupations are not easily discerned (ROBERTSHAW 1978: 29—31). The visibility of the Fish River Canyon sites is improved by the remains of stone enclosures, a characteristic shared by similar sites reported from the Zerrissene Mountains (CARR *et. al.*, 1978) and at Sylvia Hill in the southern Namib (SHACKLEY 1983), which are also poor in other surface remains.

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Invasive alien organisms in central South West Africa/Namibia: Results of a reconnaisance survey conducted in November 1984.

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ABSTRACT

Alien plants were surveyed from a moving vehicle along 2270 km of roads and 115 km in the courses of four rivers of central South West Africa/Namibia. Frequency of occurrence and abundance rating by 10 km road-lengths and 1 km river-lengths are presented for the 20 alien plant species observed. Although most species were infrequently recorded away from rivers, certain of the riverbeds held dense infestations of *Datura innoxia, Nicotiana glauca* and *Prosopis* sp.

The only alien bird species found to be widespread, the House Sparrow *Passer domesticus,* was recorded at 13 of the 21 areas of human habitation inspected.

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1 INTRODUCTION

In South West Africa/Namibia, alien organisms invading natural and semi-natural ecosystems have received little attention from biologists. In order to collate the available information on the subject, a workshop meeting was held in November 1984 (Brown *et al.,* in press). In preparation for this meeting, the authors carried out a rapid survey of the central portion of South West Africa/Namibia during 20 — 26 November 1984. This paper presents the results of the survey.

2 METHODS

2.1 Alien plants

Infestations of alien plants were surveyed using the road transect method developed by the South African Botanical Research Institute, during their survey of alien plants in the Transvaal province of the Republic of South Africa (Henderson and Musil, 1984). The method used was to rate all infestations seen from a moving vehicle over each 10 km-section of road transect and over each 1 km-section of river bed traversed. The abundance ratings used were the modified ratings developed by Macdonald and Macdonald (in prep.) in South Africa (Table 1).

In total, 2 270 km of open road was traversed and rated in 10 km sections (Fig. 1) and 115 km of riverbed over four rivers was rated in 1 km sections (Fig. 1). In addition, 20 km of roads and firebreaks was traversed along the southeastern edge of the Waterberg Plateau Park.

For vegetation types, the frequency of occurence (F) of species X in vegetation type i was computed as

$$F_{Xi} = \frac{\text{No. of 10 km-sections in vegetation type i having species X}}{\text{Total No. of 10 km-sections in vegetation type i}} \times 100$$

The same approach was adopted using the 1 km-sections of each river transect. All frequencies were expressed as percentages, even though sample sizes were less than 100 (this is purely for facilitating comparison with other similar statistics, and the large error terms associated with these estimates should be borne in mind). Mean abundance (A) for species X in vegetation type i was computed as

$$A_{Xi} = \frac{\text{Sum of abundance ratings for sp. X in vegetation type i}}{\text{No. of 10 km-sections in vegetation type i having sp. X}}$$

The same approach was adopted in calculating the mean abundance ratings using the 1 km-sections of the river surveys. Mean abundance (A_{qd}) for species X in a quarter degree grid area was computed as

$$A_{qd} = \frac{\text{Sum of abundance ratings for sp. X in a quarter degree grid area}}{\text{No. of 100 km-section in quarter degree grid area}}$$

The mean abundance ratings for vegetation types and rivers are thus not comparable with those for quarter-degree grid areas, the latter being a mean over all 10 km-sections regardless of whether or not the species was present.

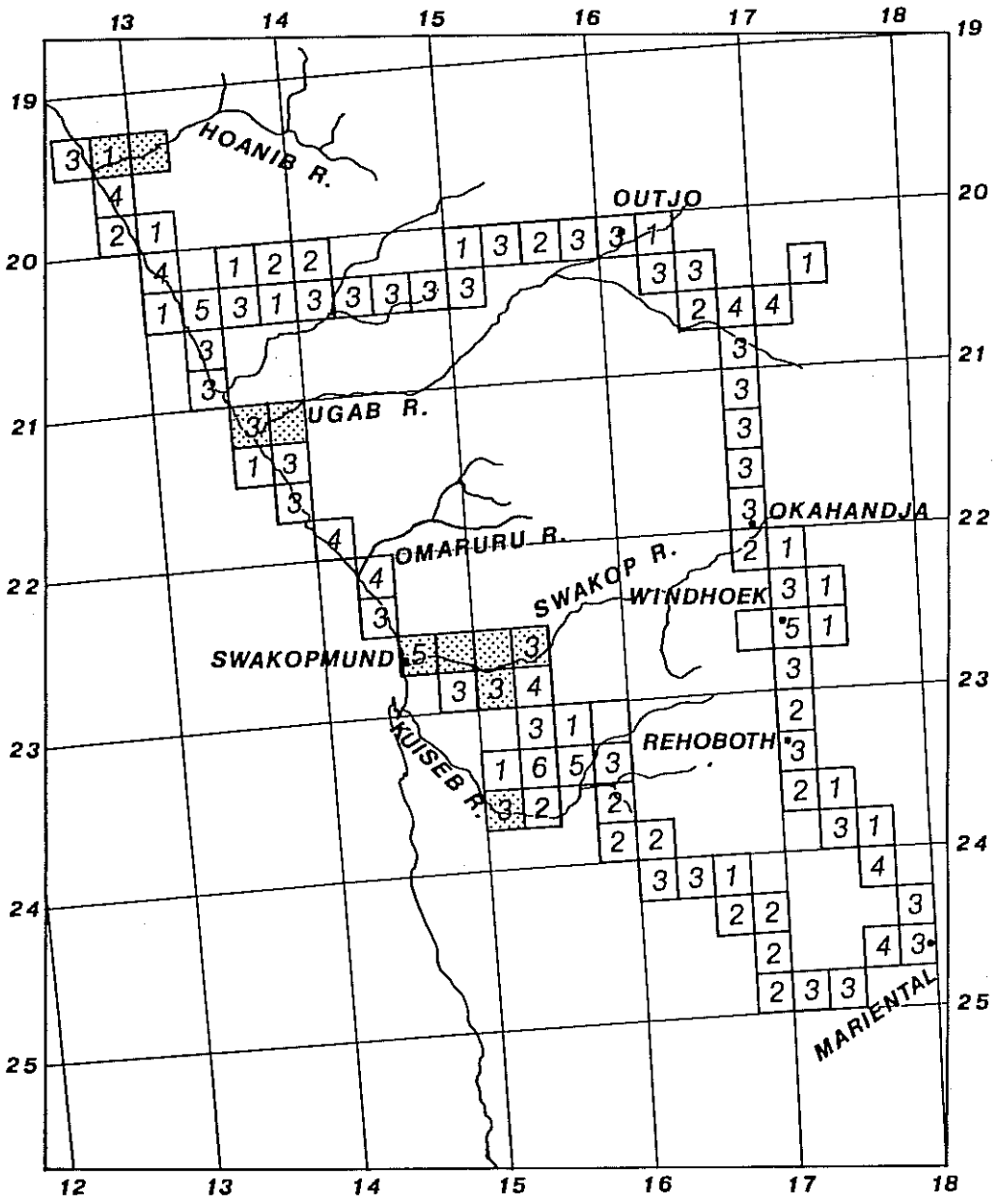

FIGURE 1: Route travelled showing number of 10 km transect sections suveyed per ¼x¼° area ( ) and ¼x¼° areas where 1 km-sections were censused along riverbeds ( ).

TABLE 1: Abundance ratings used for alien plant species in the survey.

RATING	DEFINITION	
9	Species forming a virtually continuous, almost monospecific stand at least 1 ha in extent.	
8	Species co-dominant in a virtually continuous stand at least 1 ha in extent.	
	LESS ABUNDANT THAN "8" WITH THE NUMBER OF PLANTS SEEN PER:	
	10 km-section	1 km-section
7	200 or more	20 or more
6	100 – 199	10 – 19
5	50 – 99	5 – 9
4	20 – 49	2 – 4
3	5 – 19	1
2	2 – 4	N/A
1	1	N/A

2.2 Alien birds

All birds recorded in 29 quarter-degree grid areas visited were listed (Fig. 2). In particular, the environs of 12 restcamps and isolated stations, eight small towns and one city encountered on the journey were searched for alien birds (Fig. 2).

3 RESULTS

3.1 Alien plants

The results of the roadside survey are presented according to the seven vegetation types of South West Africa/Namibia (Geiss, 1971) traversed during the survey (Table 2; Fig. 3). The distribution and mean abundance ratings in each quarter-degree grid area

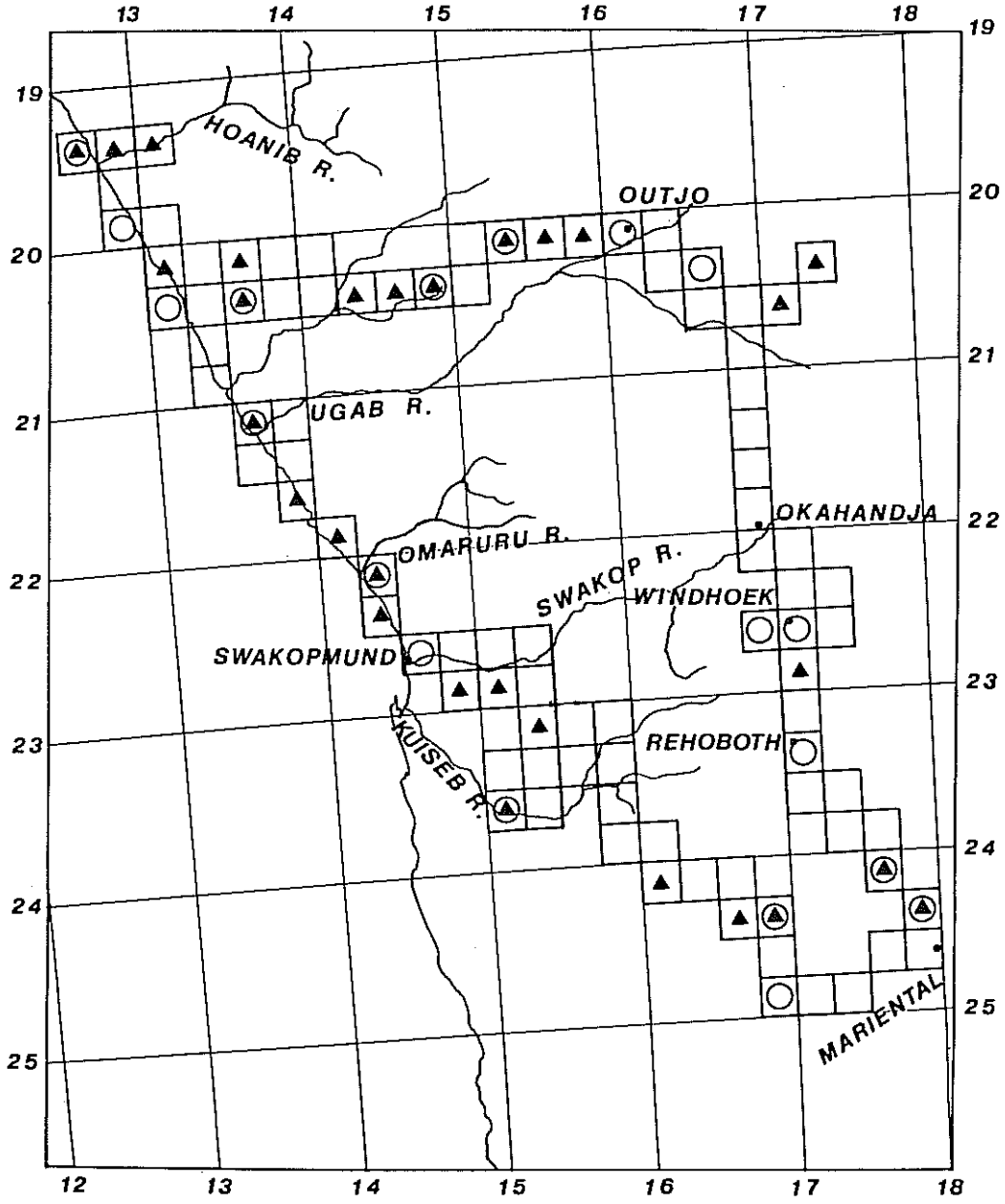

FIGURE 2: Grid squares for which all bird species were recorded (▲) and grid squares in which habitations were checked for occurrence of sparrows (○).

traversed for the most important species are presented in Figures 4 to 9. The results of the four riverbed surveys are presented in Table 3.

3.2 Alien birds

The only alien bird species recorded in the wild during the survey were Feral Pigeons *Columba livia* and House Sparrows *Passer domesticus*. Feral Pigeons were only recorded in one quarter-degree grid area (Windhoek, 2217CA), whereas House Sparrows were recorded in 13 quarter-degree grid areas and around 13 of the 21 sites of human habitation surveyed. The observations made on sparrows around habitations are summarized in Table 4. No alien birds were encountered away from areas of human habitation.

TABLE 2: The precentage frequency of occurrence (F) in 10 km-sections and mean abundance ratings (A) for alien plant species in seven vegetation types sampled on the road transects (see Fig. 3 for names and distribution of vegetation types).

Veld type no.	1		2		4		5		7		8		9	
No. 10 km sections	30		55		25		31		40		12		36	
SPECIES	F	A	F	A	F	A	F	A	F	A	F	A	F	A
Argemone subfusiformis			4	5,0	12	3,0	10	2,6	40	5,3	75	3,8	33	4,8
Asclepias fruticosa					20	3,4	13	4,0	55	4,2	50	3,0	25	1,9
Caesalpinia gilliesii									3	3,0	8	1,0		
Cereus peruvianus							3	3,0						
Datura ferox							3	3,0	8	1,3	8	2,0		
Datura innoxia			4	3,0	4	3,0	26	4,0	23	2,2	25	2,3	8	2,3
Datura stramonium					4	3,0	3	3,0	3	3,0	8	5,0		
Dodonaea viscosa							3	4,0	3	1,0				
Melia azedarach							3	1,0	3	1,0	8	3,0		
Nicotiana glauca			4	7,0	8	2,5	6	3,0	5	1,0	8	6,0	3	1,0
Opuntia ficus-indica							3	2,0			17	2,5		
Opuntia imbricata											8	1,0		
Opuntia inermis							3	7,0						
Opuntia microdasys var *lutea*											8	4,0		
Opuntia sp. unident.											8	1,0		
Prosopis sp.					12	3,3	6	2,0	13	5,4	25	3,7	53	2,6
Ricinus communis	3	1,0	2	3,0	12	3,0	3	2,0						
Schinus molle							3	2,0	3	1,0				
Tagetes minuta							3	4,0	8	4,3	42	4,6		
Tecoma stans									3	1,0				

TABLE 3: The percentage frequency of occurrence (F) in 1 km-sections and mean abundance ratings (A) for alien plant species within the riverbeds of four west-flowing rivers in the Namib desert.

River (veld type no. of area)	Section of river surveyed	No. km	SPECIES											
			Argemone subfusiformis		*Datura innoxia*		*Datura stramonium*		*Nicotiana glauca*		*Prospis* sp.		*Ricinus communis*	
			F	A	F	A	F	A	F	A	F	A	F	A
Hoanib (1)	Mouth of river to 35 km up river	35	9	3,7	94	7,2	9	4,0					6	4,0
Ugab (2)	Main road to 11 km upriver	11	73	5,9	100	6,4	45	5,2	100	8,3	27	3,0	18	3,0
Swakop (2 & 4)	Western boundary of Namib-Naukluft Park to 11 km east of Salem	47	6	3,0					21	3,5	94	5,1		
Kuiseb (border of 2 & 3)	Gobabeb to Homeb	22	32	4,1	73	6,0	55	5,7	82	6,0			27	4,2

TABLE 4: Presence (P) or absence (A) of sparrow species around human habitation in central South West Africa/Namibia. Where breeding activities were seen these are indicated by B. Where numbers were counted in the survey these are shown e.g. −6.

Locality	Quarter degree area	Presence of sparrows:				No. of spp. co-existing
		House	Cape	Great	Grey -headed	
REST CAMPS, ISOLATED STATIONS AND FARM HOMESTEADS						
Daan Viljoen Rest Camp	2216DB	P	A	P	A	2
Gobabeb Research Station	2315CA	PB	PB*	A	A	2
Hardap Dam Rest Camp	2417BD	PB	A	PB	A	2
Jackalsput Fishing Camp	2214AB	A	P−6	A	A	1
Mowe Bay Ranger Station	1912BC	P−2**	A	A	A	1
Nomtsas Farm	2416BD	A***	P	P	A	2
Power Station	2214DA	A	A	A	A	0
Springbokwater Ranger St	2013BC	PB−8****	A	A	A	1
Spykersbron Farm	2015AB	A	A	A	P	1
Terrace Bay Rest Camp	2013AC	A	A	A	A	0
Torra Bay Fishing Camp	1912DD	A	A	A	A	0
Ugabmund Ranger Station	2113BA	A*****	A	A	A	0
SMALL TOWNS						
Hentjies Bay	2214AB	PB−13	P−3	A	A	2
Kalkrand	2417BA	PB−6	A	A	A	1
Khorixas	2014BC	P	A	P	A	2
Maltahöhe	2417DC	P	?	?	?	?
Otjiwarongo	2016BC	P	A	A	A	1
Outjo	2016AA	P	?	?	?	?
Rehoboth	2317AC	A	?	?	?	?
Swakopmund	2214DA	P	?	?	?	?
CITIES						
Windhoek	2217CA	P	?	?	?	?

* Nesting in a hole in the wall of a building

** Only 1 pair, male arrived ca 2 months prior to our survey, female ca 1 month prior. Feeding far from habitation and also being fed kitchen scraps.

*** The occupant informed us that the species had been present here but that the birds has disappeared during "the drought". Numerous sparrow nests of uncertain origin were present in thorn branches intentionally placed in the rafters of a metal-roofed farm building for this purpose.

**** Has apparently been here since at least 1980 (Titos pers. comm.)

***** Vagrants turn up here irregularly but they are discouraged (B. Loutit pers. comm.)

? Areas searched too rapidly for the observers to be confident that a sparrow species had not been missed.

4 DISCUSSION

4.1 Alien plants, general

This survey showed that a variety of alien plant species is present in most of the vegetation types traversed in central S.W.A./Namibia. Alien plants were recorded at very low frequencies in vegetation types 1 and 2 of Giess (1971) the "Northern Namib" and "Central Namib" (Table 2). However, even in these extremely arid areas, the beds of irregularly flowing rivers were found to sustain alien plant assemblages which were sometimes diverse and normally had at least one species occurring at both a high frequency and density (Table 3). Although most of the species were present in each river surveyed, different species were dominant in each of them. *Datura innoxia* was the most important alien species in the lower Hoanib, *Nicotiana glauca* in the lower Ugab, *Argemone subfusiformis* at the mouth of the Omaruru river (vegetation type 2 — quarter-degree area 2214AB, surveyed as part of the main road transect), and *Prosopis* sp. in the lower Swakop. *Datura innoxia* and *N. glauca* were co-dominant in the middle Kuiseb. The infestations of *D. innoxia* in the Hoanib, *N. glauca* in the Ugab and *Prosopis* sp. in the Swakop had already assumed mas-

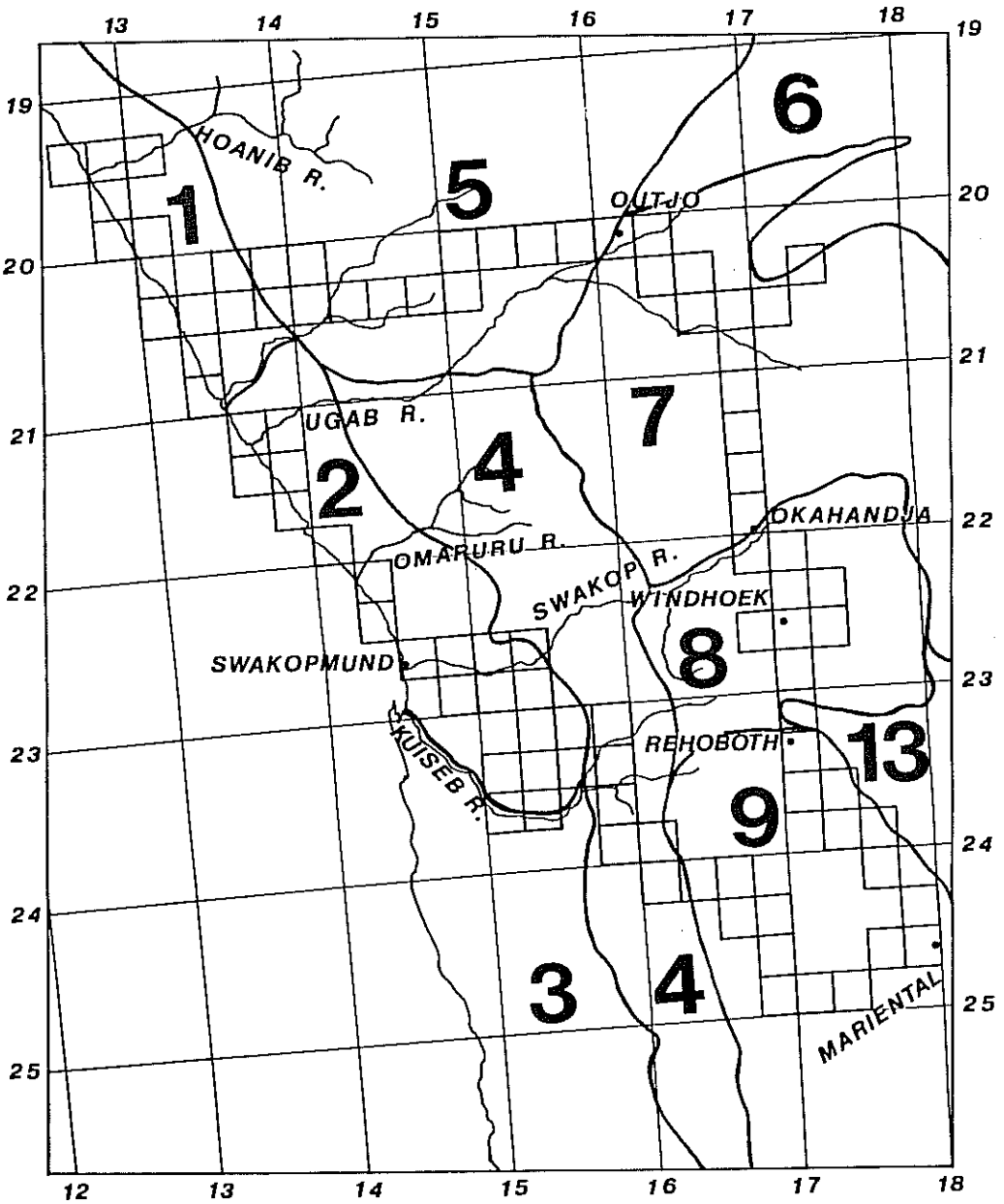

FIGURE 3: Grid squares surveyed within different vegetation types (after Giess, 1971). 1 — Northern Namib; 2 — Central Namib; 3 — Southern Namib; 4 — Semi-desert and savanna transition (escarpment zone); 5 — Mopane savanna; 6 — Mountainous savanna and Karstveld; 7 — Thornbush; 8 — Highland savanna; 9 — Dwarf shrub savanna; 13 — Mixed tree and shrub savanna (Southern Kalahari).

sive proportions. Each infestation occurred as a virtually monospecific stand covering considerable portions of the surveyed sections of the river courses. We consider it likely that these species are already responsible for undesirable impacts on the natural ecological functioning of these river systems which fall within proclaimed nature conservation areas. In this respect, it was gratifying to see that attempts had been made to control the *Prosopis* infestation on the Swakop and to learn that preliminary trials on the feasibility of controlling the other two major infestations had been initiated (P. Tarr, in litt. and R. Loutit, pers. comm.).

4.2 Alien plants, species accounts

Argemone subfusiformis was generally found in low density in sites of disturbance, such as roadsides, in the higher rainfall vegetation types (Fig. 4). Denser stands were found in river courses and the beds of dry impoundments. The species (called *A. mexicana*) was recorded in 1911 at Orab south of Mariental (Grid 2417DD) on the Fish River, and Dinter (1918) commented that it was already found "quiet often" in S.W.A./Namibia soon after the turn of the century. Presumably the species has now reached virtually all suitable areas in central S.W.A./Namibia. The few scattered plants found in the Hoanib appeared to be pioneers, and it would possibly be worth attempting to eradicate the species there.

Asclepias fruticosa was mainly found in roadside ditches and other sites of water run-in in the higher rainfall vegetation types (Table 2, Fig. 5). It was most

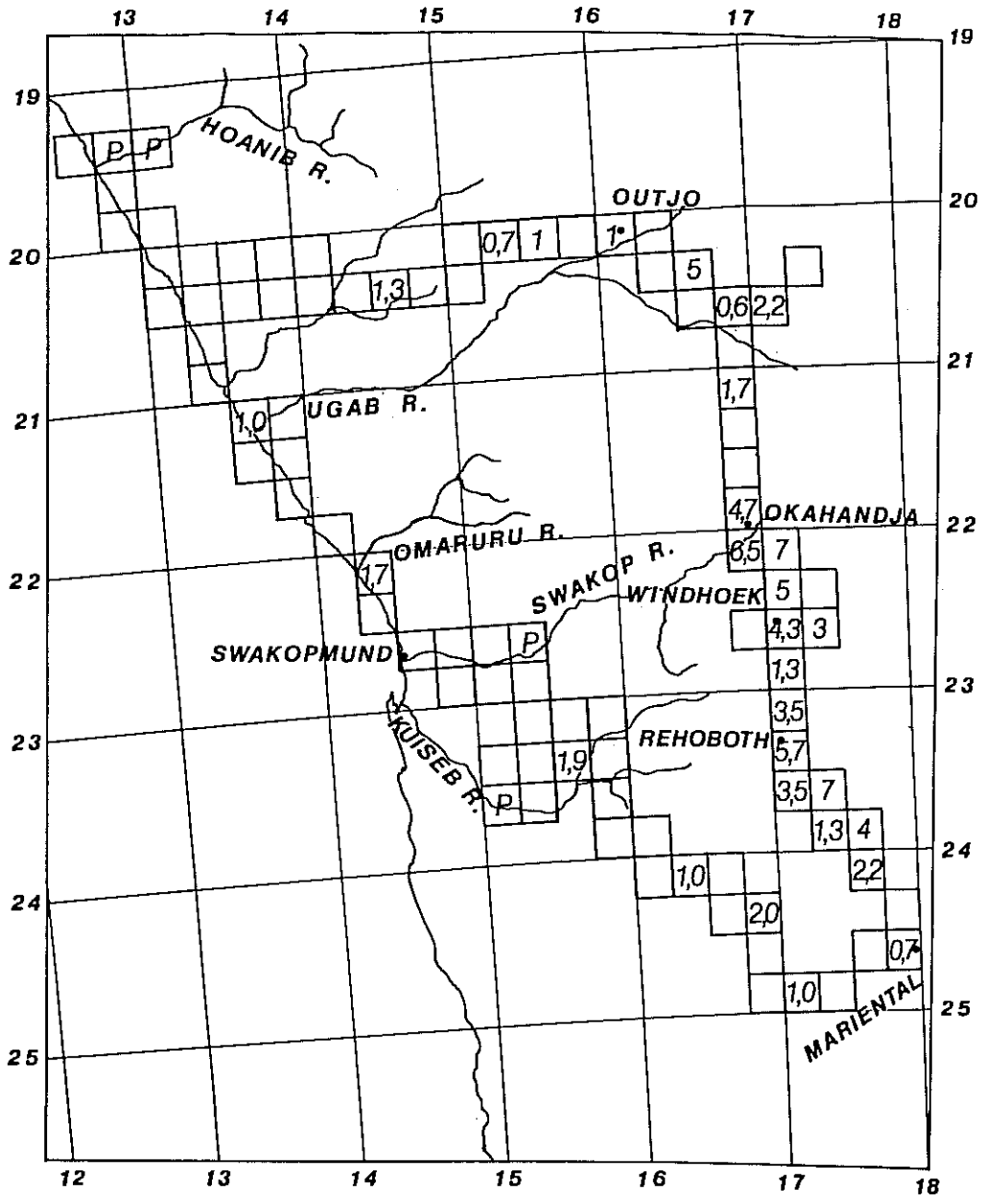

FIGURE 4: Mean abundance ratings for 10 km-sections (A_{qd}) for *Argemone subfusiformis*. P = where recorded outside the main road survey.

abundant in the road reserve between Outjo and Okahandja where the woody vegetation had been removed i.e. where competion for moisture would have been considerably reduced. Whether this species is alien to S.W.A./Namibia has not been conclusively established. However, Dinter (1909) reported that the species had been introduced from South Africa, that it indicated where there was water close to the surface and that by this date it was already one of "the commonest plants" in S.W.A./Namibia. As a ruderal in disturbed sites the species appears to pose little ecological threat in S.W.A./Namibia.

Caesalpinia gilliesii showed limited short distance spread into indigenous vegetation in the vicinity of Okahandja, Windhoek and Aris. This species could be eliminated with ease, at its present levels of infestation. However, its continued use in gardens would require that these operations be repeated at regular intervals in the future.

Cardiospermum grandiflorum was not recorded during the road transect but was found spreading into the indigenous vegetation at Rodenstein in the Waterberg Plateau Park. This species has become a major problem in localized areas in Natal (Macdonald and Jarman, in press) and should be eradicated wherever present in S.W.A./Namibia.

Cereus peruvianus was only recorded showing limited (? vegetative) spread from a cultivated plant on Spykersbron (Omasima) farm (2015AB). This species has become a major problem in certain of the savanna regions in the Republic of South Africa (Taylor &

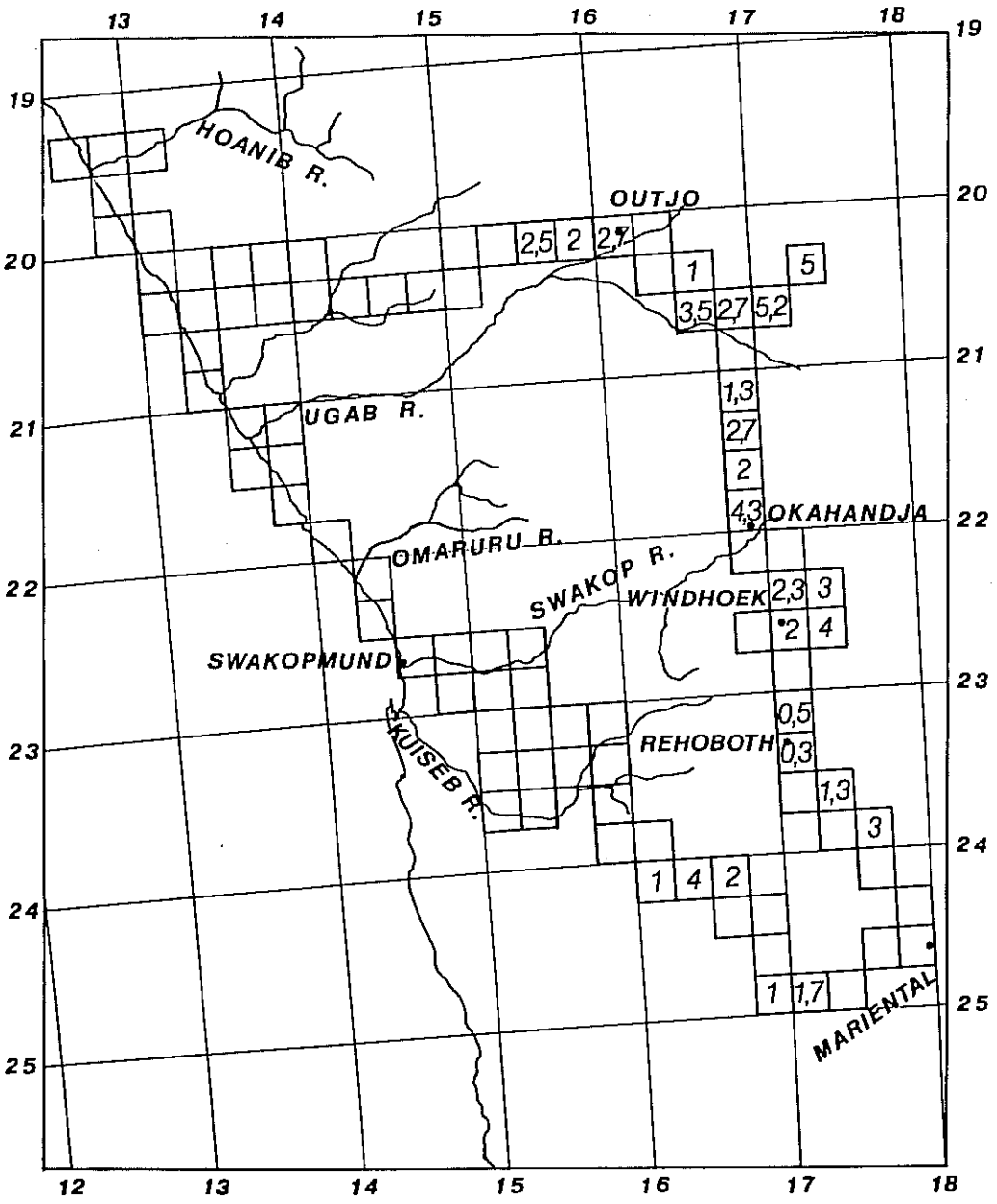

FIGURE 5: Mean abundance ratings (A_{qd}) for *Asclepias fruticosa*.

Walker 1984 and Macdonald pers. obs) and should be eliminated from S.W.A./Namibia wherever possible.

Datura ferox was found at low densities in scattered roadside infestations in the higher rainfall vegetation types (Table 2).

Datura innoxia was found in every vegetation type surveyed (Tables 2 & 3, Fig 6), although in all of them the species was restricted to river courses. This localized occurrence resulted in the species showing low quarter-degree abundance ratings (Fig. 6) compared to widespread aliens such as *A. subfusiformis* (Fig. 4). It was only in the riverbeds of the Namib that the species was abundant (Table 3). The species is apparently absent from the Swakop river system and efforts should be made to maintain this situation. .

Datura stramonium was not found in the dry Dwarf Shrub Savanna (Table 2), and in the Namib vegetation types was only found in river courses (Tables 2 & 3). It was always less common than *D. innoxia* and nowhere was seen to form a dense infestation. This species does not appear to pose a major threat to any of the ecosystems it has invaded in S.W.A./Namibia. If *D. innoxia* were to be controlled, *D. stramonium* could possibly increase in systems such as the Ugab and Kuiseb where it is already widespread. In this respect, it would possibly be advisable to attempt to eradicate this species from the Hoanib before a major control programme is initiated there for *D. innoxia.*

Dodonaea viscosa was seen to be showing limited spread in the vicinity of Outjo and Otjiwarongo. This

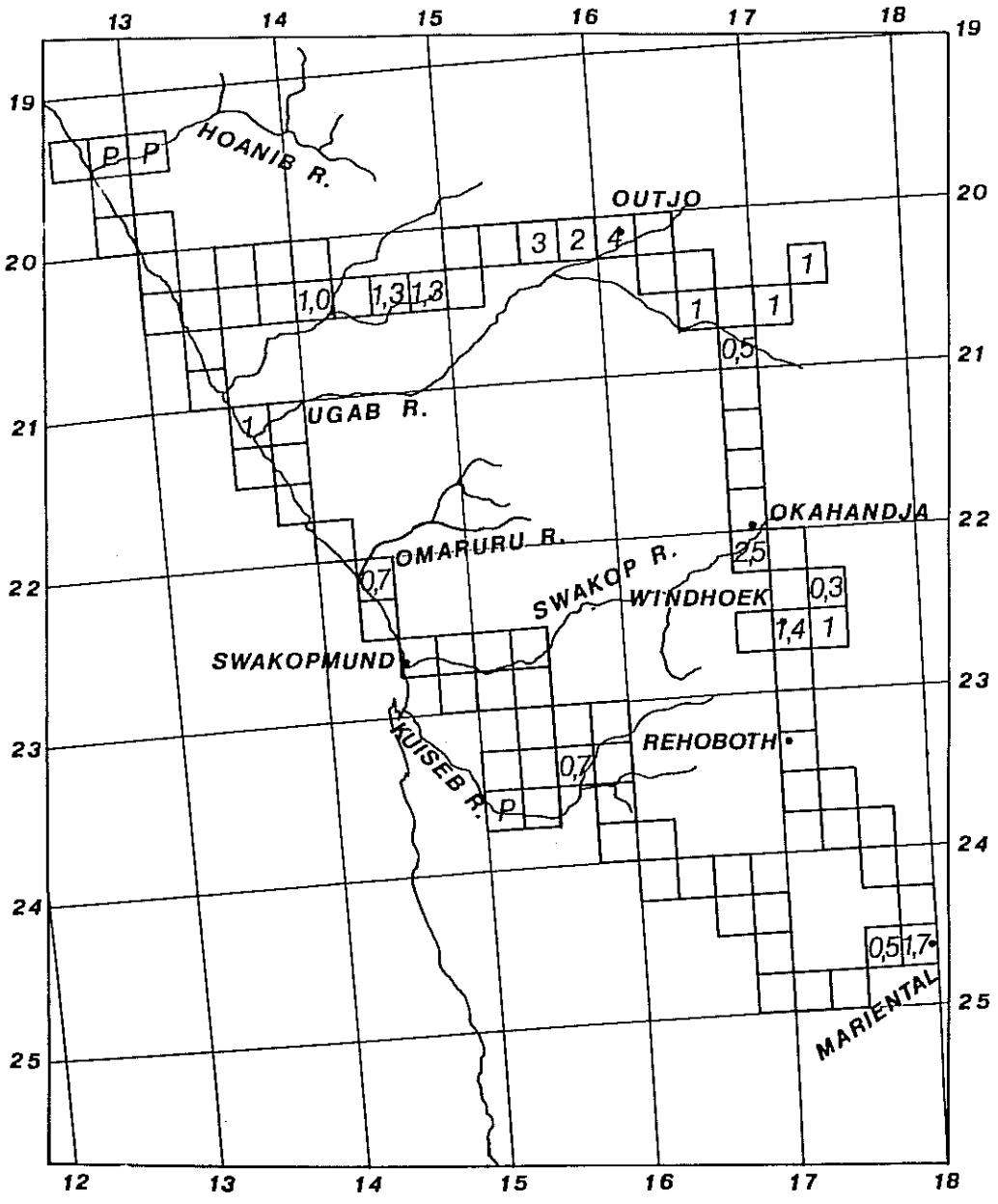

FIGURE 6: Mean abundance ratings (A_{qd}) for *Datura innoxia.* P = where recorded outside the main road survey.

species has spread into natural vegetation in areas outside its original range elsewhere in southern Africa and should be controlled while infestations are still light. The species should not be cultivated within nature conservation areas in the higher rainfall areas of the territory.

Lantana camara, although not recorded on the road transect, was seen to be invading indigenous vegetation in a kloof of the Waterberg Plateau Park around an old farm homestead. The plants observed had all been heavily browsed and the infestation was not dense. Browsing by indigenous ungulate communities can limit the spread of this species in southern Africa (Macdonald 1983).

Melia azedarach was seen as single individuals on the roadside near Outjo, Otjiwarongo and Windhoek. Whether these individuals had been planted or were self sown could not be determined. If the species is invasive in this area it is apparently not very successful and was certainly not posing a problem in any of the areas visited during this survey. The species is highly invasive in the moister eastern part of the subcontinent (Macdonald 1983) and should, ideally, not be planted in the vicinity of perennial or seasonal rivers in the northeastern ares of S.W.A./Namibia.

Nicotiana glauca was one of the most widespread alien plants found in this survey (Tables 2 & 3, Fig. 7). Although not recorded in the southernmost portion of

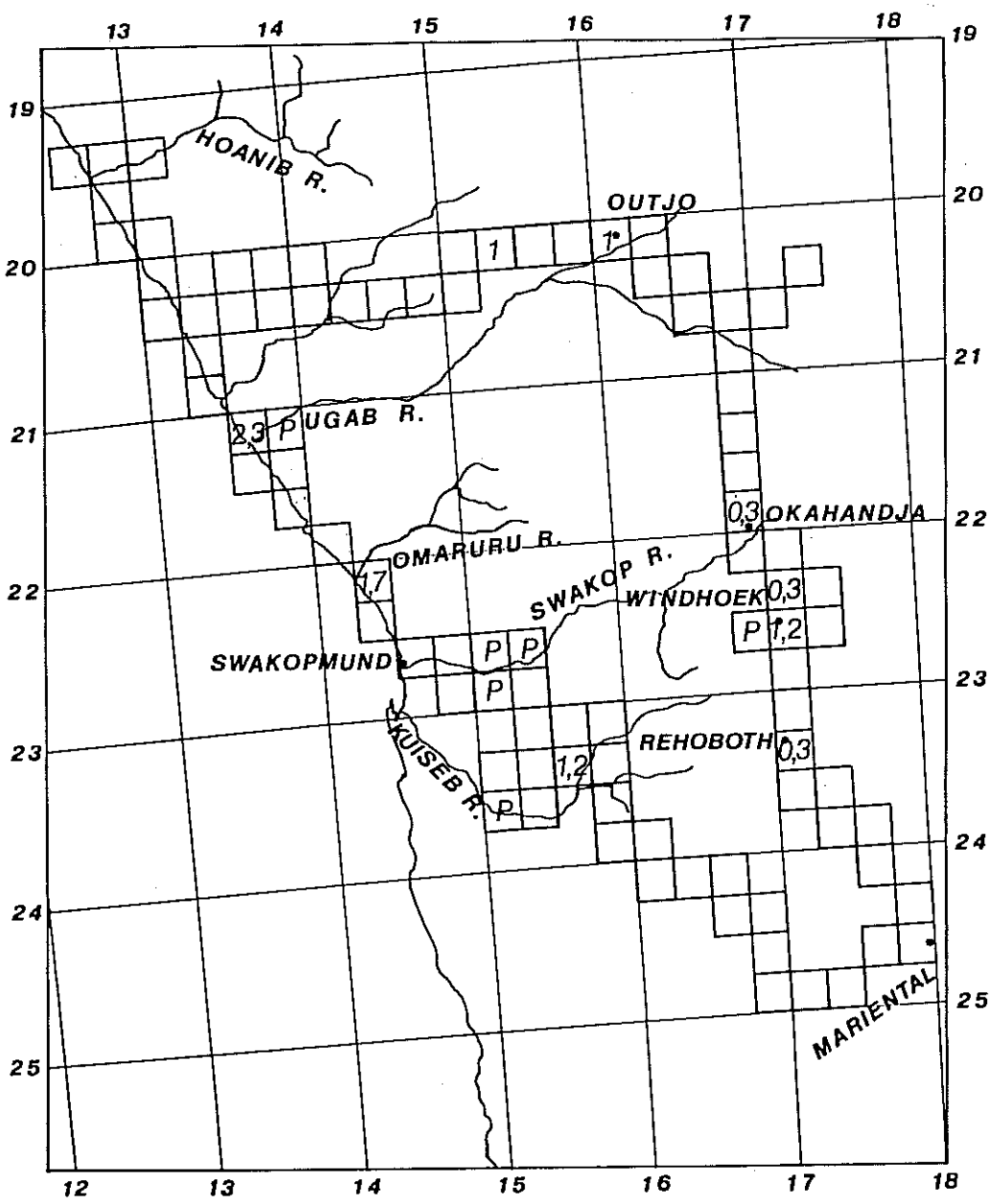

FIGURE 7: Mean abundance ratings (A_{qd}) for *Nicotiana glauca.* P = where recorded outside the main road survey.

the survey, this species was recorded in 1911 by Dinter (1918) on the Fish River at Orab south of Mariental (2417DD). That *N. glauca* was already well established in the territory by 1918 is borne out by it having been one of the four most common species at the mouth of the Swakop River in 1913 (Dinter 1918). The species is apparently absent from the Hoanib River system and considerable effort should be expended to maintain this desirable situation.

Opuntia ficus-indica was observed in the Mopane Savanna only as a light infestation around Spykersbron (Omasima) farm (2015AB). In the Highland Savanna it was observed as a few scattered individuals near Windhoek and Aris. The most extensive infestation observed was on the edge of the plateau in the Waterberg Plateau Park. In this locality it was being well controlled by an introduced Cochineal insect *Dactylopius* sp. The species has apparently become less common than was the case early this century (Dinter 1909).

Opuntia imbricata, Opuntia microdasys var *lutea* and *Opuntia* sp. unident. were all observed showing very limited spread from garden plantings around Windhoek.

Opuntia inermis was observed as an extensive infestation in Mopane veld around the homestead of Spykersbron (Omasima) farm (2015AB). None of

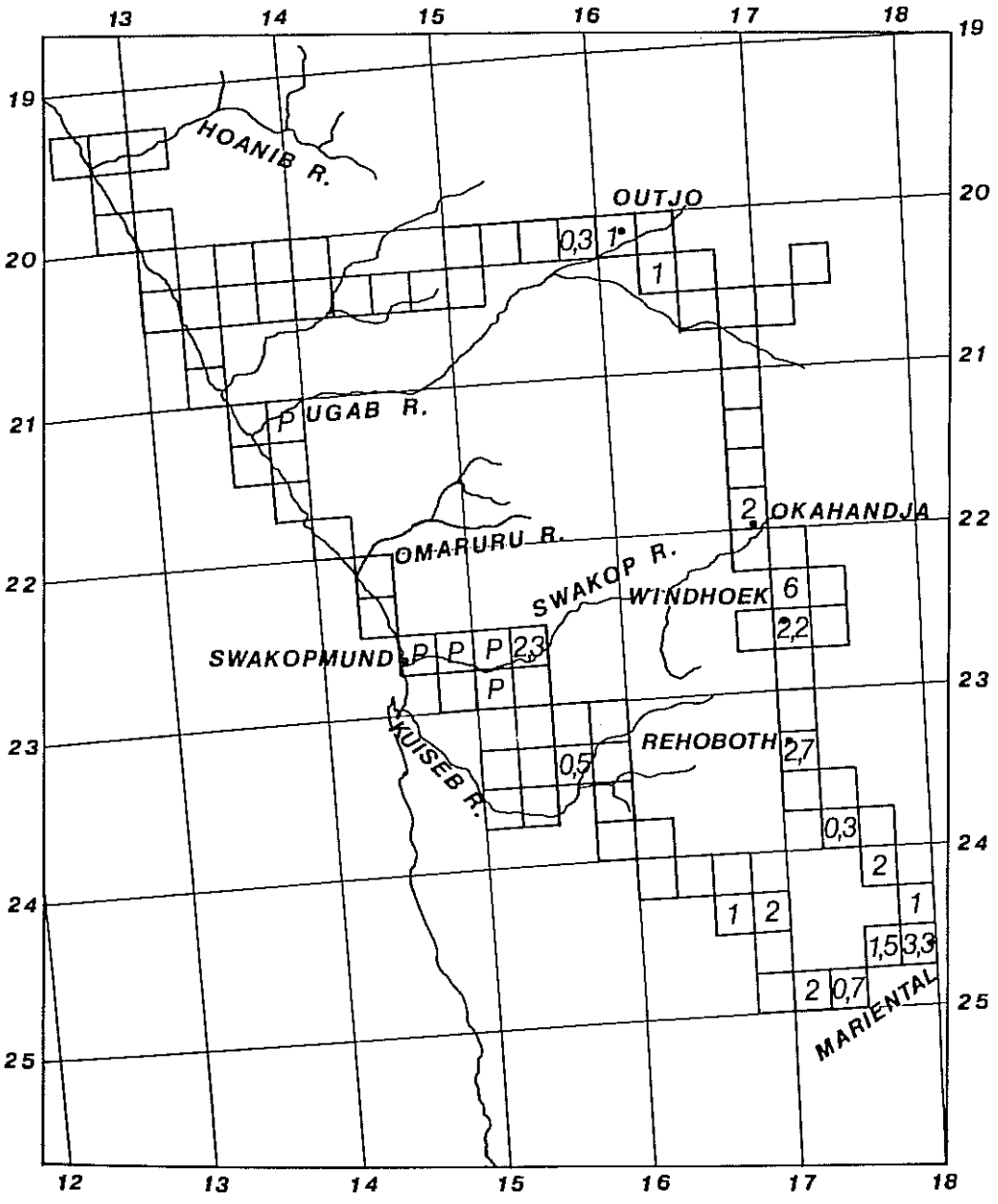

FIGURE 8: Mean abundance ratings (A_{qd}) for *Prosopis* sp. P = where recorded outside the main road survey.

these plants showed signs of being attacked by introduced biocontrol insects.

Prosopis sp. was found to be cultivated around most of the towns and farm homesteads visited during this survey. The species was first introduced to S.W.A./Namibia in 1912 (Müller, in press). The most extensive infestations seen were on the Swakop River and around Windhoek. Infestations were most widespread in the Dwarf Shrub Savanna (Table 2, Fig. 8), possibly as a consequence of the long history of cultivation at the numerous farm homesteads found in this vegetation type. Although present at low density in the upper catchment of the Kuiseb River (on the Gaub River) no individuals were seen in this river between Gobabeb and Homeb. The upper reaches of this river warrant clearing in order to prefent dense infestations, such as those found in the Swakop River, from developing. Similarly, the elimination of the few *Prosopis* trees established in the lower Ugab River should be accorded a high priority. In all cases where riverine infestations of this species are to be controlled, operations should be initiated at their source. In this respect the control operations observed near Riet Gaop on the Swakop River are clearly not ideal. Although it is uncertain how far *Prosopis* seed is transported by flood waters in such a river, it is certain that seed will continue to be brought into the cleared portion from the farming areas east of the Namib Naukluft Park. An infestation of *Prosopis* was observed on the banks of the upper Swakop River near Okahandja. That this species is still being planted as a roadside shade tree in S.W.A./Namibia (as was observed at a lay-bye on the road between Otjiwarongo and Oka-

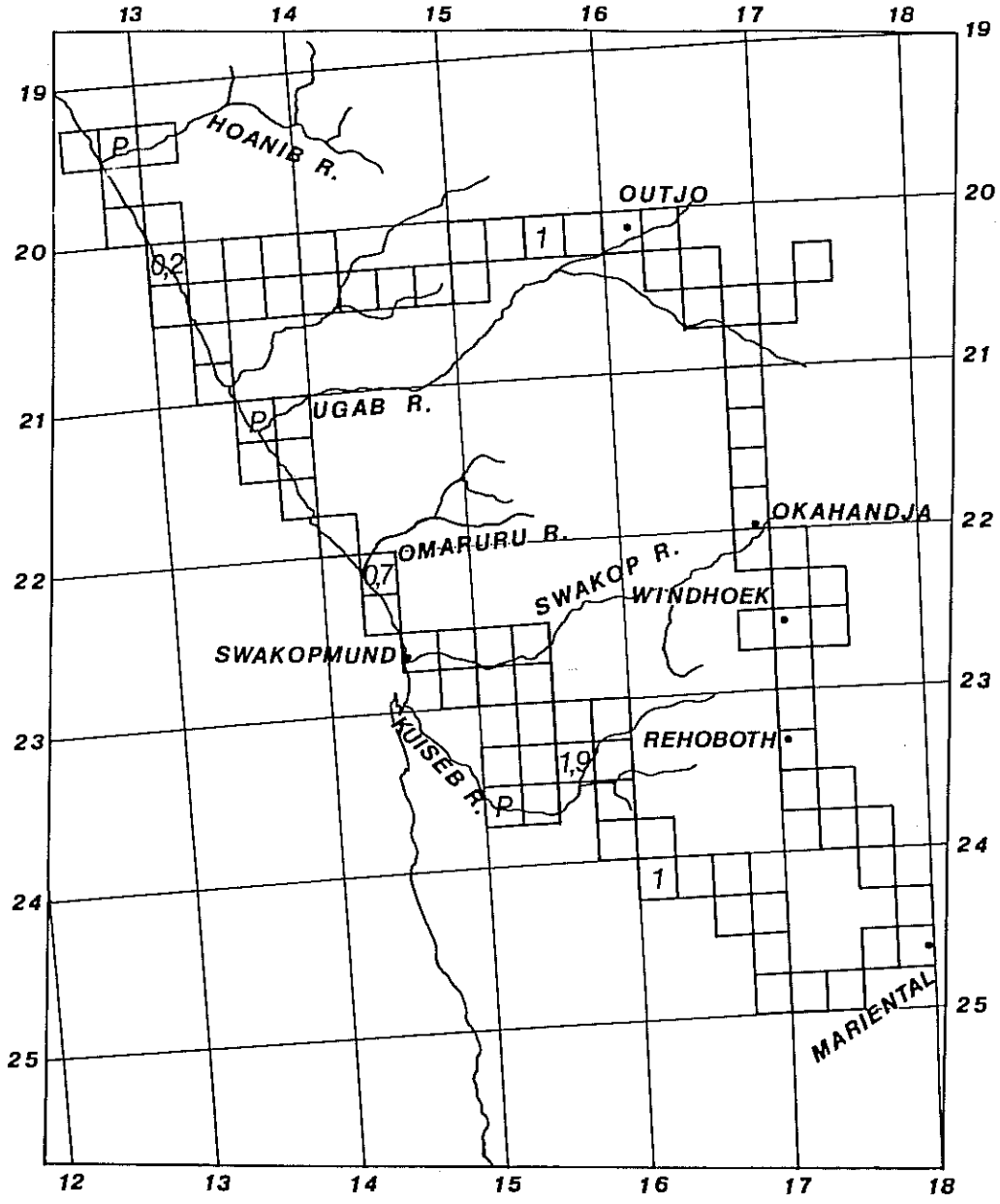

FIGURE 9: Mean abundance ratings (A_{qd}) for *Ricinus communis*. P = where recorded outside the main road survey.

handja) is remarkable, given its obvious invasive potential in the territory. Although *Prosopis* has not been shown to have deleterious ecological effects in S.W.A./Namibia, extrapolation from elsewhere indicates that this will be the case (Macdonald, 1985). Already the species has been shown to have deleterious effects on human health in S.W.A./Namibia (Ordman 1959).

Ricinus communis was only found as scattered plants, mainly along rivers such as a tributary of the Tsondab, the Gaub, Kuiseb, Omaruru, Ugab and Hoanib. One plant was observed growing next to an isolated pumphouse on the road between Torra Bay and Terrace Bay, indicating that the species is inadvertently spread by man in this area. On the middle Kuiseb River the species was being extensively browsed and the only relatively intact individuals seen were those growing in the protection of fallen branches. The browsing was probably being carried out by goats *Capra hircus* which were herded by the Topnaar inhabitants of the Namib-Naukluft Park and which had consumed most of the palatable herbage within their reach by the time of our survey of the river. The species was already common in S.W.A./Namibia early this century and Dinter (1909) was not certain as to whether or not the species was indigenous to the territory. If it is an alien it is certainly having a negligible impact on the rivers it was found in at the time of this survey.

Schinus molle was found as a few self-seeded individuals in the vicinity of Outjo and Otjiwarongo. This species has been found invading, albeit very slowly, karoo riverine fringe vegetation in the Republic of South Africa (Macdonald pers. obs).

Tagetes minuta occurred mainly in the relatively well-watered Highland Savanna region (Table 2). It was present almost exclusively as a roadside ditch invader. It was also recorded below the plateau in the Waterberg Plateau Park.

Tecoma stans was seen once growing on the road-verge south of Outjo. Whether this plant was self sown or not could not be determined.

In addition to the above species, the alien forb *Flaveria bidentis* was seen growing as a roadside weed between Nomtsas and Gamis where rain had fallen recently. This species could not be adequately surveyed from a moving vehicle, because there are several indigenous species which are similar in appearance and it was flowering in only one area. Similarly, *Bidens biternata* was observed in the Waterberg Plateau Park. The alien grass *Polypogon monspeliensis* occurs in the bed of the Swakop River (H. Kolberg, pers. comm.) but was not recorded by us during this survey. The preceeding list is neither comprehensive nor complete for the alien plant species present in S.W.A./Namibia. It is a list of the conspicuous species that could be observed in a rapid survey such as the present. The value of our survey lies not in its completeness but in its repeatibility for those conspicuous species surveyed.

4.3 Alien birds

The House Sparrow was the only widespread alien bird species seen in S.W.A./Namibia. Since Uys (1962) first recorded this species at Grünau (2718CB) in 1961, the species has apparently colonized the whole of the territory, at least as far north as was surveyed on this trip. At this most northerly point, Möwe Bay (1912BC), the species had only arrived during 1984 (Ryan *et al.*, 1984, P. Tarr pers. comm.).

Although three and, in some areas, four species of *Passer* occur sympatrically in those portions of S.W.A./Namibia traversed during this survey (Maclean 1985), in no locality were more than two species found around an area of human habitation (Table 4). At the small, intermittently occupied, sites in the Namib often no sparrow species were recorded. These sites appear marginal for House Sparrows as, apparently, was the Nomtsas farm homestead where the species had disappeared after an initially successful colonization.

At Gobabeb both House Sparrows and Cape Sparrows *Passer melanurus* were breeding at the time of our visit. As the House Sparrow was already present here by 1966 (Willoughby & Cade 1967) it is apparent that the two species have been able to coexist here for at least 19 years. This is made more interesting by the observation that the Cape Sparrow was nesting in a hole in the wall of a building at Gobabeb which is the preferred nest site of the House Sparrow. The Grey-headed Sparrow *Passer griseus* was observed entering the roof of a farm outbuilding on Spykersbron farm.

The Great Sparrow *Passer motitensis* which is generally considered "has not adapted to human settlement" in southern Africa (Maclean 1985) was found around two restcamps, one homestead and one small town. At Hardap Dam Rest Camp the species was nesting in a small indigenous shrub growing approximately 30 m from the buildings. At this locality the recently constructed buildings do not apparently offer many suitable nest sites for House Sparrows and the population of these was small. One pair of House Sparrows was observed nesting in a Greater Striped Swallow's *Hirundo cucullata* nest at the reception building and several individuals were seen at the entrance gate building. At Khorixas the Great Sparrow was observed to be far more abundant than the House Sparrow. These observations agree with those of Winterbottom (1964), who observed farther north in the territory that the statement "that the Greater Sparrow is a shy and retiring species of the bush and does not frequent human habitations is certainly not true of S.W.A.". It will be interesting to see whether the relatively recent arrival of the House Sparrow in these areas gives rise to any long term changes in the abundance of indigenous sparrows around habitations. At Kalkrand, where House Sparrows were already present in July 1968

(Macdonald pers. obs), no other species of sparrow was observed in November 1984. However, farther north in S.W.A./Namibia at Okakuejo, where the House Sparrow arrived in December 1976, both the Grey Headed and Great Sparrows were still present in the restcamp in 1985 (Nott pers. obs). The observation that no more than two species of sparrow were present at any of the habitations visited in the central portion of the territory indicates that sparrow "niche space" is limited in S.W.A./Namibia and potential interspecific competititon should be watched for.

5 CONCLUSION

Alien plants were found to be invading most of the vegetation types observed. Infestations of *Datura innoxia, Nicotiana glauca* and *Prosopis* sp. in some of the west-flowing rivers were considered to constitute a conservation problem.

The only alien bird found to be widespread was the House Sparrow which was only found in close association with human habitation.

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First approximation of food preferences and the chemical composition of the diet of the desert-dwelling black rhinoceros, *Diceros bicornis* L.

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ABSTRACT

Food preferences of black rhino inhabiting an area of extreme aridity in Damaraland SWA/Namibia were examined using a transect survey method. A wide variety of plant species were browsed by rhino in this region. Of the 103 species of plants encountered, 74 were used and the selection indices showed a moderate degree of selectivity on the part of browsing rhino. The chemical composition of a selected number of plants favoured by rhino contained moderately high levels of soluble tannins but these chemical deterrents apparently had no effect on the feeding preferences of these animals.

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1 INTRODUCTION

The hooklipped or black rhinoceros, *Diceros bicornis* Linn. (1758) was originally widely distributed in the southern African subregion. In South West Africa/Namibia their distribution extended from the Kunene river southwards along the escarpment to the Orange river and eastwards past Gobabis at 22° (Joubert and Eloff 1971). Early hunters and explorers eliminated a large proportion of the original population, leaving isolated but viable breeding populations in the arid terrain of the north west regions. From 1970 to 1972, 43 rhino were removed from the population still surviving in Damaraland and taken to the Etosha National Park in an attempt to protect the species (Hofmeyr et al. 1975). The estimated number of rhino now remaining in the arid desert habitat of the Skeleton Coast, Kaokoland and Damaraland is about 60; their distribution covers more than 20 000 km². Western Damaraland supports the majority of the present population which ranges over this very rugged and arid terrain, an area entirely unsuitable for conventional farming and where the human population is very small. More recently the illegal trade in rhino horn which has escalated throughout the world has caused an 85% decrease in the population world wide in only 14 years (Bradley Martin 1984). The International Union for the Conservation of Nature (IUCN) has recommended that these South West Africa/Namibia rhino receive priority conservation status within the arid habitat in which they live. Negotiations for the proclamation of areas to protect these rhino are presently underway.

The purpose of this investigation was to examine the diet of the rhino within the arid northwestern portion of SWA/Namibia (Plate 1). Several extensive studies on rhino diet have been carried out elsewhere in Africa (Goddard 1968, 1970, Joubert 1971, Hall-Martin et al.

1982, Mukinya 1977, Schenkel and Schenkel-Hullinger 1969), but in view of the extreme aridity prevailing in this region results from elsewhere cannot be directly applied here. Food availability and food preferences during the dry season plus the possible role of water, protein, fat, crude fibre, ash and tannin content, which may influence these preferences, were examined. The area under investigation is situated in the southernmost region of the distribution of the rhino population. (Fig. 1). It was hoped that this investigation would contribute information towards formulating priorities for the conservation and management of the Damaraland rhino.

2 PROCEDURE

2.1 The Study Area

The study area is situated east of the Skeleton Coast Park and west of the inhabited farmlands in Damaraland (Plate 2). The annual rainfall is less than 100 mm and periodic droughts may last for three of four years. Open gravel plains are interspersed with outcrops of granite boulder islands and transected by sandy riverbeds, which sustain the main food plants of the rhino. These tributaries run into hot dry valleys surrounded by rugged shale, schist, quartzite and mar-

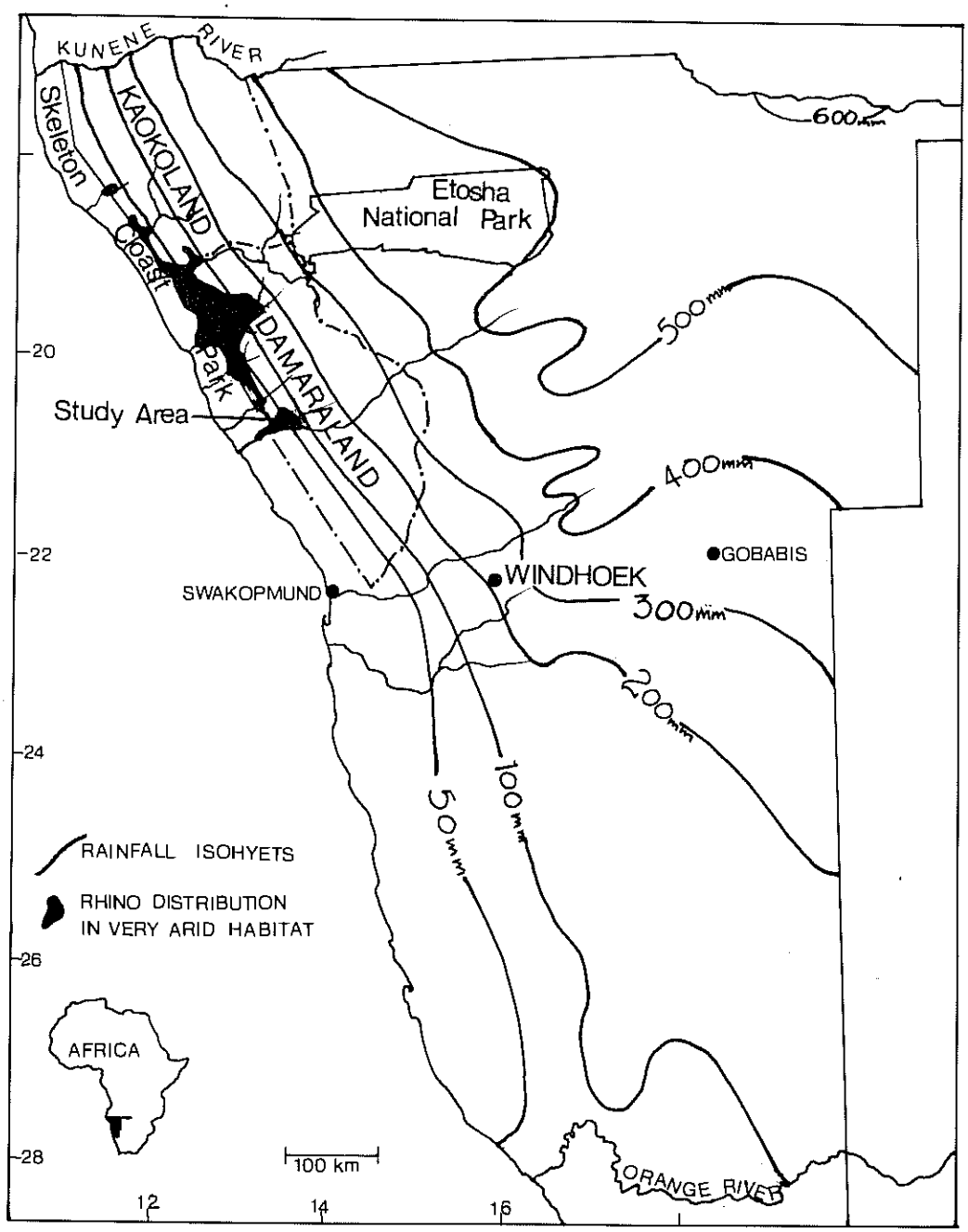

FIGURE 1: Position of the study area in relation to the distribution of black rhino in Damaraland and Kaokoland.

ble ridges which form the Ugab river valley (Hodgson 1972). Annual rains to the east of the study area result in flooding of the riverbeds and support growth of permanent vegetation in these riverbeds. Isolated waterholes and the succulent flora in the mountains of the study area are maintained by scattered and irregular, local showers which occur from January to March.

2.2 Animal Observations

The movements of each rhino we studied were plotted on a map. Observations were sometimes by direct sightings. When direct sightings were not possible because of the vast and rugged nature of the terrain, fresh and recognisable foot impressions of the rhino spoor that were clearly visible on the substrate were considered to be sufficient evidence of their presence. These spoor were measured and compared with an identification file of the spoor sizes and photographs of the rhino in the area and their positions were plotted on a map. Seasonal movements of individuals were then recorded and an estimate of their home ranges determined. Seventeen direct sightings were recorded during the 576 hours spent monitoring the home range. Thirteen of these sightings were cow and calf pairs, three were cow and bull pairs and a lone bull was recorded once.

2.3 Food Preference

A list of plants definitely eaten by rhino was compiled from direct observations and verified by speciments collected for identification. These observations were facilitated by the paucity of other large herbivores in the study area and the characteristic damage inflicted on plants by feeding rhino. The home range was monitored each month to determine the routes most often used by the animals. It was found that they tended to re-use routes to feed and that fresh tracks were usually present on each monitoring visit. This led to the selection of six feeding routes. Each one represented a variation in the vegetation types which were frequently used and they were titled ROUTES A,B,C,D,E & F.

During January 1985, the driest month before the rains fell, each of the six feeding Routes was studied by first locating rhino tracks and indications of feeding having taken place or by location of one or more feeding rhino. Thereafter the following sampling method was employed. After selecting a route, all the

PLATE 1: Large male black rhino in excellent condition feeding on *Euphorbia virosa*, a plant possessing strong chemical defenses against herbivores.

species of plants available within a circle of 20 m diameter from a designated point, together with the number of individuals within each plant species, were recorded to assess the availability of the various species. The feeding track was then followed for 200 m to a second circle where the above estimate of availability was repeated. While following the 200 m route exactly along the track taken by the rhino, the number of bites (Hall-Martin et al. 1982) from each plant species browsed by the rhino was recorded on a pocket tape recorder. Availability of species along this track was not recorded. The entire procedure was repeated six times on each Route A,B,C,D,E and F. A total of 36 feeding tracks and their 72 'availability' circles was studied. Eventually a list of all the plant species together with the number of bites taken from the browsed plants was compiled (Table 1). Because of the difficulties experienced in differentiating between the two species *Merremia querichii* and *M. bipinnatipartita* during the collection of field data, these two species have been comined in this report as *Merremia* spp. both species were equally well favoured and all parts of the plant were eaten.

Hills' N_2 values: - ($N_2 = {}^1/CP,^2 + P_2 + \ldots Pn^2$) (Hill 1973) were calculated for the number of bites taken and for the number of plants available on the six portions of each route. These N values provided an indication of the diversity of available forage and the diversity of plants eaten.

2.4 Analytical Procedures

The 19 plant species collected for analyses were selected during the preliminary monitoring of Routes and observations of feeding behaviour. They represent some of the plants browsed by the rhino within the investigation area. All samples were placed in plastic bags immediately after collection in the field and were kept at 4°C prior to air shipment to the University of Cape Town within 48 hours. They were frozen on arrival at the laboratory and stored for later analyses. All samples were replicated three times and the following analyses performed.

2.4.1 Proximate Analysis

Water content was determined by oven-drying to a constant weight at 60°C. The plant samples were then coarsely ground in a Wiley mill and sub-samples received further grinding in a mortar and pestle. Total ash determinations were made by heating samples to 450°C for 3 hours in a muffle furnace. Crude fibre,

PLATE 2: A *Euphorbia virosa* severely damaged by browsing rhino.

protein and crude fat determinations were carried out by using standard A.O.A.C. methods (A.O.A.C. 1975), while soluble carbohydrates were estimated by difference. The energy content of each plant food was calculated from the results obtained from the proximate analysis (Durrin and Passmore 1976).

2.4.2 Determination of Tannin/Polyphenols

Plant material was stored frozen without drying. When required for analyses, the samples were thawed and each was cut into small pieces. A thoroughly mixed sub-sample of 3-5g was then homogenised in

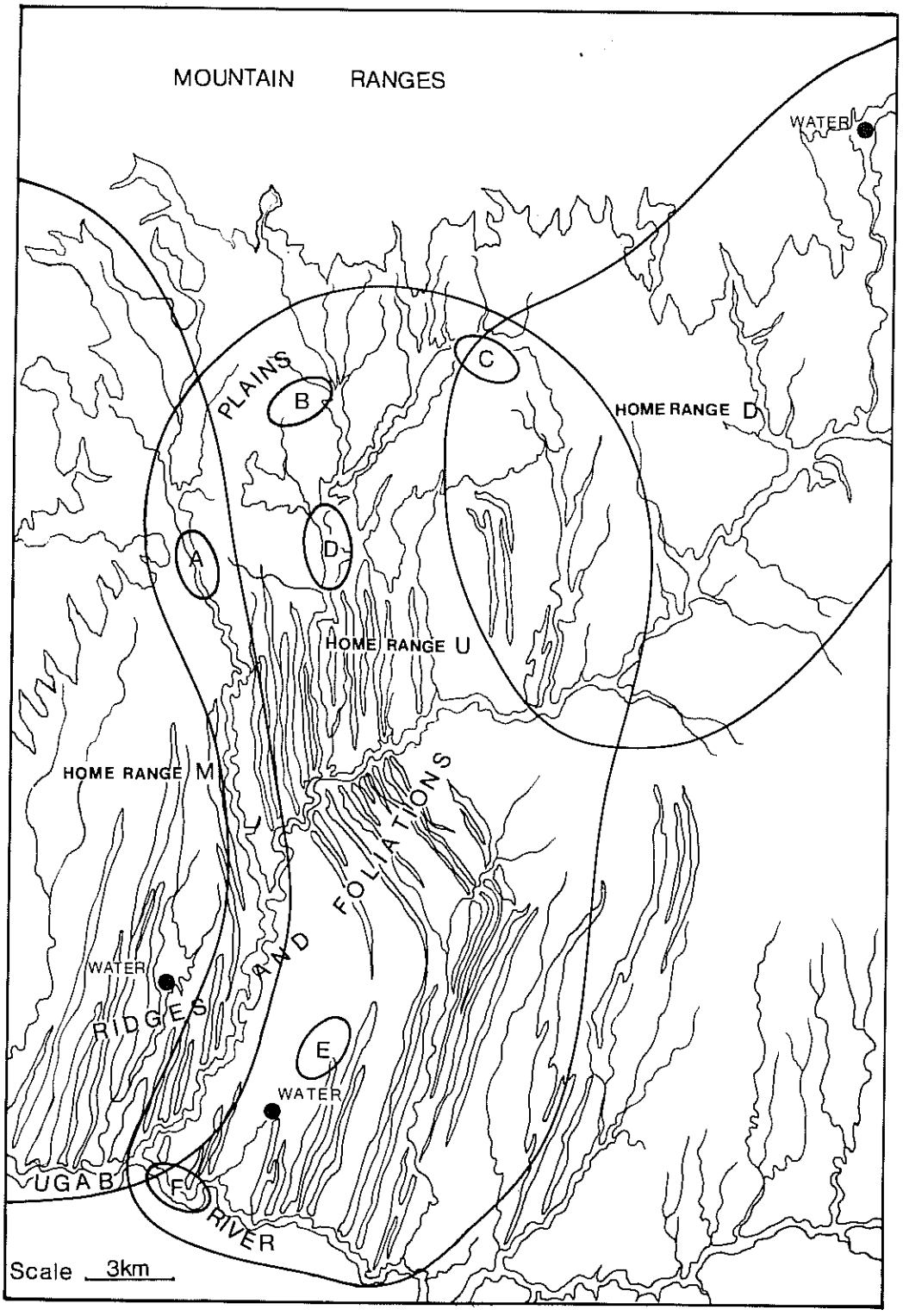

FIGURE 2: Estimated size and position of the three home ranges "D", "M", and "U" (map from Hodgson 1972). See text for explanation.

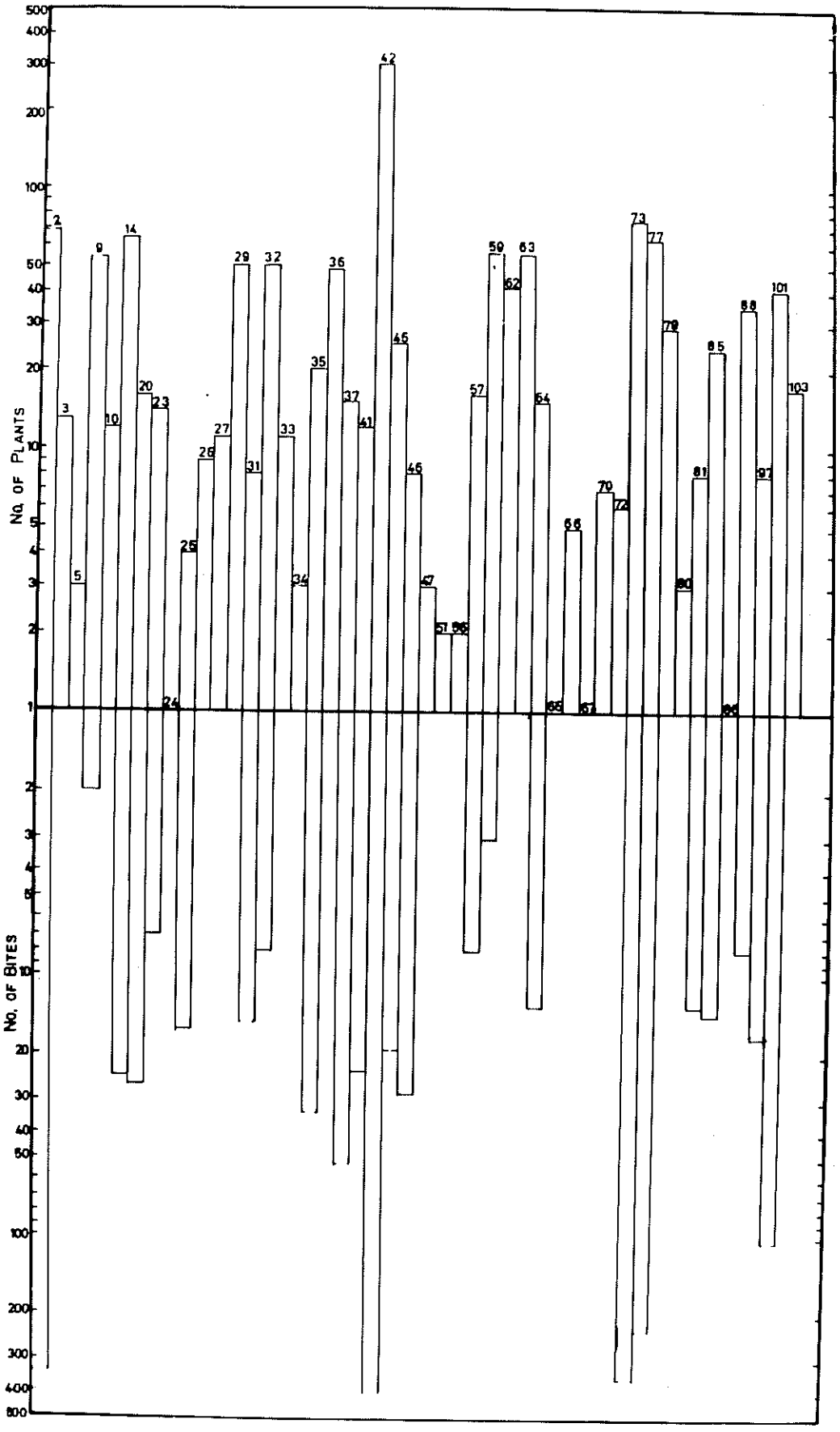

FIGURE 3: ROUTE A — Graphic presentation on semi-log scale of the abundance of various plant species plotted opposite their usage by the black rhino. The number above each bar denotes a particular plant species listed in Table 1.

50-100 ml of pure (98%) methanol using a high-speed blender. The methanol was decanted and extraction completed by washing the residue three times in boiling pure methanol (70°C) and then twice in boiling 50% methanol (80°C). Each wash lasted approximately 5 min. The pure and 50% extracts were pooled and filtered through Whatman No. 1 cellulose filter paper (in a few cases vacuum filtration using GF/C filters was necessary). The final volume was then measured and the extract refrigerated until analysed.

Soluble tannins were determined using Folin-Denis reagent, as outlined by Allen (1974). Dillutions of a freshly prepared aqueous solution of tannic acid (0.1 mg ml^{-1}) were used to construct a standard curve. After addition of Folin-Denis reagent and Na CO solution, samples and standards were kept at 25°C for 20 min and the absorbance measured at 760 nm. The tannin content of the plants has been expressed as a percentage of the wet weight.

2.4.3 Faecal Calcium and Phosphorus

The levels of calcium and phosphorus in rhinoceros faeces were determined to estimate the nutritional status of the animals with respect to these two important minerals (Belonje 1978). Calcium was analysed by the standard atomic absorption technique and phosphorus by the method description by Hanson (1950).

3 RESULTS AND DISCUSSIONS

3.1 Home Ranges

Three home ranges, covering an area of circa 2000 km^2, overlap in the area chosen for the study. The central and most heavily utilised range 'U' (circa 500 km^2) was selected for the feeding investigation (Fig. 2). This home range was monitored each month for six months during the dry season which was the critical time. The period just preceeding and during full moon was chosen to facilitate sightings of rhino at waterholes. Five rhino used Home Range 'U'; a mature cow with a calf of nearly a year old, a younger cow which gave birth to a calf nearly halfway through the dry period and a mature bull. The overlapping home range 'M' accommodated three animals one of which was a mature bull, the remaining two were seen once but were not sexed. Home range 'D' which overlapped from the east, accommodated four rhino consisting of two mature bulls, a sub-adult cow and one of unknown sex.

3.2 Route Descriptions

ROUTE A

This route traversed a dry watercourse with scattered vegetation occupying the sandy riverbed which ran between broken shale ridges. Throughout the dry season 48 species of plants were recorded; rhino fed upon 25 of these species during the time of the investigation (Fig. 3). The two *Merremia* species were the most favoured, *Blepharis gigantea, Gossypium anomolum* and *Acacia reficiens* were fairly abundant and equally favoured.

ROUTE B

Route B traversed sparsely vegetated gravel plains with granite boulder outcrops. Rhino tended to feed on these plains during the early hours of the day and during the cool evenings and nights. Throughout the dry season 34 species of plants were noted; the rhino fed upon 22 of these species (Fig. 4). *Adenolobus pechuelii* was the most abundant species and the species most frequently consumed. *Merremia* spp. and *Calicorema capitata* were somewhat less abundant and together with *Acacia reficiens,* were the next most preferred food items. *Boscia foetida* was fairly abundant but was not highly favoured; *Sterculia africana* was very scarce but well favoured; 50% of the available *Welwitschia mirabilis* showed signs of browsing.

ROUTE C

This route was a winding path climbing steeply up an extremely rocky gulley on which the vegetation became increasingly sparse as the route progressed up the edge of an ancient, heavily eroded crater. On this route 35 plant species were noted of which 23 were eaten by rhino (Fig. 5). *Petalidium variable* and *Commiphora kraeuseliana* were the most abundant species and showed about 50% usage, whereas *Euphorbia virosa* was most frequently eaten although it was only 30% as abundant. The most common plant species recorded in the 'availability' circles were poorly represented (7%) among the species browsed by the rhino.

ROUTE D

Route D traversed a dry, sandy riverbed bordered by fairly well vegetaged banks and was the most frequently used feeding route, situated approximately 20 km from the dry-season waterpoint. Forty-six species were recorded, of which 35 were eaten by the rhino (Fig. 6). Six species were particularly abundant: of these *Stipagrotis damarensis, Petalidium variable, Calicorema capitata* and the two *Merremia* species were frequently eaten but the other common species were not. Instead the less common species, e.g. *Blepharis gigantea, Acacia reficiens, Terminalia prunioides* and *Gossypium anomalum,* constituted the species more frequently eaten by the rhino. A well worn pathway and a large number of dung middens on this route indicated a high intensity of usage by rhino in the dry season.

ROUTE E

This route traversed extremely rocky and arid terrain where the vegetation was very sparse. The route was

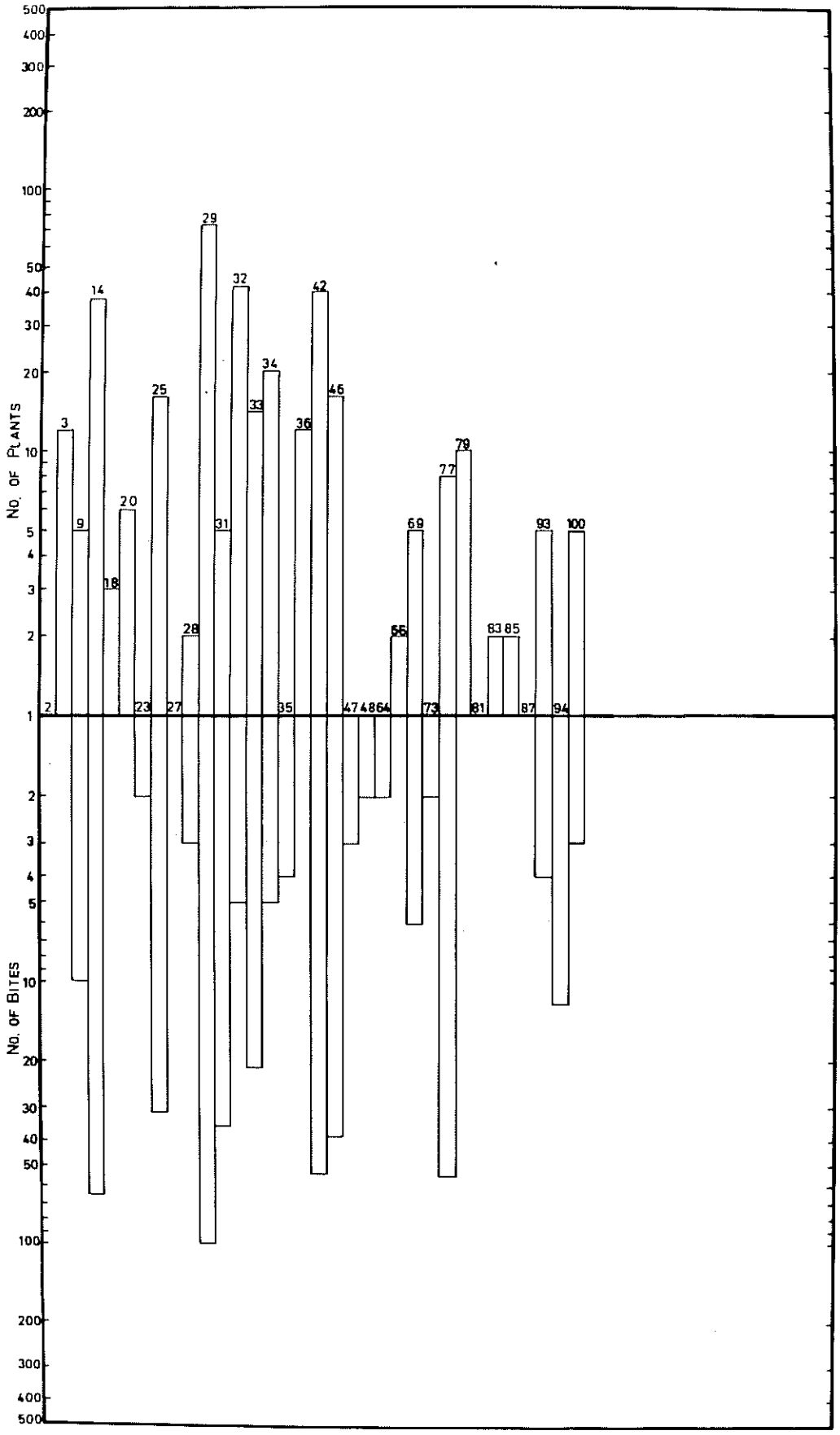

FIGURE 4: ROUTE B — Graphic presentation on semi-log scale of the abundance of various plant species plotted opposite their usage by the black rhino. The number above each bar denotes a particular plant species listed in Table 1.

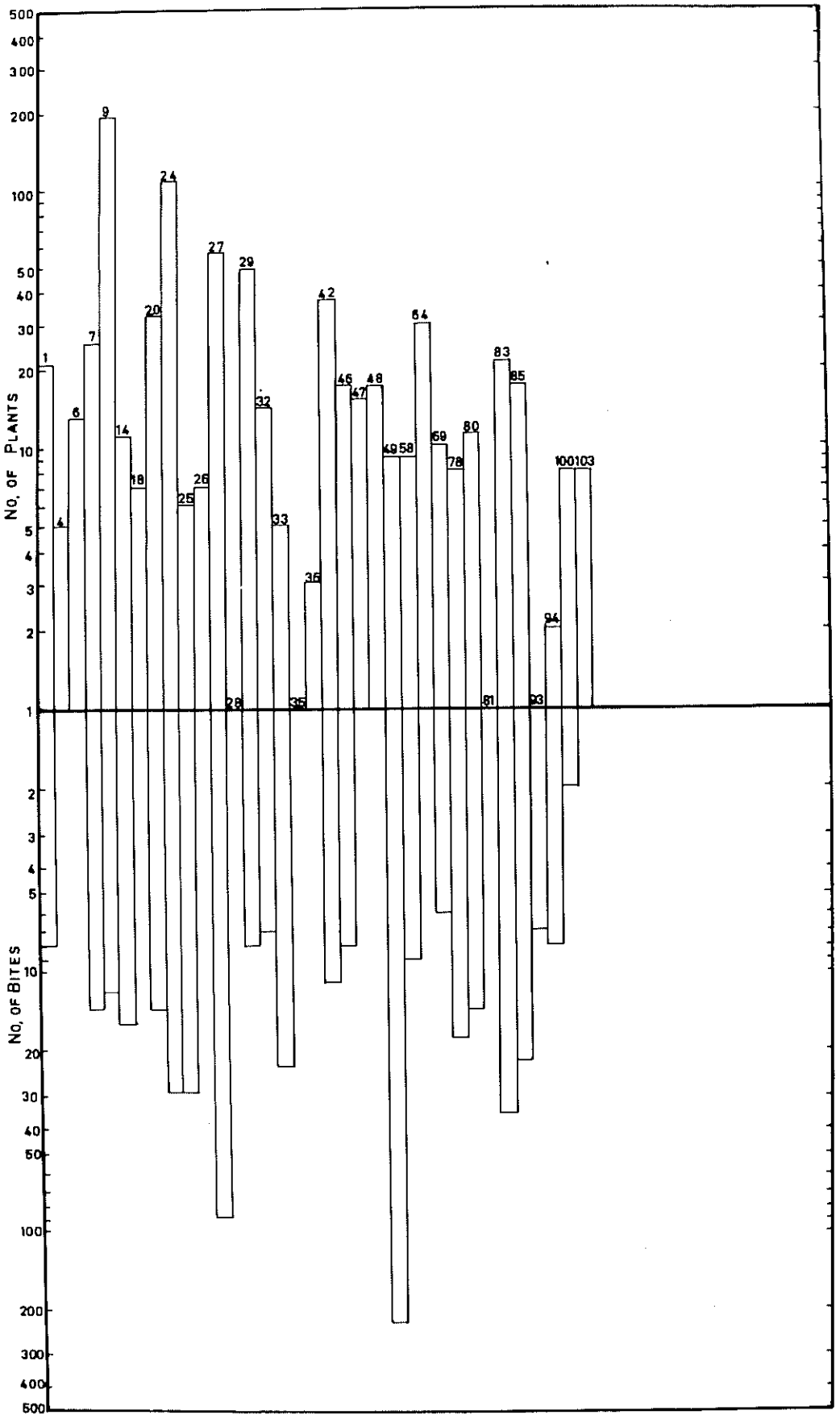

FIGURE 5: ROUTE C — Graphic presentation on semi-log scale of the abundance of various plant species plotted opposite their usage by the black rhino. The number above each bar denotes a particular plant species listed in Table 1.

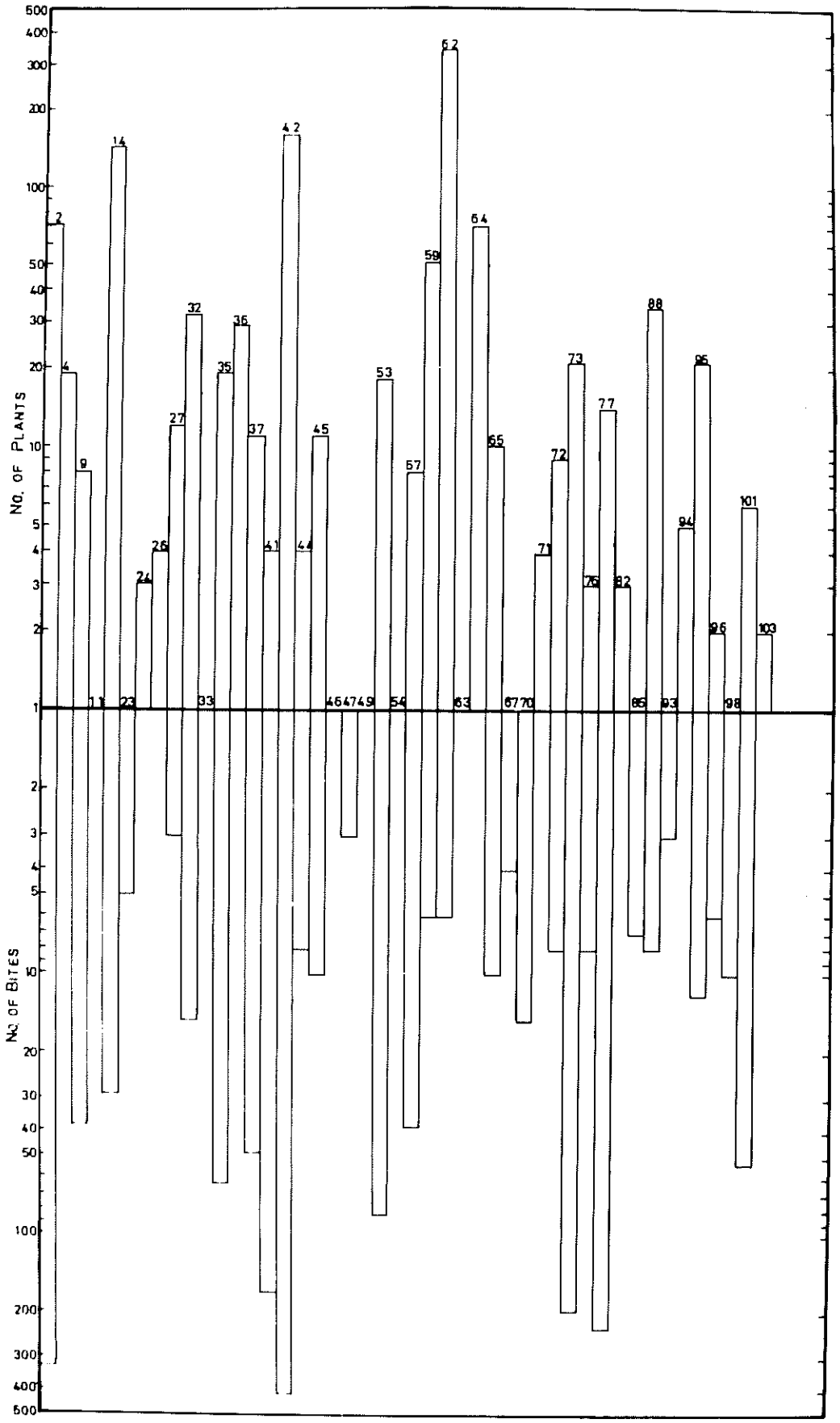

FIGURE 6: ROUTE D — Graphic presentation on semi-log scale of the abundance of various plant species plotted opposite their usage by the black rhino. The number above each bar denotes a particular plant species listed in Table 1.

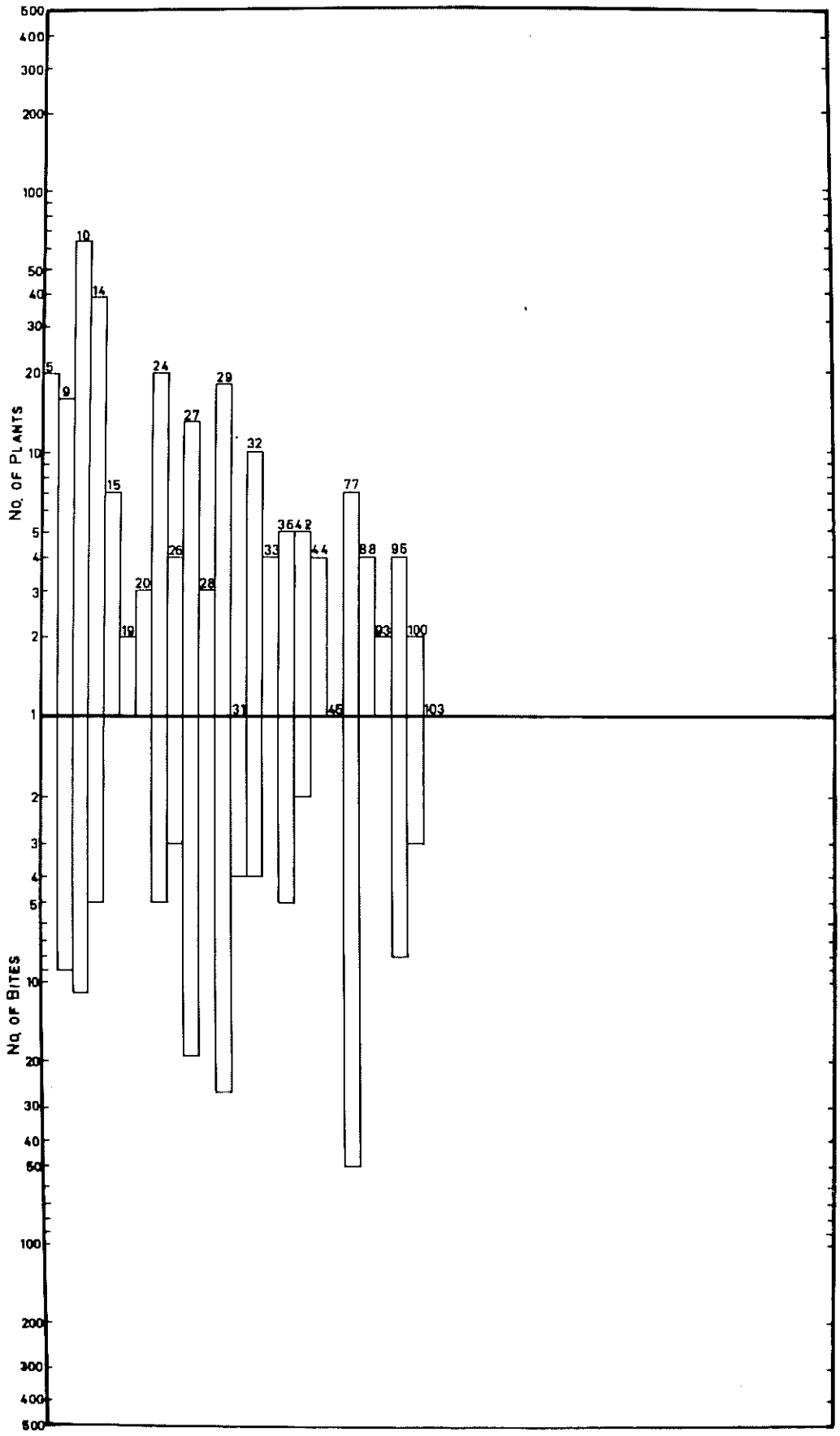

FIGURE 7: ROUTE E — Graphic presentation on semi-log scale of the abundance of various plant species plotted opposite their usage by the black rhino. The number above each bar denotes a particular plant species listed in Table 1.

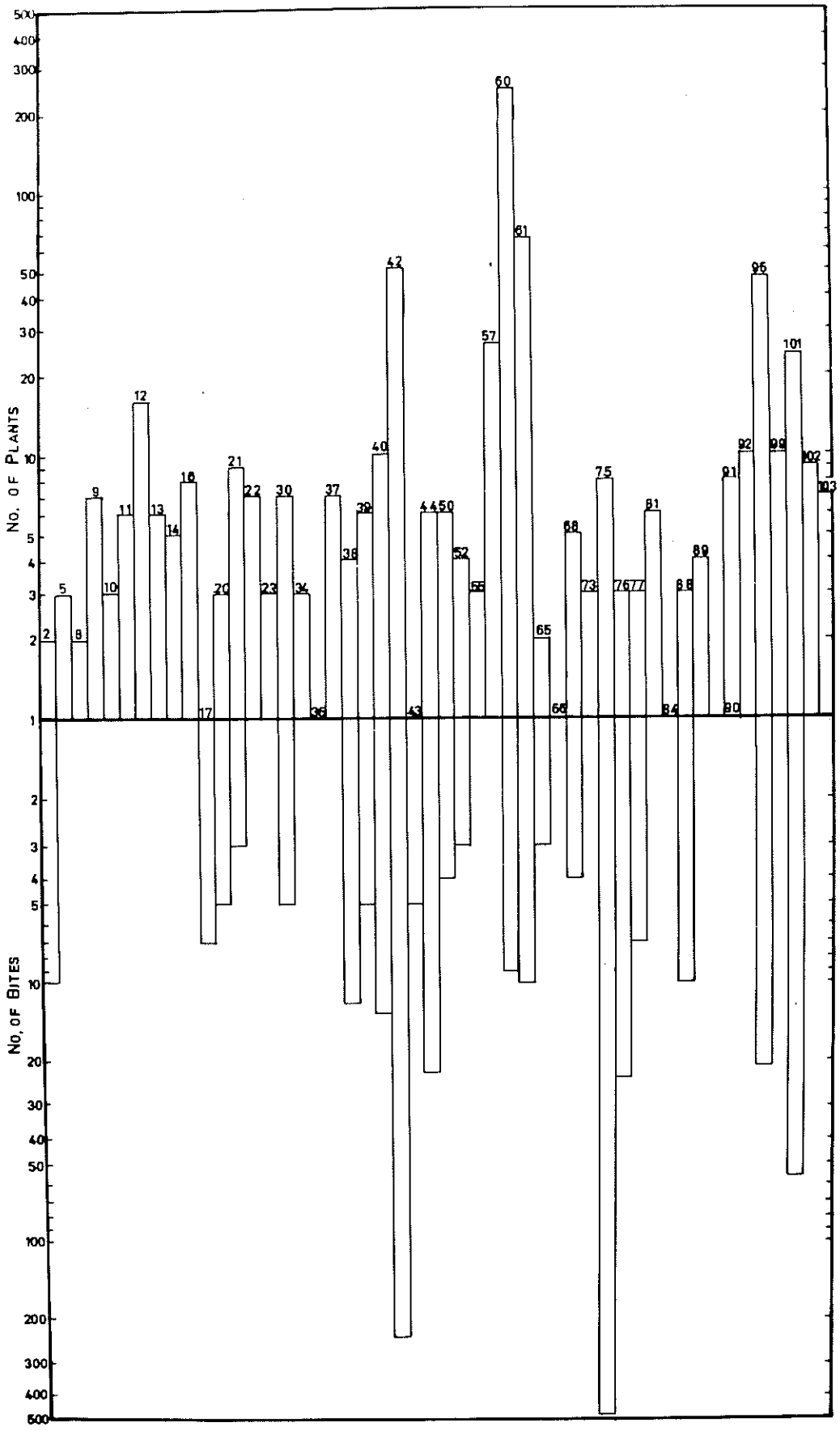

FIGURE 8: ROUTE F — Graphic presentation on semi-log scale of the abundance of various plant species plotted opposite their usage by the black rhino. The number above each bar denotes a particular plant species listed in Table 1.

heavily used by rhino because this pathway provided direct access to water from the feeding grounds (ROUTES A,B,C,D). The rhino tended to forage over the rugged terrain on the return trip from the water to the favoured feeding ground. This route showed the lowest diversity of plant species available, 25, of which only 14 were eaten (Fig. 7). *Commiphora virgata* and *Adenolobus pechuelii* were nearly equally available and each equally well browsed. The tree *Acacia reficiens* grows as a stunted shrub because of continual browsing by rhino but was not readily available.

ROUTE F

This route traversed a major river course with intermittent patches of open water and relatively abundant vegetation, separated by open stretches of sand where vegetation was limited. The route was situated within easy reach of the waterpoint on Route E, but was infrequently used by rhino during the investigation period. This was possibly due to the presence of humans in the area where vehicles frequently traversed the riverbed. On Route F, 50 species were recorded of which 25 were eaten (Fig. 8). The reed *Phragmites australis* was the most abundant plant species but was only eaten in localised patches. The survey technique showed a low abundance of *Acacia albida,* because of the large areas occupied by the tree canopies. It was, however, well browsed. The creeper forbs of the two *Merremia* species were again fairly well represented and well used.

3.3 Food Preferences

The plants available in the area as well as those consumed by the rhino have been listed alphabetically according to family (Table 1). Genus and species names have been included wherever possible. The list of species consumed also indicates food preferences, expressed as number of bites divided by availability, during the period of this investigation. These preferences included unexpected species such as *Euphorbia virosa* (Plate 3) even though this species was not well represented on the study routes. *Euphorbia virosa* grows in the study area on steep slopes covered by rocky scree difficult to traverse but evidence of rhino having fed upon these plants was abundant. A rhino cow was observed (R. Loutit, pers. comm.) feeding on one such plant for an hour and a half. The remains of the plant were examined after the rhino had left and measurements were taken. The diameter of the basal cover of the plant measured 178 cm. and the height of the branches from ground level was 165 cm. The lower sections of 68 branches which remained indicated that

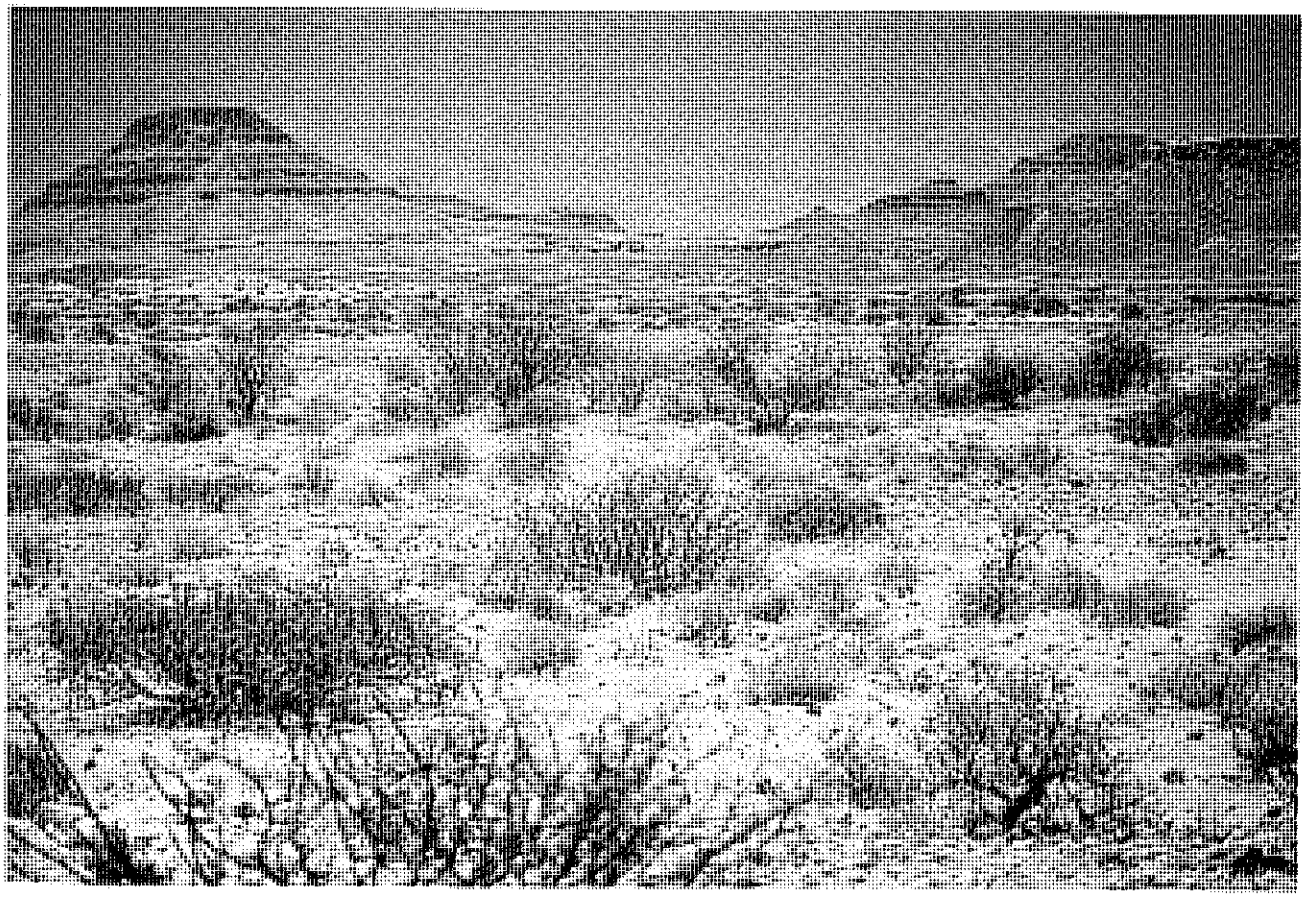

PLATE 3: Study area in the dry season.

TABLE 1: List of all species encountered in the six routes (A–F) and their associated availability circles. Families are ordered alphabetically and genera are listed alphabetically within families. For each route an index of usage (number of bites taken along track/number of plants in 'availability' circles) was calculated. A '0' indicates no bites were taken; a '+' indicates bites were recoded on track but plant was not recorded in circles; a blank indicates neither bites nor plants were noted. ID No. refer to this study only.

PLANTS	ROUTES						
	A	B	C	D	E	F	ID No.
ACANTHACEAE							
Barleria rogersii			0.38				1
Blepharis gigantea	4.88	0		4.54	0	5.00	2
B. bossii	0	0					3
Monechma arenicola			0	0.05			4
M. divaricatum	0				0	0	5
Petalidium Sp. nov			0				6
P. canescens				0.56			7
P. halimoides						0	8
P. pilosi-bracteolatum	0				0.17	0	9
P. variabile	0.04	2.00	0.06	0.19	0.56	0	10
Ruellia diversifolia				+		0.17	11
AIZOACEAE							
Sesuvium sesuvioides						0	12
AMARANTHACEAE							
Arthraerua leubnitziae						0	13
Calicorema capitata	0.38	1.71	1.45	0.20	0.13	0	14
Leucosphaera bainesii					0		15
ASTERACEAE							
Calostephane marlothiana						0	16
Epaltes gariepina						+	17
Helichrysum herniarioides		0	0				18
H. roseo-niveum					0		19
Osteospermum microcarpum spp. septentrionale	1.62	0	0.44		0	1.67	20
Pechuel-Loeschae leubnitziae						0.33	21
Pluchea dioscoridis						0	22
BORAGINACEAE							
Trichodesma africanum	0.50	+		+		0	23
BURSERACEAE							
Commiphora kraeuseliana	0		0.26	0	0.25		24
C. pyracanthoides	4.00	2.63	4.83				25
C. saxicola	0		0	0	0.75		26
C. virgata	0	0	1.57	0.75	1.46		27
C. wildii		1.50	0		0		28
CAESALPINIACEAE							
Adenolobus pechuelii	0	1.36	0.17		1.44		29
Colophospermum mopane						0.71	30
Parkinsonia africana	1.88	7.00			4.00		31
CAPPARACEAE							
Boscia foetida	0.16	0.10	0.50	0.47	0.40		32
Cadaba schroeppelii	0	1.5	4.6	0	0		33
Cleome foliosa	0	0.75				0	34
Maerua juncea	1.65	+	0	3.32			35
M. schinzii	0	0	0	0	1.00	0	36
CELASTRACEAE							
Maytenus senegalensis	3.47			4.36		0	37
CHENOPODIACEAE							
Atriplex vestita						*3.00*	*38*
Salsola aphylla						0.83	39
Suaeda plumosa						1.30	40
COMBRETACEAE							
Terminalia prunioides	1.92			41.50			41
CONVOLVULACEAE							
Merremia bipinnatipartita and M. guerichii	1.32	1.32	0.31	2.61	0.40	4.61	42
CYPERACEAE							
Juncellus laevigatus						+	43
Scirpus dioicus				2.00	0	3.67	44

PLANTS	ROUTES						
	A	B	C	D	E	F	ID No.
EBENACEAE							
Euclea pseudebenus	0.76			0.89	0		45
EUPHORBIACEAE							
Euphorbia damarana	3.50	2.38	0.47	0			46
Euphorbia sp. nov.	0	+	0	+			47
E. phylloclada		+	0				48
E. virosa			24.89	0			49
Ricinus communis						0.67	50
FABACEAE							
Crotalaria damarensis	0						51
C. platysepala						0.75	52
Indigofera guerrana				4.56			53
Otoptera burchellii				+			54
Psoralea obtusifolia						0	55
Rhynchosia candida	0						56
Sesbania pachycarpa subsp. dinterana	0.50			4.75		0	57
GERANIACEAE							
Sarcocaulon mossamedense	0.05		1.00				58
GRAMINEAE							
Centropodia mossamedense				0.12			59
Phragmites australis						0.04	60
Sporabolus consimilis						0.15	61
Stipagrostis damarensis	0			0.18			62
S. hochstetterana	0			0			63
S. uniplumis var. *uniplumis*	0.87	2.00	0	0.01			64
HELIOTROPIACEAE							
Cordia sinensis	0			9.00		1.50	65
Heliotropium tuberlosum	0	0				0	66
HYDROPHYLLACEAE							
Codon schenkii	0			4.00			67
JUNCACEAE							
Juncus rigidus						0.80	68
LILIACEAE							
Protaspraragus sp.		1.20	0.60				69
LOASACEAE							
Kissenia capensis	0			+			70
LORANTHACEAE							
Plicosepalus sp.				0			71
Tapinanthus oleifolius	1.17			0.89			72
MALVACEAE							
Gossypium anomalum	4.71	2.00		9.24		0	73
MESEMBRYANTHEMACEAE							
Psilocaulon salicornioides						0	74
MIMOSACEAE							
Acacia albida						59.88	75
A. erioloba				2.67		7.67	76
A. reficiens	3.62	6.75		16.29	7.14	2.33	77
Elephantorrhiza suffruticosa			2.25				78
MOLLUGINACEAE							
Gisekia africana	0	0					79
NYCTAGINACEAE							
Boerhavia deserticola	0		1.27				80
Phaeoptilum spinosum	1.63	0	0			0	81
PEDALIACEAE							
Sesanum marlothii				0			82

PLANTS	ROUTES						
	A	B	C	D	E	F	ID No.
PERIPLOCACEAE							
Curroria decidua		0	1.67				83
Ectadium virgatum						0	84
PLUMBAGINACEAE							
Dyerophytum africanum	0.58	0	1.29	7.00			85
RHAMNACEAE							
Ziziphus mucronata	0						86
RUBIACEAE							
Kohautia lasiocarpa		0					87
SALVADORACEAE							
Salvadora persica	0.23			0.24	0	3.33	88
SOLANACEAE							
Datura innoxia						0	89
Lycium decumbens						+	90
Nicotiana glauca						0	91
Solanum nigrum						0	92
STERCULIACEAE							
Hermannia amabilis		0.80	+	+	0		93
Sterculia africana		12.00	4.00	0			94
TAMARICACEAE							
Tamarix usneoides				0.57	2.00	0.45	95
TILIACEAE							
Grewia flava				3.00			96
G. bicolor	2.12						97
G. tenax				+			98
VAHLIACEAE							
Vahlia capensis						0	99
WELWITSCHIACEAE							
Welwitschia mirabilis		0.60	0.25		1.50		100
ZYGOPHYLLACEAE							
Tribulus zeyheri	2.51			8.83		2.75	101
Zygophyllum simplex						0	102
Z. stapffii	0		0	0	0	0	103

more than half of these had been consumed. The rhino had fed heavily on every plant of this species which was accessible to them in that locality. *Boscia foetida* and *Maerua schinzii* were neglected when other vegetation was available. They were however well browsed during a prolonged period of drought in 1979/80/81.

Petalidium variable was also neglected during the study period but, again, they were well browsed during the prolonged drought of 1979/80/81. *Sterculia africana* was scarce but browse evidence recorded during the monitoring of home ranges, showed that in dry rocky areas this tree was often reduced to a stump through continuous feeding. The plant showed very good recovery after rains fell. *Blepharis gigantea* was browsed and *Welwitschia mirabilis* was lightly browsed wherever they were available. During this investigation all parts of *W. mirabilis* were eaten throughout the dry period but freshly chewed and matted sections of leaves were found discarded on pathways leading to water.

During the preliminary monitoring of the Routes it was observed that *Commiphora* species were favoured in the less vegetated areas (Routes B,C and E). The results show that *Commiphora pyracanthoides* was fairly well favoured during this study although it was not included as a food plant by Joubert (1971). This may have been due to the availability of other vegetation in the higher rainfall area where the latter study was carried out.

3.4 Nutritional Value

The nutritional values of eleven species of food plants used by rhino are listed in Table 2. Water content varied considerably but did not appear to markedly influence selection. The plants with the highest water content were *Euphorbia virosa* and *Merremia* spp.

The ash content of *Salvadora persica* was found to be unusually high which may serve as a deterrent to herbivory. Nevertheless, rhino and other herbivores have been observed to feed on this plant but not to any great extent. Several plant species consumed by the rhino were found to have a high crude fibre content. In particular the values for *Commiphora virgata, Sterculia africana* and *Eurphorbia damarana* were very

TABLE 2: Proximate analysis of thirteen species of plants browsed by rhino and of rhino dung

Plant	Water Content (%)	Ash (% dry wt)	Crude Fibre (% dry wt)	Protein (% dry wt)	Crude Fat (% dry wt)	Carbo-hydrate (% dry dry wt)	Energy value (kJ. g^{-1} dry wt)
Blepharis gigantea	46.0	11.9	20.7	5.9	1.2	60.4	15.8
Boscia foetida	37.2	8.8	23.1	17.9	1.3	48.9	17.1
Cadaba schroeppelli	39.4	13.0	16.7	15.2	2.0	53.1	16.3
Commiphora virgata	13.7	5.8	49.8	2.1	0.7	41.6	16.3
Euphorbia damarana	38.6	4.1	34.8	2.8	24.2	34.1	22.0
Euphorbia virosa	80.4	11.2	27.1	3.3	6.3	52.1	16.8
Merremia spp.	76.0	13.2	23.4	13.1	1.7	48.6	16.3
Phragmites australis	64.4	10.1	28.0	10.1	1.5	50.3	16.3
Salvadora persica	64.3	41.3	9.6	8.4	0.5	40.2	10.7
Sterculia africana	54.1	12.9	32.5	4.0	0.6	50.0	15.5
Welwitschia mirabilis	58.5	14.5	19.1	10.7	1.1	54.6	15.5
W. mirabilis seeds	3.8	9.4	18.1	11.8	0.8	59.9	16.3
Dung	4.5	6.1	45.4	5.8	5.7	37.0	16.0

high. This is reflected in the high crude fibre content found in the dung samples and agree with the results obtained by Hall-Martin et al (1982) during the dry period of their investigation. *Welwitschia mirabilis* has a relatively high water and fibre content which may account for the leaves being chewed and then discarded. *Euphorbia damarana*, which has a high crude fibre value (34.8%), was also chewed by the rhino and then discarded.

Crude fat values for *Euphorbia damarana* and *E. virosa* were also unusually high. The analytical procedure used, namely ether extraction, does not reflect true lipid content and the high values are probably due to the high latex content of these plants. The high crude fat values also found in the dung samples suggest that this component may not be fully utilised by the rhino.

3.5 Soluble Tannins

The soluble tannin content of the browsed plants that were investigated varied from 0,15% to 4,06% on a wet mass basis (Table 3). Harbourne (1982) is of the opinion that tannin content is a key factor in determining the choice of food plants but cites a threshold value of at least 0,2% tannin on a dry mass basis to be effective in this regard. If the values in Table 3 are converted to a dry mass basis then all the plants that were investigated exceed this threshold value. It can be concluded therefore that, within the group of plants selected for analysis, the tannin content was moderately high and represents a potential defense against herbivory. * Other means of defense were also evident. These included the formidable spines and highly irritating latex of *Euphorbia virosa* which surprisingly (see Cooper and Owen-Smith 1986) did not deter the rhino from feeding heavily on this plant (Plate 1). The lower face and muzzle of one rhino observed feeding in *E. virosa* was covered with this white latex (R. Braby pers. comm.) (Plate 1). In fact, it was a favoured plant in spite of causing severe skin irritation to the person

TABLE 3: Soluble tannins in seventeen species of plants browsed by rhino and in rhino dung.

Plant	Soluble tannins (% wet wt)
Acacia albida	0.63
Acacia erioloba	2.23
Acacia reficiens	1.52
Blepharis gigantea	0.86
Boscia foetida	0.28
Cadaba schroeppelii	0.15
Calicorema capitata	0.48
Commiphora tenuipetiolata	1.87
Euphorbia damarana	1.34
Euphorbia virosa	0.37
Gossypium anomalum	1.54
Maerua juncea	0.53
Maerua schinzii	0.63
Merremia spp.	0.25
Phragmites australis	0.29
Salvadora persica	0.29
Welwitschia mirabilis	1.69
Welwitschia mirabilis seeds	4.06
Dung	0.68

preparing a sample of this plant for analysis. It would appear then that rhino are able to overcome some major chemical and physical defenses of plants without any apparent harm. According to Cooper and Owen-Smith (1985), however, large mammalian herbivores are influenced not by soluble tannins but mainly by condensed tannins due to their dependence upon microbial fermentation of plant cell walls for part of their energy needs.

3.6 Calcuim and Phosphorus

The calcium levels found in rhino dung varied from 2,05 - 6,51% (= 3,30; SE = ± 0,26) on a dry mass basis. These values are considerably higher than the normal range reported for cattle (0,55 — 1.55%) by the

Regional Veterinary Laboratories in Windhoek. These high values may be a reflection of the high calcium content of the calcrete soils in the study area. Phosphorus levels measured in rhino faeces fell within the normal range reported for cattle and sheep. These results suggest that the rhino do not suffer any deficiency of these two important minerals.

4 CONCLUSION

Estimates of feeding preferences are subject to sampling errors (Owen-Smith and Cooper in press). Moreover, plant surveys in desert areas are notoriously difficult because of the sparse nature and patchy distribution of the vegetation. This proved to be the case in the present investigation and the results obtained can only be considered a first approximation. Nevertheless, the feeding track method used proved to be useful in establishing the major preferred food items in the diet of these desert-dwelling rhino. Gener-

TABLE 4: Diversity (Hill's N_2 index) of the plants in the 'availability' circles and of bites taken along the tracks by browsing rhino for Route A–F.

Route	Hill's N_2	
	Plants in circles	Bites
A	12.919	6.577
B	10.527	8.395
C	9.829	5.899
D	8.634	8.064
E	8.912	6.032
F	6.332	3.182

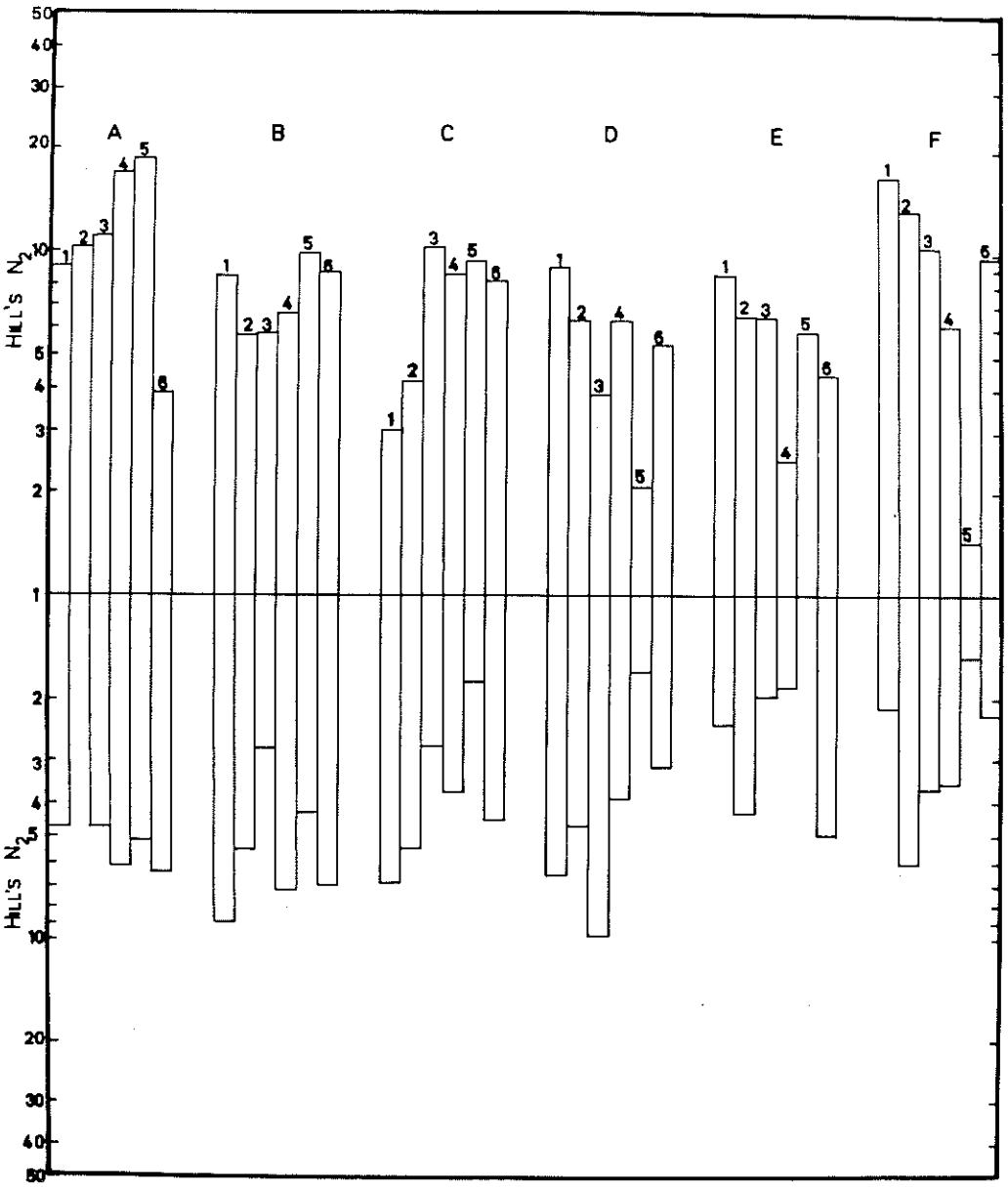

FIGURE 9: Diversity (Hill's N_2 index) of the plant species available (above the line) plotted opposite diversity of usage of these species (below the line) by the black rhino for each replicate (1—6) within each feeding Route, A, B, C, D, E, and F.

al observations supplemented the feeding track method and the total list of plants (74) browsed by the rhino in this unusual habitat should be of value in planning their future conservation.

In desert habitats the selection of food items may be guided by factors other than nutritional value, for example, water content of the plants (Harbourne 1982). Prior to the feeding track study, general observations on these rhino had been carried out. The tentative conslusion reached from these observations was that almost every plant was browsed by these animals and that they were feeding non-selectively. However, when the diversity of available forage was calculated for this study (Hill's N), it was found to be higher than the diversity of plants actually consumed in almost every instance (Fig. 9, Table 4). This result suggests that, at least during the time of this study, the rhino were feeding somewhat selectively from the plants available. The coeffecient of variation was calculated from the mean and standard deviations obtained when the diversity values for the separate portions of each route were combined (Table 5). For four of the six routes, the coefficient of variation for the diversity of availability was greater than for the diversity of the plants consumed. These calculations again suggest that the rhino were being somewhat selective in their diet.

In view of the extreme aridity of the study area, comparisons with previous studies carried out in more mesic habitats (Goddard 1968, 1970; Joubert 1971, Hall-Martin et al. 1982, Mukinya 1977, Schenkel and Schenkel-Hullinger 1969) are not particularly rewarding. Nevertheless, several common conclusions can be drawn with these studies, namely that rhino feed on an usually wide variety of species and shift their feeding preferences according to circumstances. They are also able to use plants which, because of their formidable chemical defenses, are denied to most other herbivores. In fact, this is one of the major conclusions to be drawn from this study. The food plants in this desert region are sparsely distributed and rely heavily on chemical defense for their survival. They are also in many instances extremely fibrous. In spite of this the resident population of rhino used these plants successfully; they remained in good condition throughout the driest periods and their reproduction was normal.

TABLE 5: An indication of the between route section variablility of plants and bites obtained by calculating the coefficient of variation from the means and standard deviations of Hill's N_2 diversity index value for sections 1–6 of each route (A–F).

Route	Plants		Bites
A	43 %	>	42 %
B	22 %	<	34 %
C	39 %	<	42 %
D	39 %	<	58 %
E	36 %	<	56 %
F	56 %	>	52 %
Mean	39 %	<	47 %

From the conservation viewpoint there were no indications of pressure on the habitat and a limited increase in their population should be encouraged. Competition with other large herbivores is probably minimal in view of the extreme aridity of the region and the inability of many other herbivores to overcome the chemical defenses of some of the more important food plants favoured by the rhino.

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A comparative study of the diet of the wedge-snouted sand lizard, *Meroles cuneirostris* (Strauch), and the sand diving lizard, *Aporosaura achietae* (Bocage), (Lacertidae), in the Namib Desert

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ABSTRACT

The diets of two sympatric lizards, *Metroles cuneirostris* and *Aporosaura anchietae*, collected in the same areas at the same time, were compared by analysis of the stomach contents. Observations of the feeding behaviour of *M. cuneirostris* were also made.

A. achietae has an omnivorous diet, with seeds constituting the major portion of the items consumed. *M. cuneirostris* consumes largely arthropods. Although rainfall appeared to influence the relative proportions of the different prey items, prey volumes in the stomachs did not increase significantly after heavy rains.

M. cuneirostris has an active bimodal foraging pattern during the day. However *M. cuneirostris* also employs "sit and wait" tactics, often robbing *Camponotus detritus* ants of food and waiting at newly formed termite mounds. Although there is some evidence of opportunistic feeding, *M. cuneirostris* generally appears to be selective in the type of food taken.

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1 INTRODUCTION

The Namib wedge-snouted sand lizard (*Meroles cuneirostris*) and the Namib sand-diving lizard (*Aporosaura anchietae*), are two common lacertids from the Namib Desert of coastal south-western Africa (Fitzsimons 1943, Holm and Scholz 1980). These two lizards are of a similar size and are found in narrow sympatry in the parallel dune-system south of the Kuiseb River in the central Namib. *M. cuneirostris* (5-9 g) is found mainly on the lightly vegetated dune base but is also occasionally found in the sandy interdune areas. *A. anchietae* (3-6 g) occurs mainly on the dune slipfaces but is also occasionally found on the dune base or sandy interdune areas. The micro-habitats of these two species thus overlap slightly in the dune environment.

The diets of these two lizards have been previously examined (Louw and Holm 1972, Robinson and Cunningham 1978, Stuart unpublished) but never in the same area at the same time. The object of this study was to compare the diets of these two sympatric lacertids using material collected in the same area at the same time and to observe the feeding behaviour of *M. cuneirostris*, the less well studied of the two species.

2 MATERIALS AND METHODS

M. cuneirostris and *A. anchietae* were collected from the dunes more than 10 km south of Gobabeb (23° 33'S, 15° 05'E). Lizards were sampled monthly from June 1978 till May 1979. A total of 101 *M. cuneirostris* and 95 *A. anchietae* stomachs were collected and analysed. Between 6 and 12 individuals were captured each month. Stomachs from an additional *M. cuneirostris* were obtained from the same areas during December 1980 and January 1981.

Analysis of the stomach contents was as follows: Number of prey items or segments thereof were counted. Prey items were identified with the aid of a dissecting microscope and a reference collection. The volume (in ul i.e. mm^3) of prey in each stomach was estimated by spreading the stomach contents uniformly out on a piece of graph paper in a petri dish and estimating the relative areas covered by each prey item, and visually estimating each item's height.

TABLE 1: Monthly stomach analyses of *Meroles cuneirostris*. – Numbers refer to: no. of items and vol. (mm³) respectively (ad = adults; l = larvae).

No. of stomachs	JUL 78 12		AUG 78 11		SEP 78 11		OCT 78 11		NOV 78 6		DEC 78 10		JAN 79 12		FEB 79 9		MAR 79 6		APR 79 7		MAY 79 6		DEC 80 6		JAN 81 4		TOTAL 111	
ORDER SQUAMATA																												
Fam. *Lacertidae (Meroles juv.)*																			1	450							1	450
ORDER ARANEAE	1	24	15	42	6	16	7	30	2	44	4	195	–	24	–	6	3	36	2	12	2	2	2	4	7	7	44	435
ORDER SOLIFUGAE					1	30					–	9			1	6									1	104	3	149
ORDER ISOPTERA																												
Fam. *Termitidae*	54	166	2	1	67	1652	20	1500													34	40			17	234	194	3593
ORDER MANTODEA																												
Fam. *Mantidae*	1	1																									1	1
ORDER ORTHOPTERA																												
Fam. *Acrididae*					1	105																					1	105
Fam. Undetermined							2	2	1	5			6	450							12	29					21	486
ORDER HEMIPTERA																												
Sub-order *Heteroptera*			21	85	18	70					10	40	4	256					1	40							54	431
Sub-order Undetermined	1	10	8	10	7	14	30	197	1	2	2	18			–	12	3	8	–	24							52	293
ORDER NEUROPTERA																												
Superfamily *Myrmeleontoidea* (l)			1	21			1	60					4	59							–	6					6	146
ORDER COLEOPTERA																												
Fam. *Carabidae*	2	4																									2	4
Fam. *Tenebrionidae* (ad)			18	870	11	81	7	60			33	1160	30	128	43	830	22	600							12	720	181	4449
(l)	1	25	4	180			1	90			4	130					1	40	3	80							14	545
Fam. *Staphylinidae* (l)					1	2													3	3							4	5
Fam. Undetermined (ad)	62	60	37	174	52	375	30	115	24	334	7	122	21	102	66	777	16	210	7	14	23	273	2	4	19	174	366	2734
(l)							1	240	2	10											4	18					7	269
Superfamily *Curculionoidea*					1	126					29	288	5	50													35	464
ORDER DIPTERA	2	2	5	4			1	4			7	192			1	16			6	40							22	258
ORDER LEPIDOPTERA	1	1																									1	1
ORDER HYMENOPTERA																												
Superfamily *Formicoidea*																												
Fam. *Formicidae*																												
Sub-fam. *Formicinae*							1	6	44	150									18	70	5	140			3	4	71	370
Sub-fam. *Myrmicinae*	19	10							229	343	36	42											8	4	1	2	293	401
Sub-fam. Undetermined					13	35			2	2																	15	37
Superfamily *Apoidea*																												
Fam. *Apidae*					5	4																					5	4
Fam. Undetermined					8	14	1	45																			9	59
Superfamily *Ichneumonoidea*																												
Fam. *Braconidae*																	9	15									9	15
Superfamily *Chrysidoidea*	1	6																									1	6
Superfamily Undetermined	29	14			2	6	46	312	40	103	21	29			1	40	2	2	68	134	4	2			1	80	214	722
UNDETERMINED INSECTS (ad)	12	9	13	28	23	66	3	48					24	33	1	32	–	24	10	78	10	255	3	12			99	533
(l)			8	65	1	3					3	13	8	94	5	90			3	9	1	6					29	280
PLANT MATERIAL	2	5	6	5	1	2	2	10	1	2											4	38	1	4			17	66
UNDETERMINED MATERIAL			–	54							1	81			–	9					–	20	1	8	–	45	2	217
TOTAL	188	337	138	1539	218	2601	153	2719	346	995	1157	2317	102	1196	118	1818	56	935	122	952	99	829	17	36	54	1363	1773	17637
RAINFALL (mm)	0		0		0		0		0		0		0		2.75		0.1		appr. 4.0		1.6		0		0		8.45	

The foraging behaviour of *M. cuneirostris* was observed for 10 days in December 1980 and for 4 days in April 1981 on a 600 m² study area located on the dunes 8 km south of the Kuiseb. Lizard movement and foraging behaviour within this site was recorded by 3 to 7 observers using binoculars. In December the first 3 days were spent observing numerous lizards. From the third day a charcteristic female (2 tailed) was observed and her feeding behaviour recorded. A total of 33,2 lizard observation hours were accumulated during this study period. During April, 23 hours of observations were obtained.

Sand surface temperatures were recorded during observation periods using a mercury thermometer. Readings were taken at half hour intervals.

During December, an estimate of total insect activity was obtained by "fixing" the binoculars on a spot on the sand surface about 10 m distant and counting the number of insects passing through the field of vision in 5 minutes.

Samples of the most common ant species were collected, 160 of the common, unidentified myrmicine ant and 1075 *Camponotus detritus* of various sizes. These were weighed and individual ants measured to obtain an indication of their potential energy yields.

3 RESULTS

Analysis of the stomach contents of 111 *M. cuneirostris* (Table 1) indicated that coleopterans were by far the most important food for this lizard species on a volumetric basis. Isoptera and Hymenoptera also figured promimently. In contrast, analysis of 95 stomach contents of *A. anchietae* (Table 2) indicated that seeds were the most common food item both on a numerical and volumetric basis.

When foraging, individuals of *M. cuneirostris* were often observed ascending small tussocks on which they would remain for long periods. From here they apparently preyed upon small myrmicine ants, which constituted the most commonly observed prey consumed by *M. cuneirostris* (Table 3). Termites were the second most common prey type, 68% of which were taken as they moved upward through the sand toward the surface. Whilst the myrmicine ant foraging pattern is indicative of a 'sit and wait' foraging tactic, that of the termites appears to follow an active foraging search.

Sixteen per cent of the total feeding observations involved items robbed from other animals, mainly termites taken from the jaws of *C. detritus*. On more than one occasion, a lizard was observed to lie motionless in the shade of a bush and allow all the solitary *C. detritus* ants to pass. However those ants carrying objects in their jaws were almost always robbed by the lizard. On a few occasions the lizard did not eat the stolen item which was in each case found to be an inanimate object such as dry faeces.

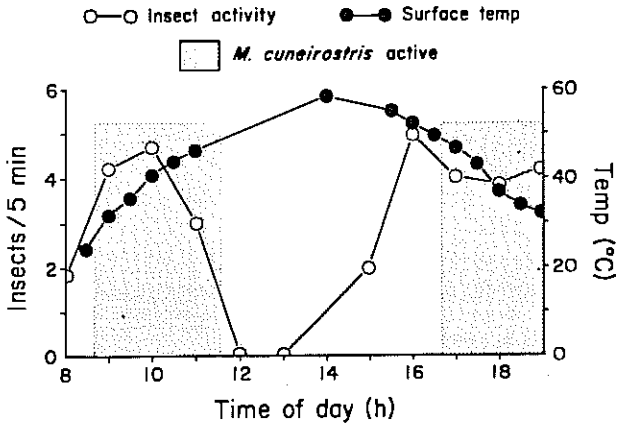

Figure 1: Graph of insect activity and temperatures versus time of day

C. detritus was the most common insect observed in the study area although not often consumed by *M. cuneirostris*. It is much larger than the myrmicine ants commonly preyed upon (*C. detritus* — weight: 41,0 mg, n= 1075, length: 12,7 ± 1,7 mm, n = 150; myrmicine ants — weight: 1,5 mg, n = 160, length: 4,2 ± 0,3 mm n = 142).

Insect activity and lizard activitiy, derived from total counts of individuals, were found to be distinctly bimodal with lowest activity during the hottest part of the day and peak activity occurring during the cooler periods of mid-morning and late afternoon, (Fig. 1).

4 DISCUSSION

Our observations on the dietary preferences of *M. cuneirostris* and *A. anchietae*, collected from a dune area south of Gobabeb, suggest that *M. cuneirostris* prefers a more insectivorous diet whilst *A. anchietae* a more omnivorous one. Stomach analyses (Tables 1 and 2) indicate that both these lacertid lizards eat a wide variety of arthropod species, consisting mainly of insects. Although *A. anchietae* forages on insects belonging to orders which are amongst those foraged upon by *M. cuneirostris*, monocotyledonous seeds appear to constitute the largest proportion of the diet of *A. anchietae*.

The diet of *M. cuneirostris* has previously been examined by Robinson and Cunningham (1978), in the Kuiseb River floodplain (near Rooibank 23° 9'S 14° 35'E), and by Stuart (unpubl.) in the low vegetaged eastern Namib Dunes (Kamberg Dunes, approx 23° 40'S 15° 40'E). Observed diets in these studies differed considerably from each other and from the current study.

Robinson and Cunningham (1978) found, on a numerical basis, that Lepidopteran larvae, followed by ants (Formicidae), other hymenopterans, tenebrionid lar-

TABLE 2: Monthly stomach analyses of *Aporosaura anchietae*. – Figures in each column refer to no. and vol. (mm³) respectively (ad = adults; l = larvae).

NO. OF STOMACHS	JUNE 78 6	JULY 78 6	AUG 78 12	SEP 78 11	OCT 78 12	NOV 78 6	DEC 78 12	JAN 79 12	FEB 79 6	MAR 79 6	APR 79 6	TOTAL 95
CLASS MONOCOTYLEDONAE Fam. *Gramineae* (seeds)	17 45	192 360	165 270	14 20	184 400	60 100	50 80	180 300	222 750	102 340	239 540	1425 3205
CLASS DICOTYLEDONAE (seeds)	12 14		106 160		112 200	46 40	43 30	186 260		78 100	57 20	640 824
CLASS ARACHNIDA ORDER ARANEAE		1 1	1 2		1 20		– 30			1 125		4 178
CLASS INSECTA ORDER THYSANURA Fam. *Lepismatidae*											1 3	1 3
ORDER ISOPTERA Fam. *Termitidae*	2 4	2 1		1 2								5 7
ORDER ORTHOPTERA Fam. *Pyrgomorphidae*				1 300								1 300
Fam. undetermined						1 32		1 50				2 82
ORDER HEMIPTERA Sub-order *Heteroptera* Fam. *Tingidae*				2 60								2 60
Sub-order undetermined					– 20					3 9		3 29
ORDER COLEOPTERA Fam. *Tenebrionidae* (ad)			6 25						2 56			8 81
(l)				36 1152	7 350			2 100				45 1602
Fam. *Curculionidae*	1 400											1 400
Fam. *Staphylinidae* (l)						4 6					2 1	6 7
Fam. *Meloidae* (l)			1 81									1 81
Fam. undetermined (ad)				33 200	6 48	– 150	1 24					40 422
(l)							4 24					4 24
ORDER DIPTERA (l)			3 15								1 1	4 16
ORDER HYMENOPTERA Fam. *Formicidae*						5 5						5 5
Fam. *Chalcidae*					6 8						1 1	7 9
Fam. undetermined	1 1		2 1									3 2
UNDETERMINED INSECTS (ad)			13 30		20 105	– 20			2 4	– 50		35 209
(l)			10 50		2 6				– 9			12 65
(pupae)								6 240				6 240
UNDETERMINED MATERIAL		– 49					– 110	– 200				– 359
TOTAL	33 464	195 411	307 634	87 1734	332 1109	122 251	97 424	376 1174	226 819	184 624	301 566	2260 8210
RAINFALL (mm)	0	0	0	0	0	0	0	0	2.75	0.1	appr. 4.0	6.76

TABLE 3: Observed feeding responses of *Meroles cuneirostris* during the December 1980 and April 1981 study periods. Active, robbed and dead refers to prey individuals that were active at the time of their capture; individuals that were robbed from other organisms and dead individuals respectively

Prey type	Active	Robbed	Dead	Total
Myrmicine ants	51	–	–	51
C. detritus	–	1	3	4
termites	19	9	–	28
dipterans	1	–	–	1
unidentified	–	4	–	4
				88

vae and weevils (Curculionidae), were the preferred dietary items of *M. cuneirostris*. Orthopterans, mantids, and wasps were reported to have been eaten seasonally, but tenebrionid adults and larvae, other Coleoptera, ants, undetermined Hymenoptera and lepidopterans were taken nearly every month.

Stuart's (unpubl.) analyses (Table 4) indicated that isopterans, adult and larval coleopterans and ants were significant prey items, with a high percentage occurence each months.

The present study revealed that an unidentifiable form of adult coleopteran, other hymenopterans, tenebrionid adults and termites contributed substantially to the diet of *M. cuneirostris*.

Apparent differences (Table 5) in the prey preferences could be related to the faunal and ecological differences between the three habitat types, although the data necessary to confirm this are currently not available.

The study by Robinson and Cunningham (1978) near Gobabeb on the diet of *A. anchietae*, is comparable to the present study. Both studies suggested that this lizard has an omnivorous diet. In both studies, insects were the largest animal component. On a numerical basis grass seeds, followed by *Trianthema hereroensis* seeds, unidentified bugs (Hemiptera) and thysanurans dominated the diet of the *A. anchietae* examined by Robinson and Cunningham (1978). Grass seeds, dicotyledonous seeds, adult tenebrionids, undetermined adult coleopterans and undetermined adults insects were numerically dominant prey items in the present study. Both studies thus indicate graminous seeds to be important in the diet of *A. anchietae*. According to Robinson and Cunningham (1978) seeds of several species of grass (*Stipagrostis gonatoschys, S. ciliata, S. sabulicola* and *S.* cf. *namaquensis*), are available at all times of the year and constitute an important energy resource for *A. anchietae*.

Availability of some of the prey items noted by the 3 studies may reflect responses to climatic factors. The rainfall that was recorded during Robinson and Cunningham's (1978) study (87mm) was much higher than that recorded for the Kamberg or Gobabeb studies (although 107,5 mm of rain had fallen prior to the commencement of the 1980 study.) Heavy rain may produce an expansion of the niches occupied by certain animals and plants to the extent that overlap occurs in specific instances (Seely and Louw, 1980).

Differences in foraging behaviour, i.e. active foraging versus a 'sit and wait' type foraging tactic, has been suggested by Huey et al (1984) to reflect differences in locomotor capacity or even differences in potential activity levels. However, both the physiology and morphology must be expected to affect the locomotor abilities of lizards. *M. cuneirostris* and *A. anchietae* seem well adapted to living in narrow sympatry in the Namib Desert. They are morphologically similar and have a very similar diurnal activity pattern, but they differ markedly in their diet, reproductive activity and habitat (Goldberg and Robinson 1979). Differences in

TABLE 4: Monthly stomach analyses of *Meroles cuneirostris* from the kamberg dunes during 1974. (C. Stuart unpubl.). Numbers refer to % occurence – calculated using number of prey items. (ad = adults; l = larvae).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	MONTHLY
No. of Stomachs analyzed	11	0	13	15	13	16	12	16	8	21	15	10	151	13,73
Order Scorpiones			8								7		15	1,36
Order Solifugae				7	8			6		5			26	2,36
Order Isoptera	9		85	73	23	37	67	62		9	13	10	388	35,27
Order Orthoptera					8	6			11	5			30	2,73
Order Hemiptera	9				8				22		7		46	4,18
Order Neuroptera									33				50	4,55
Order Coleoptera (ad)	9		8	27	23	25	8	37	33	38	33	70	373	33,91
(l)	27				23	12			44	43	13		162	14,73
Order Diptera				13		6					20		39	3,55
Order Lepidoptera				7	8					5	7		27	2,45
Order Hymenoptera														
Fam. Formicidae	18		15	60		44	8	6	22	29	20	20	242	22
Undetermined	9				23	6	16	6		5			65	5,91
Rainfall	– – – – 14,0 – – – –							– – – – 10,5 – – – –						

TABLE 5: Percentage of prey items consumed on a monthly basis by *Meroles cuneirostris*. Observations from the Kamberg Dune study (Stuart unpubl.); Rooibank study (Robinson and Cunningham 1978) and the present study site. Monthly values are standardized to the total samples using: –

$$\frac{\text{no of stomachs analyzed in a month}}{\text{total no of stomachs analyzed}} \times \text{\% occurence of the prey items}$$

(ad = adults; l = larvae)

Animal Material	JAN Site* K (11)	JAN Site* R (15)	JAN Site* G (12)	FEB Site R (15)	FEB Site G (9)	MAR Site K (13)	MAR Site R (15)	MAR Site G (6)	APR Site* K (15)	APR Site* R (15)	APR Site* G (7)	MAY Site K (13)	MAY Site R (15)	MAY Site G (6)	JUNE Site K (16)	JUNE Site R (15)	JULY Site* K (12)	JULY Site* G (12)	AUG Site K (16)	AUG Site R (15)	AUG Site G (11)	SEP Site K (9)	SEP Site R (15)	SEP Site G (11)	OCT Site* K (21)	OCT Site* R (15)	OCT Site* G (11)	NOV Site K (15)	NOV Site R (15)	NOV Site G (6)	DEC Site K (10)	DEC Site R (15)	DEC Site G (10)
Order Scorpionida						0,69							0,58															0,70					
Order Aranea		0,58	0,96	1,66	0,99			1,98		0,58	0,98		0,58	1,02		0,58		0,96		0,58	2,97		0,58	0,99			1,98		1,08	1,98		0,58	2
Order Solifugae					0,99				0,70			0,69							0,64					0,99	0,70								1
Order Thysanura																																	
Fam. Lepismatidae		0,58								0,58													3,32						0,58	1			
Order Orthoptera												0,69			0,64							0,66			0,70								
Fam. Acrididae													1,66			0,58				0,58				0,99									
Fam. Tettigoniidae							0,58						1,08																				
Fam. Undetermined			0,96											1,98													0,99			1,02			
Order Isoptera	0,66					7,32			7,25			1,98			3,92		5,32		6,60						1,25			1,29			0,66		
Fam. Termitidae							2,24							1,02				3			0,99			2,97			0,99						
Order Dictyoptera																																	
Fam. Mantidae				1,08			0,58			0,58			0,58					0,96													0,58		
Fam. Blattidae										0,58																							
Order Thysanoptera																																	
Fam. Thripidae				0,58																													
Order Hemiptera	0,66											0,69										1,31						0,70					
Sub-order Heteroptera			3,96								0,98										2,97			1,98									2
Fam. Pentatomidae							1,66						0,58										0,58									0,58	
Sub-order, Undetermined		0,58		0,58	0,99		1,08	1,02			0,98		0,58			0,58		0,96			0,99		0,58	1,98			6,05		1,08	1,02			2
Order Neuroptera	0,66					0,69																1,97											
Fam. Myrmeleontidae		0,58	2,04							1,08				1,02						0,58	0,99		0,58			0,58	0,99						
Fam. Chrysopidae										0,58													0,58										
Order Coleoptera																																	
Fam. Carabidae				0,58														0,96								1,66							
Fam. Cicindelidae							2,74																										
Fam. Curculionidae			0,96							0,58			0,58			3,32				2,74			1,66	0,99		3,32			2,24			1,66	1
Fam. Tenebrionidae (l)	1,97	1,66		1,08				1,02		2,24	2,03	1,98	1,66		1,27	4,98		0,96		2,24	0,99	2,62	2,74		5,98	2,24	0,99	1,29	2,24			1,66	1
(ad)	4,66	3,90	0,96	0,58	1,98	1,29	1,08	1,02	2,68	1,66		1,98	0,58		2,65		0,64		3,92	1,66	1,98	1,97		0,99	5,28	1,08	0,99	3,28	0,58		4,64	2,24	2
Fam. Staphylinidae		0,58									2,03													0,99									
Fam. Undetermined (l)							0,58						0,58	1,02						1,08			0,58				0,99			1,98			
(ad)				2,74			1,66				2,03		1,66	3		1,66		6		1,08	6,05		0,58	6,05		1,08	4,95		2,24	4,02			2
Order Lepidoptera						0,70			0,69									0,96							0,70			0,70					
Fam. Undetermined (l)		0,58		1,08			2,74			4,40			1,66			2,24				0,58									2,24			0,58		
(ad)			3,96		6,03			1,02		0,58			1,08							0,58						0,58			1,66					
Order Diptera					0,99				1,29		0,98				0,64			2,04			0,99						0,99	1,99					1
Fam. Asilidae							0,58																									0,58	
Fam. Undetermined (l)																							0,58										
(ad)							0,58						1,08					-					0,58			1,66			0,58			1,66	
Order Hymenoptera																																	
Fam. Formicidae	1,31	2,24		2,24		1,29	1,08		5,96	1,08			2,74		4,66		0,64		0,64	1,08		1,31	1,66		4,03	0,85		1,99	0,85		1,32	1,08	
Sub-family Formicinae											0,98			1,02																1,98			
Sub-family Myrmicinae																		2,04									0,99			4,02			2
Sub-family Undetermined																								0,99						1,02			
Superfamily Apoidea																																	
Fam. Apidae																								0,99									
Fam. Undetermined		4,98																						0,99			0,99						
Superfamily Ichneumonoidea				0,58																													
Fam. Braconidae								1,02								1,08																1,08	
Superfamily Chrysoidea																		0,96															
Fam. Pompilidae													1,08																				
Fam. Vespidae													1,08																			0,58	
Fam. Undetermined				1,08	0,99		1,66	1,02		2,74	3,01		1,08	1,02		1,08		5,04		1,66			2,24	0,99		1,08	3,96		4,40	3,96		1,66	2
Order Squamata																																	
Fam. Lacertidae											0,98																						
Fam. Scincidia																							0,58										
Order Undetermined (l)			3,96		2,97						0,98			1,02							3,96			0,99									2
(ad)			2,04		1,98			1,98			4,97			4,98				3			2,97			4,95			1,98						
Plant Material																																	
Fam. Gramineae													0,58										0,58										
Fam. Undetermined							0,58							-1,98		0,58		2,04			1,98			0,99			0,99			1,02			2
Undetermined Material	0,66	0,58			0,99		0,58			0,58		1,98		1,02	0,64		1,27		0,64	0,58	1,98				0,70								

* K = Kamberg 1974 R = Rooibank 1976; January 1977 G = Gobabeb January – June 1979; July – December 1978

diet may therefore be a reflection of the relative abundance and preferred dietary alternatives present within each habitat type.

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Seasonal abundance and the distribution of coastal birds on the northern Skeleton Coast, South West Africa/Namibia

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ABSTRACT

Densities of coastal birds along the northern Skeleton Coast, between March 1984 and August 1985 are given. Whitefronted plovers *Charadrius marginatus*, grey plovers *Pluvialis squatarola*, turnstones *Arenaria interpres*, sanderlings *Calidris alba* and curlew sandpipers *C. ferruginea* were the most abundant waders (Charadrii) and made up 92% of all shorebirds counted during the summer months. Only 3,8% of the Palaerctic waders overwintered on the northern Skeleton Coast during June/July 1985. Counts made in 1981 and 1984/85 show that shorebird and Palaearctic tern densities were 31,1% and 97,4% lower respectively in 1984/85. In the southern part of the study area the highest densities of shorebirds were concentrated on mixed shores of sand and rock and on sandy beaches with kelp wrack. In the north, beaches close to coastal wetlands supported the highest densities of shorebirds. The distribution of seabirds was patchy.

1 INTRODUCTION

In recent years summer surveys of coastal birds have been conducted along much of the South West African coast and at coastal wetlands (Whitelaw *et al* 1978; Cooper *et al* 1980; Hockey 1982; Ryan *et al* 1984). Ryan *et al* (1984) report on the distribution and abundance of birds along the entire Skeleton Coast during November and December 1981 and compare their results with data gathered from other areas in southern Africa.

This paper reports on the seasonal abundance and distribution of coastal birds on the northern Skeleton Coast over a period of 18 months, between March 1984 and August 1985. Factors influencing the spatical distribution of shorebirds within the study area are discussed.

The northern Skeleton Coast is bordered by the Hoanib River in the south and the Kunene river in the north (Fig. 1). Surveys of rocky shores (Penrith and Kensley, 1970) and sandy beaches (Tarr *et al* 1985) indicate that this area lies within a biogeographical transition zone. Kelp beds (*Laminaria schintzei*), associated with the cool temperate conditions created by the Benguela upwelling system, occur in the southern section of this area but are no longer noticeable 65 km north of Möwe Bay (pers obs.). The coast is backed by the dry and barren Namib desert and throughout the study area human disturbance is minimal.

This paper forms part of a study of the importance of stranded kelp to the shore ecology of South West Africa.

2 STUDY AREA AND METHODS

The study area was divided into 10 blocks based according to a ¼° square reference system (Fig. 1). The coastline of the northernmost ¼° square was divided into two blocks (9 and 10). Monthly coastal bird counts were made along the traversible 120 km between Möwe Bay (19° 23′S, 12°42′E) and False Cape Frio (18° 29′S, 12° 01′E) incorporating the five most southerly blocks of the study area. It was not possible to visit the northerly five blocks on a monthly basis but, whenever the opportunity arose, a count was made along the 131 km of coast between Angra Fria (18° 17′S, 12° 42′E) and the Kunene river mouth (17° 15′ S, 11° 45′E). All birds roosting or feeding on the shore between the primary dune hummocks and

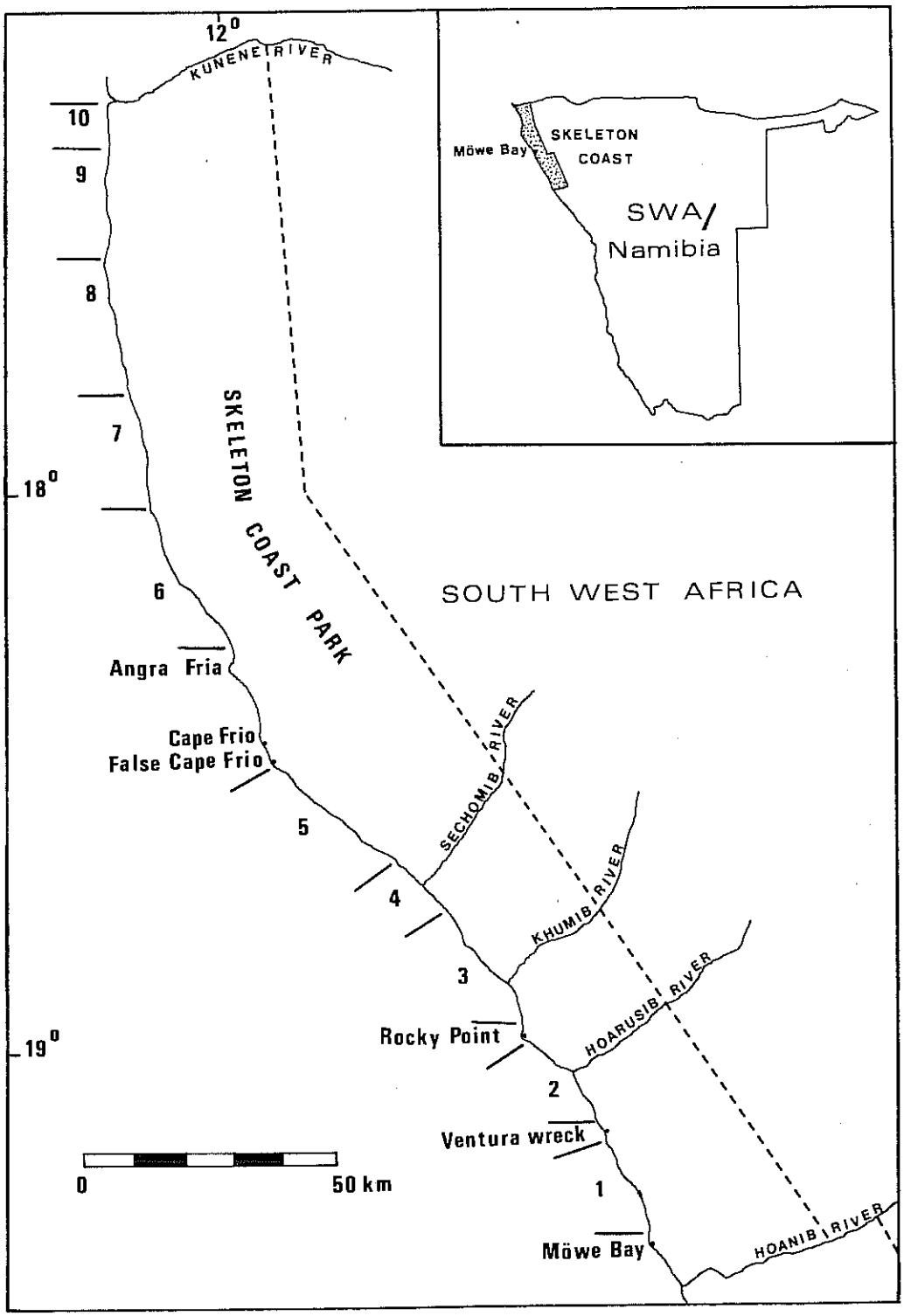

FIGURE 1: The northern Skeleton Coast SWA/Namibia, showing the 10 coastal blocks referred to in the text.

breaking waves were counted from a slow moving vehicle at spring low tide. In the first two blocks the substrata on which the shorebirds were encountered was recorded. Kelp gulls (*Larus dominicanus*) were often observed feeding on the shore and were thus grouped with the shorebirds and not the roosting seabirds. Common terns (*Sterna hirundo*) and Arctic terns (*S. paradisaea)* were not counted separately.

The average density of stranded kelp plants. block $^{-1}$ was estimated by marking out 1 km long plots in the five most southerly blocks and counting and weighing all freshly stranded kelp plants within these plots on a monthly basis between March 1984 and August 1985. A ground patrol was conducted in order to map the shoreline between Möwe Bay and the Kunene River mouth.
All seasons referred to in the text are austral.

3 RESULTS

Blocks 1 to 10 are described in Table 1. The densities (birds. km $^{-1}$) of the more abundant coastal birds encountered between Möwe Bay and False Cape Frio for the period March 1984 to August 1985 (excluding April and August 1984) are depicted in Table 2. During this period four counts were completed between Angra Fria and the Kunene River mouth. These results are depicted in Table 3. Figures in these tables have been corrected to one decimal place and all positive densities of $< 0{,}1$ birds. km^{-1} have been assigned a value of 0,1.

3.1 Coastal bird abundance and distribution

3.1.1 Seasonal variations

Whitefronted plovers (*Charadrius marginatus*) were the only resident (non-migratory) waders encountered during all seasons throughout the study area. Their numbers were variable and seemingly unrelated to season (Table 2). These birds were often observed feeding on terrestrial insects behind the primary dune hummocks. (pers. obs.). McLachlan *et al.* (1980) state that wind direction may play an important role in determining whether whitefronted plovers feed intertidally or behind the dunes. Although the prevailing wind on the northern Skeleton Coast is south-westerly occasional easterly winds occur. During the coastal count done in July 1984 a strong easterly wind blew south of the Sechomib River and appears to have forced out large numbers of whitefronted plovers from behind the dunes, resulting in unusually high densities recorded in blocks 1, 2 and 3 (Table 2). Because the whitefronted plover is a resident species, these high numbers are probably a close reflection of the total population of these brids for that area (McLachlan *et al* 1980).

Of the 11 species of Palaearctic waders observed during the course of this study, grey plovers (*Pluvialis squatarola*), turnstones (*Arenaria interpres*), curlew sandpipers (*Calidris ferruginea*) and sanderlings (*C. alba*) were found to be the only common summer visitors to the northern Skeleton Coast (Tables 2 and 3). These four species, together with white-fronted plovers constituted on average, 92% of the total number of shorebirds counted in blocks 1 to 5 during the summer months. Although not often encountered elsewhere, little stints (*C. minuta*) were observed in comparatively high numbers on the beaches in the vicinity of the Kunene River mouth during January 1985 (Table 3). Bartailed godwits (*Limnosa lapponica*), curlews (*Numenius arquata*), knots (*C. canutus*) and ringed plovers (*Charadrius hiaticula*) were observed infrequently and in low numbers.

The abundance of Palaearctic waders on the northern Skeleton Coast showed marked seasonal fluctuations (Fig. 2). Numbers increased from September to November when, migrating birds returned from their breeding grounds in the Arctic and northern temperate regions. Thereafter there was a steady decrease until February when numbers were reduced by 25%. During March and April a second peak in the Palaearctic wader population occurred when birds formed large flocks before migrating north. By June 1985 the total Palaearctic wader population between Möwe Bay and False Cape Frio had decreased by 95,7%. Between January and July 1985 the total number of Palaearctic

TABLE 1: A detailed description of the 10 blocks which constitute the study site.

BLOCK	1	2	3	4	5	6	7	8	9	10
Distance (km)	24	20	31	15	30	36	32	31	22	10
% Mixed shotre of sand and rock	66	33	27	1	1	22*	4*	40*	23*	23*
% Sandy Beach	34	67	72	99	99	78	96	60	77	77
% Rocky Shore	0	0	1	0	0	0	0	0	0	0
Average density of stranded Kelp (plants/km)	150	120	50	0,5	0,5	–	–	–	–	–
Average wet mass of stranded kelp (kg/km)	134,2	98,9	34,8	0,3	0,28	–	–	–	–	–

* Sandy beaches with isolated rocky outcrops.

waders between Angra Fria and the Kunene River mouth decreased by 98,5%. Thus, although Ryan *et al.* (1984) mention that large numbers of Palaearctic waders may overwinter on the Skeleton Coast, only 59 individuals were counted along the traversible 251 km between Möwe Bay and the Kunene River mouth during July 1985.

Kelp gulls (*Larus dominicanus*) were the only shorebirds other than waders" that were present in all blocks during all seasons, although their numbers fluctuated seasonally (Tabels 2 and 3). The abundance of these birds on the northern Skeleton Coast increased noticeably during April and May. During these two months in 1983 their numbers reached 1500 and 1221 respectively for the area between Möwe Bay and False Cape Frio (Skeleton Coast Park unpubl. data). The lowest counts for kelp gulls in this area were recorded during their breeding season in mid-summer, when the majority of these birds are believed to mi-

TABLE 2: Densities (Birds km^{-1}) of the most abundant coastal birds recorded between Möwe Bay and False Cape Frio for the period March 1984 – August 1985.

MONTH	March 1984					May 1984					June 1984					July 1984				
BLOCK	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SHOREBIRDS																				
RESIDENT WADERS																				
African black oystercatcher *Haemotopus moquini*																	0,2			
whitefronted plover *Charadrius marginatus*	1,2	0,5	0,9	0,2	0,3	3,2	1,5	1,3	0,8	0,8	2,1	0,6	0,5	0,3	0,1	7,8	3,3	2,9	0,6	0,1
TOTAL RESIDENT WADERS	1,2	0,5	0,9	0,2	0,3	3,2	1,5	1,3	0,8	0,8	2,1	0,6	0,5	0,3	0,1	7,8	3,5	2,9	0,6	0,1
PALAEARCTIC WADERS																				
grey plover *Pluvialis squatarola*	3,9	6,6	2,2	0,6	1,5	1,1	1,9	0,7	0,4	0,1	0,8	0,7	0,4		0,1	1,0	1,0	0,3		
turnstone *Arenaria interpres*	0,3	1,2				0,9										0,1				
curlew sandpiper *Calidris ferruginea*		0,1								0,1						0,1				
little stint *C. minuta*																0,1				
sanderling *C. alba*	11,8	17,3	6,6	11,7	13,3		q	0,1		0,1	0,1					1,1	0,4			
whimbrel *Numenius phaeopus*																				0,1
TOTAL PALAERCTIC WADERS	16,0	25,2	8,8	12,3	14,8	2,0	1,9	0,8	0,4	0,3	0,9	0,7	0,4	0	0,1	2,4	1,4	0,3	0	0,1
NON-WADERS																				
grey heron *Ardea cinerea*		0,1					0,1				0,1						0,1			
kelp gull *Larus dominicanus*	3,8	8,5	4,3	3,2	2,4	9,1	10,7	2,9	1,3	3,0	3,6	5,6	3,3	5,1	2,3	5,0	2,7	1,5	0,2	0,9
pied crow *Corvus alba*	0,1	0,3	0,2		0,1		0,2	0,1				0,2	0,5	0,2			0,4	0,5	0,1	0,1
Cape wagtail *Motacilla capensis*	0,2	0,7																		
TOTAL NON-WADERS	4,1	9,6	4,5	3,2	2,5	9,1	11,0	3,0	1,3	3,0	3,7	5,8	3,8	5,3	2,3	5,0	3,2	2,0	0,3	1,0
TOTAL SHOREBIRDS	21,3	35,3	14,2	15,7	17,6	14,3	14,4	5,1	2,5	4,1	6,7	7,1	4,7	5,6	2,5	15,2	8,1	5,2	0,9	1,2
SEABIRDS																				
white breasted cormorant *Phalocrocorax carbo*	4,3	1,0	0,4		0,5	0,2	0,3	0,3	0,2	0,1	3,8	0,5	2,3		0,5	2,0	0,2	0,6		0,1
Cape cormorant *P. capensis*	0,9	0,3	0,1		0,2	4,3	2,1	0,6		0,1	1,8	1,9	2,3	0,1	0,2	0,8	1,0	5,1	0,9	1,1
sandwich term *Sterna sanvicensis*			1,2	0,1	0,1	0,6	0,3	1,1	0,1	0,1										
common/Arctic tern *S. hirundo/paradisea*	0,2		2,8	0,1		0,2		0,7	0,2		0,1					0,8				
Damara tern *S. balaenarum*	6,5	0,1	3,6		1,4			0,8	0,5		0,2				0,1					
TOTAL SEABIRDS	11,9	1,4	8,1	0,2	2,2	5,3	2,7	3,5	1,0	0,3	5,9	2,4	4,6	0,1	0,8	3,6	1,2	5,7	0,9	1,2

MONTH	September 1984					October 1984					November 1984					December 1984				
BLOCK	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SHOREBIRDS																				
RESIDENT WADERS																				
African black oystercatcher *Haemotopus moquini*	0,2	0,1									0,3									
whitefronted plover *Charadrius marginatus*	5,0	1,6	1,0	0,5	0,3	3,4	1,5	1,0	0,4	1,0	1,3	1,3	0,9	0,1	0,2	2,6	1,7	0,7	0,1	0,1
TOTAL RESIDENT WADERS	5,2	1,7	1,0	0,5	0,3	3,4	1,5	1,0	0,4	1,0	1,6	1,3	0,9	0,1	0,2	2,6	1,7	0,7	0,1	0,1
PALAEARCTIC WADERS																				
grey plover *Pluvialis squatarola*	4,7	2,2	1,0	0,3	0,2	6,8	3,5	1,9	0,6	0,7	2,8	2,8	1,0	0,5	0,2	4,0	2,5	1,7	0,1	0,4
turnstone *Arenaria interpres*	8,4	1,4	1,1	0,2		6,5	0,4			0,1	0,5		0,1			0,5				
curlew sandpiper *Calidris ferruginea*	0,2	1,2		0,1		0,5	1,5		0,1		0,1	0,6	1,2			2,1	0,2	0,5		
little stint *C. minuta*																				
sanderling *C. alba*	5,5	6,6	5,6	1,8	4,1	8,3	15,3	8,9	4,9	0,3	15,5	24,2	8,8	9,6	1,2	13,5	18,0	9,1		1,1
whimbrel *Numenius phaeopus*		0,2					0,1			0,1	0,2	0,1	0,1		0,1	0,1				
TOTAL PALAERCTIC WADERS	18,8	11,6	7,7	2,4	4,3	22,1	20,8	10,8	5,6	1,2	19,1	27,7	11,2	10,1	1,5	20,2	20,7	11,3	0,1	1,5
NON-WADERS																				
grey heron *Ardea cinerea*												0,1								
kelp gull *Larus dominicanus*	2,3	1,6	0,9	0,5	0,7	2,2	2,4	0,6	0,1	0,7	0,5	0,4	0,7	0,7	0,2	0,8	0,1	0,3	0,9	0,2
pied crow *Corvus alba*		0,1	0,4	0,1	0,1		0,1	0,2	0,3	0,2	0,1	0,1	0,3		0,1	0,1	0,3	0,1	0,1	
Cape wagtail *Motacilla capensis*												0,1	0,1							
TOTAL NON-WADERS	2,3	1,7	1,3	0,6	0,8	2,2	2,5	0,8	0,4	0,9	0,6	0,7	1,1	0,7	0,3	0,9	0,4	0,4	1,0	0,2
TOTAL SHOREBIRDS	26,3	15,0	10,0	3,5	5,4	27,7	24,8	12,6	6,4	3,1	21,3	29,7	13,2	10,9	2,0	23,7	22,8	12,4	1,2	1,8
SEABIRDS																				
white breasted cormorant *Phalocrocorax carbo*	2,7	0,2	0,1		0,4	0,7	0,1	0,1		0,1	1,5	0,3	0,1	0,1	0,1	0,6	0,3	0,1		0,1
Cape cormorant *P. capensis*	0,3	0,6	0,2				0,2					0,3					0,2			
sandwich term *Sterna sanvicensis*	0,1	0,3	0,1		0,2	0,3	0,1				0,1				0,2					
common/Arctic tern *S. hirundo/paradisea*	0,3		0,9	0,2	0,3	0,6	0,2		0,2		1,6	0,1	0,3	0,1	0,1	0,1			0,1	
Damara tern *S. balaenarum*										0,1					11,7	0,1			0,1	
TOTAL SEABIRDS	3,4	1,1	1,3	0,2	0,9	1,6	0,6	0,1	0,2	0,2	3,2	0,7	0,4	0,2	12,1	0,8	0,5	0,1	0,2	0,1

grate to breeding grounds to the south of the Skeleton Coast Park (R. Loutit pers. comm.). A total of 48 birds was recorded between Möwe Bay and False Cape Frio in November 1981 (Ryan *et al.* 1984), 66 birds in November 1983 (Skeleton Coast Park unpubl. data) and 52 birds in December 1984.

Pied crows (*Corvus alba*), although not mentioned elsewhere as shorebirds, were often encountered during the course of this study (Tables 2 and 3). Their presence on the isolated northern beaches, sometimes as far north as Bosluisbaai (14 km south of the Kunene River mouth), indicates an independence from the human settlements with which they are often associated.

In recent years there appears to have been a decrease in the total abundance of shorebirds present on the northern Skeleton Coast (Table 4). The density of

TABLE 2 continued

MONTH	January 1985					February 1985					March 1985					April 1985				
BLOCK	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SHOREBIRDS																				
RESIDENT WADERS																				
African black oystercatcher *Haematopus moquini*																0,1				
whitefronted plover *Charadrius marginatus*	2,0	1,2	1,3	0,6	0,4	2,2	1,1	0,5	0,8	0,2	2,8	3,1	1,2	0,7	0,3	2,8	1,3	0,6	0,3	0,2
TOTAL RESIDENT WADERS	2,0	1,2	1,3	0,6	0,4	2,2	1,1	0,5	0,8	0,2	2,8	3,1	1,2	0,7	0,3	2,9	1,3	0,6	0,3	0,2
PALAEARCTIC WADERS																				
grey plover *Pluvialis squatarola*	1,8	2,0	1,3	0,2	0,2	4,3	2,6	1,2	0,5	0,3	4,3	3,4	1,0		0,6	6,0	2,7	1,1	0,2	0,5
turnstone *Arenaria interpres*	1,2					2,3	0,3				6,3	0,2				7,0	1,2			
curlew sandpiper *Calidris ferruginea*	0,1	0,6	0,6		0,1															
little stint *C. minuta*												0,3							
sanderling *C. alba*	19,0	14,3	12,2	2,3	0,5	17,3	8,0	9,6		0,8	15,8	22,8	12,0	9,2	5,8	6,3	10,9	9,5	0,4	3,1
whimbrel *Numenius phaeopus*						0,1										0,1				
TOTAL PALAERCTIC WADERS	22,1	16,9	14,1	2,5	0,8	24	10,9	10,8	0,5	1,1	26,4	26,7	13,0	9,2	6,4	19,0	14,8	10,6	0,6	3,6
NON-WADERS																				
grey heron *Ardea cinerea*	0,1							0,1			0,1		0,1							
kelp gull *Larus dominicanus*	0,5	1,4	0,3	0,8	0,5	1,3	1,9	0,9	0,6	0,2	5,1	3,2	3,5	3,7	1,2	6,6	4,3	3,0	1,7	3,0
pied crow *Corvus alba*	0,1	0,1	0,1					0,1	0,1			0,1	0,1			0,1				
Cape wagtail *Motacilla capensis*								0,1												
TOTAL NON-WADERS	0,7	1,5	0,4	0,8	0,5	1,3	1,9	1,2	0,7	0,2	5,7	3,3	3,7	3,7	1,2	6,7	4,3	3,0	1,7	3,0
TOTAL SHOREBIRDS	24,8	19,6	15,8	3,9	1,7	27,5	13,9	12,5	2,0	1,5	34,9	33,1	17,9	13,6	7,9	29,0	20,4	14,2	2,6	6,8
SEABIRDS																				
white breasted cormorant *Phalocrocorax carbo*	1,6	0,2	0,1		0,3	1,2	0,5	0,1			0,8		0,4		0,1	3,3	0,1	0,2		0,1
Cape cormorant *P. capensis*			0,1				0,1	0,1			12,0	0,8	23,0	1,1	0,6	0,4	1,5	4,7	0,7	1,5
sandwich tern *Sterna sanvicensis*											1,7					0,5	0,1			
common/Arctic tern *S. hirundo/paradisea*					0,1						8,3							13,3		
Damara tern *S. balaenarum*			0,1																	
TOTAL SEABIRDS	1,6	0,2	0,3	0	0,4	1,2	0,6	0,2	0	0	22,8	0,8	23,4	1,1	0,7	4,2	1,7	18,2	0,7	1,6

MONTH	May 1985					June 1985					July 1985					August 1985				
BLOCK	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SHOREBIRDS																				
RESIDENT WADERS																				
African black oystercatcher *Haematopus moquini*																				
whitefronted plover *Charadrius marginatus*	2,2	1,7	0,6	0,4	0,4	1,9	1,0	0,6	0,3	0,1	1,5	0,2	0,5	1,5	0,3	3,0	1,3	1,0	0,7	0,2
TOTAL RESIDENT WADERS	2,2	1,7	0,6	0,4	0,4	1,9	1,0	0,6	0,3	0,1	1,5	0,2	0,5	1,5	0,3	3,0	1,3	1,0	0,7	0,2
PALAEARCTIC WADERS																				
grey plover *Pluvialis squatarola*	4,7	2,5	0,9	0,3	0,6	0,8	1,0	0,2		0,1	1,0	0,5	0,1		0,1	0,3	0,3	0,1	0,2	
turnstone *Arenaria interpres*	10,2	0,3	0,1			0,6					0,1					0,6	0,1			
curlew sandpiper *Calidris ferruginea*					0,2															
little stint *C. minuta*																				
sanderling *C. alba*	1,0		0,5		3,0	0,1		0,5			0,2				0,2					
whimbrel *Numenius phaeopus*	0,2	0,1									0,1					0,1				
TOTAL PALAERCTIC WADERS	16,1	2,9	1,5	0,3	3,8	1,5	1,0	0,7	0,0	0,1	1,4	0,5	0,1	0,0	0,3	1,0	0,4	0,1	0,2	0
NON-WADERS																				
grey heron *Ardea cinerea*	0,1	0,1									0,1					0,1				
kelp gull *Larus dominicanus*	12,6	7,5	4,0	2,7	3,0	7,4	4,9	1,6	0,5	1,6	4,9	3,1	1,9	0,8	1,8	3,4	4,3	1,0	0,9	0,8
pied crow *Corvus alba*		0,1	0,1				0,1		0,1		0,3	0,3	0,5				0,2	0,1		
Cape wagtail *Motacilla capensis*	0,1		0,1				0,1													
TOTAL NON-WADERS	12,8	7,7	4,2	2,7	3,0	7,4	5,1	1,6	0,6	1,6	5,3	3,4	2,4	0,8	1,8	3,5	4,5	1,1	0,9	0,8
TOTAL SHOREBIRDS	31,1	12,3	6,3	2,8	7,2	10,8	7,1	2,9	0,9	1,8	8,2	4,1	3,0	2,3	2,4	7,5	6,2	2,2	1,8	1,0
SEABIRDS																				
white breasted cormorant *Phalocrocorax carbo*	3,0	0,1	0,6		0,1	0,4	0,7	0,3	0,1		2,8	0,2	0,4		0,1	0,6	0,2	0,1		
Cape cormorant *P. capensis*	250,0	70,0	10,6	0,1		0,1	0,2	0,1	0,1		1,0	0,8	0,4		0,1	2,4	0,4	0,3	0,1	0,1
sandwich tern *Sterna sanvicensis*			0,2																	
common/Arctic tern *S. hirundo/paradisea*	0,8		0,1	3,5	0,1															
Damara tern *S. balaenarum*																				
TOTAL SEABIRDS	253,8	70,1	11,5	3,6	0,2	0,5	0,9	0,4	0,2	0	3,8	1,0	0,8	0	0,2	3,0	0,6	0,4	0,1	0,1

TABLE 3: Densities (birds km^{-1}) of coastal birds observed between Angra Fria and the Kunene mouth.

MONTH	July 1984					September 1984					January 1985					July 1985				
BLOCK	6	7	8	9	10	6	7	8	9	10	6	7	8	9	10	6	7	8	9	10
SHOREBIRDS																				
RESIDENT WADERS																				
African black oystercatcher *Haemotopus moquini*																	0,1	0,1		
whitefronted plover *Charadrius marginatus*	0,2	0,2	0,2	0,4	1,8	0,7	0,3	0,4	0,4	0,9	0,6	0,3	0,1	0,8	0,7	0,4	0,3	0,5	0,5	0,7
TOTAL RESIDENT WADERS	0,2	0,2	0,2	0,4	1,8	0,7	0,3	0,4	0,4	0,9	0,6	0,3	0,1	0,8	0,7	0,4	0,4	0,6	0,5	0,7
PALAEARCTIC WADERS																				
grey plover *Pluvialis squatarola*					0,3	0,2	0,5	0,5	0,4	0,8	0,2	0,1	0,2	0,1	0,3					
turnstone *Arenaria interpres*						0,1	0,5	0,1	0,1	0,1										
curlew sandpiper *Calidris ferruginea*					1,5															
little stint *C. minuta*															12,0					
sanderling *C. alba*			0,2			1,2	5,3	2,0	1,1	1,9	2,1	0,8	2,2	0,9	20,4	0,1			0,2	
whimbrel *Numenius phaeopus*			0,1	0,1		0,1														
TOTAL PALAERCTIC WADERS	0	0	0,3	0,1	1,8	1,6	6,3	2,6	1,6	2,8	2,3	0,9	2,4	1,0	32,8	0,1	0	0	0,2	0
NON-WADERS																				
grey heron *Ardea cinerea*																				
kelp gull *Larus dominicanus*	0,7	0,3	0,3	1,0	0,2	0,2	0,3	0,5	0,4	0,7	0,8	0,1	0,3	0,1	0,6	0,8	0,8	0,5	0,9	0,5
pied crow *Corvus alba*	0,1		0,1	0,1			0,1	0,1	0,1					0,1		0,1				
Cape wagtail *Motacilla capensis*																				
TOTAL NON-WADERS	0,8	0,3	0,4	1,1	0,2	0,2	0,4	0,6	0,5	0,7	0,8	0,1	0,3	0,2	0,6	0,9	0,8	0,5	0,9	0,5
TOTAL SHOREBIRDS	1,0	0,5	0,9	1,6	3,8	2,5	7,3	3,7	2,5	4,4	3,7	1,3	2,8	2,0	34,1	1,4	1,2	1,1	1,6	1,2
SEABIRDS																				
white breasted cormorant *Phalocrocorax carbo*	1,5	0,8	0,1	0,4	0,8		0,7	0,1	0,2	0,2	0,1	0,1		0,1	1,4	0,8	0,5	0,1	0,1	
Cape cormorant *P. capensis*	3,4	0,1	0,1	0,1	1,5	0,1	1,1	0,4	0,5	0,5					1,8	0,1	3,1	2,4		11,6
sandwich term *Sterna sanvicensis*						0,3		0,2	0,1	0,1								0,1		
common/Arctic tern *S. hirundo/paradisea*	0,1					0,6	0,1	1,7												
Damara tern *S. balaenarum*								0,1	0,1	0,1	0,4	0,4	0,4	0,7	16,1					
TOTAL SEABIRDS	5,0	0,9	0,2	0,5	2,3	1,0	1,9	2,5	0,9	0,9	0,5	0,5	0,4	0,8	19,3	0,9	3,6	2,6	0,1	11,6

TABLE 4: Shorebird abundance on the northern Skeleton Coast during November 1981 and November 1984.

	NOVEMBER 1981		NOVEMBER 1984	
	Angra Fria to Rocky Point	Rocky Point to Hoanib River	False Cape Frio to Rocky Point	Rocky Point to Möwe Bay
Distance (km)	87,4	65,1	76	44
Number of Birds	1086	2076	623	1114
Density (birds/km)	12,4	31,9	8,2	25,3

shorebirds recorded between Möwe Bay and False Cape Frio during November 1984 was 31,1% lower than that recorded by Ryan *et al* (1984) for the same period in 1981.

Cape and whitebreasted cormorants (*Pharlocrocorax capensis* and *P. carbo*) were the only seabirds observed throughout the year but their abundance was variable and their distribution patchy (Tables 2 and 3). Cormorants feed predominently on dense shoals of pelagic fish (Shannon 1983) and Cape cormorants undergo periodic migrations up and down the South West African coast (Berry 1976). Berry (1976) mentions further that post breeding migrations of Cape cormorants may occur with large scale dispersal of immature birds. This species breeds in South West Africa between late dispersal of immature birds. This species breeds in South West Africa between late September and March (Berry 1976) and this, together with the fact that dense concentrations of pilchard are predicted to occur close to shore in the vicinity of Möwe Bay and the southern Skeleton Coast during the autumn and winter (Boyd and Cruikshank, 1983), may explain the unusually large flocks recorded in May 1985 when more then 7000 birds were counted in blocks 1 and 2.

In 1984 Pelaerctic terns arrived on the northern Skeleton Coast during September and November (Table 2). Thereafter there was a steady decrease in numbers until February 1985 when no common, Arctic or Sandwich terns (*S. sandvicensis*) were recorded in the study area. Numbers once again increased during autumn when the birds gathered in large flocks before migrating northwards to their breeding grounds.

3.1.2 Geographical variations

There is a clear spatial distribution pattern of whitefronted plovers on the northern Skeleton Coast. On average, 66% of all birds counted between Möwe Bay and False Cape Frio occurred in blocks 1 and 2, whereas between Angria Fria and the Kunene River mouth, 20% of all birds counted occurred in the 10 Km stretch south of the Kunene River mouth.

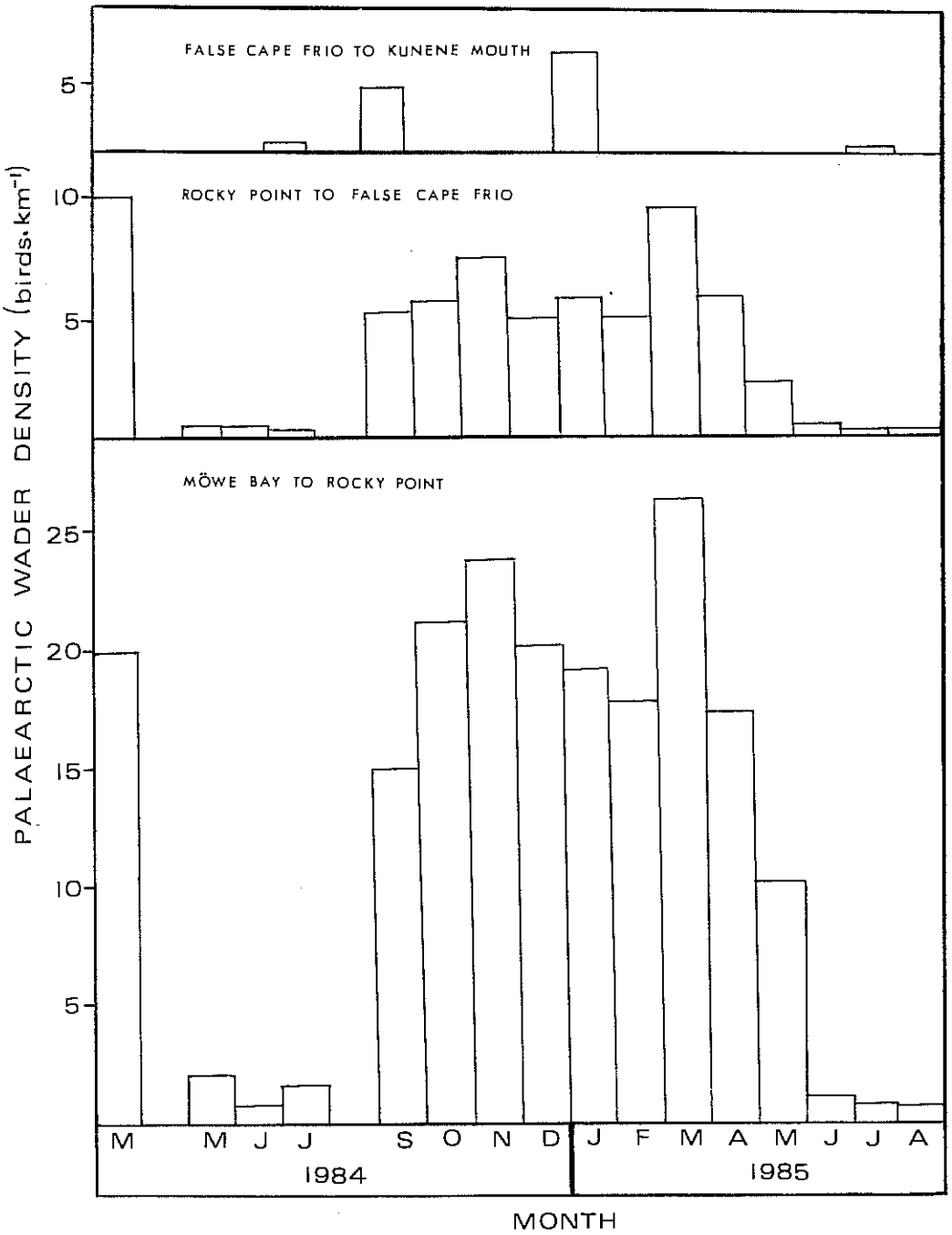

FIGURE 2: Densities (birds, km -1) of Palaearctic waders on the northern Skeleton Coast (March 1984-August 1985). Blank spaces indicate months in which no data was gathered.

In July 1985 two African black oystercatchers (*Haematopus moquini*) were observed 85 km north of Angra Fria. Although three birds have been recorded from Angola (P.A.R. Hockey pers. comm.) these birds are infrequently encountered on the Skeleton Coast and, within this area, have previously been recorded only as far north as Rocky Point (Ryan *et al* 1984), 190 km south of the July 1985 record.

As with whitefronted plovers there is a clear spatial distribution pattern of migrant waders on the northern Skeleton Coast (Fig. 2). On average, 61% of all birds counted between Möwe Bay and the Kunene River mouth were recorded between blocks 1 and 2. Despite the generally low numbers of waders north of Rocky Point, large numbers were sometimes encountered within 10 km of the Kunene River mouth (Table 3).

Fluctuations in the geographical distribution of kelp gulls occurred. During April and May, when these birds are most abundant, the majority (between 66% and 80%) of all kelp gulls counted south of False Cape Frio were found in blocks 1 and 2. For the remaining months their distribution was patchy.

On average 62,2% of all shorebirds counted occurred between Möwe Bay and Rocky Point although this

area constitutes only 17,5% of the entire shoreline surveyed.

It appears that the majority of Palaearctic terns spent the summer of 1984/85 to the south of the study site. Whitelaw *et al* (1977) state that the size and locality of Palaearctic tern flocks show variations from year to year, and it is interesting to note that the numbers of these birds recorded between Möwe Bay and False Cape Frio during November 1984 were a mere 2,6% of the 2424 birds counted in the area by Ryan *et al* (1984) for the same period in 1981.

The rare Damara tern (*S. balaenarum*) breeds on the Skeleton Coast during the summer months (Clinning 1978; Skeleton Coast Park unpubl. data) and in November 1984 a flock of 350 birds was seen just north of False Cape Frio. Although very few birds were encountered between Möwe Bay and False Cape Frio during the following summer months and no birds were counted during the autumn of 1985 (Table 2), a flock of 161 was seen at the Kunene River mouth during January 1985. Damara tern breeding records between False Cape Frio and Terrace Bay (80 km south of Möwe Bay) during the 1985 breeding season dropped by 88,8% from that of the previous year (Skeleton Coast unpubl. data). Breeding numbers in the southern Skeleton Coast were also reported to be considerably lower than in the previous year (R. Loutit pers. comm.). These observations suggest that the majority of Damara terns possibly bred in the far northern areas of the Skeleton Coast Park and possibly along the southern Angolan coast during this period.

Greater and lesser flamingoes (*Phoenicopterus ruber* and *P. minor*) were often observed on the beach in the nearby vicinity of the Hoarusib River mouth (block 2) and nine greyheaded gulls (*Larus cirrocephalus*) were observed during July 1984 in block 9 and 10. Flocks of great white pelicans (*Pelecanus onocrotalus*) were often seen on the northern bank of the Kunene River mouth (pers. obs.) although only four birds (one in block 10 and three in block 1) were counted within the study area between March 1984 and August 1985. 30 Caspian terns (*Hydroprogne caspia*) were observed in block 10 during January 1985 but were not recorded elsewhere on the northern Skeleton Coast during the course of this study.

3.2 Habitat-type variations in shorebird distribution and relationship with stranded kelp

Summers *et al* (1977) and Griffiths *et al* (1983) mention the importance of stranded kelp for waders in the western Cape and Figure 3 depicts the marked drop in both average shorebird density and the presence of stranded kelp north of Rocky Point. On sandy beaches the presence of decomposing kelp attracts a large variety of air-breathing arthropods (Griffiths and Stenton-Dozey 1981). Surveys conducted on the Skeleton Coast showed that the southern beaches, which receive a constant supply of kelp wrack, support a biomass of potential prey organisms that is 74% higher than beaches in the far north which are devoid of stranded kelp (Tarr *et al* 1985).

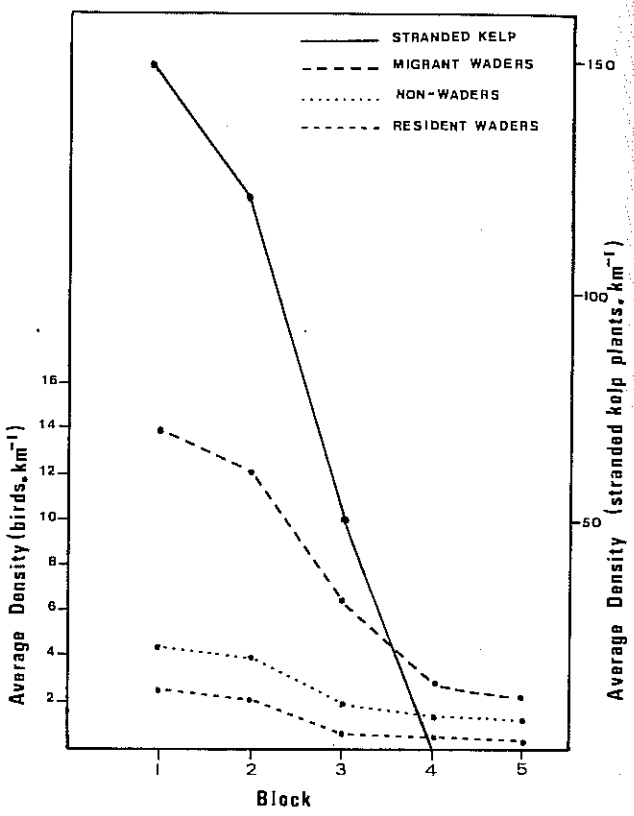

FIGURE 3: Average shorebird and stranded kelp densities recorded in five blocks on the northern Skeleton Coast between Möwe Bay and False Cape Frio (March 1984 — August 1985).

The majority of the five most abundant shorebird species counted between Möwe Bay and Rocky Point were observed on mixed shores of sand and rock (Table 5). These mixed shores may be described as sandy beaches which extend down to a rocky platform. Kelp, which grows on the infratidal fringe of the rocky substratum is stranded along the driftline of the beach, and at low tide both the beach and part of the rocky platform are exposed making a large variety of prey organisms potentially available to shore-feeding birds. Similar observations of waders and their distribution on mixed shores have been made in the southwestern Cape (Summers *et al* 1977) and on the Namib coast, South West Africa (Whitelaw *et al* 1978). A survey of a typical mixed shore north of Möwe Bay showed that five of the eight intertidal prey species present on the sandy beach were dependent to a large degree on decomposing kelp (J.G. Tarr unpubl. data). North of Rocky Point the occurrence of mixed shores of this type drops noticeably, eventually giving way to long sandy beaches with occasional areas of isolated rock.

Cape wagtails (*Motacilla capensis*) together with tractrac chats (*Ceromela tractrac*) and European swallows

TABLE 5: Composition (percent) of five major shorebird species based on average abundance on three shore types for the area between Möwe Bay and Rocky Point.

	Mixed shores of Sand and Rock	Sandy beaches with kelp wrack	Sandy beaches without kelp wrack
white fronted plover	66,1	23,2	10,7
sanderling	93,5	4,9	1,6
grey plover	83,4	12,2	4,4
turnstone	97,3	1,9	0,8
kelp gull	43,3	42,2	14,5

(*Hirundo rustica*) have been observed on Skeleton Coast beaches feeding in the vicinity of decomposing kelp (pers. obs.) and pied crows, although usually found in the vicinity of Cape fur seal (*Arctocephalus pusillus*) carcasses, were also observed pecking amongst stranded kelp plants and the flotsam and jetsam present along the sandy beach driftlines.

4 DISCUSSION

Ryan *et al* (1984) compare the Skeleton Coast north of Angra Fria with the Natal coast of South Africa. Both areas are characterized by long stretches of sandy beach, a low abundance of potential prey organisms, low shorebird densities and the presence of ghost crabs (*Ocypode* sp.) (Dye *et al* 1981, Ryan *et al* 1984, Tarr *et al* 1985). Ghost crabs are predatory scavengers and are believed to compete indirectly with shorebirds for food resources (Bally 1981, Ryan *et al* 1984). On the Skeleton Coast *O. cursor* and *O. africana* are seldom observed south of Rocky Point (pers. obs.). However, during the summer of 1984/85 small numbers were seen on the beaches near the Uniab River mouth (R. Loutit pers. comm.), approximately 110 km south of Möwe Bay, their accepted southerly range (Kensley 1970).

The relatively high numbers of shorebirds in the vicinity of the Kunene River mouth may be explained by the fact that this is the only perennial river on the entire Skeleton Coast. Large flocks of waders gather on the mud flats in the vicinity of the river mouth during the summer months and it can be expected that these birds will sometimes feed on the nearby beaches. This idea is supported by the fact that little stints, which are primarily a species of estuaries, lagoons and vleis (Summers *et al* 1977) are periodically seen in high densities on the beaches of block 10 but are seldom encountered elsewhere on the Skeleton coast.

The northernmost limit of the Benguela upwelling system is believed to be in the vicinity of Cape Frio (Nelson and Hutchings 1983). With respect to shorebird density the area between Rocky Point and Angra Fria may be considered as a transitional zone between the Benguela influenced, cool temperate, southern areas of the South West African and western Cape coasts, and the area north of Angra Fria which is comparable to the sub-tropical Natal coast (Ryan *et al* 1984). In the southwestern Cape a similar transitional zone, marked by the approximate dividing line of the influence of the Agulhas and Benguela currents, occurs between Cape Point and Cape Agulhas (Summers *et al* 1977).

Thus, the northern Skeleton Coast may be divided into three areas with respect to shorebird abundance and distribution: a southern area supporting a mean summer density of 24 birds. km^{-1}; the area between Rocky Point and False Cape Frio which supports a mean summer density of 7,4 birds. km^{-1}; the area north of Angra Fria (excluding block 10) which supports a mean summer density of 2,5 birds. km^{-1}. It appears that the geographical distribution of shorebirds is primarily determined by the availability of food and that the presence of stranded kelp and the nature of the substratum are the two most important factors which determine the abundance of potential prey organisms available to shore-feeding birds.

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On the application of stomach-flushing to Namib Desert lizards

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ABSTRACT

A stomach-flushing technique used on North American turtles, lizards and anurans is examined with respect to seven species of Namib Desert lizards and is evaluated in detail for several of these. The procedure reliably provides stomach contents for subsequent analysis. Variation in body size can influence its effectiveness in some species, although the influence is minimal. Mortality from the procedure is low (2.5%, overall).

1 INTRODUCTION

Dietary investigations of reptiles generally involve the collection and sacrifice of individuals within a population. This practice provides information on the population diet and, perhaps, inter-individual variation, but precludes information on within-individual variability since each lizard can yield only one datum point. Such dietary studies are incompatible with demographic studies of the same populations. In cases where both dietary and demographic data are required, faecal analyses may be possible for some species (e.g., *Agama agama,* Harris 1964), however, the general approach has been to collect individuals for dietary data from areas nearby the principal study area (e.g., Dunham 1983). This approach requires assumptions about both the similarity of the food base between areas and about individual feeding habits in those areas. In extremely patchy habitats these assumptions may not be valid, thus limiting the usefulness of dietary data. Nonetheless, even this approach may not be suitable for studies of rare or endangered species (e.g., Powell & Russell 1984).

Stomach-flushing has been described as a feasible method of obtaining diet samples from turtles, lizards and anurans (Legler 1977, Legler & Sullivan 1979). It has been evaluated for several North American lizard species with respect to the acquisition of diet samples, the accuracy with which the effectiveness of an individual flushing event can be assessed, and post-flushing survival (Pietruszka 1981). This analysis demonstrated the general efficacy of the technique but also indicated that inherent species differences could significantly influence its effectiveness. The present study was undertaken, therefore, to assess the suitability of stomach-flushing for dietary analysis of Namib Desert lizards.

PLATE 1: Stomach-flushing sequence and apparatus. (a)- rubber prosthesis holding mouth open; (b)- insertion of stomach cannula; (c)- recovery of food bolus; (d)- stomach-flushing equipment.

2 MATERIALS AND METHODS

Between 8 November 1984 and 22 August 1985 120 lizards of seven species (*Aporosaura anchietae, Angolosaurus skoogi, Mabuya capensis, Meroles cuneirostris, M. suborbitalis, Pachydactylus laevigatus, Rhoptropus afer*) were captured and subjected to stomach-flushing either at Gobabeb, Namibia, or at a study site on the Unjab River in the northern Namib Desert. Results from each flush were coded numerically as either "complete", "incomplete" or "stomach empty". Stomach contents were labelled and preserved in 70% ethanol. Any harmful effects due to stomach-flushing were noted. Lizards were then maintained individually in cloth bags for 12-24 h to check for latent effects. Eighty-one lizards were subsequently autopsied; each stomach was examined and assigned a subjective numerical classification as to its degree of fullness (empty, partially full, <1/2; full; distended, Pietruszka 1981). Effectiveness of stomach-flushing was analysed statistically using the methods of Neter & Wasserman (1974) and Sokal & Rohlf (1981).

2.1 Stomach-flushing Procedure

The method used in this study is similar to that described by Legler (1977) and Legler & Sullivan (1979). However, it differs in several details that result in less trauma to individual lizards and so it will be described fully here. The principle behind stomach-flushing is that, given a stream of water of appropriate intensity, a food bolus located in the stomach can be dislodged by displacement and forced out through the esophagus and mouth without damage to the lizard. The apparatus used in the procedure consists of a syringe to which is attached a two-way valve and filling tube, allowing for continuous filling from a small container of water, and a stomach cannula. Legler & Sullivan (1979) describe an inexpensive apparatus using disposable plastic syringes. However, the two-way valve mentioned by these authors has become excessively expensive (price ca. $36.00(US) in August 1984). An excellent alternative which is locally available is the Vetmatic Continuous Syringe (5 ml barrel) which currently sells for under R30.00. The stomach cannula used in this study consisted of ca. 75 mm of catheter tubing (1.7 mm O.D.) attached to a shortened 18-gauge syringe needle. Although Legler & Sullivan (1979) used a variety of cannula sizes in their application, I have found this unnecessary for lizards ranging from 1.0 g body weight to lizards in excess of 120 g.

During flushing, the lizard is held in one hand and its mouth is gently opened by inserting a small plastic ruler between the jaws and applying steady downward pressure to the lower mandible. Once open, the mouth is held in that position by placing a small rubber stopper (in this study a 3-7 mm diameter cylindrical pencil eraser) at the angle of the jaw so as not to block the opening to the esophagus. This is held in place by pressure applied to the jaws with the thumb and forefinger (Plate 1a). The remaining three fingers are used to support the lizard's body and palpate the stomach. The stomach cannula is then moistened with water and inserted into the stomach through the esophagus (Plate 1b). During insertion a small amount of water may be injected into the stomach for lubrication but this is often unnecessary. With slightly built species the cannula can be felt (by palpation) as it is inserted into the stomach. This, coupled with an increased resistance once the stomach has been entered, serves to indicate that the cannula is in place. Subsequently, a stream of water is injected into the stomach. At the same time the cannula is momentarily withdrawn about 5 mm to reduce the likelihood of forcing water past the pyloris. This sequence is continued until the food bolus passes through the esophagus and out of the mouth (Plate 1c). The bolus is caught in a square of cotton gauze held by a metal sieve. A complete flush can be assessed by palpation of the stomach and by the emergence of a small amount of mostly digested material after retrieval of the main bolus. Although it may be fragmented, in many cases the bolus is retrieved intact, covered by a mucous film, and ends in a mass of digested material. Diet samples obtained in this way are then labelled and stored for later analysis.

The above procedure differs considerably from that of Legler & Sullivan (1979) in that their method requires propping the mouth open through the use of plastic rings that must be removed once the bolus reaches the mouth. The food is then removed with forceps and the cannula reinserted as many times as necessary to recover the stomach contents. The necessity for continued reinsertion of the cannula during flushing increases the likelihood of passing it through the pyloric sphincter and injecting water into the intestine with death usually following (Legler & Sullivan 1979, Pietruszka 1981). With a rubber stopper properly in place there is very often no need of using forceps at all to remove stomach contents; forceps were generally only used to remove large food items from the mouth when it was felt that further increases in water pressure would injure the lizard.

3 RESULTS

To adequately assess the usefulness of this technique requires information on (1) post-flushing survival, (2) how efficiently stomach contents may be obtained from particular species, and (3) the accuracy with which an investigator can assess the effectiveness of a specific flushing event (Pietruszka 1981). Since lizards are flushed independently of one another, each outcome can be classified as either successful or unsuccessful relative to several categories of possible stomach-flushing results. Data of this type were used to calculate, in all species with sufficient sample sizes, binomial estimates of success (Hollander & Wolfe 1973) for several categories of stomach-flushing

results: the probabilities of 1) obtaining the entire stomach contents from non-empty stomachs, 2) obtaining all or most of the stomach contents from non-empty stomachs, 3) obtaining at least some of the contents from non-empty stomachs, 4) accurately assessing an individual stomach-flushing event (i.e., complete, entire contents obtained; incomplete, but most of the contents obtained; stomach empty) and 5) survival after flushing.

As with a study of North American lizards (Pietruszka 1981), the present analysis indicates that the overall effectiveness of stomach-flushing is quite good (Table 1). One nearly always covers something from non-empty stomachs and there is a high probability of obtaining all or most of the stomach contents. Also as in North American lizards, the effectiveness of particular flushing events can be assessed (by palpation and the visual characteristics of the food bolus) with a high degree of accuracy. Finally, the survival of lizard species exposed to flushing is high (97.5% overall).

In contrast with the earlier study of North American lizards, there was no statistically significant heterogeneity among those lizard species for which I had adequate sample sizes (*A. anchietae, M. cuneirostris, R. afer*) for any category of stomach-flushing results (G-tests, $P>0.5$, all categories). This may be because none of the species for which I have adequate sample sizes appears to exhibit food gorging as does *Cnemidophorus tigris* in the Great Basin Desert of the United States. In that species gorging significantly lowered the effectiveness of stomach-flushing (Pietruszka 1981).

3.I Influence of body size

An inverse relationship between stomach-flushing success and body size has been suggested for turtles (Legler 1977). The presence of a similar relationship was demonstrated among several species of North American lizards (Pietruszka 1981); however, this had only a minor effect on the overall effectiveness of the technique for these species and was, in fact, produced by attributes inherent to one of the species used in the analysis. In the present study, the body sizes (snout-vent length, SVL) of lizards stomach-flushed ranged from 32.7 mm (*Aporosaura*) to 155.0 mm (*Angolosaurus*). For three species there were sufficient sample sizes over a range of body sizes to examine whether body size might influence individual results. Linear regressions of success on lizard body size (using indicator variables, Neter & Wasserman 1974) were used to determine whether variation in size altered stomach-flushing effectiveness. In *Aporosaura* (SVL range: 32.7-49.9 mm) these analyses revealed no significant relationships between body size and any category of stomach-flushing result, although for category 1 (all contents obtained) the trend towards increased effectiveness at larger body sizes was suggestive ($n=19$, $r=0.3084$, $0.05<P<0.10$).

For *Meroles cuneirostris* (SVL range: 34.5-58.0 mm) significant positive relationships were apparent between body size and three categories of stomach-flushing results: (1) category 1, all contents obtained ($n=28$, $r=0.5407$, $P<0.005$), (2) category 2, all or most contents obtained ($n=28$, $r=0.6182$, $P<0.001$), and (3) assessment accuracy ($n=28$, $r=0.6228$, $P<0.001$). In the first case 29.24% of the variation in stomach-flushing results could be explained by differences in body size; in the latter two cases 38.22% of the variation in results was thus explained. Thus for *M. cuneirostris* one obtains more of the stomach contents and can more reliably assess them with lizards of large size.

The sample of *Rhotropus afer* comprised a narrow range of body sizes (43.3-53.5 mm SVL). Nonetheless,

TABLE 1: Probabilities (p ± SD) of stomach-flushing success.[1] Sample sizes for the total number of lizards flushed/autopsied in parentheses.

Species	Category				
	(1)	(2)	(3)	(4)	(5)
	Stomach contents obtained			Observer assessment accuracy	Survival
	all	all/most	some		
Aporcosaura anchietae (31/28)	.789 ± .10*	.789 ± .10*	.789 ± .10*	.786 ± .08	.936 ± .04
Meroles cuneirostris (33/28)	.929 ± .05	.929 ± .05	1.000	.933 ± .07	1.000
Pachydactylus laevigatus (5/1)	1.000	1.000	1.000	1.000	1.000
Rhoptropus afer (37/15)	.867 ± .09	.867 ± .09	.933 ± .07	.800 ± .11	.973 ± .03
Meroles suborbitalis (2/0)	–	–	–	–	1.000
Mabuya capensis (2/0)	–	–	–	–	1.000
Angolosaurus skoogi (10/9)	.667 ± .33*	.667 ± .33*	1.000*	.778 ± .15	1.000
Overall (118/81)	.864 ± .04*	.879 ± .04*	.942 ± .03*	.852 ± .04	.975 ± .01

1 – p = B/n, where B = number of successful trials, n = sample size; SD = [p(1 – p)/n – 1] .5

* – Calculations are based on smaller sample sizes due the presence of lizards with empty stomachs: A. *anchietae* – 19; A. *skoogi* – 3; overall – 66.

several patterns of potential body size effects were apparent. First, a marginally significant negative relationship was evident between body size and post-flushing survival ($n=37$, $r=-0.2753$, $P=0.048$). Although this suggests greater mortality from stomach-flushing with larger lizards, it must be noted that only 1 of 37 *Rhoptropus* died as a result of the procedure. Thus, this statistical result may be biologically trivial. There was also a suggestive trend between body size and the likelihood of obtaining all or most of the stomach contents from non-empty stomachs (category 1). Here also the relationship was negative but was nonsignificant ($n=15$, $r=-0.3506$, $0.05<P<0.10$). In this case body size can explain only about 12.3% of the variation in stomach-flushing success.

Looking at the general relationship between body size and stomach-flushing success across species, only one category of results showed any relation to lizard body size. There was a highly significant positive trend between body size and the likelihood of obtaining at least some of the contents of non-empty stomachs (category 3: $n=66$, $r=0.2988$, $P<0.01$). However, this explains only 8.93% of the variation in stomach-flush results. In general, body size appears to have little influence on the acquisition of diet samples, although it may be more important for some species than for others.

3.2 Weight gain from stomach-flushing

Previous studies have indicated a slight weight gain in lizards subjected to stomach-flushing as a result of water retention in the gut (Legler & Sullivan 1979; Pietruszka 1981). On average all species in the present study showed a positive weight gain as a result of the stomach-flushing procedure, although this amounted to only a small percentage of pre-flushing body weight (Table 2). In *Aporosaura* the average weight gain due to water retention from stomach-flushing (Table 2) was considerably less than the 10.8% average increase observed by Louw & Holm (1972) under conditions of voluntary water consumption after prolonged dehydration. This suggests that for some Namib species, at least, the amount of water introduced into the digestive tract during flushing may be well within physiological tolerance limits. The degree to which water is retained in a lizard's gut (with a resultant weight gain) appears to depend on the size of the food bolus and the ease with which it is dislodged during flushing. When food was retrieved in a well consolidated bolus it was often obtained easily and with little weight gain by the lizard (and in some cases a weight loss). On the other hand, when the bolus was fragmented, there was always an increase in weight after flushing. Lizards with empty stomachs at the time of flushing tended to have the largest increases in body weight although this was not always the case.

3.3 Mortality

In the present study, the vast majority of lizards stomach-flushed recovered from the procedure almost immediately. Only three of the 120 lizards subjected to stomach-flushing died as a direct result of the procedure, corresponding to an overall mortality of 2.5%. Among the species to which the procedure was applied, only those that subjectively appeared to be the most delicate suffered any mortality: *Aporosaura*, 6.4%; *Rhoptropus*, 2.7%. In the cases where death did occur, signs of severe distress similar to those noted for North American lizards (Pietruszka 1981: gasping, loss of righting response) were apparent within several minutes after flushing. In all cases mortality was the result of forcing the water stream past the pyloris and filling the intestine with water, which resulted in an immediate and irreversible inflation of the body and subsequent death. Death from stomach-flushing can also result from rupture of the stomach or esophageal wall, although this is realized principally in species with a gorging type feeding behaviour (Pietruszka 1981).

TABLE 2: Weight gain (g) as a result of stomach-flushing. Values are averages; SD in ().

Species	N	weight before	weight after	Percent change
Aporosaura anchietae	27	2.5 (1.0)	2.6 (1.0)	+5.03 (4.71)
Meroles cuneirostris	33	4.8 (1.5)	4.9 (1.5)	+2.69 (4.47)
Pachydactylus laevigatus	2	15.4 (4.0)	16.3 (4.2)	+5.51 (0.06)
Rhoptropus afer	36	3.5 (0.6)	3.7 (0.4)	+8.17 (12.76)
Meroles suborbitalis	2	6.5 (1.9)	7.1 (2.5)	+6.66 (6.69)
Mabuya capensis	2	3.5 (0.1)	3.6 (0.1)	+4.32 (1.96)
Angolosaurus skoogi	10	44.5 (28.2)	47.9 (30.5)	+6.17 (5.37)
Overall	112	–	–	+5.47 (8.36)

The potential for delayed mortality from stomach-flushing appears minimal for at least one of the species investigated. Subsequent work with individually marked *M. cuneirostris* (now) > 20 have been stomach-flushed), revealed no alteration of normal behaviour patterns over days to weeks, indicating the absence of latent effects from the procedure. Similar long term responses are expected for other Namib Desert species.

4 DISCUSSION

The results of the use of stomach-flushing on Namib Desert lizards generally agree with those conducted with North American species. Stomach-flushing represents an excellent non-destructive way of obtaining stomach samples for dietary analysis in lizard populations. An apparent difference of the present study from earlier work, however, is the greater potential among Namib species for lizard body size to affect stomach-flushing efficiency, with reduced efficiency in very small individuals. While for most species this influence appears to be small, it must, nevertheless, be considered in the analysis and interpretation of dietary data derived from stomach-flushing. To a large degree, however, such body size effects may be overcome by practicing the method on a particular species (Pietruszka 1981). It is, therefore, wise for researchers using the technique to familiarize themselves with it on fairly large lizards before applying it to smaller individuals.

The stomach-flushing procedure used in the present study is similar to that described by Legler & Sullivan (1979). The principal difference is associated with the prosthesis used to hold the mouth open during flushing. Legler & Sullivan's plastic rings, through which the stomach cannula was inserted, appear to be cumbersome and potentially injurious to lizards as they require additional manipulation of the lizard besides the actual flushing. This additional manipulation (forceps removal of food, cannula reinsertions) undoubtedly increases the trauma to lizards and may well have been responsible for the "slight to extreme lethargy" in stomach-flushed individuals noted by these authors. Because of this, Legler & Sullivan's variation of the stomach-flushing technique cannot be highly recommended.

As stomach-flushing is being applied to more and more species of lizards, the generality of its applicability is becoming apparent. The technique can be used in the field by a single worker and large numbers of lizards can be processed in a relatively short time. Based upon the lizard species used in this study, stomach-flushing should be widely applicable to Namib Desert species. Because of the high reliability and low mortality associated with the technique and hence the low impact on natural populations, stomach-flushing is the preferred method of obtaining dietary information for many species, especially where characterization of population diets is the study goal. The fact that diet samples can be obtained repeatedly from the same individuals through time (Legler & Sullivan 1979; Pietruszka 1981) allows for the investigation of individual feeding preferences and thus adds an important dimension to studies of feeding biology in lizards.

5 ACKNOWLEDGEMENTS

I wish to thank the Transvaal Museum and the Research Grants Division of the CSIR for financial support during this study. The Department of Agriculture and Nature Conservation provided the facilities and permission to work in the Namib-Naukluft Park. I also thank Dr. C.S. Crawford, Dr. M.K. Seely, Dr. W.S. Branch, and Prof. G. Louw for reviewing the manuscript.

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Improved method for staining skeletal components of tilapias and some other fish in Alizarin Red S

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ABSTRACT

The use of morphometrical characteristics in the identification of freshwater fish species require certain specialized techniques. The staining of vertebrae and other skeletal components proved to be a tedious and timeconsuming affair in the past. The method that will be presented allows the staining of certain fish skeletons to an extent that it is possible to identify individual bone segments within a period of two days at the most. It is also less expensive than previous methods.

1 INTRODUCTION

The current taxonomic criteria for the determination of tilapias are still mainly based on classical morphometric analysis (Avtalion *et al.*, 1976). Vertebrae and intermuscular bones, as well as ray and spine counts on fins, have greatly assisted to accomplish the taxonomic differentiation between species (Boulenger, 1899, 1915; Dannevig, 1932; 1950; Trewavas, 1966; 1983; Jubb, 1967; 1974). This is especially usefull in areas, such as the Eastern Caprivi, where several closely related species inhabit the same water bodies. To facilitate classical morphometric analysis, it was necessary to find a method whereby skeletal features could be rapidly and reliably distinguished.

Some of the most generally used techniques include the following: Russell's (1973) improved method (a modification of the method described by Davies and Gore, 1936); include a fixation period for at least one week, digestion for up to four days, staining for 12 hr., destaining and clearing for up to four weeks. Sedra's (1950) method on the other hand, takes about two weeks and Humason's (1962; 1967) methods six days to complete. Taylor (1967) and Dingerkus & Uhler (1977) proposed enzyme methods for the clearing and staining of small vertebrates. These methods, although very effective, are far too expensive for everyday use.

The present method differs from those of the abovementioned authors in that less fixation is required and less chemicals are thus used accordingly. It is mainly the elimination of fixation that is responsible for the time gain by this method. At the most, it will take about two days to complete this technique. It will thus enable taxonomists and morphologists who are interested in the counts of vertebrae, intermuscular bones, spines and even rays to differentiate more rapidly between species.

2 MATERIAL AND METHODS

The following procedure is a modification of the standard methods and can be used for staining the vertebrae and bones of Osteichthyes.

(i) Kill the fish by transferring it into 70% ethanol and remove it from the ethanol when dead.

(ii) The fish is skinned, dissected and enviscerated so that only a thin layer of muscle and connective tissue is left to keep the skeleton intact.

(iii) Immerse into staining solution for some time depending on the size of the specimen. (About three hours for a 10 cm fish and longer for bigger fish).

Staining solution: 0,5 g Alizarin Red S
500 ml (4%) Potassium hydroxide

(vi) Destain overnight, or until the muscles are transparent, in three parts of a 4% solution KOH and one part (100%) glycerine.

(v) Counts, photographs, and morphometrical characteristics of the skeleton can now be analysed and the specimen can be stored in one part (4%) KOH and three parts (100%) glycerine.

It is recommended that small fish (7-30 cm) are used as specimens because less chemicals are required and the handling of small fish is much easier.

3 RESULTS

4 DISCUSSION

This is a simple and effective method that helps skeletal evaluation in fishes. The tissue is partially digested in KOH, stained with alizarin and cleared by adding glycerine to the muscles of the fish. When completed, there is a brilliant red skeletal structure in the transparent muscle and connective tissue due to the faster destaining of these tissues in comparison with bone. The specimen can then be stored in 100% glycerine or embedded in plastic. The use of less fixation did not cause putrefaction of the speciemens; seeing that fish are being stored, at present, for more than a year and a half with no signs of decay.

This method was tested on the following species: *Tilapia rendalli, T. sparrmanii, Serranochromis robustus jallae, S. macrocephalus, S. angusticeps, S. thunbergi, Sargochromis giardi, S. carlottae, S. codringtoni, Oreochromis mossambicus, O. andersonii, O. macrochir, Hemichromis elongatus, Chetia flaviventris, Labeo capensis, L. umbratus, Barbus holubi* and *B. aeneus* and was proved to be successful in all cases.

5 ACKNOWLEDGEMENTS

The authors would like to thank the Department of Nature Conservation, South West Africa; and especially Mr. Grobler for the opportunity and help in collecting samples from the Caprivi.

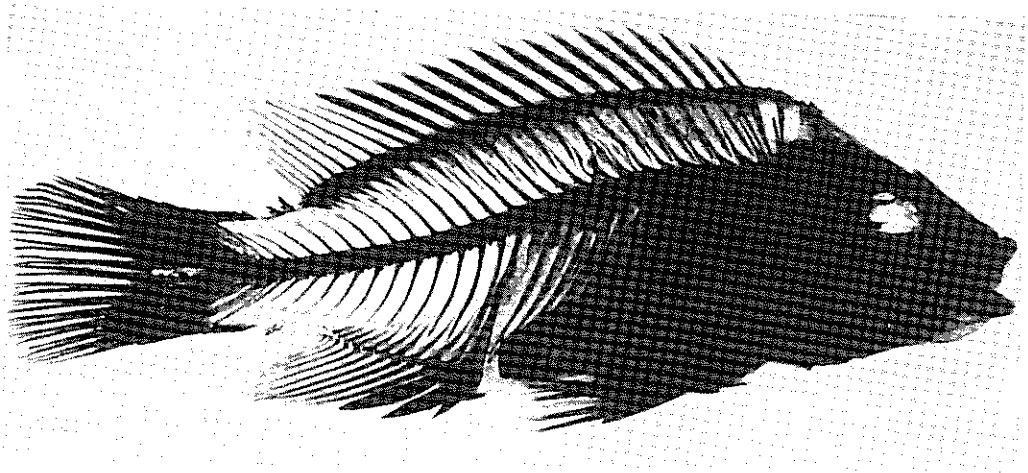

PLATE 1: *Oreochromis mossambicus* stained with Alizarin Red S.
It is evident that individual skeletal components such as vertebrae, pterygiophores, fin rays and spines can be clearly distinguished.

SHORT NOTE

New wintering records for the Sooty Falcon in southwestern Africa

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The breeding range of the Sooty Falcon *Falco concolor* extends from eastern Libya to the coast and islands of the Red Sea, the eastern Persian Gulf, Israel and southwards to Somalia (Cramp & Simmons 1980, Frumkin & Pinshow 1983). Sooty Falcons breed late in the boreal summer and autumn to take advantage of the large numbers of birds migrating southwards at that time of year (Moreau 1969). Sooty Falcons migrate to their main wintering area in Madagascar, where they remain from early December to May (Clapham 1964, Snow 1978).

Whereas in the past Sooty Falcons were considered rare vagrants to the southeastern coast of Africa (Clancey 1969), they are now frequently and reliably seen in Natal each year (Cyrus & Robson 1980), and occasionally in the Transkei and northeastern Cape Province (Brooke 1978, Vernon 1983). A single bird was seen near Johannesburg, Transvaal on 25 January 1983 (Sinclair, *et al.* 1986). Although Sooty Falcons may have been overlooked in the past, because of their quiet, crepuscular habits, G L Maclean *(personal communication) has suggested that there may have been a recent shift in their wintering range to southeastern Africa (Figure 1).

This may explain why many of the Sooty Falcons seen each year are immature birds (Clancey 1969, 1970, Brooke 1978, Hanmer & Blackwood 1983).

On the basis of sight records from Choma and Kitwe in Zambia (Penry 1979a & b) and one sight record from the Kalahari Gemsbok Park (Liversidge, *et al.* 1981), Hanmer & Blackwood (1983) suggested that there may be another wintering area in southwestern Africa.

On 20 February 1983 two fairly dark, uniform slaty blue-grey falcons were seen perched on a low *Acacia sp.* tree in the vicinity of Epukiro Mission in Hereroland East (21 41 S; 19 08 E). Although it was fairly late in the afternoon (about 17h00), there was sufficient light to identify these falcons as adult Sooty Falcons, before they flew off. Their uniform grey colour distinguished them from the more commonly seen Western Redfooted Kestrel *Falco vespertinus,* and the rare Dickinson's Kestrel *Falco dickinsoni.* Their wing tips extended slightly beyond the tips of their tails while perched, distinguishing these birds from the very similar Grey Kestrel *Falco ardosiaceus,* where the wing tips lie well short of the tip of the tail (personal observations, Cade 1982, Steyn 1982).

On 15 March 1983 an adult male Sooty Falcon was recovered alive in Windhoek (22 34 S; 17 06 E). The bird was in extremely poor condition, weighing only 125 ± 10 grams, and died two days after capture. Newton (1979, page 343) has documented the weight of an adult female to be 210 grams.

The latest Natal, Zambia and Malawi sighting dates, and those estimated by Snow (1978), suggest that the Namibia records fit well into the expected wintering period. Sooty Falcons prey on birds, bats and locusts

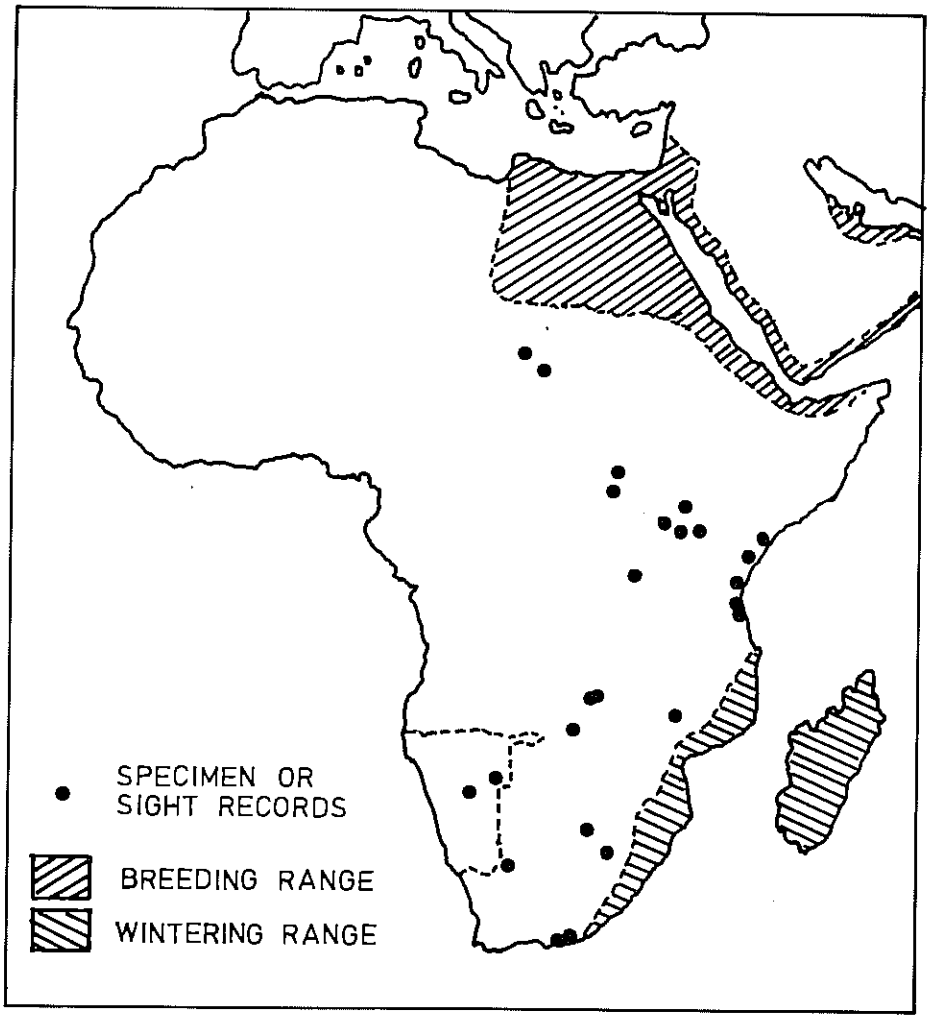

FIGURE 1: Breeding and wintering ranges of the Sooty Falcon. Adapted from Snow (1978).

in their winter quarters (Liversidge, *et al.* 1981), and therefore may not necessarily be precluded from occurring in the dry Namibia habitat.

The paucity of sight records from the central and western regions of southern Africa, suggest that these first records of Sooty Falcons in Namibia were probably of vagrant birds.

ACKNOWLEDGEMENTS

I Sinclair and the SAOS rarities committee are thanked for accepting the identity of the Epukiro and Windhoek Sooty Falcons and C Brown is thanked for useful comments on an earlier draft of this note. R Brooke kindly extracted appropriate literature from the PFIAO library. R. Orford is acknowledged for keeping vigil during the Windhoek Sooty Falcon's last few days of life. The Secretary of National Education is acknowledged for permission to write this note.

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SHORT NOTE

Extension of the breeding range of the African Black Oystercatcher *Haematopus moquiini*

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The African Black Oystercatcher *Haematopus moquiini* is endemic to the coasts of southern Africa between Transkei on the Indian Ocean coast and the Skeleton Coast park in SWA/Namibia (Hockey 1983a). The established northerly breeding limits are Lüderitz (26°20'S 15°20'E) on the mainland and Ichaboe Island (26°20'S 14°59'E) offshore (Hockey 1982a, Hockey in press). Nonbreeding birds have been recorded as far north as Lobito, Angola (12°35'S 13°25'E) (Hockey 1982b). Observations by staff of the Skeleton Coast Park, reported here, have extended the known breeding range of this species by *c.* 800 km.

On 11 February 1984 two eggs were found in a nestscrape about 2 km south of the Hoanib River mouth (19°30'S 12°50'E). The nestscrape was situated among scattered dry *Laminaria* kelp strands just above the high water mark. These eggs had disappeared when the nest was checked again on February 18 and were possibly taken by Blackbacked Jackal *Canis mesomelas* as fresh jackal tracks were found near the nest. A second nest was found about 100 m above the high water mark among vegetated sandy hummocks on the south bank of the Hoanib River on March 4. The eggs in this nest were found deserted on April 2. Because of the small (max. 16 birds) local population and the timing of two clutches it is suspected that both breeding attempts were made by the same pair. The main egg-laying period of this species in South Africa is between December and February with a January peak and most replacement clutches are laid after late January (Hockey 1983b, Maclean 1984).

Both clutches were of two eggs. Average measurements were 58.1 x 40,8 mm with a range of 58.0-58.4 x 39.9-42.1 mm. these are smaller than the established average size of eggs of this species (60.7 x 40.1 mm) but well within the normal size range of 55.8-65.2 x 37.9-43.7 mm (Hockey 1983b). Further observation is needed to establish whether breeding is regular so far north of the established breeding range and whether one or more pairs are involved.

I thank A.J. Williams and P.A.R. Hockey for help in revising the text of this communication.

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SHORT NOTE

A first record for *Prosymna visseri* in southern Africa.

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The small snake *Prosymna visseri* was previously known from three specimens all collected in Angola, and housed in the Transvaal Museum, Pretoria. While looking for geckos north-west of Kamanjab, the writer encountered a specimen in a deep granite fissure about 3m above ground level. The locality is at 19° 25' S, 14° 29' E.

Morphologically the specimen agrees with the descriptions by FitzSimons (1957) and Broadley (1980) except that the loreal shield is fused with the large prefrontal so that the latter is in contact with the first and second upper labials. There is also a very small interparietal at the anterior end of the interparietal suture.
Lines of pits are present along the hind-margin of the internasal and prefrontal; also along the lateral margins of the frontal.
The specimen is a male, ventrals 189, subcaudals 52. Stomach empty.
Dimensions, HB 263, tail 60 mm. The colour-pattern of the head is slightly different from the specimen figured by Broadley (1980:543, fig. 18). The pale vertebral stripe which was yellowish in life, does not bifurcate on the nape but stops abruptly two scales behind the head-shields. Where the lateral arms of the bifurcation would have been there are two pale triangular marks (see plate 1).

The addition of this species to the list of Namibian snakes means that no less than four species of *Prosymna* occur in the northern half of the territory — *P. visseri, angolensis, frontalis* and *bivittata.*

P. visseri differs from all the other members of the genus *Prosymna* in habits, as all the known specimens have been found deep in granitic fissures where they presumably seek food, probably in the form of gecko eggs. The country north-west of Kamanjab is mopane woodland with bold granite koppies and outcrops, hence the name Kamanjab which means "large rocks". The rainfall averages 325 mm per annum. The specimen SAM 46951 is housed in the South African Museum, Cape Town.

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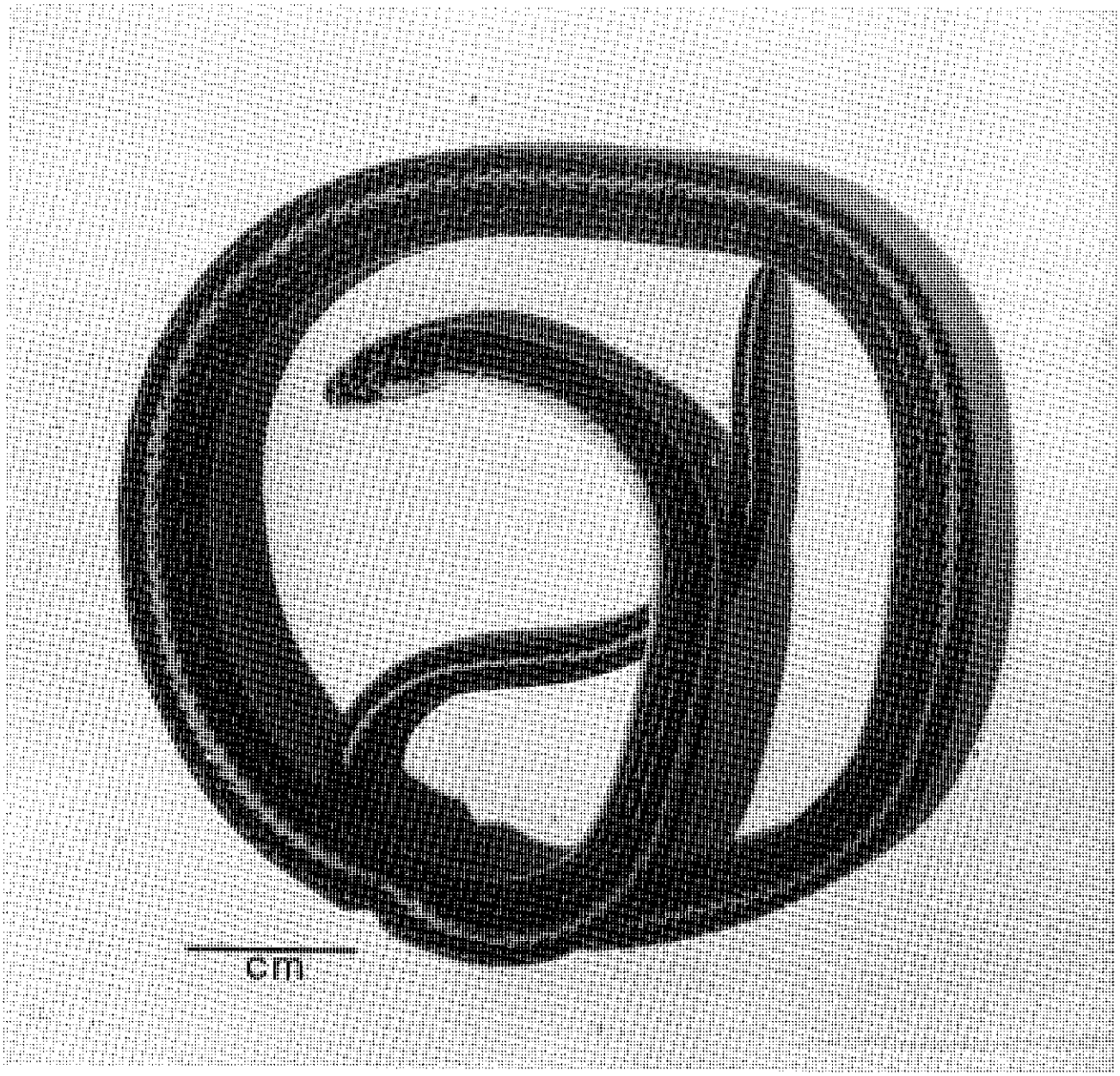

PLATE 1: *Prosymna visseri* from north of Kamanjab.

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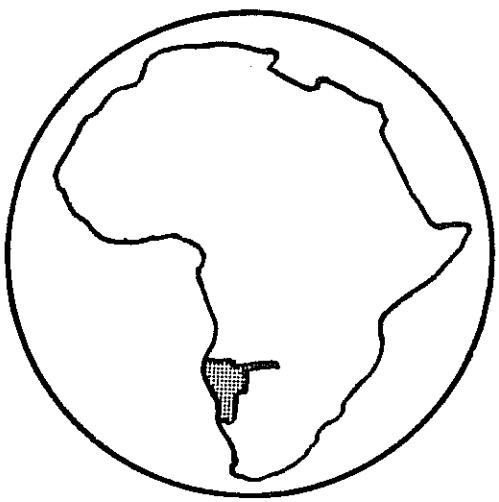
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