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Distribution and control of photosynthetic pathways in plants growing in the Namib Desert, with special regard to *Welwitschia mirabilis* Hook. fil.

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Lehrstuhl für Pflanzenökologie der Universität Bayreuth

**ABSTRACT**

The present study investigates the physiological bases of species which compose the typical vegetation types of the Northern Namib: the savannas, the subtropical grasslands and the succulent deserts. The relative role in terms of vegetation cover and species diversity of the various pathways of photosynthetic production (*Crassulacean acid metabolism, CAM* type; *C₄*-dicarboxylic-acid metabolism, *C₄* type; and *Calvin* type of CO₂-fixation, *C₃* type) is determined and the environmental factors responsible for the distribution of the various metabolic types is discussed. In the savanna almost half of the total species and about two thirds of the vegetation cover belong to plants with the *C₃* type of metabolism. *C₄* plants dominate the zone of tropical grasslands, whereas CAM and the *C₄* type of metabolism are most important in the coastal desert in terms of cover and species diversity. In the case of *Welwitschia mirabilis* representing the CAM type, water stress and saline conditions cannot explain the geographical variation of CAM. However, temperature seems to be a decisive factor. Night temperatures are probably too high for CAM in the grassland zone. In contrast to CAM is the *C₄* metabolism: plants with this metabolism are specially adapted to the hot and dry climate of the inland region of the desert belt. It is probably too cold in the coastal area for the *C₄* type of CO₂-fixation to be efficient enough competitively.

**1 INTRODUCTION**

During plant evolution various options of CO₂-fixation during photosynthetic production have evolved in plants, each adapted to special conditions of the natural environment (Evans, 1971; Marcelle, 1975). The normal type of CO₂-fixation operates via the Calvin cycle and to this group of so-called *C₃* plants belongs the majority of higher plant species. They are most successful in moderate environments, but form an important part of the arid flora of the world as well. However, under extreme conditions of stress — especially those of water, high temperature and salinity — plants having other physiological pathways of CO₂-fixation seem to be better adapted (Hatch et al., 1971). *Crassulacean acid metabolism (CAM)* is probably most commonly known (Klug, 1972) and provides one way of increasing the efficiency of water use during photosynthetic production (Ting and Szarek, 1975). Under certain conditions of environmental stress, some species, mostly the succulents, close their stomata during the dry and hot part of the days and thus reduce water loss, whereas during the cool and more humid conditions prevailing at night they take up CO₂. It has been shown repeatedly that these species selectively opt between CAM and *C₄* metabolism according to the environmental conditions prevailing (Osmond, 1973). But there is another specialized way of CO₂-fixation which is physiolog-
ically related to CAM. However, in contrast to CAM, where malate is formed and used in a night-day cycle, C₄ acids are respectively produced and metabolized in spatially separated mesophyll and bundle sheath cells. Also contrary to CAM plants, C₄ plants have been shown to be specially adapted to high temperatures and strong sunlight (Björkman, 1971). Due to an absence of photorespiration, they have a most efficient water use at a high absolute level of CO₂ uptake and waterloss with open stomata during the hot and dry time of the day (Pearcy et al., 1974).

The ecological significance of various options of photosynthetic production in higher plants has often been stressed (Marcelli, 1975). However, little information is available on the geographical patterns, the relative role of such specially adapted plant species in the vegetation cover, and the environmental factors which are responsible for the distributional range (Mooney et al., 1974; Osmond, 1975; Osmond et al., 1975). This problem was investigated along a climatic gradient in an arid region of the Namib Desert, with its distinct distribution of savanna in the inland, grassland in the central region and succulent flora at the coast.

2 METHODS

The investigations were carried out in February 1975. Plant material (1-2 g fresh weight) of all species of representative sample plots, was collected on a transect from the inland to the coast in the northern (Khorixas-Torrabey) as well as in the middle (Uis-Brandberg-West-Cape Cross) and in the southern (Gobabeb-Swakopmund) distributional areas of Welwitschia mirabilis. Since it was the general aim of this study to get to know more about the distribution of Welwitschia (see also Schulze et al., 1976) the sample areas were selected according to the presence of this species. The vegetation cover was very dry during the time of investigation. Although an attempt was made to get as complete a species list as possible by collecting dead and remnant plant material from the various sites, it cannot be overlooked that in such an arid area species composition and cover might be completely different after a rain. The present study primarily includes, therefore, perennial phanerophytes, chamaephytes and hemicyryptophytes, as well as annuals with woody stems.

Total plant cover and the cover of trees, shrubs, herbs, grasses and succulents were estimated. This proved to be difficult in some habitats because of the large scatter and patchy distribution of the vegetation. In the data following, average values were calculated on 2 to 3 independent estimates at each site.

The discrimination rate of heavier ¹³C as compared with lighter ¹²C during the process of CO₂-fixation was taken as an indication of the metabolic pathway exhibited by the various plant species (Smith and Brown, 1973). The discrimination rate was defined by the ¹³C/¹²C sample:

\[ \delta^{13}C = \frac{1000}{1000} \times \frac{[13C]/[12C]_{\text{sample}}}{[13C]/[12C]_{\text{standard}}} - 1 \]

C₄ plants usually show a δ¹³C value of about -12 %/oo, and C₃ plants exhibit a δ¹³C value of about -27 %/oo. Succulent plants capable of CAM may vary within this range of discrimination rates because of their ability to change their metabolic pathway between light and dark fixation of CO₂ (Bender et al., 1975). The determination of the ¹³C and ¹²C content was made with a mass spectrometer as described in detail by Osmond et al., (1975). For Welwitschia the length of the green leaves and the stem diameter was determined. Total ash content was measured during the preparations for mass spectrometry. Chlorine (Cl⁻) content was measured by titration.

We are very grateful to the South African National Department of Education, Pretoria, who supported these studies. We also thank the South West African Department of Nature Conservation (Mr. de la Bat), the Wissenschaftliche Gesellschaft in Windhoek (Dr H. J. Rust) and the Director of the SWA Herbarium (W. Gies) for helpful assistance and many supporting suggestions. We are also obliged to Prof. O. H. Volk, Würzburg, who helped during initial planning of this work and with plant identification, and to Prof. Dr H. Walter for valuable discussions.

3 CLIMATIC CONDITIONS OF THE NORTHERN AND CENTRAL NAMIB

The Northern and Central Namib is a 50-150 km broad coastal zone ranging from the southern border of Angola to the Kuiseb river in South West Africa (Gies, 1970). It is characterized climatically by the cold Benguela current. There are few climatic data available for the Northern Namib. However, the principle change of climate from the coast to the inland becomes obvious from measurements made in the Central Namib by Beseler (1972). Figure 1 shows only a few mm of rainfall at the coast. Rains are very rare; however, there are frequent heavy fogs and dewfalls. With increasing distance from the coast, precipitation by summer rains increases up to 100-150 mm at the inland border of the desert area (Walter, 1973). There is a cool, oceanic temperature climate at the coast with only 5°C temperature difference between the average minimum and maximum day temperatures. With increasing distance from the coast, maximum temperatures increase rapidly. In Figure 1 the highest temperatures are reached about 60 km from the coast. But this station (Gobabeb) is still influenced by drifting coastal fogs, whereas the next station (Ganub) is already at the inland edge of the desert zone about 1,000 m above sea level. It is quite likely that higher average temperatures occur between these two stations. Night temperatures decrease in the vicinity of the coast because of increasing night radiation.
DISTRIBUTION AND CONTROL OF PHOTOSYNTHETIC PATHWAYS

Figure 1. The change of absolute maximal temperature (abs. max. temp.), average maximal temperature of the rain season (av. max. temp. rain season), average minimal temperature of the rain season (av. min. temp. rain season), the potential evaporation (pot. evap.) and precipitation in the Northern (N) and Central (C) Namib as related to the distance from the coast.

But further inland, night temperatures also increase considerably and, as was pointed out above, it is very likely that night temperatures are higher in the inland region of the desert area. Because of increasing temperatures, the aridity (expressed by the difference between potential evaporation and precipitation) increases two-fold in the inland area as compared to the coast.

4 RESULTS AND DISCUSSION

Figure 2 shows the change of relative cover of various morphogenotypes (trees and shrubs, grasses, succulents) in the vegetation along a transect from the inland to the coast in the Northern Namib. The data points indicate an average value of 2—3 independent estimates at similar sites because of the rapidly changing and patchy vegetation in an arid habitat. For detailed description of the vegetation, see Walter (1975), Giess (1970) and Volk (1966). At about 140 km from the coast, the savanna, dominated by *Colophospermum mopane* (*Caesalpinioideae*), has a total plant cover of about 15—25%, approximately two-thirds of which is trees, herbs and shrubs and one third is grasses. There is a very sparse cover of succulents. *Welwitschia* grows in some places (Plate 1, Farm Bloemhof) with numerous specimens of small stems (up to 28 cm stem diameter, 63 cm length of green leaf). Closer to the coast, there is an abrupt change in vegetation. The total plant cover decreases. Trees and shrubs can exist only on stony hill sites or as 'contracted' vegetation in the dry valleys. The vegetation is more and more dominated by grasses, which are eventually almost the only life form in this zone of subtropical grasslands. Plate 1 shows this region at 60 to 80 km from the coast. Also in this zone succulents have only a small cover. *Welwitschia* occurs with few but very large specimens (up to 78 cm stem diameter and 170 cm length of green leaves). With decreasing rainfall, not only does grass cover become sparse (Plate 2), but all other plants are rare. *Welwitschia* occurs as large plants which, however, often have very short leaves (up to 95 cm stem diameter, 55 cm length of leaves). There is another abrupt change in vegetation at the coastal zone. Following a 'full desert', where *Welwitschia* was found in some cases to be the only living plant species (Plate 3), there is the zone of heavy coastal fogs and dawfalls. It is dominated by succulent, evergreen dwarf shrubs and lichens (Plate 4). In this area large specimens of *Welwitschia* were found (up to 170 cm stem diameter, 135 cm length of leaves). Larger specimens of *Welwitschia* than those observed in this investigation were reported by Giess (1969) in a general survey of the distribution area and by Bornman et al., (1972).

The relative change in life forms and morphogenotypes on the transect from the inland to the coast — which also was found on an elevational gradient in Baja, California, and in Chile (Mooney et al., 1974, a; Rundel and Maah, 1976) — is accompanied by a corresponding change in the dominant option of photosynthetic pathways of the species present. Plate 5 shows the number of C3, C4 and CAM species in relative terms based on the total species number found in the different habitats. The relative proportion of C4 species is small in the savanna. This vegetation type is dominated by C3 species. There is also quite a variety of CAM plants. In the grassland area (70 km distance from the coast), there is a conspicuous increase in the relative number of C3 species, whereas the relative number of C3 and CAM species decreases. When considering only the perennial vegetation, the C4 type would be almost the only morpho-genotype in this zone. Moving closer to the coast, the relative proportion of C3 species increases slightly. More conspicuous is the large increase in relative number of CAM species and a strong decrease of the C4 type. Table 1 shows the species being investigated so far. The C3 species having a δ13C value of -22 to...
—25 %/o belong to a great variety of families. This is different with the C4 species, which belong almost entirely to the Gramineae. The succulent species and the aphyllous shrubs, together with Welwitschia, are a very heterogenous group of plants. Some of the aphyllous succulent shrubs (e.g. Arthrocoma leucobata) and some of the succulents (Zygophyllum starfishii) seem to belong to the C4 type of metabolism. With some other species (Hoodia currarii, Sarscoaulon viminalis) it is not clear from the δ13C ratio if they belong to the group of CAM or of C4 plants. More work is necessary on this subject.

It is an important ecological question which environmental factors cause this typical zonation of vegetation in this area (see also Walter, 1956, 1959). For CAM plants this has been studied most extensively for Welwitschia (Schulze et al., 1976). Figure 3 shows the δ13C values of various C3 and C4 species and of Welwitschia as related to the geographic distance from the coast. It is obvious that Welwitschia does not have a constant δ13C value as was found for C4 plants (—12.8 %/o) or for C3 species (—23.8 %/o). The differences between the δ13C values of Welwitschia and the C4 species is largest in the coastal zone but it is not statistically different from the C3 species in the grassland area; however, it is again significantly different in the savanna. The data not only indicate that Welwitschia is capable of CAM, which has already been shown in the laboratory (Dittrich and Huber, 1975) and cytologically (Whetley, 1975), but that the proportion of CO2 fixed via CAM is largest at the coast and smallest in the grassland region.

It has been observed that plants which are capable of performing CAM have the ability to change between CAM and C4 metabolism and that various environmental factors may be responsible for such change (Neales, 1975; Osmund, 1975). Increasing salt stress was found repeatedly to induce CAM (Winter and von Willert, 1972). This factor does not seem to be responsible for the metabolic change in Welwitschia. Schulze et al. (1976) showed that the relative chloride content of leaf tissue increases from inland to the coast and shows no relation to the corresponding δ13C value. Also, the ash content of the tissue, being a measure of the total anion and cation content, shows that the less negative δ13C values are not obtained at high ash content, as would be expected if such a relationship existed. It was already shown by Walter (1936) that Welwitschia is not a typical halophyte.

Water stress was found to cause a change from the Cs pathway to CAM (Kluge et al., 1973). It cannot be ruled out that this factor causes a change in the metabolism of Welwitschia. In the savanna, for instance, sun-exposed plants showed less negative δ13C values (i.e. more CO2 fixed via CAM) than plants growing in the shadow of trees (Schulze et al., 1976). However, it is not likely that water stress induces the change in metabolism on a broad geographical scale. The largest specimens, with fresh green leaves were found with CAM just in the coastal area, and not in the grassland zone where they did exhibit the Cs metabolism which is usually found in non-stressed plants. In this region the total length of the yellow-green leaves was often reduced by dying of the leaf tips (Walter, 1973). There is no correlation between total leaf length and the δ13C value. But this is not a final proof, since the δ13C value represents the conditions during the period of active growth and it may be that water conditions during that time of year are better in the grassland zone than they are near the coast. Additional measurements are necessary to solve this problem.

Temperature was found to significantly influence CAM (Kluge et al., 1973; Neales, 1973). Osmond et al. (1973) showed that for Kalanchoe blossfeldiana an increase of night temperature of only 5°C could determine whether or not CAM was possible. Figure 1 shows a very cool climate for the coast and an increase of night temperatures further inland. This increase would be in a range of temperatures that could cause a change from CAM to Cs metabolism in other succulent species. The present data indicate that temperature regime and water stress as modifying factors determine the night fixation of CO2 in Welwitschia. The high water use efficiency associated with CAM would allow a continuous growth at a low rate in the coastal climate. In the grassland zone the high night temperatures cause a change to Cs metabolism, but since growth rates are larger with Cs metabolism than with CAM (Osmond, 1973), this again may be advantageous for competition with other plants during the rainy season. The drying of leaf tips occurs then only in the dry season at a time when other perennial and annual species are dormant.

Contrary to the behaviour of CAM plants is the metabolism of that of the Cs species. They were found to be specially adapted to hot conditions, with strongest production at a high light intensity (Björkman, 1973). The distribution of Cs plants, which in the study area are mainly represented by the grass type, strongly reflects this climate situation. The highest temperatures, which exist inland of the belt of coastal fog, favours the existence of Cs species. Besides a few annual herbs and some succulents, the vegetation is dominated by Cs species. Only a relatively narrow range of conditions favours this metabolism. At the coast, as well as further inland,
the C₄ species are not as successful, which is obvious from the relative number of species as well as from the relative vegetation cover.

The C₃ species were found to be most important in the higher rainfall areas of the savanna. This metabolic type is almost absent among perennial plant species in the actual zone of the grassland, due primarily to drought and heat. It is surprising, however, that in the coastal area, which has been described as most extreme in terms of rainfall, the C₃ type of metabolism is quite successful again. In this range it is very often found even in aphyllous succulent dwarf shrubs. Although further experimental work is necessary, the present data indicate the influence of environmental conditions on the geographical distribution of various types of metabolic pathways which determine the specific vegetation cover.

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Table 1. List of investigated species. Average values of multiple determinations of the $^{13}$C value are indicated by +.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>$^{13}$C %/o</th>
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<tr>
<td>1. Cs plant species</td>
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<tr>
<td>Acanthaceae</td>
<td>Monoclea arnica</td>
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<td>Monoclea genistijllium</td>
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<td>Adenolobus pociueli</td>
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<td>Capparaceae</td>
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<td>2. Cs plant species</td>
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<td>Weitelschia nitribils</td>
<td>-20.72 +</td>
</tr>
<tr>
<td></td>
<td>Zygophyllum duplex</td>
<td>-14.03 +</td>
</tr>
<tr>
<td></td>
<td>Zygophyllum stapfii</td>
<td>-23.23 +</td>
</tr>
</tbody>
</table>
Plate 1. Vegetational aspect of the mopane savanna with *Colophospermum mopane* (Caesalpinaceae). In the foreground several specimens of *Walvietzia mirabilis* (Walvitiaceae) and *Cadaba aphylla* (Cyperaceae) can be seen. The spaces between the trees is covered with grasses (*Sipagrostis hirtigluma, Fagonia villosa*).

Plate 2. Vegetational aspect of the grassland zone with great cover and species diversity of *Gramineae*. Several specimens of *Walvietzia mirabilis* can be seen.
Plate 3. Transition zone of grassland and full desert with a sparse cover of mainly Stipagrostis species. There are few herbaceous plant species (Gisakia, Heliotropium, Mouemat) and Welwitschia mirabilis.

Plate 4. Aspect of a ‘full desert’ with Welwitschia mirabilis only.
Plate 5. Vegetational aspect of the coastal fog desert with *Wolffia fruticulosa mirabilis* and many other succulent and evergreen dwarf shrubs (*Atriplex leubnitziae*).
Body measurements, carcase and organ mass of mammals from the Etosha National Park

by

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Division of Nature Conservation and Tourism, Windhoek

ABSTRACT

The measurements and mass of zebra Equus burchelli antiquorum, springbok Antidorcas marsupialis, gemsbok Oryx gazella and wildebeest Connochaetes taurinus, as well as the mass of certain organs and the hides from these animals are recorded. These animals were shot to feed cheetah Acinonyx jubatus which were being introduced to the Etosha National Park. The mass of the animals and certain organs are compared with similar data from elsewhere in Africa.

1 INTRODUCTION

During the period of January to April 1970, a number of ungulates were shot to feed captive cheetah which were being introduced to the Etosha National Park. Those animals were zebra Equus burchelli antiquorum, springbok Antidorcas marsupialis, gemsbok Oryx gazella and wildebeest Connochaetes taurinus. The animals were measured, their mass determined and dressed and the mass of their organs determined. The mass of some of the cheetah Acinonyx jubatus were determined and measured upon arrival in the Park. Mass and measurements of animals destroyed for other purposes have also been included. This paper provides mass and measurements to partially fill a gap which exists in the literature on published mass and measurements. Due to certain practical considerations the accepted dressing methods could not be followed.

2 METHODS

Depending on the mass of meat required to feed the cheetah, one to three animals were shot per day and usually before 09h00. Neck shots were preferred as blood loss was minimal. The carcases were transported to the temporary abattoir where they were measured and their mass determined with a suspended spring balance. Thereafter each carcase was skinned to behind the head and down to the fallcots. During the slaughtering process, the heart, lungs, liver, spleen and kidneys were removed and their mass determined provided they were undamaged. In each case the mass of the organ itself was determined after all attached arteries, veins, membranes and surrounding fat had been removed, in order to obtain uniformity in mass determination procedures. In all cases the hearts were opened and drained of blood.

The mass of springbok were determined from a smaller spring scale while all organs had their mass determined on a pan scale. The mass of the skins weights were determined by subtracting the mass of the skinned carcase from the unskinned carcase. The mass given below are from adult animals as determined by an examination of the dentition and age determinations, based on dentition, were carried out on zebras and springbok according
to the methods prescribed by Klingel (1965) and Rautenbach (1971) respectively.

In cases of pregnant animals the mass of the gravid uterus was deduced from the animal’s total mass.

Measurements taken were those as prescribed by Roberts (1951) with heart girth as an additional measurement and is therefore directly comparable to some of the measurements given by Sachs (1967).

The original measurements were in British Standard Units: for this paper those have been converted to the Metric system.

3 RESULTS AND DISCUSSION

3.1 Springbok

The results are shown in tables 1, 2, 3 and figure 1. In the case of the springbok, an attempt was made to collect large individuals only and this has resulted in a certain amount of bias in favour of large adults. However, this was done with the purpose of ascertaining maximum mass for this subspecies as it is claimed to be the largest of the species (Roberts, 1951). Numerous persons, especially hunters (A. Port, P. Brand, pers. comm.) have questioned the validity of this. There is no doubt that *A. m. angolensis* is larger than *A. m. mar supremacistus* from places such as the Transvaal and Northern Cape (Table 3) but it does appear, from the few collected by J. Hofmeyr (pers. comm.) that those *A. m. hofmeyri* from the southern half of South West Africa are heavier than *A. m. angolensis*. Considering the fact that the mass given by J. Hofmeyr represents total body mass less blood (these springbok were bled) then an increase of 11.5% (males) is remarkable. Unfortunately the mass of the one female, as supplied by J. Hofmeyr, includes the foetus.

According to T. Lichtenstein (pers. comm.) springbok in southern South West Africa lamb twice a year and on his farm (Locholklo) juveniles of all ages can be seen, presumably a result of the exceptional rains of 1973-1974. This differs from the springbok in Etosha where there is only one main lambing season: December to February.

Should the indication that springbok from the southern SWA are the heaviest be confirmed at a later date when more data is available, further investigation will probably show that an environmental factor is responsible. P. Brand (pers. comm.) has indicated that springbok collected from this area carry much fat whereas those from the Etosha National Park had very little fat deposits.

3.2 Zebra

It is of interest to note that a mass difference of 11.5% exists between male *E. burchelli* from SWA and Hluhluwe Natal, and this difference can probably also be ascribed to differences in habitat. It also appears that no significant mass difference exists between *E. burchelli*, from South West Africa and those from Central Africa although the mass given for those from Serengeti appear to be extremely low when compared with those from the Luangwa Valley. (Note: Hitchins, Sachs and authors cited b von le Chevallerie and Robinett omitted to name the subspecies involved. Three subspecies occur in Zambia *E. b. boehmi*, *E. b. seioasi* and *E. b. antiquorum*, according to Sidney (1965) and from the localities given in Table 3 it would appear that most of them are *E. b. boehmi* and those from Natal would be *E. b. antiquorum*.

3.3 Wildebeest

Wildebeest from the various localities (Table 3) do not differ significantly in mass (range for males 201.1-245 kg) excepting for *C. taurus* from the S.A. Lombard Game Reserve, Transvaal. The last mentioned were introduced into this area.

3.4 Gemsbok

No reliable references could be traced, underscoring the paucity of information which exists in this field. However, the oryx has a discontinuous distribution in Africa with *O. gazella* occupying the arid South West and the others i.e. *O. beisa*, *O. galleratus*, *O. angasii* and *O. callosus* distributed over central and northern Africa from Tanzania to the Red Sea coast (Ansoll, 1971). All members of the species appear to favour arid regions and make mass comparisons interesting. *O. beisa* and *O. callosus* appear to have the same mean mass with *O. gazella* somewhat heavier (10-12%).

3.5 Cheetah

Lamprey (1964), citing Meinertzhagen, gives mass for cheetah from an unspecified locality. These mass are considerably heavier than those from SWA. However, the cheetah from SWA were in a rather poor condition but even if they had been in good condition it is questionable if they would have come close to the mean cited by Lamprey.

3.6 Organ mass

The comparative differences which exist between the organ mass of the species are shown in figure 1. Most of these differences are insignificant. The small spleen mass of the springbok is probably due to a more severe catecholamine reaction at the time of death than a species reaction. Hofmeyr, Louw and du Preez (1973) have shown that sufficiently alarmed and stressed zebra elicit autonomously controlled reflex reactions which are typically brought about by the catecholamines and it is suspected that in springbok the same reactions are elicited even when shot.
4 CONCLUSION

There appears to be significant variation in mass of the animals discussed, especially intra-specific, which again supports the separation of the species. However, this could be more a case of environmental factors contributing to mass differences, as shown by A. m. hofmeyri from southern South West Africa and those from the Transvaal and Northern Cape. Zebra also show differences but the wildebeest appear to adhere to a common mean mass. There also appears to be a significant difference in mean mass between the southern and northern subspecies of Oryx gazella. From the little information available on cheetah it would also appear that large mass fluctuations could be expected between different populations.

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VAN ZYL, J. H. M.

VON LE CHEVALLERIE, M.
Table 1. Mean values and ranges (in parenthesis) of body mass and body measurements according to sex of animals from the Etosha National Park.

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>No.</th>
<th>Mass (kg)</th>
<th>Head and body</th>
<th>Tail</th>
<th>Hind foot</th>
<th>Heart girth</th>
<th>Shoulder height</th>
<th>Ear</th>
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<td>Zebra</td>
<td>m</td>
<td>30</td>
<td>307.3 (261–362)</td>
<td>223.0 (209.6–246.4)</td>
<td>46.3 (31.8–52.1)</td>
<td>55.1 (45.7–57.8)</td>
<td>145.1 (137.2–163.8)</td>
<td>138.0 (123.1–140.9)</td>
<td>16.1 (14.6–17.9)</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>16</td>
<td>289.6 (236–358)</td>
<td>223.9 (203.2–240.7)</td>
<td>46.7 (40.0–53.3)</td>
<td>52.3 (48.3–55.9)</td>
<td>140.4 (129.3–156.2)</td>
<td>136.7 (127.0–152.4)</td>
<td>16.5 (15.2–17.2)</td>
</tr>
<tr>
<td></td>
<td>m + f</td>
<td>46</td>
<td>301.2</td>
<td>222.2</td>
<td>46.5</td>
<td>52.8</td>
<td>145.5</td>
<td>138.1</td>
<td>16.3</td>
</tr>
<tr>
<td>Gemsbok</td>
<td>m</td>
<td>7</td>
<td>194.1 (170–222)</td>
<td>187.7 (173.3–204.5)</td>
<td>49.2 (41.9–57.2)</td>
<td>51.9 (50.2–53.3)</td>
<td>151.7 (142.2–160.0)</td>
<td>150.6 (140.5–150.7)</td>
<td>20.2 (19.1–21.6)</td>
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<td>f</td>
<td>4</td>
<td>197.3 (179–213)</td>
<td>186.1 (177.8–194.3)</td>
<td>51.8 (48.9–54.6)</td>
<td>51.9 (50.5–52.1)</td>
<td>153.4 (141.9–158.8)</td>
<td>134.0 (132.1–139.7)</td>
<td>20.2 (19.1–21.6)</td>
</tr>
<tr>
<td></td>
<td>m + f</td>
<td>19</td>
<td>195.3</td>
<td>187.1</td>
<td>50.1</td>
<td>52.0</td>
<td>152.3</td>
<td>135.5</td>
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<td>Springbok</td>
<td>m</td>
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<td>136.5 (119.4–138.4)</td>
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<td>125.9 (123.2–124.5)</td>
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<td></td>
<td>m + f</td>
<td>20</td>
<td>39.8</td>
<td>126.3</td>
<td>27.7</td>
<td>41.3</td>
<td>82.9</td>
<td>88.0</td>
<td>17.6</td>
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<td>Wildebeest</td>
<td>m</td>
<td>15</td>
<td>221.3 (177–254)</td>
<td>154.7 (185.4–207.0)</td>
<td>59.6 (55.9–64.8)</td>
<td>52.0 (49.5–57.8)</td>
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<td>143.3 (132.1–148.6)</td>
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<td>–</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>m + f</td>
<td>15</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Cheetah</td>
<td>m</td>
<td>8</td>
<td>44.1 (38.6–57.0)</td>
<td>170.8 (126.4–141.0)</td>
<td>71.6 (68.0–81.5)</td>
<td>30.1 (27.9–31.8)</td>
<td>70.1 (66.0–78.7)</td>
<td>85.7 (78.7–96.5)</td>
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<td></td>
<td>f</td>
<td>8</td>
<td>35.9 (29.5–44.5)</td>
<td>124.8 (117.5–134.6)</td>
<td>68.3 (62.2–76.2)</td>
<td>28.3 (27.3–30.5)</td>
<td>67.0 (54.6–89.9)</td>
<td>80.8 (75.7–87.6)</td>
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<tr>
<td></td>
<td>m + f</td>
<td>16</td>
<td>40.0</td>
<td>127.8</td>
<td>70.0</td>
<td>29.2</td>
<td>66.6</td>
<td>83.5</td>
<td>7.5</td>
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<tr>
<td>Species</td>
<td>No. of hides</td>
<td>Mean mass</td>
<td>% of mean body mass</td>
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<td></td>
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<tr>
<td>Zebra</td>
<td>35</td>
<td>22.4</td>
<td>7.4%</td>
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<td>Gemsbok</td>
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<td>8.2%</td>
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<td>Springbok</td>
<td>20</td>
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<td>5.5%</td>
<td></td>
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<td>Wildebeest</td>
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Table 3. Comparison of live body mass of various species from different localities.

<table>
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<tr>
<th>Species</th>
<th>Sex</th>
<th>No.</th>
<th>Mass (kg)</th>
<th>Range (kg)</th>
<th>Locality and Author</th>
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<tbody>
<tr>
<td>Springbok</td>
<td>m</td>
<td>18</td>
<td>40.8</td>
<td>34.7 – 46.5</td>
<td>E.N.P. (S.W.A.) – Present study</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>2</td>
<td>30.9</td>
<td>29.9 – 31.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>4</td>
<td>42.0</td>
<td>33 – 50</td>
<td>S.W.A. – Skinner et al. (1971)</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>3</td>
<td>40.5</td>
<td>31 – 45</td>
<td>Holfrey</td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>5</td>
<td>36.0</td>
<td>29 – 42</td>
<td>R.S.A. Unknown locality – Skinner et al. (1971)</td>
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<tr>
<td></td>
<td>f</td>
<td>7</td>
<td>30.7</td>
<td>24 – 32</td>
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</tr>
<tr>
<td></td>
<td>m</td>
<td>35</td>
<td>35.4</td>
<td>32.7 – 38.6</td>
<td>Lombard Game Reserve, Transvaal – Van Zyl (1968)</td>
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<tr>
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<td>f</td>
<td>12</td>
<td>28.0</td>
<td>25.0 – 35.6</td>
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<tr>
<td>Zebra</td>
<td>m</td>
<td>8</td>
<td>327.3</td>
<td>322.5</td>
<td>Fort Jameson Plateau from von le Chevallerie (1970)</td>
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<tr>
<td></td>
<td>f</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>2</td>
<td>312.4</td>
<td>275.1</td>
<td>Fort Jameson Plateau from von le Chevallerie (1970)</td>
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<tr>
<td></td>
<td>f</td>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>m</td>
<td>10</td>
<td>275.9</td>
<td>240 – 320</td>
<td>Hluhluwe, Zululand – Hitchins (1968)</td>
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<td></td>
<td>f</td>
<td>7</td>
<td>260.1</td>
<td>314</td>
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<tr>
<td>Wildebeest</td>
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<td>0</td>
<td>281.9</td>
<td></td>
<td>Nakabima South Province – from Robinette (1963)</td>
</tr>
<tr>
<td></td>
<td>f</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>m</td>
<td>13</td>
<td>247.8</td>
<td>219.1</td>
<td>Serengeti, Tanzania – Sachs (1967)</td>
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<tr>
<td></td>
<td>f</td>
<td>8</td>
<td>232.0</td>
<td>175.5 – 241.5</td>
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<td></td>
<td>m</td>
<td>2</td>
<td>283.0</td>
<td>260.0</td>
<td>Tarangire Game Reserve – Lamprey (1964)</td>
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<td></td>
<td>m</td>
<td>5</td>
<td>315.1</td>
<td></td>
<td>Fort Jameson Plateau from von le Chevallerie (1970)</td>
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<td>f</td>
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<tr>
<td></td>
<td>m</td>
<td>30</td>
<td>507.3</td>
<td>289.6</td>
<td>Etosha National Park SWA – Present study</td>
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<tr>
<td></td>
<td>f</td>
<td>16</td>
<td>236 – 358</td>
<td></td>
<td></td>
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</tbody>
</table>

<p>| Wildebeest  | m   | 2   | 228.2     |            | Luangwa Valley – from von le Chevallerie (1970) |
|             | f   | 2   | 220.9     |            |                     |
|             | m   | 33  | 238.6     | 177.8 – 293.9| Hluhluwe Game Reserve – Hitchins (1966) |
|             | f   | 22  | 190.0     | 141.5 – 216.8|                     |
|             | m   | 10  | 243.3     | 192.0      | East Africa – Ledger (1968) |
|             | f   | 10  |           |            |                     |
|             | m   | 98  | 236.7     | 178 – 284  | Hluhluwe Game Reserve – Hitchins (1968) |
|             | f   | 95  | 190.0     | 142 – 252  |                     |
|             | m   | 40  | 201.1     | 171.0 – 242.0| Serengeti, Tanzania – Sachs (1967) |
|             | f   | 41  | 163.0     | 140.8 – 186.8|                     |</p>
<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>No.</th>
<th>Mass (kg)</th>
<th>Range (kg)</th>
<th>Locality and Author</th>
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<tr>
<td></td>
<td>m</td>
<td>1</td>
<td>211.1</td>
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<td>Ngomo, Southern Province from Robinette (1963)</td>
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<td></td>
<td>m</td>
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<td>147.1</td>
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<td>14</td>
<td>245.2</td>
<td>266.9</td>
<td>Locality unknown — from von le Chevallerie (1970)</td>
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<tr>
<td></td>
<td>m</td>
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<td>221.3</td>
<td>177 — 254</td>
<td>Etosha National Park, S.W.A. — Present study</td>
</tr>
<tr>
<td>Cheetah</td>
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<td>65.1</td>
<td>Locality unknown from Lamprey (1964)</td>
</tr>
<tr>
<td></td>
<td>f</td>
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<td></td>
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<tr>
<td></td>
<td>m</td>
<td>8</td>
<td>44.1</td>
<td>35.9</td>
<td>Etosha National Park, S.W.A. — Present study</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gemsbok</td>
<td>m</td>
<td>7</td>
<td>194.1</td>
<td>197.3</td>
<td>Etosha National Park, S.W.A. — Present study</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>4</td>
<td>170.0 — 222.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>10</td>
<td>173.0</td>
<td>149.7</td>
<td>East Africa — Ledger (1963)</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>m</td>
<td>10</td>
<td>176.4</td>
<td>161.7</td>
<td>East Africa — Ledger (1968)</td>
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<tr>
<td></td>
<td>f</td>
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<td></td>
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<tr>
<td></td>
<td>m</td>
<td>2</td>
<td>173.7</td>
<td></td>
<td>Kenya — from von le Chevallerie (1970)</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>0</td>
<td></td>
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</table>

Figure 1. Comparative organ masses.  
(a = zebra, b = gemsbok, c = springbok, d = wildebeest)
Plate 1. Determining the mass of the carcase.

Plate 2. Removing the meat from the carcase.

Plate 3. Determining the mass of the hind-quarters.

Plate 4. Determining the mass of the skeleton.
Fluvio-marine deposits south-east of Swakopmund, South West Africa

by
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ABSTRACT

Up to two conglomerate layers carrying specimens of *Striosetra margaritacea* are interbedded in a layered deposit of unconsolidated and gypsum-cemented sand which occurs up to 50 m above sea-level. Size distribution analysis of the sand and surface characteristics of the sand grains indicate sheet-flood action and rapid burial, but aeolian and marine reworking is evident and mixing of fluvialite, aeolian and marine sand populations occurred in a fluvio-marine environment. The littoral fauna suggests freely circulating sea water during periods of limited detrital supply. At other times complete restriction of the depository led to evaporation and the precipitation of gypsum. Final burial took place in an embayment or tidal lagoon which was periodically isolated from the open sea. The association of sheet-flood action and evaporite minerals strongly suggests that an arid environment existed at the time of deposition.

1 INTRODUCTION

A previously unknown, 18-km long deposit of horizontally bedded unconsolidated sand, gypsum-cemented sand and conglomerate containing up to two fossiliferous layers (Plate 1), was exposed by trenching south-east of Swakopmund. The deposit

![Plate 1. Layered fluvio-marine deposit of unconsolidated and gypsum-cemented sand with conglomeratic layers that contain specimens of *Striosetra margaritacea*.](image)
occurs at an elevation of between 35 and 50 m above sea-level and the most northerly fossil occurrences are 37 km from the main Swakopmund–Usakos road (Map 1). The deposit is described and a mechanical analysis of the sand has been carried out in an attempt to establish its origin.

A similar deposit which occurs between Haigamchab and Nonidas on the Swakop River has been described by Gevers and Van der Westhuysen (1951). This contains a 60 cm thick layer of halite but lacks fossils.

2 LITHOLOGY

Lithological characteristics of measured sections located 26 and 29 km south of the main Swakopmund–Usakos road respectively are shown in figure 1. The deposit is composed largely of sand but conglomerate and clayey layers are also present. Individual beds persist over considerable distances. In the 29-km section the contact between layers 7 and 8 is paraconformable. Local lenseshaped cross bedded layers occur.

Halite and gypsum are present in all but layer 4 of the 26-km section. Layer 2 of the same section contains only a trace of halite. Gypsum forms a cement and occurs as isolated crystals, as patches of crystals either in the form of “desert roses” or thin irregular root-like columns, and as solid masses cementing complete layers. Crystals are all less than 5 mm in diameter and all enclose sand grains. The gypsum-cemented layers are coloured red by disseminated hematite. Most of the halite occurs as separate crystals but in layer 8 of 29-km section there are small crystal aggregates. The latter enclose only very few sand grains. The fossiliferous layers vary in thickness from 4 to 45 cm and are all conglomeratic.

2.1 THE SAND LAYERS

A meaningful size-distribution analysis could only be carried out on layer 4 of the 26-km section as all other layers contain evaporate minerals.

The histogram and cumulative curve of layer 4 are given in figure 2. The sand is fairly well sorted and has a distinct negative skewness. Plots of skewness versus mean, standard deviation and kurtosis (figure 3) show that the sand falls within the regions where characteristics of dune, beach and river sands overlap.

Although all sand grains of layer 4 are frosted a gradation from slightly to highly frosted occur.
separate they are only vary in fragment.

Figure 3. Textural characteristics of sand from layer 4 of the 26-km section (0.5 mm). Dune, river and beach sand characteristics after Friedman (1961).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Mesh range</th>
<th>25</th>
<th>35</th>
<th>45</th>
<th>60</th>
<th>80</th>
<th>120</th>
<th>170</th>
<th>230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 4</td>
<td>Frosted (f)</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>26-km section</td>
<td>Unfrosted (uf)</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
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</tr>
<tr>
<td>Layer 1</td>
<td>Roundness</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>29-km section</td>
<td>Frosted (f)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Unfrosted (uf)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
</tbody>
</table>

In sands from all other layers minor proportions of both rounded and angular grains show no frosting at all. These are most abundant in the 45 to 120-mesh range (figure 4). Many of the angular unfrosted grains are in the form of distinctive sharp-edged flakes. The typical decrease in the degree of rounding with decrease in grain size is shown by all samples (figure 4). Heavy minerals (biotite, hornblende, garnet, apatite, zircon, tourmaline, rutile, sphene, and epidote) are well rounded, highly frosted and are concentrated in the 170 to 325-mesh range. Micas are relatively abundant in all fractions.

2.2 The pebbles

The maximum pebble diameter is 10 cm. All pebbles are well rounded and sphericity varies from good to poor. Rock types present are schist, calc-silicate rock, marble (all from the Damara Group), shale (Karoo Sequence), granite, quartzite and quartz.

Figure 4. Rounding and frosting characteristics of sand fractions between 25 and 230-mesh (0.5–4 g). Figures in per cent. r = well rounded, rounded, subrounded; z = angular, subangular.
3 FOSSILS

Specimens of _Striastrea margaritacea_ occur in all the fossiliferous layers. Most of the left valves (attached valve) are fragmental, soft and extremely friable. In contrast the right valves are rather sturdy and many are unbroken. The specimens show scarcely any signs of abrasion and broken shells are all sharp edged.

In addition, fish vertebrae, crustacean and barnacle fragments and two gastropod specimens (as yet unidentified) have been found.

4 DISCUSSION

Consideration of the data provided by microscopic examination and by figures 3 and 4 indicates that the samples are composed of several populations.

Evidence for a fluviatile sand population is provided by relatively abundant mica in all sieve fractions, by unfrusted angular quartz flakes which indicate very limited transport and rapid burial, and by pebbles of Karoo shale. The nearest present-day outcrops of these rocks are 150 km inland at Erongo. All the other pebbles are not sufficiently diagnostic as possible source areas over large tracts inland and along the coast.

A beach or lagoon sand population is indicated by the distinct negative skewness of layer 4 of the 26-km section (dune sand is positively skewed, Allen, 1970, p. 103), by the good sorting and lack of angular unfrusted grains in this layer, and by the lateral extent of beds. Marine conditions are indicated by the oyster valves and by the presence of halite and gypsum. The characteristic fauna points to periods when there was scarcely any supply of detritus, to a fairly free circulation of sea water and to possible warmer water temperatures than prevail at present along the coast. _S. margaritacea_ requires a minimum summer water temperature of 25°C (Korrinda, 1956). Association of the fauna with conglomeratic horizons (see figure 1) suggests a littoral environment.

In a littoral environment some reworking by wind is to be expected so that frosting of grains is not particularly diagnostic. However, spherical, highly frosted grains indicate intense wind action. Such grains are common in the coarser fractions indicating that at least some of the clastic material has been derived from an aeolian environment.

The alteration of gypsum-rich and gypsum-poor layers suggests that periodically during deposition a restricted environment developed preventing circulation of sea water. Evaporation led to precipitation of gypsum as a cement. Such conditions of temporary isolation could occur in local basins isolated temporally in a shallow deltaic environment or in a coastal embayment or tidal lagoon. The latter environment appears to be the most probable because the unabraded shells indicate that even when water was able to circulate freely the littoral zone was protected from strong wave action.

No exposure connects the deposits with the gravel and salt deposits occurring between Hailgamchab and Nonidas on the Swakop River (Gevers and Van der Westhuysen, 1951). However, since the deposit occurs at the same elevation as the gravels at Nonidas and as the intervening bedrock outcrops are only small and sporadic it is probable that the two deposits can be correlated.

5 CONCLUSIONS

The sequence is probably mainly fluviatile in origin, having been formed by sheet flood action of the Swakop River. Depositional conditions appear to have varied considerably during accumulation of the deposit. For the most part burial was rapid but aeolian and marine reworking is evident and mixing of fluviatile, aeolian and marine facies occurred in a fluvo-marine environment. Periods of rapid supply of material were interspersed with periods during which very limited deposition took place. During the later periods sea water either circulated freely enabling a littoral fauna to thrive, or was not able to circulate at all and accompanying slow evaporation in the depositional led to the precipitation of gypsum. Final burial took place in an embayment or tidal lagoon which was periodically isolated from the open sea.

The association of sheet-flood action and evaporite minerals strongly suggests that an arid environment existed at the time. This is further substantiated by the probable correlation of the deposit with a sand and gravel sequence on the south bank of the Swakop River which contains beds of pure halite.

6 ACKNOWLEDGEMENTS

The authors are indebted to Mr B. F. Kensley of the South African Museum and Mr A. J. Carrington for identifying the fossils, and to Mr L. N. J. Engelbrecht of the Geological Survey in Windhoek for criticism of the manuscript.

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KORRINGA, P.
Hand-rearing abandoned Greater Flamingoes Phoenicopterus ruber L. in Etosha National Park, South West Africa.

by
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Okaukuejo
9224

A B S T R A C T

Five out of seven P. ruber were hand-reared to the flying stage on artificial diet. Mortality was due to secondary pulmonary infection, probably arising from food particles accidentally entering the respiratory tract. Two of the survivors were hatch in captivity, the remainder being up to four days old when captured. The difference in growth between chicks reared on artificial diet and those which initially received food from the parents was the most noticeable aspect of the experiment. Both species of African flamingo have now been successfully hand-reared in the Etosha National Park.

1 I N T R O D U C T I O N

Bock and Haas (1974) claim the first known completely successful hand-rearing of a flamingo during 1972 in the Wuppertal Zoo, although Lesser Flamingo Phoeniconaias minor were successfully hand-reared to the flying stage in Etosha National Park during 1971 (Berry 1974). During July 1974 the opportunity arose to repeat the experiment on Greater Flamingo Phoenicopterus ruber chicks. Late flamingo hatchlings are usually abandoned by the parents and we accordingly removed five recently hatched (immobile) P. ruber from a typically drying and deserted nesting site on the Etosha Pan. From experience gained during the hand-rearing of P. minor it was decided not to attempt to rear more than this number under intensive care.

Age of chicks

Two chicks were newly-hatched (day-old), one was estimated to be two days old and two were estimated to be four days old. At least three of the chicks had therefore been fed by their parents, a fact supported by their significantly greater body mass. In addition, two pipped eggs were also taken to time the duration of hatching. As both these chicks unexpectedly survived, they were added to the group of five. Their age was therefore precisely known.

2 M E T H O D

Food: Due to field conditions the chicks were not fed for the first 24 hours of captivity, although water was administered to them sparingly through an eye dropper. “Pro Nutro” (analysis given in Table 1) was mixed with water at body temperature to a consistency of thin porridge. Two egg yolks of domestic fowl were beaten in and given through a hand syringe (Plate 2) as described by Berry (1974) five times daily at three-hourly intervals. Egg albumen was included in the food after eight days.

* manufactured by Hind. Bros. and Co. Ltd., Republic of South Africa.
Feeding took place between 06h00 and 22h00, leaving a period of eight hours at night during which the chicks were not fed. After 12 days the feeding frequency was reduced to four times daily and the egg was omitted after 21 days. At 27 days three feeds a day were given. This was maintained until they could feed independently. Food and water mixture was then made available every morning and evening in a shallow dish measuring 0.35 m² and 5 cm deep. Fermentation of the mixture was avoided by flushing all residues in the dish away, outside the cage, before each feed. Fowl egg shells and clay from the Etohos Pan were made available throughout the captive period and were readily eaten in the initial stages.

Shelter: All seven chicks were taken to Okaukuejo, the main rest camp, one day after removal from the Pan. There they were maintained together indoors in a cardboard container which was warmer during the winter nights over a thermostatically controlled water bath set to give a temperature of 35°C inside the box. The container was lined with newspaper, changed daily.

During the warmer part of the day (10h00—17h00) they were allowed to exercise in a holding pen on the lawn and shallow dishes were put out for bathing. Initially they were bathed daily in warm water to remove food and excreta which soiled their down. When they began bathing themselves at three weeks of age, the supplementary warming at night was dispensed with. At this age they were given free outdoor range daily for increased exercise, although constant supervision was provided.

When the chicks were eight weeks old and feathering, they were kept outdoors until their release. Two enclosures were provided: one of 20 m² with a shallow pond of 2.5 m² for day use (Plate 3) and one of 10 m² for overnighting. Both were totally enclosed with chicken wire mesh and fish net. The cage used at night was imbedded in the ground with bricks and a 1-metre wide strip of double hessian was fastened around the sides to screen off predators.
2h00, leaving which the feeding daily and the days three gained until water mixtures containing and 35 mg of 3500 l.u. 3 1.0 mg 1.5 mg 1.0 mg 1.5 mg 14.0 mg 0.5 mcg 53.0 mg 413 Kca.

Plate 3: P. ruber in an outdoor enclosure at age five months.

3 DISCUSSION AND CONCLUSIONS

Mortality: Two chicks, both of which were a day old when taken from the nest, died in captivity after seven and nine weeks respectively. Although always reluctant to feed, their gain in body mass was proportionate to the others until a week before death. One of them was killed in a weakened state by a slender mongoose, Herpestes sanguineus. Post mortem indicated that their weakened condition was due to secondary pulmonary infection (Ebedes pers. comm.), probably resulting from involuntary inhalation of food particles while being force-fed.

Amount of food eaten: The captive chick's initial intake was 10–35 ml of the food-water mixture per day. This increased gradually to 400–600 ml daily, after which they were able to feed independently. During the first seven weeks when food was given exclusively by syringe, a total of 14 kg was eaten. From seven to 27 weeks of age 180 kg of food was provided. When all five remaining chicks were independent feeders they ate on average a total of 1250 g dry mass of food each day. Prior to release their combined body mass was 13,080 g, indicating a daily food intake of 9.6% of their body mass. This can be considered a minimum requirement as they expended energy only for maintenance under captive conditions. Barreda (1959) gives a minimum daily food intake of 10% of body mass required by the piscivorous Guanay Phalacrocorax bougainvillii for sustenance in captivity.

Gain in body mass: (Figure 1) The body mass of the chicks was always measured before feeding while they were dependant on a syringe. Predictably their body mass fluctuated during the latter period of captivity as they were then feeding independently. The day preceding their release, at an age of 6½ months, their body mass was (g) 2,040, 2,200, 2,400, 3,200 and 3,240, a range which indicates sexual differences. This is, however, misleading and another factor, which relates to the age at which they were fed an artificial diet, may have been involved. The two heaviest birds were also the oldest when captured (four days) and had already benefited from natural food. The chick whose body mass was 2,400 g had less parental feeding (two days), while the two chicks with the lowest body mass were hatched in captivity. They therefore never received natural food. The difference of 37% in body mass between the largest and smallest chick cannot therefore be explained on the grounds of possible sexual differences alone and was probably strongly influenced by the presence and absence of parental feeding respectively. Plate 4 shows the difference in size between the largest and two smallest chicks a day before their release (age 28 weeks).
Development: Growth rates of wing, tarsus, and culmen were measured according to standard procedures and are given in Figures 2, 3 and 4. A comparison of these vital external measurements of the full grown captives and wild P. ruber is given in Table 2. Wing and culmen measurements are comparable, but remarkable differences occur in the tarsal length. One captive flamingo had a tarsus length of 350 mm which is 20–27% greater than the range of 240–265 mm given for 12 wild P. ruber by McLachlan and Liversidge (1970).}

Figure 1. Body mass of 7 captive P. ruber.

Figure 2: Wing growth of 7 captive P. ruber.

Figure 3. Tarsal growth of 7 captive P. ruber.

Plate 4. Size difference between the largest and smallest hand-reared P. ruber at 26 weeks of age.
The egg-tooth disappeared at 20 days of age from the chick, which was most developed when captured, but remained visible up to 40 days of age on the two chicks hatched in captivity. Similarly, secondary down began replacing the natal down between three and five weeks of age, the change being complete at seven weeks. At this stage feathers were first noticeable on the scapulars, while primary and secondary flight feathers erupted on the wings at eight to nine weeks. White, sub-adult plumage began slowly replacing the grey, juvenile plumage at 10 weeks. It predominated only after age 20 weeks.

Bill colour changed at 11 weeks from coral red to light blue-grey proximally, while the distal area gradually blackened. Thereafter the proximal bill’s colour became off-white, turning pink at six months of age. Leg colour changed slowly from deep pink through dull black to off-white when the chicks were nine to 12 weeks old, except for the tibio-tarsal joint which remained darker until their release after six months.

**Behaviour:** Similar to captive *P. minor* chicks *P. ruber* were less agitated during the early stages of captivity when kept in darkened boxes. They too formed bonds of attachment, always between smaller and bigger chicks. We observed food-begging by the smaller chicks but saw no “foster-feeding” reaction by the bigger chicks, as was the case with *P. minor* (Berry 1974). Fresh water was preferred and when the pond was flushed out weekly, it induced bathing and drinking.

Two of the seven chicks were difficult to feed by syringe, a factor which probably contributed to their deterioration in condition and subsequent death. The remaining five fed eagerly from a syringe until they could feed independently. Natural feeding first occurred at seven weeks, while one of the larger, older chicks only became independent of the syringe at 14 weeks of age.

**Release procedure:** We decided to release the captive flamingoes at an age of 28 weeks when they showed no further significant gain in body mass or increase in vital external measurements. The captives were transported similarly to *P. minor* (Berry 1974) except that each bird’s head and neck was also enclosed in soft muslin (Plate 5). The release point was at Fisher’s Pan, 130 km east of their place of rearing. Transport injuries were limited to chafing of the upper tibia of two birds.

Before release a numbered metal ring (12.5 mm internal diameter) was placed on the right tibia of each bird. In addition six plastic colour rings were placed on each tibia in combinations of green, red, white and yellow.

Because previous experience had shown that an overnight enclosure at the release point attracts predators, especially black-backed jackal *Canis mesomelas*, the birds were given total freedom immediately after arrival at 10h00. They were released in proximity to several hundred wild *P. ruber* as it was hoped the latter would attract the reared birds, providing them with the stimulation for alertness ne-
cessary to survive in nature. This however was not the case and the hand-reared birds avoided the wild flamingoes, remaining separate and tightly grouped. They attempted flying with only partial success, regrouping each time.

Moreover their failure to join the wild population and their tendency to stay near the pan’s edge resulted in two being killed by jackals the night after release. No further rings or carcasses have been recovered since, but this does not necessarily mean that the remaining birds established themselves successfully in nature. We suggest, after experience with the release of *P. minor* and *P. ruber*, that hand-reared flamingoes have little chance of surviving in Etosha National Park under the release conditions so far tried, because of the abundance of predators. It would seem more appropriate to donate such birds to a zoo where they can be used to greater advantage.

4 ACKNOWLEDGEMENTS

We wish to thank Capt. A. Karas who helped locate abandoned nesting colonies on the Etosha Pan by helicopter and the Game Capture Unit of the Division of Nature Conservation for their assistance, Dr H. Ebedes, Etosha State Veterinarian, performed the post mortems. Marien Kungongileba provided much of the daily care required by the flamingoes when they were maintained outdoors.

This work was carried out as an *ad hoc* research project while the senior author was employed by the South West Africa Administration.

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Plate 5: Method of transporting *P. ruber* by vehicle to the release point.
Breeding adaptations of the Damara Tern Sterna balaenarum

by

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ABSTRACT

The breeding of the Damara Tern Sterna balaenarum near Swakopmund, South West Africa, is described. Loose aggregations of nesting birds occur on gravel plains about one kilometre inland from the sea. At any one locality the nests were well spaced. Clutch size was one. The parent birds were relatively unaggressive towards human intruders. These features are discussed in relation to the possible selection pressures involved in their evolution. The implications that these adaptations have for the conservation of the species are discussed. It is stressed that the area reported on in this paper represents the only currently known regular breeding area of the species. Like other terns, the Damara Tern may be susceptible to disturbance when breeding. The area north of Swakopmund is a popular resort for tourists during December—January, when the tern breeding season is at a peak. It is suggested that efforts be made to assess the extent and effect, if any, of human disturbance at the breeding sites. If necessary, other breeding areas, where more rigid protection can be enforced, should be located. Finally, it is noted that a survey needs to be undertaken to assess what changes, if any, are occurring in the population status of this little known species, endemic to southern Africa.

1 INTRODUCTION

The Damara Tern Sterna balaenarum is a small tern confined, during the breeding season (November—April), to the coastal waters of southern Africa from Cabinda (5 10S, 12 10E), south to Cape Agulhas (34 25S, 20 05E) (Bannerman, 1953; Livesidge, 1959) and eastwards as far as Cape Votce (34 20S, 21 55E) (pers. obs.). Biological productivity along the south west African coast is high, due to the influence of the cold, nutrient-rich Benguela current (Cushing, 1971). Outside the breeding season, Damara Terns have been recorded regularly from Lagos (6 20N, 3 20E) in the Gulf of Guinea (Elgood, Fry & Dowsett, 1973).

Almost nothing is known of the species' biology. Ecologically, the Damara Tern appears to belong to the little tern complex, which includes the Least Sterna albifrons, Yellow billed S. superciliiaris, Fairy S. nereis and Peruvian S. lorata terns (see Moynihan, 1959; Schnell, 1970 a, b, for details of tern systematics, and Ashmole, 1971, for a summary of the feeding ecology of the group). Like most of these species the Damara Tern is essentially an inshore feeder which usually frequents sheltered bays, estuaries and lagoons (McLachlan & Livesidge, 1970). It is said to feed on small fish and crustaceans (Mackworth-Praed & Grant, 1962; Walsom, 1966). The past and present population status of the species is not known. Andersson (1872) found Damara Terns breeding at Walvis Bay (22 40S, 14 30E) where he described them as being common. Our unpublished data suggest that the situation is no different today; Walvis Bay and nearby coast are the only areas where these terns can be observed reg-
ularly. Moreover the coastal region north of Swakopmund (22 33S, 14 35E) is the only area where Damara Terns currently are known to breed in any numbers. There are historical records of this tern breeding near Cape Town (Gill, 1945; Vincent 1946), though these colonies apparently are now extinct. Recent observations suggest that small numbers of Damara Terns may breed at a few widely scattered localities along the southern Cape coast, but the size of the population is not known.

In a recent compilation of the rare and vulnerable birds of South Africa (Siegfried, Frost, Cooper & Kemp, in press) the Damara Tern was considered to be one of twenty species in need of immediate investigation. In part, this concern was prompted by the apparent uncommonness of the species away from the Walvis Bay—Swakopmund area. The species is rarely seen now in the southern portion of its breeding range, an area where considerable coastal development has taken place. In both Europe and North America, populations of the ecologically similar Least Tern have declined markedly in recent years, the major reasons appearing to be the displacement of breeding colonies through coastal development and the disturbance caused by increased public access to formerly isolated beaches (Norman & Saunders, 1969; Cramp, Bourne & Saunders, 1974; Wilbur, 1974). Similar factors may be affecting Damara Terns in southern Africa.

This paper describes some features of the species’ breeding biology and discusses the probable selection pressures involved in their evolution. Finally, the implications of these features for the conservation of the Damara Tern are discussed. There is a paucity of basic biological data on this species and it is hoped that this paper will generate some interest and further research.

2 OBSERVATIONS

Observations were made during early December 1974 at a number of small breeding aggregations of Damara Terns located on inland gravel plains north of Swakopmund, at the western edge of the Namib Desert. The plains are situated about one km from the sea. The lichens Parmelia and Teloschistes and the halophytic bush Arthrocnemum are the only plant life occurring on these plains.

The terns typically nested in small, loose aggregations. Thirteen breeding pairs were recorded at five different localities. A further five birds appeared to be incubating at these localities but the nests were not checked. At two localities single nests only were recorded, while at the other localities the birds nested in aggregations of seven, five and four pairs, respectively. Time spent by us in the vicinity of these aggregations was kept short, in order to minimise disturbance. Consequently, no attempt was made to find nests peripheral to these aggregations, so that the figures for colony size may be slightly underestimated. The nests at any one locality were widely dispersed, the estimated distance between neighbouring nests varying from 100 to 150 m. The nests were simple unlined scrapes usually situated in fine gravel (although one nest was found in an area of large (fist-sized) boulders).

Clutch size was invariably one. Eleven nests contained single eggs while two newly-hatched chicks were located at different sites. The chicks were not in nest scrapes, but were found crouching motionless in the gravel (Plate 1). One parent bird was at attendance at each clutch and brood. The eggs were pale fawn, sparsely covered with dark brown fleckles and faint purple blotches. The chicks were whitish beneath and pale fawn above. The upperparts were covered with small black speckles. Newly hatched chicks of this species have never previously been described (Mackworth-Praed & Grant, 1962). In general pattern they are very similar to, though paler than, Least Tern chicks. Both the eggs and the chick matched perfectly the background colour of lichen covered gravel (Plate 1).

When approached, incubating birds left their nest early. However, unlike other little terns, Damara Terns do not appear to be particularly aggressive to wards intruders at the nests. Although the birds flew overhead, and called loudly, they did not mob or harass intruders. Birds with chicks vocalised more persistently than those birds with eggs. Furthermore, only those birds with nests in the immediate vicinity of the observer flew overhead. Other birds, nesting farther away, did not exhibit alarm until their nest was approached. These reactions to disturbance contrast markedly with those of most other tern species, in which mobbing is a well developed anti-predator strategy (Cullen, 1960).

The aggregations of breeding terns observed by us were all located close to the coastal road from Swakopmund to Cape Cross. The terns ignored motor traffic passing along this road. Moreover, those terns that we disturbed, returned readily to their nests usually within two minutes of our departure from the vicinity. However, this readiness to resume incubation may indicate that the eggs were not hatching, rather than that the birds were tolerant of disturbance per se. On returning to a nest, the bird instead of alighting on the nest, would land a few yards away, pause, then walk over to the egg. Similar behaviour has been noted for the Peruvian Tern another species that nests on desert plains away from the sea (Murphy, 1936). Possibly the behaviour is associated with nest location in a relatively featureless environment.

3 DISCUSSION

Several features of the breeding biology of the Damara Tern merit discussion: the scattered distribution of small colonies along the coast; the apparent tendency to nest on inland gravel plains away from the sea; the spacing of nests within the colony; the absence of an aggressive, anti-predator mobbing response; and the one egg clutch. Becau
The nests were not motionless, for the eggs were white, and the chicks were hatched normally (1962). In some cases, the chicks of lichen-eating birds were found to be lighter in color than their nestmates. Damara Terns, being aggressive toward intruders, often mobbed or attacked nearby nests, resulting in the disturbance of their nest sites. The terns in this area developed a strategy to avoid predation by utilizing their nesting sites effectively. The paucity of information about this species has led to considerable speculation on the breeding behavior of the tern. The breeding environment is the Peruvian Tern (Murphy, 1936; Johnston, 1966). Its biology is poorly known, and indeed, the terns of the Damara Tern species are better adapted to this environment than others. However, it is hoped that further research will enhance our understanding of this species.

Plate 1. Newly hatched Damara Tern chick. Note egg tooth (arrowed) and absence of nest scrape. The lichens on the gravel are Parmelia.

In contrast to the Least Tern, which nests on shingle and shell beaches just above the high tide mark (Norman & Saunders, 1969), the Damara Tern nests on inland gravel plains, away from the sea. This increases the distance that the birds must fly to the feeding grounds, in apparent contradiction of the arguments outlined in the preceding paragraph. However, along this particular coast, beaches are probably unsuitable for the establishment of successful breeding colonies. Firstly, the beaches consist largely of sand, a smooth and homogeneous substrate that offers little potential for concealment. Secondly, the dunes are steeply undulating and relatively bare of vegetation. This indicates instability, presumably due to the strong onshore prevailing winds. Consequently, one might expect considerable drift and therefore an unstable nest site. Thirdly, the strand zone, above the high tide mark, attracts a number of scavenging animals. Black-backed Jackals Canis mesomelas, and a number of other predators, occur regularly along the coast, apparently feeding largely on washed up carcasses (pers. obs.). Proximity to areas patrolled by these predators would make colonization of these sites more vulnerable. Furthermore, the conformation of the dune system limits the horizon of nesting birds. This makes the early detection of predators difficult. It is suggested that, as a consequence, Damara Terns...
have established colonies inland in the Namib Desert. This is not meant to imply that Damara Terns necessarily always nest away from the sea and never nest in sand dunes. In fact, where there are suitable sites (e.g. shingle or pebble beaches) Damara Terns could be expected to nest on the beach. Furthermore, Vincent (1946) found Damara Terns nesting in extensive sand dune systems north of Cape Town. However in this case there were broad slack areas between the dunes in which shingle and other debris accumulated. These were the preferred nesting areas.

In the Namib Desert, inland breeding sites are advantageous because the overall visibility is better, and nesting birds, their eggs and chicks, can be more effectively concealed. However, while the density of predators on these plains may be lower than along the shore, any aggregation of birds nesting in close proximity to one another would be both conspicuous and accessible to predators. This would negate any advantage gained by nesting inland. By nesting in loose aggregations, with considerable distances between neighboring nests, breeding terns should be less conspicuous and thus less vulnerable to predation.

Most tern species exhibit anti-predator mobbing. Species in which mobbing is weakly developed, such as the Sandwich Tern Sterna sandvicensis, generally nest in areas inaccessible to predators or nest in association with more aggressive species such as the Black headed Gull Larus ridibundus (Cullen, 1960). Therefore, it is surprising that the Damara Tern does not exhibit mobbing, particularly as we consider predation to be important in determining nest site selection and breeding dispersion. The related Least and Fairy Terns are very aggressive towards intruders (Cullen, 1960; Serventy, Serventy & Warham, 1971). It could be argued that a combination of small body size, small aggregations of breeding birds, and the wide dispersion of nests militates against effective mobbing. There would seem to be little advantage in mobbing a predator that was not in the immediate vicinity of the nest. However, this does not seem to be the whole answer as the Peruvian Tern, which nests in similar situations, is aggressive towards intruders (Murphy, 1936). Possibly, nesting dispersion in this species is different. Furthermore, it should be noted that we have only recorded the response of Damara Terns to human intruders; their response to other potential predators may be different.

The Damara Tern is further anomalous in laying only one egg. We have been unable to verify statements that this species may lay two eggs (Mclachlan & Liversidge, 1970). All the records available to us indicate a one egg clutch, though the occasional two egg clutch can not be ruled out. All other temperature zone, inshore-feeding terns lay two, or occasionally three, eggs (Table 1). In terms generally, single egg clutches are associated with either pelagic foraging, or, in tropical species that feed close to the nest site, with a sparse food supply. In addition, single egg clutches are correlated with a relatively large egg and a long incubation and fledging period (Lack, 1968). Obviously, such features can only evolve in environments where predation is an insignificant factor. Where the risk of predation is high, these phases have been shortened. In most terns, both parents feed the young, at least from about three days onwards (Witherby, Jourdain, Tiechurst & Tucker, 1941). Growth rates are consequently rapid. Moreover, most young terns fledge relatively prematurely, and there is an extension of parental care away from the colony (Lack, 1968).

Incubation and fledging periods for the Damara Tern are unknown, but the egg is similar in size to those of ecologically equivalent species (Table 1). Furthermore, the masses of two incubated eggs were 7.8 g and 9.5 g respectively (Khunah pers. comm.), which is similar to the mass of the Least Tern egg (Lack, 1968). As the breeding range of the Damara Tern falls within a region of high biological productivity (Cushing, 1971), it is unlikely that the low clutch size is related to a poor food supply per se. We suggest that clutch size in this species is largely the consequence of selection for maximum growth rate of the young, as a result of the exposed nest site and the risk of predation.

Table 1. Mensural and other data for five ecologically similar species of tern.

<table>
<thead>
<tr>
<th>Species</th>
<th>Feeding habitat</th>
<th>Breeding habitat</th>
<th>Breeding dispersion</th>
<th>Mean wing length (mm)</th>
<th>Mean culmen length (mm)</th>
<th>Mean egg size (mm)</th>
<th>Usual clutch size</th>
<th>Mobbing behaviour</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least S. albifrons</td>
<td>inshore</td>
<td>beach shingle</td>
<td>C</td>
<td>172</td>
<td>30.6</td>
<td>33.0 x 23.9</td>
<td>2-3</td>
<td>yes</td>
<td>Witherby et al., 1944</td>
</tr>
<tr>
<td>Fairy S. nova</td>
<td>inshore</td>
<td>small nearshore islands</td>
<td>C</td>
<td>183</td>
<td>32.7</td>
<td>34.7 x 25.2</td>
<td>2-3</td>
<td>yes</td>
<td>Serventy et al., 1971</td>
</tr>
<tr>
<td>Yellowbilled S. supercilios</td>
<td>rivers and coastal lagoons</td>
<td>river sand banks</td>
<td>S-SC</td>
<td>184</td>
<td>33.1</td>
<td>30.5 x 23.6</td>
<td>2-3</td>
<td>yes</td>
<td>Escalante, 1970, Jonson, 1966</td>
</tr>
<tr>
<td>Peruvian S. tato</td>
<td>inshore</td>
<td>desert plains</td>
<td>C-SC</td>
<td>181</td>
<td>31.0</td>
<td>31.4 x 23.9</td>
<td>2</td>
<td>yes</td>
<td>Johnson, 1966, Murphy, 1936</td>
</tr>
<tr>
<td>Damara S. balaenarum</td>
<td>inshore</td>
<td>desert plains</td>
<td>SC</td>
<td>167</td>
<td>30.0</td>
<td>32.9 x 23.9</td>
<td>1</td>
<td>no</td>
<td>Mclachlan and Liversidge, 1970, pers. obs.</td>
</tr>
</tbody>
</table>

a Breeding dispersion = C colonial – SC semi-colonial – S solitary
The growth rates of young birds are related to the rate at which the parent birds supply food, the quality of the food, and to the number of young in the brood. The rate at which parent birds supply food is a function of the distance that the birds forage from the nest site, the size of the food items and their availability. Furthermore, Pearson (1968) has shown that the amount of time required by small seabirds to obtain food for their young increases rapidly with decreasing body size of the birds. Thus the Common Sterna hirundo and Arctic S. paradisaea terns (both more than twice the size of the Damara Tern) are at almost the minimum size at which it remains economical to feed the young on small fish. This is confirmed by the reduced growth rates of tern chicks in broods larger than one (Pearson, op. cit.), suggesting that the parent birds were unable to forage at a rate sufficient to maintain maximum growth rates in the larger broods. However, both the Common and Arctic Terns feed some distance from the nest site. Smaller, inshore-feeding terns, because of the proximity of their food supplies, may be able to continue supplying food sufficiently frequently to rear two young at, or near, maximum growth rate. In fact this is so. The Least Tern supplies food to its chicks at nearly double the rate of the larger Arctic Tern (Borodulina, 1960).

However, two factors may militate against this happening in the Damara Tern. Firstly, the species breeds inland. Secondly, there are few sheltered bays and estuaries along the South Western African coast. The immediate onshore waters are often turbulent and murky. One of us (P.F.J.) has observed Damara Terns, in breeding plumage, over five km from land during the breeding season. This suggests that breeding birds may have to forage further from shore than do other inshore-feeding terns (but not necessarily as far offshore as large tern species). Both these factors tend to increase the distance over which fish must be collected, which will, in turn, affect the feeding rate. Therefore, in order to rear chicks at maximum growth rate, birds laying one egg clutches appear to have been selected for, as they would be vulnerable to predation for a shorter period. A time-energy budget is needed to test this idea.

It is not known if the Damara Tern is single or multiple-brooded. Eggs have been recorded in all months from November to February (Table 2). This may indicate either a prolonged breeding season, with a considerable spread in the breeding activity of individuals; multiple-breeding by individuals; or, renesting after an initial failure resulting from predation or disturbance. In this latter respect, a single egg clutch might be advantageous. If the probability of predation on eggs or chicks is high, it may be better to commit only a proportion of the available productivity energy to any particular breeding attempt. A small clutch can be replaced more rapidly than a larger clutch. Moreover the problem of low clutch size (and therefore a low reproductive rate) could be overcome by multiple brooding. Obviously, these considerations, if they apply in the Damara Tern, are not mutually exclusive from those outlined earlier. In fact they appear consistent with the hypothesis that predation has been a major force in the evolution of this species’ breeding strategy.

### Table 2. Recorded breeding for Damara Terns from Swakopmund

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of pairs with Eggs</th>
<th>Young</th>
<th>Fledglings</th>
<th>Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Dec</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>this study</td>
</tr>
<tr>
<td>18-19 Dec</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>Clinning; NRC’s</td>
</tr>
<tr>
<td>5 Jan</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>Kinalhan; pers. comm.</td>
</tr>
<tr>
<td>3 Feb</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Clinning; NRC’s</td>
</tr>
<tr>
<td>22 Feb</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Patton; NRC’s</td>
</tr>
</tbody>
</table>

4 CONSERVATION

In general, the conservation of terns poses considerable problems, largely because of their vulnerability to disturbance during the breeding season. The major adverse influences on their numbers have been the disruption and displacement of breeding sites through coastal development and public recreation. Bays and lagoons are dredged, reclaimed, or polluted by industrial development while estuaries are favoured by the developers of coastal townships and marinas. Furthermore, with the advent of off-road vehicles, formerly isolated beaches have become accessible to the general public. These and other factors have been implicated in the decline of several tern species (Norman & Saunders, 1969; Cramp et al., 1974; Bourne & Smith, 1974; Wilbur, 1974). Similar alterations of coastal areas are taking place in southern Africa (Rand, 1971), and may be having, or be expected to have, a similar adverse effect on breeding Damara Terns.

The status of the Damara Tern in South Africa is poorly known. The species used to breed near Cape Town 40–50 years ago (Gill 1945; Vincent 1946) but these sites apparently are no longer occupied. Industrial and urban development may have been a contributing factor in the desertion of these sites. Currently, small numbers of Damara Terns may breed at scattered localities along the southern Cape coast, but breeding has only been confirmed so far at one of these sites. This coast is very popular with holiday makers during the summer months, and disturbance is likely to be high.

The only known localities where this species breeds regularly lie along the coast north of Swakopmund. This area is extremely popular with tourists, particularly during the holiday period mid-December to mid-January. This coincides with the middle of the Damara Tern’s breeding season. The incidence of off-road traffic is high, as witnessed by the number of wheel tracks seen between the coastal road and the sea (Plate 2). It is not known to what extent this potential disturbance affects breeding...
success. Birds breeding as late as February may be repeat breeders who lost or deserted their nests earlier in the season as a result of disturbance.

All terns are protected by nature conservation ordinance in both South and South West Africa. Protection is also afforded through the Sea Birds and Seals Protection Act, 1973, which covers the offshore islands and the territorial waters of South Africa. However, these legislative provisions only deal with the birds themselves and do not necessarily protect the birds against loss of vital habitat or unwitting disturbance while breeding. In short, the continued coexistence of viable populations of different organisms is not assured simply by granting statutory protection. Species that are rare and vulnerable to disturbance must receive more direct protection. In the Damara Tern this could prove to be a complex issue.

The conservation problems posed by the Damara Tern are fourfold. Firstly, their overall population size appears to be low. This is suggested by the paucity of observations on the species. It appears to be generally true that inshore-feeding seabirds have small populations. This may be related to the restricted amount of habitat available for exploitation, compared to that available for offshore-feeding species (Ashmole, 1971).

Secondly, the Damara Tern has a small clutch size and therefore a limited capacity for rapid increase in numbers. Consequently, it becomes imperative to afford strict protection to breeding aggregations of this species. Thirdly, the breeding colonies are small and spread over a wide area. This makes it difficult to incorporate a sizeable population within a protected area. Finally, the pressure of predation appears to have been important in determining colony site selection and breeding dispersion. Thus there has been strong selection for an isolated breeding site that is relatively safe from disturbance. In this respect, the general tendency in terns to desert readily any site where disturbance increases, must be seen as a necessity for species nesting in situations where isolation and safety from predators is of a tenuous nature. Thus areas set aside as reserves may be deserted, unless steps are taken to keep disturbance to a minimum. Clearly, a flexible approach is needed when protecting tern colony sites.

In view of the fact that Damara Terns are currently known to breed regularly in only one area in southern Africa and that this area is accessible to, and heavily utilised by the public, efforts should be made to:

i assess the effect of human disturbance on the breeding birds;
ii locate other breeding areas where more rigid protection can be applied;
iii determine what changes, if any, are occurring in the population status of the species, and the factors effecting such changes.

5 ACKNOWLEDGEMENTS

John Kinahan, C. F. Clining and R. W. Summers made available their unpublished observations. R. Liversidge and G. L. McLachlan assisted in the location of old breeding records. P. D. Shaughnessy, W. R. Siegfried and A. J. Williams read and commented on a draft manuscript. We are grateful to these persons for their help.

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VINCENT, A. W.
Sumpfrohrsänger (*Acrocephalus palustris*) in Südwestafrika

von
P. Becker und H. Lütgens
Bundesrepublik Deutschland

**Abstract**

The European Marsh Warbler *Acrocephalus palustris* was recorded for the first time in South West Africa. From a number of birds found in the study area east of Windhoek, two individuals were collected. A third individual was ringed. Song and habitat are described. Measurements are given and moult is described.

**1 Einleitung**


**2 Der Biotop**

Das Otihaserivier, das die gesamte Farm von West nach Ost durchquert, führte vor unserer Beobachtungszeit viel Wasser, wies aber dann nur einige Rinnale oder stehendes Wasser in Form kleiner Pfützen auf. Die Ufervegetation, in der sich die Sumpfrohrsänger aufhielten, bestand aus hohen Bäumen (*Prosopis juliflora* und *Acacia karroo*) und undurchdringlichem, an einigen Stellen etwas aufgelockertem Buschwerk (*Acacia karroo* und *Poinciana gillettii*), an dessen Randzonen dichtes Bestände von Korbblüttern (*Nidorella resedifolia*, *Tagetes miniata* und *Coriza bonaventura*) bis zu einem Meter hoch wuchsen. Dieser Biotop entspricht im Grunde dem Lebensraum des Sumpfrohrsängers in seinem Brutgebiet. Auch die begleitende Vogelwelt setzte sich aus einigen Vertretern seines Heimatraumes zusammen. So hielten sich neben afrikanischen Arten wie z.B. Graurücken-Camaroptera (*Camaroptera*...
breviculae) und Rotscheitelnistensänger (Cisticola chinita) 3–4 Flüsse (Phylloscopus trochilus), 2–3 Gelbspötter (Hippolais icterina), mehrere Neuntöter (Lanius collurio), Schwarzstirnwürger (Lanius minor) und Grauschnäpper (Muscicapa striata) hier auf, die z.T. ebenfalls eifrig sangen.

3 ZUM GESEHN


4 MASSE UND MAUSER DER GEFANGENEN VÖGEL


Tabelle 1. Maße der Acrocephalus palustris von Farm Fruenslein, Gebiet Windhoek*.

<table>
<thead>
<tr>
<th>Beleg-Nr.</th>
<th>I.</th>
<th>II.</th>
<th>III.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geschlecht, Alter</td>
<td>$\delta$ imm.</td>
<td>$\delta$ imm.</td>
<td>$\delta$ Alter</td>
</tr>
<tr>
<td>Gesamtänge</td>
<td>146 mm</td>
<td>140 mm</td>
<td>144 mm</td>
</tr>
<tr>
<td>Flügel</td>
<td>(64) mm</td>
<td>68 mm</td>
<td>70 mm</td>
</tr>
<tr>
<td>Culmen</td>
<td>11,5 mm</td>
<td>11,0 mm</td>
<td>12,0 mm</td>
</tr>
<tr>
<td>Tarsus</td>
<td>22,5 mm</td>
<td>22,0 mm</td>
<td>22,0 mm</td>
</tr>
<tr>
<td>Fuß</td>
<td>24,0 mm</td>
<td>25,5 mm</td>
<td>25,0 mm</td>
</tr>
<tr>
<td>Schwanz</td>
<td>52 mm</td>
<td>51 mm</td>
<td>52 mm</td>
</tr>
</tbody>
</table>

* Gemessen an frischen Exemplaren; Bestimmung des Alters nach Gefiedersmerkmalen und des Geschlechts nach einer Gnadentaherauspritzung durch J. Dixon.


II.: Großgefiedern neu, voll ausgensemiert, H9 noch nicht ganz verhornt.

III.: Wie II.

5 DISKUSSION


Wir vermuten, daß der Gesang des Sumpfrösersängers bei den einheimischen Ornithologen nicht bekannt genug war, und diese Art deshalb vielleicht übersehen bzw. überhört, möglicherweise sogar mit dem Gelbspötter verwechselt wurde.

P. A. CLANCEY, der dankenswerterweise die Bestimmung der beiden gesammelten Rohrsänger be stätigte (brieft.), ist der Meinung, daß diese Exemplare „agree with the eastern elements of the species, separated as A. p. laricus PORTENKO, 1955: De- mavend, northern Iran“. Bezieht man jedoch auch

Tafel 2. Sumpfrohrsänger Acerosphalus palustris ♂ von Farm Frauenstein, 21. 3. 75. (Photo P. Becker)

den Gesang bei der Bestimmung mit ein, möchten wir unsere Sänger doch eher zur Westpaläarktis und somit zur Nominatform rechnen, denn Girllitz, Wiesenberg und Heckenbraunelle — im Gesang ähneln — sind typische Vertreter dieser Region. Die initiierten Vogelstimmen können nur im Heimatgebiet erltern worden sein, da diese Arten nicht nach Südafrika wandern. Die Rassenfrage kann wohl nur durch einen Vergleich mit größeren Serien von *A. p. palustris* und *A. p. liricus* gelöst werden, die möglichst im gleichen Monat gesammelt wurden, denn es ist ja bekannt, daß Federn durch längere Sonneneinwirkung heller werden. VAURIE (1959, p. 245) schreibt zu dieser Rasse: „The populations of Iran ("liricus") are very slightly paler, the difference being a little more distinct in the juvenile plumage“.

6 DANKSAGUNGEN


7 ZUSAMMENFASSUNG


8 SUMMARY

Occurrence of the European Marsh Warbler *Acrocephalus palustris* in South West Africa was confirmed with the first definite records from a farm near Windhoek in March 1975. Two mistnetted specimens were preserved and a third ringed and released. One of these birds was in heavy moult, while the other two were in virtually complete fresh plumage. The birds were among approximately half-a-dozen singing males occupying loose territories in rank weeds and thickets along a short stretch of the pool-dotted (normally dry) Oijhase River. The characteristic song typically included mimicry of many birds, among them several European species not extending to southern Africa. The mimicked species list indicates that the nominate race of *A. palustris* from Europe was probably involved, although morphological characters of the skins suggested the Middle Eastern form *liricus* to P. A. Clancey.

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Notes on birds of the north-eastern Namib Desert Park and adjoining farms

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1 INTRODUCTION

A geological survey of the area shown in Figure 1 was carried out between February and June 1975. The area comprises 560 square kilometres and was traversed on 43 lines, each 1 kilometre apart and at right angles to the southeast boundary. The area is some 14 kilometres wide and was traversed for about 7 kilometres south-eastwards from the Swakop River and the return trip on the same day was made on the adjoining line. The remaining halves of the lines were completed by traversing from and back to the southeast boundary. Birds were counted on the traverses and groups of four adjacent traverses were synthesised into transects. Dates on which pairs of traverses were made are shown on Figures 2–5.

Observations of the bird population in the Swakop River were made in the vicinity of camps near the mouth of the Onanis River between February and April, and on the farm Horebis Süd between April and June.

2 PURPOSE OF THE STUDY

It was hoped to determine the species composition and population density of the avifauna in relation to the environment, particularly with respect to the late summer rains. Observations made by the writer are compared with those of Willoughby and Cade (1967) in an adjoining area of the Namib Park (Figure 1).

3 THE ENVIRONMENT

The area is bounded on the northwest by the Swakop River, an elongate oasis at an elevation of some 620 metres above sea level. The ground to the southeast is largely rocky and culminates in the Horebisberge which constitute the spine of the area and reach an altitude of about 1200 metres. There is some flatish, sandy ground southwest of the Horebisberge. The Onanis, Achaas and Rooikusieb Rivers have sandy river beds with trees and cross the area to join the Swakop River. All these rivers have dry beds for most of the year, carrying floods at the peak of good rainy seasons and rapidly drying up thereafter except for isolated longer-lasting pools.

The area can be considered an extension of that classified as Inner Namib by Willoughby and Cade (1967) and has a partly continental climate with a considerable range of temperature. The rainfall is about 100 mm per annum and comes mostly as thunder showers in the latter half of the summer. In 1975, 106 mm of rain was recorded by Mr. H. W. Strubing whose house is near the northern campsite (Figure 1) and it fell mostly between 20th March and 5th April. In the Namib Park semi-permanent water is found in water holes and seeps in the Swakop River and some of its tributaries (S Figure 2), whereas on the farmland there are also boreholes with accompanying reservoirs (P Figure 2).

Broadly there are four different types of habitat:
a) The riverine forest in the Swakop River, and to a much lesser extent in its tributaries, which accommodates many birds characteristics of more inland regions.

b) The generally rocky, hilly terrain rising from the Swakop River.

c) The Horebisberge and their southwest extension which rise up to some 600 metres above the bed of the Swakop River.

d) The sandy and calcite-covered flats southeast of the Horebisberge.

4 AVIFAUNAL COMPOSITION

Ninety-seven different species were recorded and in Table 1 the more interesting of these, as suggested by Dr. R. A. C. Jensen, are listed and their distributions are related to habitats and seasons. The movements of the four most numerous species are clearly related to rainfall and are discussed in some detail. The distribution of these species is shown in Figures 2–5 in which populations are shown as the number of observations made over individual distances (truncepts) of 2 kilometres. These numbers are the averages of counts from four adjacent traverses each 1 kilometre apart.

4.1 Laughing Dove (Streptopelia senegalensis)

The distribution of Laughing Doves is shown in Figure 2 and it is noteworthy that this dove was recorded up to a few kilometres from the nearest water whereas the Cape Turtle Dove (Streptopelia capicola) and the Namaqua Dove (Oena capensis) were much scarcer and always near water.

4.2 Long-billed Lark (Certilauda curvirostris)

The distribution of Long-billed Larks is shown on Figure 5 and it is evident that they occur throughout the area. There seems to have been a concentration in breeding time in an area of more favourable rainfall west of the Horebisberge. However this observation may be due to the fact that the larks stopped calling loudly towards the end of May and this may account for the lower population recorded at that time east of the Horebisberge. The overall lower population in the northeast is probably due to the poorer rainfall in that area.

4.3 Dusky Sunbird (Nectarinia fusca)

There was a considerable influx of Dusky Sunbirds after the rains (Figure 4) and also a movement of large numbers away from the Swakop River into the hinterland. The maximum population was recorded in May and early June southeast of the Horebisberge and this may be due to the large population in this area of Aloe dichotoma which flowers at that time.

4.4 Lark-like Bunting (Emberiza impetuanii)

There was a considerable influx after the rains (Figure 5) and the maximum population was in the rocky areas northwest and southeast of the Horebisberge. The first young were seen flying on June 8th some ten weeks after the rains.

5 DISCUSSION

Willoughby and Cade (1967) carried out an investigation of the drinking habits of birds in the Central Namib Desert of South West Africa in the period from 1964—1966, and the Tinkas area where they worked adjoins the southwest part of the writer's area (Figure 1). These authors observed twenty-eight species not seen by the writer whereas twenty-five recordings made by the writer do not appear on Willoughby and Cade's list. This is not particularly surprising in view of the rapid increase in average annual rainfall from West to East in our joint study areas. Some of the species from our respective lists however merit some mention. These include a few species (Table 1) recorded in the Namib Park which do not appear on Willoughby and Cade's list. Several waterbirds fall in this category, including the migrant Spotted Crane and Little Stint. Another notable migrant was the European Golden Oriole. A nomadic flock of seven Temminck's Courser was seen after the rains just outside the Park fence on Wilsonfontein. "Resident" species not recorded in the Park by Willoughby and Cade (1967) include among the more interesting and less expected: Rüppell's Parrot, Pearl-spotted Owlet, Red-billed Hoopoe, Bearded Woodpecker, Three-streaked Tchagra and Plum-coloured Starling. All these species were recorded from the Swakop River only. The parrot is known to be a wanderer, although observed throughout the study period, but the other records probably represent individuals penetrating to the limits of their species' ranges.

Of some interest was the apparent confinement of the Lappet-faced Vulture to the Namib Desert Park; it was never seen outside the Park boundary. Other birds of prey were rather scarce; with the exception of the Rock Kestrel, sightings were mostly of one or a pair of each species (Table 1).

Among birds recorded by Willoughby and Cade (1967) but not by the writer, may be mentioned the Black Kite Milvus migrans and two courser species. These authors also recorded (questionably) the migrant European Swift Apus apus, a species which is difficult to distinguish from the local Bradfield's Swift. Unlike the latter, the Alpine Swift was noted to disappear between April and September (see Table 1). Among other migrant species recorded by Willoughby and Cade but not seen by the writer are European Swallow Hirunda rustica, Greater Striped Swallow H. undulata, Spotted Flycatcher Muscicapa striata and Lesser Grey Shrike Lanius minor.

6 ACKNOWLEDGEMENTS

I would like to thank Dr E. Joubert for encouragement and Dr R. A. C. Jensen for very substantial help in compiling this report.

7 REFERENCES


Table 1. Distribution of certain bird species related to habitats and seasons.

<table>
<thead>
<tr>
<th>Species</th>
<th>In Namib Park</th>
<th>Outside Namib Park</th>
<th>In Swakop River</th>
<th>In Hilly Terrain</th>
<th>In Mountains</th>
<th>On Sandy and Calcrete Flats</th>
<th>Seen Before Rains</th>
<th>Seen After Rains</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secretary Bird  <em>Sigillaria serpentina</em></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen, Swakop River</td>
</tr>
<tr>
<td>Lappet-Faced Vulture <em>Torgos tracheliotus</em></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Only seen inside Park</td>
</tr>
<tr>
<td>Lammer Falcon  <em>Falco biarmicus</em></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One pair in vicinity of Achas River</td>
</tr>
<tr>
<td>Rock Kestrel  <em>Falco tinnunculus</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>Several pairs recorded</td>
</tr>
<tr>
<td>Black Eagle  <em>Aquila verreauxi</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One pair ranged along Horebisperge</td>
</tr>
<tr>
<td>African Hawk-Eagle  <em>Hieraaetus fasciatus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>One pair seen twice in Swakop River, Horebis-Süd</td>
</tr>
<tr>
<td>Martial Eagle  <em>Polemaetus bellicosus</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen, Swakop River on Horebis-Süd</td>
</tr>
<tr>
<td>Black-breasted Snake-Eagle  <em>Circaetus pectoralis</em></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen, as above</td>
</tr>
<tr>
<td>Jackal Buzzard  <em>Buteo rufinus (angur)</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Three seen, Onanis and Rooikuiseb Rivers</td>
</tr>
<tr>
<td>Steppe Buzzard  <em>Buteo buteo</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Two seen</td>
</tr>
<tr>
<td>Spotted Crane  <em>Porzana porzana</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Three seen, at pool in Swakop near Onanis River</td>
</tr>
<tr>
<td>Kori Bustard  <em>Ois kori</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen</td>
</tr>
<tr>
<td>Little Stint  <em>Calidris minuta</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A couple in Swakop River after rains</td>
</tr>
<tr>
<td>Temminck’s Courser  <em>Cursorius temminckii</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Seven seen in party</td>
</tr>
<tr>
<td>Laughing Dove  <em>Streptopelia senegalensis</em></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>See text</td>
</tr>
<tr>
<td>Rüppell’s Parrot  <em>Poicephalus ruppelli</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Several pairs, riverine forest, throughout study</td>
</tr>
<tr>
<td>Rosy-faced Lovebird  <em>Agapornis roseicollis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Some large colonies in river gorges</td>
</tr>
<tr>
<td>African Cuckoo  <em>Cuculus canorus gularis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen, November 1973</td>
</tr>
<tr>
<td>Pearl-Spotted Owllet  <em>Glaucidium perlatum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>A few pairs in Swakop River</td>
</tr>
<tr>
<td>Bradfield’s Swift  <em>Apus bradfieldi</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Recorded throughout study period</td>
</tr>
<tr>
<td>Alpine Swift  <em>Apus melba</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Not seen between 20.4.73 and 19.73</td>
</tr>
<tr>
<td>White-backed Mousebird  <em>Colius collus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Several flocks in dry river beds</td>
</tr>
<tr>
<td>Red-faced Mousebird  <em>Colius indicus</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Along Swakop River after rains only</td>
</tr>
<tr>
<td>Purple Roller  <em>Coracias naevia</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen on Horebis-Süd, Nov. 1973</td>
</tr>
<tr>
<td>Red-billed Hoopoe  <em>Phoeniculus purpureus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One pair in Swakop River</td>
</tr>
<tr>
<td>Cardinal Woodpecker  <em>Dendrocopos fuscaenius</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>Two pairs</td>
</tr>
<tr>
<td>Bearded Woodpecker  <em>Tritilus nanaquias</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One probable pair, Onanis R. mouth</td>
</tr>
<tr>
<td>Long-billed Lark  <em>Charadrius nerostris</em></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>See text</td>
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</table>
### Table 1 (continued). Distribution of certain bird species to habitats and seasons.

<table>
<thead>
<tr>
<th>Species</th>
<th>In Namib Park</th>
<th>Outside Namib Park</th>
<th>In Swakop River</th>
<th>In Hilly Terrain</th>
<th>In Mountains</th>
<th>On South and Calcrete Flats</th>
<th>Seen Before Rains</th>
<th>Seen After Rains</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey-hackled Finch-Lark</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Several hundred nested after rains</td>
</tr>
<tr>
<td>Emberiza fuscata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Several seen, no noticeable influx after rains</td>
</tr>
<tr>
<td>Stark's Lark</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Several immatures seen in Swakop River, April 1973</td>
</tr>
<tr>
<td>Calandrella starki</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One seen on Horebils-Süd</td>
</tr>
<tr>
<td>Golden Oriole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Two pairs</td>
</tr>
<tr>
<td>Oriolus oriolus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quite common in Swakop River</td>
</tr>
<tr>
<td>Crimson-breasted Shrike</td>
<td></td>
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<td></td>
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<tr>
<td>Lamarius aristatus</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three-streaked Tchagra</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tchagra australis</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plum-coloured Starling</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chlamyrocichla leucomystax</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusky Sunbird</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>See text</td>
</tr>
<tr>
<td>Nectarinia fusca</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lark-like Hunting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emberiza impatiens</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>See text</td>
</tr>
</tbody>
</table>

### Fig. 1 LOCATION MAP OF AREA SURVEYED

Partly after Willoughby and Cade 1967 Fig. 2.
Fig. 2 Population distribution of Laughing Doves

LEGEND

- Transect done after rains
- Water spring
- Water pump

Dates in 1973 of traversing lines 1 km apart and providing data for transects. Figures on transects are numbers of Laughing Doves seen over a distance of 2 km and averaged over three or four traverses as shown.
Fig. 3 Population distribution of Long-billed Larks

Legend:
1. Dates in 1973 of traversing lines 5 km apart and providing data for transects.
Dates on transect are numbers of Long-billed Larks heard or seen over a distance of 2 km and averaged over three or four traverses as shown.
Fig. 4  Population distribution of Dusky Sunbirds

Legend as for Fig. 3
Counts are mostly of calling males
+ Trancept done after rains

4 & 17 Apr.
25 & 28 April
30 Apr & 2 May
4 & 14 May
7 & 21 May
16 & 23 May

Aram Mountains
Swakop River
Horebisberg
Sandy Flats
Horebisberg

NOTES ON BIRDS OF THE NORTH-EASTERN NAMIB DESERT

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Fig. 5  Population distribution of Lark-like Buntings

Legend is as for Fig. 3

Scale, kilometers

14 & 17 April
19 & 21 Feb.
23 & 26 Feb.
26 & 28 April
May
June
July
August
September

Aram Mountains
Swakop River
Horebisberge
Sandy flats

Namib Desert Park
Wilsonfontein 110
Aooikuiseb 109

800
960
1200
1500
1800
2000

9 & 11 April
20 & 28 Mar.
11 & 13 June
4 & 6 June
1 & 8 June
9 & 28 May
18 & 30 May
SHORT NOTE

First confirmed record of Lithognathus lithognathus sympatric with L. aureti (Pisces: Sparidae)

M. J. Penrith
State Museum Windhoek

The South African whitesteenbras Lithognathus lithognathus (Cuvier in Cuvier & Valenciennes 1830) has been recorded from the South West African coast on several occasions in the past, but in all cases these records could confidently be referred to the west coast species L. aureti Smith. (Smith, 1962; Penrith and Penrith, 1969), and no confirmed records of L. lithognathus from coastal or estuarine waters north of the Orange River mouth have been published. The record from the estuary of the Orange River reported by Penrith and Penrith (1969) was believed to be a stray. A recent publication, apparently a random list of marine animals from Sandvishawe (Stuart 1975) lists Lithognathus (lithognathus) (Cuvier). It is uncertain what the author intended to convey from this notation, but since L. aureti is not listed, it is presumed that L. aureti is intended.

During recent biological fieldwork in Sandvishawe (more widely known by its old name of Sandwich Harbour) a single example of Lithognathus clearly different from L. aureti was obtained.

Sandvishawe is a shallow, up to 15 metres deep, embayment separated from the sea by a sand bar which is usually broached by a narrow mouth at all states of the tide, and situated approximately 23°20’–23°5’ S; 14°31’ E, some 50 kilometres south of Walvis Bay.

The fish (Cat. no. SMP 1445) was taken in a gillnet set in 2 metres of water for 15 minutes at sunset on the 11/9/1974. It was taken, together with four examples of L. aureti and five Lichia amia. Standard length is 358 mm, maximum body depth 129 mm, candalopeduncle depth 41 mm, and head length 115 mm. The body depth of 2,8 in standard length, and peduncle depth 3,5 in head length, together with 48 lateral line scales, 11 dorsal spines, 10 dorsal rays, 8 anal rays and head shape especially the mouth and lips clearly identify this fish as Lithognathus lithognathus and distinguish it from all others in the genus viz L. aureti, the more northern occurring L. olivieri and the widespread L. morynurus.

The origin of this isolated record is uncertain. The cold water along the coast of south western Africa is largely due to wind induced upwelling. This system can break down for short periods. During periods when the inshore water is warmer than normal Cape species can move northward. With onset of cold water conditions they could be trapped in bays and other areas subject to solar warming. Water temperatures in Sandvishawe, Walvis Bay lagoon and Luderitz lagoon are usually 3–5° C above sea temperatures on the open coast. In certain cases this has resulted in permanent or semi-permanent populations becoming established outside their normal range, Bleiincthus brachycephalus in Luderitz (Penrith 1970), Lichia amia and Mugil cephalus in Sandvis. The single record of L. lithognathus, however, suggests a chance migrant. The coldest water on the west coast lies between Port Nolloth and Luderitz (Isaac, 1937). There are now two records of L. lithognathus from the west coast, one from within the maximum upwelling area (Orange River mouth) and the present example that had crossed the area to the warmer water in the
region of Walvis Bay (16°—18° C in summer) (Stander, 1969). Local anglers report that during periods of warm water in the Walvis Bay region steenbras with pointed snouts are taken together with Carcharhinus brevirostris (J. Simpson pers. comm.). It is probable that these steenbras are L. lithognathus.

With the ability to cross the minimum temperature zone, L. lithognathus, which, on the east coast of Africa extends to subtropical conditions and is adapted to sandy conditions, could occur anywhere on the west African coast as an isolated individual. For this reason it should be noted that the figure labeled L. aureti in Blache, Cadenat and Stauch (1970: 331 fig. 854) is clearly L. lithognathus and not L. aureti. L. aureti is figured by Smith (1962) and Penrith and Penrith (1969).

The biological study of Sandwichwe is a joint study being undertaken by the Department of Nature Conservation and Tourism; the State Museum, Windhoek and the South African Museum, Cape Town. The assistance in the field of the other members of the field party is acknowledged.

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REFERENCES

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SHORT NOTE

A record of the Namaqua Sandgrouse *Pterocles namaqua* from Rhodesia

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Many sandgrouse populations are known to be nomadic and in some cases even migratory Clancey (1967), McLaren (1944), Roberts (1932) and Vincent (1944). *Pterocles namaqua* is widely distributed throughout the Cape, Orange Free State, the Western Transvaal, South West Africa and parts of Botswana. While Vincent (1944) has recorded Namaqua Sandgrouse nomads from the Mool River area in Natal available literature shows no records of its occurrence from Rhodesia.

During the recent examination of study material held in South African museums an adult male of *P. namaqua* collected from the Matopos region of Rhodesia was located. This bird was obtained during June 1903 (Collector R. Williams), and is held in the collections of the Albany Museum in Grahamstown (AM. No. 753). This would appear to be the first record of this species from Rhodesia.

Clancey (1967) notes that there is no resident population of Namaqua Sandgrouse in central and eastern Botswana and while there are no records of this species from Rhodesia (Steyn, pers. comm.) there is no reason to doubt the Matopos locality. It confirms the belief that Namaqua Sandgrouse populations are in most, if not all cases highly nomadic.

Namaqua Sandgrouse recorded from the Melka Galla on the Usino Nyiro in Kenya McLaren (1944) are far from the normal range of this species and may refer to the Chestnut-bellied Sandgrouse *P. exustus*.

ACKNOWLEDGEMENT

I would like to convey my thanks to Dr R. A. C. Jensen for assistance rendered.

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* Presently at the Ecological Research Institute, Okakarara 92, South West Africa
At present the authorities do not have the means to continue with a full scale investigation of the finds reported on here. Until time and money is available to do so this publication is to elicit useful comments. It is known that the Tsodab River reached the ocean during earlier times, cutting its bed into the tertiary dune surface (Martin, pers. com.). When dune sand was once more deposited in the west it blocked the river from entering the sea and the river sediments could no longer reach the ocean. They consisted of highly calcareous silts which were derived from the calcareous crusts and calcrites in the catchment area of the Tsodab. These sediments were deposited in the arms and ponds of the Tsodab formed by the engulfing dunes. In such a way pans and vleis developed which probably resembled those in evidence at Sossus Vlei.

Water stored in this way was used by the animals in the area. In the course of the year the level of the water in these pans dropped due to evaporation, seepage and usage by the animals. Consequently the surface of the silt layers along the higher lying edges became increasingly exposed towards the inner, lower lying areas. The animals followed the receding water across sediments which would still be wet and soft, leaving behind their tracks. In the course of drying out the sediments would shrink and harden. While the tracks were being preserved numerous mud cracks occurred.

These silt layers were often covered by aeolian sand as well as by more recent river sediments. A part of such an older silt layer was recently uncovered.

Within the framework of an archaeological project reconstructing past environments in the Namib stone tools had been found west of Tsodab Vlei (Seely & Sandelowsky, 1974). A surface collection of fresh water snail shells was dated to approximately 10 000 years.

In August 1975 the site where the snail shells had been collected was once more inspected. Along an eroded edge of a clay layer the imprint of a bird's foot became visible on a covered silt surface. This suggested that foot prints of other animals might be found beneath the present day surface. Consequently another visit to the site was arranged in November.

In the process of uncovering one of the lower silt-layers a series of eleven large impressions in the surface were found. Five pairs of prints could be observed while one end pair appears to have been disturbed by a later silt layer. They have an oval shape and are between 60 cm and 80 cm long with a breadth of 20 cm to 25 cm. At the deepest point the impressions are 10 cm deep (fig. 1). These eleven tracks extend over a total area of 4,60 m x 1,20 m. The form of the silt indicates that the impressions were made while the surface was still soft and wet. Tracks of birds and other animals which are less striking on account of their smaller size and shallower impression can be observed on this surface as well. In other parts of the Namib similar tracks of animals today foreign to the area have been observed (Wendi, 1976).
It is not yet known what caused the pattern of large
prints, but their repetitive regularity implies the
movement of a living creature.

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We are most grateful to Mr Johan Ligthelm of the
Nature Conservation and Tourism Division for his
understanding and enthusiastic help. We also thank
Mr B. J. G. de la Bat and Mr P. S. Swart for their
cooperation and swift publication of this note.

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wildarten im westlichen Groß-Namaland. Afrikani-
scher Heimakalender.

Plate 1: Five pairs of impressions in the residual silts.
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   (a) complete title of paper — which should be concise yet clear as to the contents of the paper;
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3. The size of the printing surface of the pages is 24.7 cm X 16.8 cm.
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