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The Physiographic, Edaphic and Vegetative Characteristics found in the western Etosha National Park.

by
Eugene Joubert
Nature Conservation and Tourism Branch
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I. INTRODUCTION

During a research project on the ecology of the black rhinoceros in South West Africa a study on the edaphic and vegetative characteristics of their distribution area were included. Some of the results obtained during this study are given in this paper.

The western part of the Etosha National Park is situated in the Kaokoveld between the Hoanib and Ugab-Rivers. Physiographically the western Etosha National Park (and the Kaokoveld) may be divided into the following regions:

a) The coastal desert in the west.
b) The escarpment.
c) The plateau to the east.

According to the proposals made by the Odendaal Commission the new road linking Kamanjab and the Ruacana falls will form the western boundary of the Etosha National Park. Physiographically the western part of the Etosha National Park will then consist of only the inland plateau and a part of the transition between this plateau and the escarpment. A study area was selected in this region and was situated just south of the 19th latitude at Otjovasandu. It is bound in the south by the old Etosha Game Reserve boundary, in the east by a dolomite ridge, in the north by the Sesfontein road and in the west by an imaginary line connecting the waterholes Renosterfontein, Omborongbonga and Kowares, which will approximately form the new western border of the Etosha National Park. This area covered about 270 square miles.

II. METHODS AND PROCEDURE

2.1. Soils of the study area

Twelve localities were chosen in the study area, distributed in the various superficially-different types of soil.

Profile pits were dug as deep as possible up to a maximum depth of 6 feet. A profile was drawn and samples taken from every different layer of soil. These samples were subsequently analysed at the soil research laboratories at Neudamm.

2.2. Vegetation of the study area

Most of the plants in the study area were collected and identified in the Herbarium at Windhoek. In this way a herbarium of local plants was built up at Otjovasandu.

The vegetation at the Otjovasandu study area was divided, with the aid of aerial photos and a general knowledge of the vegetation in the area, into nine different plant associations. To characterise each plant association, quarter method surveys (Curtis and Cottam, 1962), were carried out in five plant associations and two wheelpoint surveys (Tidmarsh and Havenga, 1954), in two other plant associa-
tions. No botanical surveys were carried out in the Commiphora — Sterculia and Cataphractes alex- andri — Acacia nubrouni associations.

2.3. Quarter method

25 points \((8 + 8 + 9)\) were chosen on three predetermined compass lines. Each point was chosen by pacing 50 yards along the transect line. At each point, the space around the point was divided into four quarters, with the compass line of traverse as one bisect and another line at 90° angle to this through the point as the other. Within each quarter, the nearest tree above a height of 6 feet to the point was chosen, its distance from the point, its basal area, its height, the diameter of its crown, and its species determined. The nearest shrub (below a height of six feet) in each quarter, its distance from the point and its species were also determined.

2.4. Wheelpoint method

Each wheelpoint survey consisted of 2,000 points, counting every second time the selected spoke touched. Twenty transects, of 100 points each, were done on predetermined compass lines approximately 100 yards apart. The various definitions of strikes given by Tidmarsh and Havenga were closely followed.

In the valley community the transects were laid out diagonally across the valley.

III. Topography of the study area

Two of the three Kaokoveld physiographic regions occurred in the study area. The dolomite ridges forming the eastern boundary of the study area formed a third component. Physiographically the study area then consisted of the following:

3.1. The edge of the escarpment.
3.2. The plateau.
3.3 The eastern dolomite ridges.

3.1. The escarpment

The western edge of the plateau is marked by the 4,000 feet contour line. From here the country falls away to the west to form an extremely dis-
sected landscape. In this part a well developed, exoreic drainage system forms the headwaters of the Hoanib River catchment area just below the 4000 feet contour. Some of these seasonal streams form wide valleys with ill-defined drainage lines. The four perennial waterholes serving this area are situated in these stream beds. The stream beds are sand-filled and the water rises to the surfaces where there are natural transverse barriers — Reostervlei and Omborongbonga. At Otjovasandu the subsurface channel is narrowed by impervious rock side walls sufficiently to dam the subterranean water so that it appears on the surface.

3.2. The plateau

Apart from a few hills the plateau is mostly flat with a gentle slope towards the east. Its highest elevations are the Landskrone ridge in the north-western area and a few ridges along the western and southern edges. Some of these were extensively used as reconnaissance points during the study.

The inland plateau is endoreically drained into the Etosha Pan. Owing to the dolomite ridges in the east this catchment area is cut off from the larger system. A poorly developed local endoreic system replaces it. The smaller system consists of a number of interlaced omurambas (drainage lines) which drain into pans formed in depressions along the eastern side of the plateau. Sometimes the water collects in depressions along the omuramba bed itself. Numerous little pans are formed in this way all over the study area. Their influence on the behaviour of the black rhinoceros during the rainy season appears to be remarkable.

Besides the natural waterholes the only permanent water available is supplied by a windpump in the south-eastern portion of the plateau.

3.3. The eastern dolomite ridges

These ridges run from the south-eastern corner of the study area in a north-westerly direction. They never exceed altitudes of more than two or three hundred feet above the surrounding plateau. They are not persistent throughout their length but leave a series of openings through which animal movements take place. They cannot therefore be regarded as an ecological barrier. The dry sandveld to the east is a much more effective barrier for animal (apart from elephant) movements.

IV. GEOLOGY OF THE STUDY AREA

The study area is underlain by granite and gneiss of Archean age, followed by sediments and volcanics belonging to the Khoabendus Formation and Outjo Facies of the Damara System of pre-Cambrian age. The physical characteristics of these rocks and their different behaviour under weathering and erosion exercised a very important geomorphological influence on the evolution of the landscape, which resulted in the already mentioned physiographic features, which are characteristic of the study area.

| Table 1. The geological formations in the study area, at Otjovasandu, South West Africa. |
|---------------------------------|----------------|----------------|
| Sand, Gravel,                  | Kalahari beds | Recent Tertiary |
| Calcrete,                      |                |                |
| Soils etc.                     |                |                |
| Dolomite shale                 | Upper dolomite| Otavi series   |
| Limestone                      |                |                |
| Titlite                        |                |                |
| Dolomite                       | Lower dolomite| Damara system  |
| Limestone                      |                | Late           |
| Shale, graywacke               |                | Pre-cambrian   |
| Quartzite                      |                |                |
| Shale                          | Nosib series   |                |
| Conglomerate                   |                |                |
| Shale, limestone               | Khoabendus     |                |
| Quartzite                      | formation and  |                |
| Acid volcanics                 | Karross volcanics|            |
| Granite                        | Archaen System |                |
| Granodiorite                   | Basement       |                |
| Gneiss                         |                |                |
4.1. The Archean Basement

It is represented in the study area by granite, gneiss and granitised metasediments and metavolcanics belonging to the Huab Formation.

4.2. Khoabendus Formation

It rests unconformably over the gneiss and granite of the basement by means of a locally developed basal conglomerate. This formation consists of shale, limestone, quartzite, acid volcanics and granite. The quartzite is white and very hard. In the southern portion of the study area several of the ridges are formed by this white met quartzite. The fragments of this rock are scattered on the surface along the southern slopes of the escarpment. In the vicinity of Otjovasandu it is reported to contain a small amount of gold (Martin, 1964).

Greenish phyllites and bands of dolomite overlie the quartzite in the area to the north of Otjovasandu.

4.3. Damara System

4.3.1. The Nosib Series

It consists of a very thick sequence of feldspatic quartzite which always weathers pink. Thin bands of shale and limestone are interbedded within the quartzite. Characteristically it sometimes consists of a conglomerate of pebbles, mostly quartz and quartzite. This formation is more than 4 000 feet thick at the Hundskop Mountains. It also forms the Landskrone ridge in the study area.

4.3.2. The Otavi Series

The lower dolomite stage: The lowest members of this stage consist mainly of dolomite and dark blue-black magnesiac limestone. At places they appear interbedded with shale, sandstone and quartzite. Upper dolomite stage: The basal portion is composed of tillite which may include some iron ore. This is followed by limestone and occasionally by dolomite breccia. A thick sequence of light-grey, well bedded dolomite closes this stratigraphic succession. (Mainly after Martin, 1964).

V. SOILS OF THE STUDY AREA

Recent deposits cover most of the abovementioned geological formations, especially on the plateau and valley floors. Only on the slopes of the escarpment and on the hills is the vegetation influenced by the older geological formations. Different climates produce different types of soils having characteristic chemical and physical properties. Arid climate such as in the study area, can therefore produce only desert or semi-desert types of soil and corresponding vegetations.

The soils tend to be shallow, alkaline, high in water soluble salts, poor in phosphates and nitrogen content (See tables 2 and 3).

<table>
<thead>
<tr>
<th>Profile Pit</th>
<th>Natural plant cover</th>
<th>Soil type</th>
<th>Colour</th>
<th>Texture</th>
<th>Horizon</th>
<th>Depth</th>
<th>Structure</th>
<th>Stone</th>
<th>Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>stony layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sub-strate: — Sheet calcrite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sub-strate: — Sheet calcrite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sub-strate: — Granite divided in column blocks by root erosion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sub-strate: — Granite covered by sheet calcrite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>S. guerichii asso. and — C. alexandri — A. nebrowni asso.</td>
<td>Surface lime- stone and calcrite rubble</td>
<td>Reddish brown loamy sand</td>
<td>B₂ B₃</td>
<td>0&quot;—12&quot; 12&quot;—24&quot;</td>
<td>Column none</td>
<td>small angular</td>
<td>few none</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>S. guerichii asso. and — C. alexandri — A. nebrowni asso.</td>
<td>Surface lime- stone and calcrite rubble</td>
<td>Greyish loamy sand</td>
<td>B₂ B₃</td>
<td>0&quot;—12&quot; 12&quot;—24&quot;</td>
<td>Granular Sub-angular none calcrite rubble</td>
<td>moderate none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>S. guerichii asso. and — C. alexandri — A. nebrowni asso.</td>
<td>Surface lime- stone and calcrite rubble</td>
<td>Brown loamy sand</td>
<td>B₂ B₃</td>
<td>0&quot;—12&quot; 12&quot;—36&quot;</td>
<td>Angular Granular moderate abundant</td>
<td>moderate none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Valley community</td>
<td>Alluvial soil</td>
<td>Brown sandy loam gravel</td>
<td>B₂ B₃</td>
<td>0&quot;—48&quot; 48&quot;—54&quot;</td>
<td>Angular Solid none calcrite rubble</td>
<td>abundant none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Valley community</td>
<td>Alluvial soil</td>
<td>Reddish brown loamy clay</td>
<td>B₂ B₃</td>
<td>0&quot;—72&quot;</td>
<td>Prismatic moderate</td>
<td>moderate abundant few</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Valley community</td>
<td>Alluvial soil</td>
<td>Reddish brown sandy loam</td>
<td>B₂ B₃</td>
<td>0&quot;—34&quot; 34&quot;—50&quot;</td>
<td>Sub-angular Sub-angular gravel meta- quartzite pebbles</td>
<td>abundant none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>C. mopane — A. reficiens — T. prunioides asso.</td>
<td>Skeletal soil</td>
<td>Greyish sandy loam</td>
<td>B₂ B₃</td>
<td>0&quot;—19&quot; 19&quot;—24&quot;</td>
<td>Sub-angular Sub-angular none meta- quartzite</td>
<td>few few</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Grass on rain water pan surface</td>
<td>Claylike soil</td>
<td>Blackish sandy clay-like</td>
<td>B₂ B₃</td>
<td>0&quot;—9&quot; 19&quot;—15&quot;</td>
<td>Granular Prismatic moderate none</td>
<td>abundant none</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.1 Kalahari-like red sand

The Etosha basin forms part of the greater Kalahari Basin (Wellington, 1955). The Kalahari-like sand may have been windblown or redeposited through water action in the present localities. The greatest part of the study area is covered by this redeposited material. The sand is usually reddish and fine-grained. In some localities the colour of the sand is changed to grey or lighter by the influence of vegetation and/or bleaching. According to du Toit (1954) the Kalahari sand consists chiefly of quartz fragments together with feldspar, chalcedony and chert. Heavy minerals include limenite and magnetite.

The natural vegetation is formed by a tree and shrub savanna. The average depth of the sand (2 profile pits) is two feet overlying sheet calcrite. The sand is usually alkaline (See fig 1). On the eastern side of the study area some dunes are formed. These are usually covered by Terminalia prunioides trees and riddled with animal burrows — especially mice.

Characteristically large numbers of termite mounds (with the resulting antbear holes) are scattered throughout the Kalahari-like sand. In the study area some of these termite mounds are of a greyish, clayey soil. This indicates that the sand is a more recent deposit on an older and deeper layer of soil.
Table 3. Analysis of soil samples taken from profile pits in study area, Ojovasandu.

<table>
<thead>
<tr>
<th>Profile Pit</th>
<th>pH</th>
<th>Resistance in Ohms</th>
<th>N.</th>
<th>P₂O₅</th>
<th>K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.00/8.19</td>
<td>1200/1400</td>
<td>0.0350/0.0280</td>
<td>0.0020/0.0033</td>
<td>0.0038/0.0026</td>
</tr>
<tr>
<td>2</td>
<td>7.02/7.90</td>
<td>890/410</td>
<td>0.0434/0.0504</td>
<td>0.0024/0.0035</td>
<td>0.0036/0.0017</td>
</tr>
<tr>
<td>3</td>
<td>7.98/5.12</td>
<td>8000/10</td>
<td>0.0238/0.0196</td>
<td>0.0026/0.0014</td>
<td>0.0046/0.0017</td>
</tr>
<tr>
<td>4</td>
<td>7.11/8.16</td>
<td>2650/1900</td>
<td>0.0322/0.0238</td>
<td>0.0015/0.0010</td>
<td>0.0017/0.0018</td>
</tr>
<tr>
<td>5</td>
<td>6.38/7.86</td>
<td>1280/520</td>
<td>0.0308/0.0535</td>
<td>0.0021/0.0061</td>
<td>0.0017/0.0173</td>
</tr>
<tr>
<td>6</td>
<td>8.00/8.10</td>
<td>760/820</td>
<td>0.0728/0.0504</td>
<td>0.0111/0.0030</td>
<td>0.0139/0.0097</td>
</tr>
<tr>
<td>7</td>
<td>8.10/8.33</td>
<td>155/44</td>
<td>0.0406/0.0196</td>
<td>0.0023/0.0031</td>
<td>0.0096/0.0221</td>
</tr>
<tr>
<td>8</td>
<td>8.11/8.01</td>
<td>900/3590</td>
<td>0.1260/0.0476</td>
<td>0.0061/0.0027</td>
<td>0.0034/0.0010</td>
</tr>
<tr>
<td>9</td>
<td>8.26/8.06</td>
<td>790/670</td>
<td>0.0578/0.0378</td>
<td>0.0031/0.0042</td>
<td>0.0022/0.0036</td>
</tr>
<tr>
<td>10</td>
<td>7.06/8.34</td>
<td>3050/1880</td>
<td>0.0252/0.0182</td>
<td>0.0108/0.0096</td>
<td>0.0046/0.0068</td>
</tr>
<tr>
<td>11</td>
<td>6.65/6.57</td>
<td>460/270</td>
<td>0.0812/0.0798</td>
<td>0.0029/0.0030</td>
<td>0.0072/0.0139</td>
</tr>
<tr>
<td>12</td>
<td>6.99/7.38</td>
<td>820/610</td>
<td>0.0700/0.0406</td>
<td>0.0027/0.0019</td>
<td>0.0072/0.0038</td>
</tr>
</tbody>
</table>

5.2. Granitic coarse red sand

This sand occurs along the western edge of the plateau. It is formed on granite parent material. The grains are coarser than those of the Kalahari-like sand. Limestone occurs in a few isolated patches. The soil is usually acid, getting more so the deeper one goes (See fig. 2). The sand layer on top of the granite is never more than about two feet thick — this explains the absence of termite mounds and animal burrows. The natural vegetative cover is formed by combretums and mopanes with the dominant grass being Stipagrostis uniplanis.

5.3. Surface limestone and calcite rubble

Surface limestone covers large areas on the plateau especially where underlain by dolomite. This surface limestone is formed in the following manner: rainwater percolates downward and dissolves underlying limestone; this solution then rises by capillary action to the surface and while drying deposits as sheets of calcite on the surface or just underneath. In fig. 3 calcite nodules may be seen in the overlying soil layer. In some areas the sheet calcite has been broken by root action forming loose calcite rubble. This may form ridges giving the terrain an undulating appearance. The vegetation on these calcite ridges is usually dominated by Cataphractus alexandri and to a lesser extent by Acacia nebrownii and Sesamathamus querichi.
5.4. Alluvial soils

The alluvial soils occur in the broad valleys where the seasonal streams open out. The soils are fairly deep loam, sandy clay loam to sandy loam, dark grey to brown depending on the degree of humus impregnation. The sub-soil often contains calcareous nodules passing into beds of limestone. Out of three profile pits dug, calcrite sheets were found in one at 54 inches (See fig. 4) In profile pit no. 10 a layer of quartzite gravel was found at 34 inches. The soils are alkaline (See fig. 4).

The soils have a low permeability. The surface often becomes quite loose when dry, especially with trampling. With heavy traffic the powdery dust is sometimes up to 18 inches deep. These soils will be sensitive to trampling as a result of overgrazing, etc. Because of the depth of the soils the best tree growth in the study is found here. Tree mopane,

*Acacia tortilis*,
*Acacia hebeclada* and
*Acacia giraffae*

occur.

5.5. Skeletal soils

These soils are usually found on the ridges of exposed escarpment areas and are formed by weathered parent material. It is seldom more than a few inches deep (See fig. 5). Vegetation however finds adequate roothold in the crevices of the much weathered surface rock from which there is comparatively little run-off. The vegetative cover is usually a *Combophora-Sterculia* association. On the less pronounced slopes, with a deeper soil layer, a *Colophospermum mopane*, *Acacia reticulata* and a *Terminalia pruinoides* association with a karroid shrub layer occur.

5.6. Claylike soils in the depressions

These depressions are found in scattered locations on the plateau but are more notable along the eastern side. The soil is usually only about five to fifteen inches deep over sheet calcrite. Nodular calcrite, up to twelve inches in diameter, is often found on the surface of these little pans. The soil is alkaline and dark grey in colour (See fig 6). The surface is fine-grained and baked hard when dry. In the more frequented pans the mud is trampled while drying and hardened in this way. In some of the larger pans the surface has a table-top appearance covered with *Sporobolus* and *Enneapogon* grasses. The trees consist of *Combretum imberbe*, *Ziziphus mucronata* and on the edges, tall mopanes.

VI. VEGETATION OF THE STUDY AREA

Stocker (1964) suggested that the term savanna should not be limited to a park landscape with grassland and single trees, but instead, it should be used collectively for forest-, parkland- and grassland vegetation of tropical climates with pronounced dry periods, because these vegetational types are generally conditioned by edaphic factors. Stocker distinguished between moist savanna; dry savanna — with grass and slender trees; and thorny savanna — with low grass and thorny succulent small trees and bushes.

The Kaokoveld lies within the 0—300 mm isohyets. This arid climate therefore produces, as already mentioned, only desert or semi-desert types of soil and corresponding vegetation. The vegetation of the Kaokoveld can be divided into two main components:

- Arid savanna
  - Desert and sub-desert.
The study area falls within the arid savanna, larger and more important of the two components. According to the presence and distribution of the plants in the study area, two of the five physiographic components of a savanna that were recognized by Hopkins, occur within the study area: tree savanna, shrub savanna.

In the study area it was found that the latter two occur in a combined form in some localities. They both however, also occur in the study area as pure physiographic units. It was possible to subdivide the physiographic components of the study area vegetation into several smaller communities.

6.1. Tree savanna on sand

6.1.1. Colophospermum mopane tree savanna on granitic sand.

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**Generalised geology and soil types in the study area at Otjovasandu, South West Africa**

[Diagram showing geology and soil types]

Geology based on unpublished map by Bethlehem Exploration and Mining Corporation.

Map 1.
6.2. Tree and shrub savanna on Kalahari-like sand, granitic sand and alkaline soils

6.2.1. Colophospermum mopane — Acacia reficiens — Terminalia prunioides association.
6.2.2. Colophospermum mopane — Terminalia prunioides — Combretum apiculatum association.
6.2.3. Combretum apiculatum — Colophospermum Mopane association

6.3. Shrub savanna on calccrete rubble and alkaline soils

6.3.1. Colophospermum mopane — Catophractus alexandri shrub savanna.
6.3.2. Catophractus alexandri — Acacia nebrownii association.
6.3.3. Sesamothamnus guerichii association.

6.4. Valley community on alluvial soils

6.5. Commiphora — Sterculia association on rocky outcrops

The terms used are modified after Hopkins (1965) and Tinley (1966). Tree savanna: Stands of trees not forming a dense canopy, the crowns being spaced from touching, in aggregations, to more than twice their own crown diameter apart. The ground layer is formed dominantly by grass with shrub in scattered localities. Tree and shrub savanna: Trees are scattered, with shrub and grasses forming the dominant vegetative cover. Shrub savanna: When trees are absent and herbs and grasses form, apart from shrub, important components of the vegetative cover.

6.1. Tree savanna on sand

6.1.1. Colophospermum mopane tree savanna on granitic sand

Only a small fraction of the study area is covered by a true tree savanna. This is in the western section of the study area on secondary deposited granitic sand on valley alluvial soils. The tree canopy is formed mainly by Colophospermum mopane trees, with a relative density of 58 per cent. Although some of the mopane trees reach heights of up to 30 feet, the average height is 19 feet.

Although mopane is deciduous, it never loses all its leaves completely except after heavy frost. New leaves are usually formed from about August during the spring flush. They flower from about February to March. In the study area mopane trees are sometimes defoliated in patches by the mopane "worm" — Genimbrasia belina and to a lesser extent, the thorn tree emperor moth G. maja. This defoliation usually occurs in patches during the summer months (January — February). The defoliated mopane trees then usually have a second leaf growth soon after, from March to May.

The mopane “worm” is protein rich and is gathered by the Ovambos as a delicacy. The inhabitants of the Kaokoveld, apart from the small hunter gatherer Tjimba-Tjimba group (B. Grobbelaar pers. com. 1968), however do not eat the caterpillars. A zebra (Equus burchelli) was once observed in the study area picking the caterpillars from shrub mopane and apparently eating them. Centipedes also feed to a large extent on these caterpillars.

Another component of the tree canopy is Combretum apiculatum. This is the only locality in the area where they have a tree growth form with an average height of 12 feet. An occasional tall Boscia albitrunca and Terminalia prunioides also contributes to the tree canopy.

Table 4. Species composition and differentiation of the tree layer in the Colophospermum mopane tree savanna.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>Average height of trees (feet)</th>
<th>Average diameter of crown (inches)</th>
<th>Average circumference of trunk (inches)</th>
<th>No. of points of occurrence</th>
<th>No. of trees</th>
<th>Total basal area (square inches)</th>
<th>Relative frequency (%)</th>
<th>Relative density (%)</th>
<th>Relative dominance (%)</th>
<th>Importance value (F + D + Do)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colophospermum mopane</td>
<td>33.4</td>
<td>19.0</td>
<td>12.8</td>
<td>27.4</td>
<td>21</td>
<td>58</td>
<td>50483.32</td>
<td>52.5</td>
<td>58.0</td>
<td>62.3</td>
<td>172.8</td>
</tr>
<tr>
<td>Combretum apiculatum</td>
<td>19.7</td>
<td>12.1</td>
<td>9.7</td>
<td>27.6</td>
<td>10</td>
<td>20</td>
<td>1676.40</td>
<td>25.0</td>
<td>20.0</td>
<td>20.6</td>
<td>65.5</td>
</tr>
<tr>
<td>Boscia albitrunca</td>
<td>45.5</td>
<td>19.0</td>
<td>9.0</td>
<td>24.5</td>
<td>5</td>
<td>12</td>
<td>573.48</td>
<td>12.5</td>
<td>12.0</td>
<td>7.1</td>
<td>31.6</td>
</tr>
<tr>
<td>Terminalia prunioides</td>
<td>28.5</td>
<td>20.0</td>
<td>21.0</td>
<td>32.0</td>
<td>4</td>
<td>10</td>
<td>813.00</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>100</td>
<td>8111.20</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>300.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>300.0</td>
</tr>
</tbody>
</table>

Average distance: 31.6 feet.
Trees per acre: 42.7.
Average basal area per tree: 81.11 sq. inch.
Basal area per acre: 2563 sq. inch.
Table 5. Species composition of the more common shrubs in the *Colophospermum mopane* tree savanna.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>No of points of occurrence</th>
<th>No of plants</th>
<th>Relative frequency %</th>
<th>Relative density %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combretum apiculatum</td>
<td>11.7</td>
<td>25</td>
<td>45</td>
<td>34.4</td>
<td>45</td>
</tr>
<tr>
<td>Colophospermum mopane</td>
<td>21.6</td>
<td>11</td>
<td>11</td>
<td>16.4</td>
<td>11</td>
</tr>
<tr>
<td>Monechna genistifolium</td>
<td>20.0</td>
<td>7</td>
<td>9</td>
<td>10.4</td>
<td>9</td>
</tr>
<tr>
<td>Montinia caryophyllacea</td>
<td>20.0</td>
<td>6</td>
<td>9</td>
<td>8.9</td>
<td>9</td>
</tr>
<tr>
<td>Catophractes alexandri</td>
<td>17.0</td>
<td>6</td>
<td>8</td>
<td>8.9</td>
<td>8</td>
</tr>
<tr>
<td>Commiphora pyraanthoides</td>
<td>18.0</td>
<td>5</td>
<td>6</td>
<td>7.4</td>
<td>6</td>
</tr>
<tr>
<td>Croton subgratissimus</td>
<td>6.0</td>
<td>4</td>
<td>5</td>
<td>5.9</td>
<td>5</td>
</tr>
<tr>
<td>Rhigozum brevispinosum</td>
<td>21.3</td>
<td>3</td>
<td>4</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>Pechuel-loeschea reubnitziae</td>
<td>14.0</td>
<td>2</td>
<td>3</td>
<td>2.9</td>
<td>3</td>
</tr>
</tbody>
</table>

On the average the variety of shrub in this vegetation type is poor (See table 5), the most prominent being shrub mopane. In the ecotones of this tree savanna, and in localities where the tree canopy has been destroyed by elephant, one finds an encroachment by shrub savanna elements; apart from shrub mopane also *Combretum apiculatum* and *Catophractes alexandri*. Other shrubs which occur throughout this community are:

- *Monechna genistifolium*
- *Croton subgratissimus*
- *Commiphora pyraanthoides*
- *Montinia caryophyllacea*
- *Rhigozum brevispinosum*

In the sandy washes *Pechuel-Loeschea Leubnitziae* forms dense stands.

The grass cover is dominantly formed by *Stipa gregostis uniplanis*, *Aristida meridionalis*, *Schmidtia kalahariensis*.

6.2. Tree and shrub (thorn shrub) savanna on Kalahari-like sand, granitic sand and alkaline soils

This physiographic component forms one of the major vegetative cover types found in the Kaokoveld between the 100 mm and 300 mm isohyets. It also carries the richest mammal and bird life of the region.

6.2.1. *Colophospermum mopane*, *Acacia reficiens* and *Terminalia prunioides* association.

This vegetation type covers a large portion of the study area along the escarpment on to the edge of the plateau. It also covers the hills on the plateau in the study area. Throughout the rest of the Kaokoveld and the Etosha National Park to the west of Otjovasandu it contributes a major portion of the vegetative cover. It is also the most preferred vegetative cover for black rhinoceros, mainly due to the great variety of foodplants and protection offered.

This vegetation type may also be called the tall shrub savanna, especially in areas where the soil deepens. This community can be divided into three strata, viz. a tree canopy, a shrub layer, and a ground layer.
The tree canopy is formed by tall, usually single boled mopanes, especially on the edges of little depressions or umurubas where rainwater collects during the rainy season. Boswellia alopecuroides, Moringa oleifera, and an occasional Combretum imberbe and Ziziphus mucronata also contribute to the canopy. This stratum is between fifteen to twenty-five feet high. In areas where the soil is not very deep, the trees in the escarpment zone, this stratum is sometimes absent.

The second stratum is formed by a great variety of shrub. These shrubs are usually multistemmed and between six to fifteen feet high. The dominant components of this second stratum are Colophospermum mopane, Acacia reficiens and Tere...
minalia prunioides, from which this community’s name is derived. *A. reficiens* is a shrub and is sometimes parasitized by *Loranthus elegantissimus*.

Some other shrubs which also occur are:

- *Acacia mellifera ssp. detinens*
- *A. erubescens*
- *A. nilotica*
- *A. senegal var. rostrata*
- *Cordia gharaf*
- *Dichrostachys glomerata*
- *Croton gratissimus*
- *Albizzia anthelmintica*
- *Croton subgratissimus*
- *Adenolobus garipensis*

*Combretum apiculatum* also form a part of this stratum in some areas of the study area, especially in the ecotones to the west but are very seldom present in large numbers. On the rocky hills in the western portion *Acacia ataxacantha* is sometimes found. At a few waterholes *Combretum wattle* is also present in small numbers. *Sesamothamnus gue- richii* and *Cataphractes alexandri* is represented by a few individuals only.

The ground layer is formed by a great variety of shrubs, herbs and grasses, especially in areas where the tall shrub layer opens out on the plateau. The more important shrubs are represented by:

- *Grewia bicolor*
- *Grewia villosa*
- *Grewia tenax*
- *Grewia flavescens*
- *Mundulea sericea*
- *Maerua parvifolia*
- *Amphiophila merenskyanum*
- *Oiptera burchellii*
- *Barleria senensis*
- *Helium integrifolius*
- *Asparagus denudatus*
- *Triaspis nelsonii var. austro-occidentalis*
- *Boscia foetida*
- *Montinia caryophyllacea*
- *Gossypium triphyllum*
- *Lychnis boschii*
- *Justica odorata*
- *Veronica cinerascens*
- *Lantana dinteri*

Young plants of *Acacia* species and *Terminalia prunioides* occur in large numbers. In areas where

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Plate 5. A kudu, one of the animals which show a preference for the denser vegetation of the *C. mopane, A. reficiens, T. prunioides* association. (Photo: W. F. S. Joubert).
Table 6. Species composition and differentiation of the tall shrub layer in the *Colophospermum mopane*, *Acacia reficiens* and *Terminalia prunioides* association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>Average height of trees (feet)</th>
<th>Average diameter of crown (feet)</th>
<th>Average circumference of trunk (inches)</th>
<th>No. of points of occurrence</th>
<th>No. of trees</th>
<th>Total basal area (square inches)</th>
<th>Relative frequency (%)</th>
<th>Relative density (%)</th>
<th>Relative dominance (%)</th>
<th>Importance value (+D +Do)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia reficiens</em></td>
<td>30.1</td>
<td>8.5</td>
<td>13.6</td>
<td>44.7</td>
<td>20</td>
<td>29</td>
<td>6094.06</td>
<td>27.7</td>
<td>29</td>
<td>51.99</td>
<td>108.69</td>
</tr>
<tr>
<td><em>Colophospermum mopane</em></td>
<td>19.7</td>
<td>8.0</td>
<td>8.9</td>
<td>16.9</td>
<td>16</td>
<td>27</td>
<td>1035.72</td>
<td>2.2</td>
<td>27</td>
<td>8.38</td>
<td>58.03</td>
</tr>
<tr>
<td><em>Terminalia prunioides</em></td>
<td>28.3</td>
<td>14.2</td>
<td>15.3</td>
<td>37.0</td>
<td>16</td>
<td>23</td>
<td>2975.74</td>
<td>2.2</td>
<td>23</td>
<td>25.36</td>
<td>70.56</td>
</tr>
<tr>
<td><em>Acacia mellifera spp. detinens</em></td>
<td>19.4</td>
<td>9.8</td>
<td>12.6</td>
<td>32.2</td>
<td>8</td>
<td>9</td>
<td>996.03</td>
<td>11.1</td>
<td>9</td>
<td>8.49</td>
<td>28.59</td>
</tr>
<tr>
<td><em>Boscia foetida</em></td>
<td>36.7</td>
<td>7.2</td>
<td>6.2</td>
<td>27.0</td>
<td>5</td>
<td>5</td>
<td>424.95</td>
<td>6.9</td>
<td>5</td>
<td>3.62</td>
<td>15.52</td>
</tr>
<tr>
<td><em>Combretum apiculatum</em></td>
<td>18.0</td>
<td>9.0</td>
<td>9.0</td>
<td>12.0</td>
<td>2</td>
<td>2</td>
<td>116.02</td>
<td>2.7</td>
<td>2</td>
<td>.96</td>
<td>4.79</td>
</tr>
<tr>
<td><em>Boscia albitrunca</em></td>
<td>12.0</td>
<td>16.2</td>
<td>16.0</td>
<td>27.1</td>
<td>2</td>
<td>2</td>
<td>26.02</td>
<td>2.7</td>
<td>2</td>
<td>.02</td>
<td>4.72</td>
</tr>
<tr>
<td><em>Croton species</em></td>
<td>9.0</td>
<td>8.1</td>
<td>3.2</td>
<td>12.0</td>
<td>2</td>
<td>2</td>
<td>22.92</td>
<td>2.7</td>
<td>2</td>
<td>.01</td>
<td>4.71</td>
</tr>
<tr>
<td><em>Sesamothamnus guerichii</em></td>
<td>21.0</td>
<td>9.0</td>
<td>4.0</td>
<td>22.1</td>
<td>1</td>
<td>1</td>
<td>38.51</td>
<td>1.3</td>
<td>1</td>
<td>.03</td>
<td>2.33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72</strong></td>
<td><strong>100</strong></td>
<td></td>
<td><strong>11729.97</strong></td>
<td><strong>297.94</strong></td>
<td><strong>100</strong></td>
<td><strong>98.31</strong></td>
<td><strong>19.5</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>297.94</strong></td>
</tr>
</tbody>
</table>

Average distance: 21.5 feet.
Trees per acre: 94.23.
Average basal area per tree: 117.29 sq. inches.
Basal area per acre: 11,020 sq. inches.

Table 7. Species composition of the more common shrubs in the *Colophospermum mopane*, *Acacia reficiens*, *Terminalia prunioides* association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>No. of points of occurrence</th>
<th>No. of plants</th>
<th>Relative frequency %</th>
<th>Relative density %</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Petalidium engleranum</em></td>
<td>7.4</td>
<td>13</td>
<td>21</td>
<td>16.9</td>
<td>21</td>
</tr>
<tr>
<td><em>Colophospermum mopane</em></td>
<td>8.3</td>
<td>12</td>
<td>16</td>
<td>15.5</td>
<td>16</td>
</tr>
<tr>
<td><em>Monechma genistifolium</em></td>
<td>4.0</td>
<td>6</td>
<td>11</td>
<td>7.8</td>
<td>11</td>
</tr>
<tr>
<td><em>Grewia species</em></td>
<td>20.5</td>
<td>7</td>
<td>8</td>
<td>9.1</td>
<td>8</td>
</tr>
<tr>
<td><em>Croton species</em></td>
<td>11.6</td>
<td>5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
</tr>
<tr>
<td><em>Boscia foetida</em></td>
<td>7.2</td>
<td>5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
</tr>
<tr>
<td><em>Acacia reficiens</em></td>
<td>7.0</td>
<td>4</td>
<td>5</td>
<td>5.1</td>
<td>5</td>
</tr>
<tr>
<td><em>Terminalia prunioides</em></td>
<td>12.0</td>
<td>4</td>
<td>4</td>
<td>5.1</td>
<td>4</td>
</tr>
<tr>
<td><em>Dichrostachys glomerata</em></td>
<td>6.0</td>
<td>3</td>
<td>3</td>
<td>3.9</td>
<td>3</td>
</tr>
<tr>
<td><em>Montinia carophyllacea</em></td>
<td>4.0</td>
<td>3</td>
<td>3</td>
<td>3.9</td>
<td>3</td>
</tr>
<tr>
<td><em>Catophractes alexandri</em></td>
<td>21.5</td>
<td>2</td>
<td>3</td>
<td>2.6</td>
<td>3</td>
</tr>
<tr>
<td><em>Acacia ataxacantha</em></td>
<td>42.0</td>
<td>3</td>
<td>3</td>
<td>3.9</td>
<td>3</td>
</tr>
<tr>
<td><em>Gossypum triphyllum</em></td>
<td>12.0</td>
<td>2</td>
<td>3</td>
<td>2.6</td>
<td>3</td>
</tr>
<tr>
<td><em>Acacia mellifera ssp. detinens</em></td>
<td>16.0</td>
<td>3</td>
<td>3</td>
<td>3.9</td>
<td>3</td>
</tr>
<tr>
<td><em>Combretum apiculatum</em></td>
<td>27.0</td>
<td>2</td>
<td>2</td>
<td>2.6</td>
<td>2</td>
</tr>
<tr>
<td><em>Acacia erubescens</em></td>
<td>6.0</td>
<td>2</td>
<td>2</td>
<td>2.6</td>
<td>2</td>
</tr>
<tr>
<td><em>Berchemia discolor</em></td>
<td>9.0</td>
<td>1</td>
<td>1</td>
<td>1.3</td>
<td>1</td>
</tr>
</tbody>
</table>
the ground is more alkaline *Catophractus alexandri*
and karroid shrub occur, represented by the following
spieces:

- *Monechma genistifolium*
- *Leucosphaera bainesii*
- *Petalidium engleranum*
- *Leucas pachuelii*

*M. genistifolium* seems to have a large range
throughout the study area.

Herbs are also well represented in this community,
the more common being:

- *Blepharis obmitratra*
- *Plectranthus hereroensis*
- *Dicoma tomentosa*
- *Tribulus terrestris*
- *Bareria anecolata*
- *Hibiscus caesius*
- *Aptosimum angustifolium*
- *Geigeria ssp.*
- *Cleome diandra*
- *Cleome suffruticosa*
- *Petalidium coccineum*
- *Hibiscus micranthus*

The grasses that occur are mainly:

- *Stipagrostis birtigilama*
- *Aristida rhinchochola*
  onto the hills
- *Anthophora schinzii*
- *Triraphis ramosissima*
- *Stipagrostis uniplumis*
- *Heteropogon contortus*
- *Tragus racemosus*

*Rhynchelytrium* sp., into the omurambas *Bothriochloa radicans* and *Urochloa brachyura*. Other shrubs and herbs common in omurambas are *Lycium trothae*. *Petalidium coccineum* the *cyperaceae* eg *Cyperus fulgens*; *Justicia platyspela* and the creepers *Rhynchosia* ssp. and *Ipomoea arachnospora*.

6.2.2. The *Colophospermum mopane*, *Terminalia prunioides* and *Combretum apiculatum* association.

This association is found on the coarse granitic sand and in the western part of the study area.

The vegetation composition is very much the same as the former community. It mainly differs in that *Combretum apiculatum* replaces *Acacia reficiens* which is completely absent from this community. The former, together with *Terminalia prunioides* are the dominant species.

Two other species quite common in this community, but which only seldom occur in the former are *Commiphora pyracanthoides*, which is also present in a large number of seedlings and *Sesamanthamus guericchi*. The latter usually occurs more to the eastern side of the community in the ecotone with the neighbouring community where the soil is more alkaline.

> Figure 9. Mean and maximum height and width of crown and mean distance from the point for the four dominant tree species in the *Colophospermum mopane*, *Terminalia prunioides*, *Combretum apiculatum* association.

Tree species

- *Combretum apiculatum*
- *Terminalia prunioides*
- *Colophospermum mopane*
- *Sesamanthamus guericchi*

Shrub species

- *Combretum apiculatum*
- *Colophospermum mopane*
- *Commiphora pyracanthoides*
- *Catophractus alexandri*

The *Colophospermum mopane* are usually present in the form of trees between fifteen to twenty five feet high. The *Terminalia prunioides* is also usually taller than in the former community and may reach heights of twenty feet. *Combretum apiculatum* never reaches heights of more than ten feet but forms a dense growth in patches. *Catophractus alexandri* occur in scattered localities throughout the community. *Boscia albitrunca* occurs but *B. foutsia* is absent.

The variety and number of shrubs in this association is noticeably less than in the previous plant association.

- *Monechma genistifolium*
- *Montinia caryophyllacea*
- *Croton ssp.*
- *Mundulea sericea*
- *Greavia ssp.*
- *Catophractus alexandri*

and young plants of

- *Terminalia prunioides*
- *Commiphora pyracanthoides*
- *Combretum apiculatum*

and shrub mopane constitute the sole members of this layer.
Table 8. The species composition and differentiation of the tree layer in the *Colophospermum mopane*, *Terminalia prunioides*, *Combretum apiculatum* association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>Average height (feet)</th>
<th>Average crown length (feet)</th>
<th>Average tree thickness (inches)</th>
<th>No. of trees</th>
<th>Total basal area (square inches)</th>
<th>Relative density (%)</th>
<th>Relative dominance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Combretum apiculatum</em></td>
<td>20.1</td>
<td>9.7</td>
<td>8.1</td>
<td>25.2</td>
<td>19</td>
<td>2311.39</td>
<td>30.1</td>
<td>37</td>
</tr>
<tr>
<td><em>Terminalia prunioides</em></td>
<td>18.1</td>
<td>13.5</td>
<td>12.9</td>
<td>38.6</td>
<td>19</td>
<td>4361.51</td>
<td>30.1</td>
<td>31</td>
</tr>
<tr>
<td><em>Colophospermum mopane</em></td>
<td>21.3</td>
<td>13.6</td>
<td>11.5</td>
<td>27.6</td>
<td>15</td>
<td>1193.15</td>
<td>23.8</td>
<td>21</td>
</tr>
<tr>
<td><em>Sesamothamnus guerichii</em></td>
<td>51.5</td>
<td>14.3</td>
<td>11.1</td>
<td>107.6</td>
<td>5</td>
<td>4872.95</td>
<td>7.9</td>
<td>6</td>
</tr>
<tr>
<td><em>Commiphora pyracanthoides</em></td>
<td>21.3</td>
<td>14.3</td>
<td>7.6</td>
<td>22.3</td>
<td>3</td>
<td>121.36</td>
<td>4.7</td>
<td>3</td>
</tr>
<tr>
<td><em>Boscia albitrunca</em></td>
<td>36.0</td>
<td>15.0</td>
<td>5.0</td>
<td>21.0</td>
<td>2</td>
<td>18.16</td>
<td>3.2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.1</strong></td>
<td><strong>100</strong></td>
<td><strong>12878.52</strong></td>
<td></td>
<td></td>
<td><strong>99.8</strong></td>
<td><strong>299.6</strong></td>
<td></td>
</tr>
</tbody>
</table>

Average distance: 24.7 feet.
Trees per acre: 71.39
Average basal area per tree: 128.78 square inches.
Basal area per acre: 9064 square inches.

Table 9. The species composition of the more common shrubs in the *Colophospermum mopane*, *Terminalia prunioides* and *Combretum apiculatum* association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>No. of points of occurrence</th>
<th>No. of plants</th>
<th>Relative frequency %</th>
<th>Relative density %</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Combretum apiculatum</em></td>
<td>12.1</td>
<td>19</td>
<td>33</td>
<td>26.7</td>
<td>33</td>
</tr>
<tr>
<td><em>Colophospermum mopane</em></td>
<td>15.5</td>
<td>9</td>
<td>14</td>
<td>12.6</td>
<td>14</td>
</tr>
<tr>
<td><em>Commiphora pyracanthoides</em></td>
<td>12.4</td>
<td>11</td>
<td>13</td>
<td>15.4</td>
<td>13</td>
</tr>
<tr>
<td><em>Cotrophactes alexandri</em></td>
<td>9.8</td>
<td>8</td>
<td>9</td>
<td>11.2</td>
<td>9</td>
</tr>
<tr>
<td><em>Terminalia prunioides</em></td>
<td>9.8</td>
<td>6</td>
<td>9</td>
<td>8.4</td>
<td>9</td>
</tr>
<tr>
<td><em>Grewia species</em></td>
<td>18.1</td>
<td>7</td>
<td>9</td>
<td>9.8</td>
<td>9</td>
</tr>
<tr>
<td><em>Montinia caryophyllacea</em></td>
<td>12.1</td>
<td>6</td>
<td>7</td>
<td>8.4</td>
<td>7</td>
</tr>
<tr>
<td><em>Monechma genistifolium</em></td>
<td>17.0</td>
<td>2</td>
<td>2</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td><em>Mundulea sericea</em></td>
<td>16.0</td>
<td>1</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td><em>Acacia senegal</em></td>
<td>4.0</td>
<td>1</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
</tbody>
</table>

The more common herbs are:

- *Cleome diandra*
- *Heliotropium giesii*
- *Barleria lanceolata*
- *Helichrysum tomentosulum*
- *Hibiscus micranthus*
- *Justicia platysepala*
- *Triaspis nelsonii var. austro-occidentalis*
- *Cleome elegantissima*
- *Heliotropium ovatifolium*
- *Nelsia quadrangula*
- *Veronia posakeana*

*Neorautanenia amboensis*
*Lantana dinteri*

A wide variety of grasses occur, the following which are the more conspicuous:

- *Aristida meridionalis*
- *Pogonantha flexilis*
- *Aristida rhinichloa*
- *Anthophora schinzii*
- *Stipagrostis uniplumis*
- *Rhynchelytrum villosum*
- *Schmidtia kalahariensis* and some *Enneapogon* species
6.2.3. *Combretum apiculatum* — *Colophospermum mopane* association

This association occurs along the eastern side of the Landskrone ridge and south of the Sesfontein road. The sand is about two to three feet deep and the surface is nearly always loose — hampering movement. In some localities it may be more compact with pebbles and stone, usually metaquartzite, lying on the surface. This area is riddled with antbear holes.

The vegetation consists of scattered mopane trees, fifteen to twenty-five feet high. These trees are seldom single boled, the usual number of trunks

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**Figure 10.** Mean and maximum height and width of crown and mean distance from the point for the four dominant tree species in the *Combretum apiculatum*, *Colophospermum mopane* association.

Tree species
- *Combretum apiculatum*
- *Colophospermum mopane*
- *Boscia albitrunca*
- *Terminalia pruinoides*

Shrub species
- *Combretum apiculatum*
- *Colophospermum mopane*
- *Commiphora pyramidalis*
- *Monechma genistifolium*

---

Plate 4. The *Combretum apiculatum* and *Colophospermum mopane* association. (Photo: W. P. S. Joubert).
being two or three. Some of the trees show browsing damage by elephant. *Boscia albitrunca* occur thinly scattered throughout the area, forming trees up to twenty-five feet in height. *Terminalia prunioides* and *Combretum imberbe* mostly occur in the ecotones.

A dense growth of *Combretum apiculatum* forms a substorey six to fifteen feet high. *C. apiculatum* usually occurs in coppice-like stands with an average height of eight to nine feet. These stands are up to nine feet in diameter. Occasionally they will form a tree-like growth up to fifteen feet high.

*C. apiculatum* is one of the first plants to defoliate with the onset of winter. Also in this layer, one finds shrub mopane, *Catophractes alexandri* in isolated patches but more abundant towards the ecotone, and *Montinia coryphyltacea*, being quite numerous in certain localities. *Rhigozum brevispinosum* is also found in small numbers.

Certain shrubs occur in the grass layer; of these *Commiphora pyracanthoides* is one of the most prominent. This plant is excessively excavated by elephant who eat the roots. *Petallidium engleranum* and *Monechma genistifolium* also have a wide distribution throughout this plant association. Occurring in the ecotones are:

- *Grewia bicolor*
- *G. flavescens*
- *G. tenax*
- *Leucosphaera bainesii*

Some herbs which occur are:

- *Harpagophytum procumbens*
- *Heliotropium giessi*
- *Celosia ineriss*
- *Nelsia quadrangula*

6.3. Shrub savanna on calcrite rubble and alkaline soils

6.3.1. *Colophospermum mopane* – *Catophractes alexandri* shrub savanna.

This vegetation type occurs mainly on the red Kalahari-like sand which covers a large portion of the plateau in the study area. It occurs from the hills in the east to the *Colophospermum mopane* – *Terminalia prunioides* – *Combretum apiculatum* association in the west frequently along the omurambas. Tall trees form a very insignificant portion of this vegetation type.
These trees are:

- *Calophospermum mopane*
- *Boscia albitrunca*
- *Terminalia prunioides*
- *Combretum imberbe*
- *Lonchocarpus nelsii*

The shrub layer is formed mainly by shrub mopane and *Combretes alexandri*. The shrub mopane occur in coppice stands up to nine feet in diameter and three to four feet high. This growth form is usually fire and/or frost induced. In localities where these shrubs find protection against fire; viz. termite mounds, they grow into large trees. Other shrubs that occur are:

- *Commiphora pyracanthoides*
- *Leucosphera bainesii*
- *Grewia villosa*

- *Mundulea sericea*
- *Lycium trothae*
- *Elephantorrhiza suffruticosa*
- *Gossypium triphyllum*
- *Grewia tenax*
- *Grewia bicolor*
- *Monechma disaricola*
- *Otoptera burchelli*

The most conspicuous and dominant cover of this association, however, is formed by perennial grasses. They form tufts, sometimes widely sparated with a well defined erosion pavement. The most common perennial grass is *Antheophora pubescens*. Some other grasses are:

- *Eragrostis indensis*
- *Schmidtia kalahariensis*
- *Heteropogon contortus*

Table 10. The species composition and differentiation of the tree layer in the *Combretum apiculum, Calophospermum mopane* association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>Average of trees (feet)</th>
<th>Average of crown (feet)</th>
<th>Average circumference (inches)</th>
<th>No. of points of occurrence</th>
<th>No. of tree</th>
<th>Total basal area (square inches)</th>
<th>Relative frequency (%)</th>
<th>Relative density (%)</th>
<th>Relative dominance (%)</th>
<th>Importance value (F+D+D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combretum apiculum</td>
<td>22.1</td>
<td>8.2</td>
<td>7.5</td>
<td>15.8</td>
<td>25</td>
<td>68</td>
<td>1882.73</td>
<td>51.1</td>
<td>68.0</td>
<td>48.2</td>
<td>167.3</td>
</tr>
<tr>
<td>Calophospermum mopane</td>
<td>29.2</td>
<td>13.0</td>
<td>10.7</td>
<td>24.6</td>
<td>17</td>
<td>25</td>
<td>1544.66</td>
<td>34.7</td>
<td>25.0</td>
<td>39.3</td>
<td>99.0</td>
</tr>
<tr>
<td>Boscia albitrunca</td>
<td>25.6</td>
<td>17.0</td>
<td>11.8</td>
<td>27.8</td>
<td>55</td>
<td>5</td>
<td>348.31</td>
<td>10.2</td>
<td>5.0</td>
<td>8.9</td>
<td>24.1</td>
</tr>
<tr>
<td>Terminalia prunioides</td>
<td>39.0</td>
<td>15.0</td>
<td>15.0</td>
<td>24.0</td>
<td>1</td>
<td>1</td>
<td>45.84</td>
<td>2.0</td>
<td>1.0</td>
<td>1.2</td>
<td>4.2</td>
</tr>
<tr>
<td>Combretum imberbe</td>
<td>21.0</td>
<td>18.0</td>
<td>12.0</td>
<td>32.0</td>
<td>1</td>
<td>1</td>
<td>81.49</td>
<td>2.0</td>
<td>1.0</td>
<td>2.1</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99</strong></td>
<td><strong>100</strong></td>
<td><strong>3909.03</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average distance: 27.3 feet.
Trees per acre: 58.44.
Average basal area per tree: 39.03 square inches.
Basal area per acre: 9750 square inches.

Table 11. Species composition of the more common shrubs in the *Combretum apiculum, Calophospermum mopane*, association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>No. of points of occurrence</th>
<th>No. of plants</th>
<th>Relative frequency %</th>
<th>Relative density %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combretum apiculum</td>
<td>11.6</td>
<td>15</td>
<td>29</td>
<td>23.1</td>
<td>29</td>
</tr>
<tr>
<td>Calophospermum mopane</td>
<td>8.0</td>
<td>17</td>
<td>26</td>
<td>26.1</td>
<td>26</td>
</tr>
<tr>
<td>Commiphora pyracanthoides</td>
<td>7.8</td>
<td>10</td>
<td>16</td>
<td>15.3</td>
<td>16</td>
</tr>
<tr>
<td>Monechma genistifolium</td>
<td>9.0</td>
<td>7</td>
<td>9</td>
<td>10.7</td>
<td>9</td>
</tr>
<tr>
<td>Petalidium engleranum</td>
<td>10.6</td>
<td>6</td>
<td>8</td>
<td>9.2</td>
<td>8</td>
</tr>
<tr>
<td>Catophractes alexandri</td>
<td>10.0</td>
<td>4</td>
<td>6</td>
<td>6.1</td>
<td>6</td>
</tr>
<tr>
<td>Montinia caryophyllacea</td>
<td>4.7</td>
<td>4</td>
<td>4</td>
<td>6.1</td>
<td>4</td>
</tr>
<tr>
<td>Grewia species</td>
<td>15.0</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Leucosphera bainesii</td>
<td>2.0</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
</tbody>
</table>
Plate 6. The *Culcaspernum mopane* – *Cotophocees alexandri* shrub savanna. The tall trees in the background marks a drainage line. (Photo: W. P. S. Joubert).

Plate 7. The influence of fire on shrub mopane. Note how the new shoots are formed from the base.
**Panicum coloratum**
*Enneapogon cenchroides*
*Enneapogon brachystachus*
*Urochloa brachyura*
*Tragus racemosus*
*Aristida effusa*
*Stipagrostis uniplumis*
*Bothriochloa radicans*
*Stipagrostis hochstetteriana var. secalina*
*Eragrostis porosa*
*Eragrostis superba*
*Rhynchosylyrum villusum*

**Pogonarthria fleckii** and **Eragrostis annulata** form the main annual grass cover. Underneath the tall trees pure stands of *Cenchrus ciliaris* sometimes occur. *Triaraphus Fleckii* occurs in dense stands in isolated localities.

---

**Table 12.** Species composition and basal cover of the ground layer in the Colophospermum mopane, Catophractes alexandri shrub savanna.

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Basal Strikes</th>
<th>% Rel. Frequency</th>
<th>% Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthephora pubescens</td>
<td>109</td>
<td>22.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Pogonarthria fleckii</td>
<td>52</td>
<td>12.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Eragrostis annulata</td>
<td>49</td>
<td>9.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Eragrostis demudata</td>
<td>33</td>
<td>6.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Aristida effusa</td>
<td>32</td>
<td>6.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Schmidtia kalahariensis</td>
<td>30</td>
<td>6.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Stipagrostis uniplumis</td>
<td>23</td>
<td>4.6</td>
<td>1.15</td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>23</td>
<td>4.6</td>
<td>1.15</td>
</tr>
<tr>
<td>Heteropogon contortus</td>
<td>17</td>
<td>3.4</td>
<td>.9</td>
</tr>
<tr>
<td>Stipagrostis hochstetteriana var. secalina</td>
<td>16</td>
<td>3.2</td>
<td>.8</td>
</tr>
<tr>
<td>Bothriochloa radicans</td>
<td>14</td>
<td>2.8</td>
<td>.7</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>11</td>
<td>2.3</td>
<td>.6</td>
</tr>
<tr>
<td>Enneapogon cenchroides</td>
<td>7</td>
<td>1.4</td>
<td>.4</td>
</tr>
<tr>
<td>Enneapogon brachystachys</td>
<td>7</td>
<td>1.4</td>
<td>.4</td>
</tr>
<tr>
<td>Eragrostis porosa</td>
<td>6</td>
<td>1.2</td>
<td>.3</td>
</tr>
<tr>
<td>Urochloa brachyura</td>
<td>5</td>
<td>1.0</td>
<td>.25</td>
</tr>
<tr>
<td>Tragus racemosus</td>
<td>5</td>
<td>1.0</td>
<td>.25</td>
</tr>
<tr>
<td>Rhynchosylyrum villusum</td>
<td>5</td>
<td>1.0</td>
<td>.25</td>
</tr>
<tr>
<td>Eragrostis superba</td>
<td>4</td>
<td>.8</td>
<td>.2</td>
</tr>
<tr>
<td>Tragus berteronianus</td>
<td>3</td>
<td>.6</td>
<td>.15</td>
</tr>
<tr>
<td>Setaria verticiliata</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Aristida meridionalis</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Setaria palide-fusca</td>
<td>1</td>
<td>.2</td>
<td>.05</td>
</tr>
<tr>
<td>Stipagrostis hirtigluma var. patula</td>
<td>1</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td><strong>457</strong></td>
<td><strong>94.2</strong></td>
<td><strong>22.90</strong></td>
</tr>
</tbody>
</table>

**Shrubs and Herbs**

<table>
<thead>
<tr>
<th>Shrubs and Herbs</th>
<th>Basal Strikes</th>
<th>% Rel. Frequency</th>
<th>% Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Colophospermum mopane</em>*</td>
<td>35</td>
<td>7.1</td>
<td>1.8</td>
</tr>
<tr>
<td><em>Catophractes alexandri</em></td>
<td>22</td>
<td>4.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Leucophaera bainesii</td>
<td>7</td>
<td>1.4</td>
<td>.4</td>
</tr>
<tr>
<td>Gossypium trifolium</td>
<td>5</td>
<td>1.0</td>
<td>.25</td>
</tr>
<tr>
<td>Geigeria acaulis</td>
<td>5</td>
<td>1.0</td>
<td>.25</td>
</tr>
<tr>
<td>Mundulea sericea</td>
<td>4</td>
<td>.8</td>
<td>.2</td>
</tr>
<tr>
<td>Commiphora pyracanthoides</td>
<td>3</td>
<td>.6</td>
<td>.15</td>
</tr>
<tr>
<td>Grewia tenax</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Grewia bicolor</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Geigeria ornativa</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Cyperus fultens</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Unidentified</td>
<td>2</td>
<td>.4</td>
<td>.1</td>
</tr>
<tr>
<td>Monnchum genistifolium</td>
<td>1</td>
<td>.2</td>
<td>.05</td>
</tr>
<tr>
<td>Grewia villosa</td>
<td>1</td>
<td>.2</td>
<td>.05</td>
</tr>
<tr>
<td>Celosia linears</td>
<td>1</td>
<td>.2</td>
<td>.05</td>
</tr>
<tr>
<td>Hircicum gorteroides</td>
<td>1</td>
<td>.2</td>
<td>.05</td>
</tr>
<tr>
<td>Cleome diandara</td>
<td>1</td>
<td>.2</td>
<td>.05</td>
</tr>
</tbody>
</table>

Basal strikes recorded: 96.
** = % Basal cover: 2.00%.
** = Total basal strikes recorded: 496.
** = Total % basal cover: 24.90.

* A strike was recorded every time the selected spoke touched the ground within a shrub mopane or Catophractes stand.
** = C. mopane shrub and C. alexandri community excluded.

Herbs do occur in a very large variety. The most common are:

- *Helichrysum tomentosulum*
- *Hibiscus caesius*
- *Senecio marlothianus*
- *Geigeria ornata*
- *Harpagophyllum procumbens*
- *Petalidium variable*
- *Plectranthus hereroensis*
- *Hibiscus calyphyllum*
- *Abutilon fruticosum*
- *Geigeria acaulis*

Climbers occur in relatively large numbers especially during the rainy season. They are:

- *Gloriosa superba*
- *Neorautanenia amboensis*
- *Doichos axillaris*
- *Rhynchosia spp.*

Mainly due to the rank grasses this association is poorly utilized by game.

6.3.2. *Catophractes alexandri—Acacia nebrownii* association

On the plateau long ridges are formed by surface sheet and rubble calcite. The vegetation on these
ridges is usually short and early successional mainly due to poor humus and lime-rich soils. The dominant vegetation is formed by *Catophractes alexandri* and two to three-stemmed *Acacia nebrownii* with a height of about 8 feet. The ground layer is formed by karroid shrubs:

_Monechma genistifolium_
_Leucosphaera bainesii_
_Petalidium anglerianum_
_Leucas pachuellii_

The grasses are short, mainly annual, *Anthephora schinzii* being the most common. These ridges with the short vegetative cover are sometimes utilized by springbok.

---

Figure 11. Mean and maximum height and width of crown and mean distance from the point for the four dominant tree species in the *Sesamothamnus guericchii* association.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Shrubs species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Sesamothamnus guericchii</em></td>
<td><em>Catophractes alexandri</em></td>
</tr>
<tr>
<td><em>Terminalia prunioides</em></td>
<td><em>Colophospermum mopane</em></td>
</tr>
<tr>
<td><em>Combretum apiculatum</em></td>
<td><em>Combretum apiculatum</em></td>
</tr>
<tr>
<td><em>Colophospermum mopane</em></td>
<td><em>Rhigozum brevispilosum</em></td>
</tr>
</tbody>
</table>
Plate 9. *Catophractes alexandri* (centre) *Acacia nebrownii* (left) association. Note the karroid-like shrubs in the foreground. In right hand corner is a *Grevia bicolor*. (Photo: W. P. S. Joubert).

Plate 10. Typical growth form of a *Catophractes alexandri* shrub. (Photo: W. P. S. Joubert).
6.3.3. *Sesamothamnus guerichii* association.

This association occurs in the northern section of the study area. It is not clearly definable as most of the members of the other associations occur here in an extremely mosaic pattern. The soil is very alkaline with calcareous rubble on the surface, in some areas hampering movement.

*Sesamothamnus guerichii* is not only the dominant element, but also has a uniform distribution throughout the association. In some areas however, as around Ojikowares east of the Ohopoho road, they occur in dense stands.

Mainly due to the shallow soil the tree growth in this area is usually stunted as shown in table 13. Large trees however also occur in certain areas, and especially along the fringes of the pans they are usually taller. Trees that occur are:

- **Terminalia prunioides**
- **Colophospermum mopane**
- **Combretum apiculatum**
- **Ziziphus mucronata**
- **Boscia foetida**
- **Acacia nebrownii**

The shrub layer is formed mainly by *Cataphractes alexandri* and *Rhigozum brevispinosum*, which form pure stands in some localities, and also shrub mopane,

-Grewia bicolor
-Montinia caryophyllacea
-Petalidium engleranum
-Monechma genistifolium
-Mundulea sericea
-Maerua parvifolia

Herbs are well represented by:

- **Blepharis obminata**
- **Hiernia angolensis**
- **Helichrysum tomentosulum**
- **Euphorbia glanduligera**
- **Plinthus fruticosus**
- **Nelsia quadrangularis**
- **Pseudogaltonia pechuelii**
- **Melhania spp.**
- **Dichotoma tomentosa**
- **Lantana angolensis**
- **Tribulus zeyheri**

A creeper sometimes found in the shrub mopane and *Cataphractes alexandri* is *Dolichos avallaris*.

Grasses are:

- **Antheophora pubescens**
- **Schmidtia kalaharienses**
- **Urochloa brachyura**
- **Stipagrostis hirtigluma**
- **Pogonarthria fleckii**
6.4. Valley community on alluvial soils

The vegetation in this community shows the best growth; the trees usually being taller and the grass cover denser and higher than anywhere else in the study area.

The distribution of some trees is confined to this area. They are:

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>Average height of trees (feet)</th>
<th>Average diameter of trees (cm)</th>
<th>Average number of trees (trees)</th>
<th>No. of points of occurrence</th>
<th>No. of trees</th>
<th>Total basal area</th>
<th>Relative frequency (%)</th>
<th>Relative density (D) %</th>
<th>Relative dominance (Do) %</th>
<th>Importance value (F+D+Do) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesamothismus guerichii</td>
<td>18.1</td>
<td>11.7</td>
<td>8.8</td>
<td>82.3</td>
<td>20</td>
<td>37</td>
<td>19598.14</td>
<td>29.3</td>
<td>37</td>
<td>73.98</td>
<td>140.28</td>
</tr>
<tr>
<td>Terminalia prunioides</td>
<td>18.2</td>
<td>12.2</td>
<td>10.2</td>
<td>32.5</td>
<td>16</td>
<td>23</td>
<td>21408.22</td>
<td>23.5</td>
<td>23</td>
<td>8.08</td>
<td>54.58</td>
</tr>
<tr>
<td>Combretum apiculatum</td>
<td>14.2</td>
<td>8.2</td>
<td>5.5</td>
<td>13.1</td>
<td>14</td>
<td>17</td>
<td>32208.80</td>
<td>20.6</td>
<td>17</td>
<td>12.16</td>
<td>49.76</td>
</tr>
<tr>
<td>Colophospermum mopane</td>
<td>37.7</td>
<td>12.5</td>
<td>8.8</td>
<td>29.5</td>
<td>12</td>
<td>15</td>
<td>1118.02</td>
<td>17.6</td>
<td>15</td>
<td>4.22</td>
<td>36.82</td>
</tr>
<tr>
<td>Boscia foetida</td>
<td>19.5</td>
<td>7.0</td>
<td>3.5</td>
<td>15.0</td>
<td>4</td>
<td>4</td>
<td>108.92</td>
<td>5.8</td>
<td>4</td>
<td>0.41</td>
<td>10.21</td>
</tr>
<tr>
<td>Acacia nebrownii</td>
<td>21.0</td>
<td>12.5</td>
<td>8.0</td>
<td>30.0</td>
<td>2</td>
<td>4</td>
<td>297.94</td>
<td>2.9</td>
<td>4</td>
<td>1.12</td>
<td>8.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68</td>
<td>100</td>
<td>2648.64</td>
<td>99.7</td>
<td>100</td>
<td>99.87</td>
<td>299.67</td>
</tr>
</tbody>
</table>

Average distance: 21.4 feet.
Trees per acre: 95.1.
Average basal area per tree: 264.84 square inches.
Basal area per acre: 66200 square inches.

Table 14. Species composition of the more common shrubs in the Sesamothismus guerichii association.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average distance from point (feet)</th>
<th>No. of plants</th>
<th>Relative frequency %</th>
<th>Relative density %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cataphractes alexandri</td>
<td>5.0</td>
<td>22</td>
<td>26.8</td>
<td>35</td>
</tr>
<tr>
<td>Colophospermum mopane</td>
<td>12.0</td>
<td>14</td>
<td>17.1</td>
<td>15</td>
</tr>
<tr>
<td>Combretum apiculatum</td>
<td>13.2</td>
<td>8</td>
<td>9.7</td>
<td>9</td>
</tr>
<tr>
<td>Rhigozum brevispinosum</td>
<td>11.0</td>
<td>7</td>
<td>7.3</td>
<td>7</td>
</tr>
<tr>
<td>Monechma genistifolium</td>
<td>6.0</td>
<td>6</td>
<td>7.3</td>
<td>6</td>
</tr>
<tr>
<td>Grewia bicolor</td>
<td>6.3</td>
<td>6</td>
<td>7.3</td>
<td>6</td>
</tr>
<tr>
<td>Gossypium triphyllum</td>
<td>6.5</td>
<td>6</td>
<td>6.1</td>
<td>6</td>
</tr>
<tr>
<td>Petalidium engleranum</td>
<td>5.0</td>
<td>4</td>
<td>3.6</td>
<td>4</td>
</tr>
<tr>
<td>Boscia foetida</td>
<td>16.0</td>
<td>4</td>
<td>4.8</td>
<td>4</td>
</tr>
<tr>
<td>Mundulea sericea</td>
<td>5.0</td>
<td>2</td>
<td>2.4</td>
<td>2</td>
</tr>
<tr>
<td>Commiphora pyracanthoides</td>
<td>7.0</td>
<td>2</td>
<td>2.4</td>
<td>2</td>
</tr>
<tr>
<td>Sesamothismus guerichii</td>
<td>18.0</td>
<td>2</td>
<td>2.4</td>
<td>2</td>
</tr>
<tr>
<td>Montinia caryophyllacea</td>
<td>13.0</td>
<td>2</td>
<td>2.4</td>
<td>2</td>
</tr>
</tbody>
</table>
ments also found in the ecotones are Sesamathamus guinechii and Cotophractes alexandri are common in some localities with scattered Acacia nebrownii. Other shrubs are:

- Gossypium triphyllum
- Grevaia bicolor
- Grevaia vittosa
- Montinia caryophyllacea
- Mundulea sericea
- Lycium bosciformium
- Grevaia tenax
- Adenium boehmianum

Herbs are also very common, the following occurring:

- Nerine duparquetiana
- Cyperus fulgens
- Cleome elegansissima
- Cassia italic var. micrantha,
- Ranphionacme ssp
- Ammocharis carnica
- Cleome diandra
- Petalidium coccinum

This community is very popular and is frequented by a large number of zebra, gemsbok and springbok. In areas where overgrazing occurs, it is

- Pachuel-loeschea leumnziza
- Indigofera pechuellii
- Bidens biternata
- Leucas pechuellii and
- Tribulus terrestris

The latter is very conspicuous in the early rainy season. Crotalaria podocarpa sometimes forms pure stands during good rainfall year. Other legumes occurring are:

- Indigofera rautanenii
- Sylitra biflora
- Lessoria benguelensis

Seeds formed by all the latter species support a large number of guinea fowl in this area.

A creeper sometimes encountered is Cyphostemma sp.

A great variety of grasses also occur in this community. The dominant grass cover is formed by:

- Anthophora schinzii
- Schmitidia kalahariensis
- Monelytrum luederitzianum
- Enneaepogon brachystachyus
- Cenchrus ciliaris
- Rhynecholytrum villosum
- Panicum coloratum
- Eragrostis porosa
- Aristida effusa
- Stipagrostis uniplumis
- Eragrostis rotifer
- Eragrostis superba
- Heteropogon contortus
- Bothriochloa radicans
- Tragus racemosus

Where streams debouch onto these valleys, stands of Sorghum verticilliflorum sometimes occur.

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Basal Strikes</th>
<th>% Rel. Frequency</th>
<th>% Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthophora schinzii</td>
<td>95</td>
<td>21.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Eragrostis porosa</td>
<td>85</td>
<td>19.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Schmitidia kalahariensis</td>
<td>82</td>
<td>18.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Aristida effusa</td>
<td>37</td>
<td>8.4</td>
<td>1.9</td>
</tr>
<tr>
<td>Monelytrum luederitzianum</td>
<td>27</td>
<td>6.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Stipagrostis uniplumis</td>
<td>15</td>
<td>3.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Setaria palidefusca</td>
<td>14</td>
<td>3.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Eragrostis rotifer</td>
<td>12</td>
<td>2.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Enneaepogon brachystachyus</td>
<td>9</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Eragrostis superba</td>
<td>5</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>4</td>
<td>0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Heteropogon contortus</td>
<td>4</td>
<td>0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Rhynecholytrum villosum</td>
<td>4</td>
<td>0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Setaria verticillata</td>
<td>3</td>
<td>0.7</td>
<td>0.15</td>
</tr>
<tr>
<td>Bothriochloa radicans</td>
<td>2</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>2</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Tragus racemosus</td>
<td>2</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Stipagrostis hirtigluma</td>
<td>2</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Aristida rhinchocha</td>
<td>1</td>
<td>0.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Urochloa brachyura</td>
<td>1</td>
<td>0.2</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Sub Total: 406 Basal Strikes: 91.3% Cover: 20.65%

<table>
<thead>
<tr>
<th>Herbs</th>
<th>Basal Strikes</th>
<th>% Rel. Frequency</th>
<th>% Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribulus terrestris</td>
<td>16</td>
<td>3.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Gossypium triphyllum</td>
<td>8</td>
<td>1.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Cyperus fulgens</td>
<td>5</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Unidentified herbs</td>
<td>4</td>
<td>0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Cassia italic var. micrantha</td>
<td>3</td>
<td>0.7</td>
<td>0.15</td>
</tr>
<tr>
<td>Cleome diandra</td>
<td>1</td>
<td>0.2</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Sub Total: 37 Basal Strikes: 8.3% Cover: 1.90%

Total Basal Strikes recorded: 443 Basal Cover: 22.55%

6.5. Commiphora — Sterculia association on rocky outcrops

This association only occurs in rocky outcrops on the dolomite ridges in the study area. These rocky outcrops are strikingly covered by several Commiphora species, viz.: 
C. multijuga
C. glaucescens
C. mollis
C. crenato-serrata and
also by Sterculia quinqueloba and S. africana.

Other trees that occur are
Vangueria infausta
Berchemia discolor
Acacia nilotica
Ficus cordata
Acacia senegal var. rostrata

Combretum apiculatum sometimes occurs in a large
tree growth form. Due to the large number of
fruitbearing trees this community harbours a great
variety of fructivorous and insectivorous birds
during the spring and summer months. This tree
layer is fully deciduous.

A few shrubs occur here:
Euclita divinorum
Berberis senensis
Manuleopsis dinteri
Acacia ataxacantha
Hiernia angolensis

and also stunted growth of Terminalia prunioides.

Herbs occurring are:
Peliostomum leucorrhizum
Sesamum schinzianum
Bonamia schizantha
Rogeria adenophylla
Blepharis obnitrata
Aptosimum spp.
Plectranthus hereroensis

Grasses that occur are mainly:
Stipagrostis uniplumis
Triraphis ramosissima
Danthoniopsis dinteri

VII. ABSTRACT

The western Etosha National Park may be divided
into three physiographic regions, viz. the coastal
desert, the escarpment and the inland plateau. A
study area was selected on the transition between
the escarpment and the inland plateau. The soils
tend to be shallow, alkaline, high in water-soluble
salts, poor in phosphates and nitrogen content. The
study area falls within the arid savanna. The vege-
tation is sub-divided into nine smaller associations.
VII. ACKNOWLEDGEMENTS

I am grateful to Mr. B. de la Bat, Director of Nature Conservation and Tourism for his advice and criticism and under whose direction the work took place. Mr. W. Giess, of the Herbarium, Windhoek is thanked for his invaluable assistance in identifying all the plants collected during the study and for reading through the manuscript.

I wish to extend grateful appreciation to the following persons: Mr. G. A. Roux and J. J. van Zyl who analysed the soil samples collected in the study area, Dr. van Wyk and his geologists and Ken Tinley for encouragement.

I am very much obliged to the Administration of South West Africa for permission to include the information gathered during this study as part of a M. Sc. (Wildlife Management) thesis.

I am grateful to my wife who typed this manuscript.

---

Map 2.

VEGETATION MAP OF THE STUDY AREA AT OTJOVASANDU
SOUTH WEST AFRICA

Compiled and drawn by E. Jeubert.
IX. REFERENCES

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WELTY, J. C.

WIGHT, H. M.

WILDLIFE INVESTIGATIONAL TECHNIQUES
The Past and Present Distribution and Status of the Black Rhinoceros
(Diceros bicornis Linn. 1758) in South West Africa.

by
Eugene Joubert
Nature Conservation and Tourism Branch
South West Africa Administration

I. INTRODUCTION

To determine the past distribution and status of the black rhinoceros in South West Africa the following sources were used to a large extent to obtain information. All available records and old reports on expeditions through SouthWest Africa were consulted. In comparison with the rest of Southern Africa, South West Africa is covered remarkably well by journals and official reports of early expeditions. Rhino engravings and/or paintings, and also excavation sites where rhino remains were found were also used. Regarding the more recent distribution and status a direct census was carried out and numerous interviews were held with old inhabitants and settlers in certain areas. With all this evidence in hand a more or less complete picture of the past and present distribution of the black rhinoceros was obtained.

For the direct census the following method was used: the census was carried out during October, November and December 1966. This is the driest and hottest time of the year and during this time the rhino tend to drink every night. Every known waterhole in the Kaokoveld and western Etosha National Park was visited in turn. If any indication could be found of it being frequented by rhino camp was pitched about a mile or more distant. Two or three nights were spent at every waterhole, all depending on circumstances. During daytime reconnaissance was carried out in the vicinity looking for tracks, frequency and size of dung heaps and the amount of vegetation that showed browsing by rhino.

By using this method one had to make two assumptions.

1. That all the waterholes are known. Everyone acquainted with the arid parts of South West Africa knows how important a role water plays in the existence of man and animal. One can thus safely presume that all the permanent waterholes are known especially those in the populated part north of the Hoanib River. A very good military map, showing all the waterholes, was also used extensively.

2. That a rhino uses only one waterhole. During the drier part of the year the distances between perennial waterholes are considerable. In areas where waterholes were located nearer to each other, precautions were taken, eg. more time was spent in the area.

Information was gathered from the police stations at Kamanjab, Otjipa, Otiwaungo and Welwitschka to determine on which farms rhinos occurred. These farms were visited during March 1967 to complete the census.

II. PAST DISTRIBUTION

2.1 Distribution before 1900

During July 1761 Ryk Tulbagh sent a party of volunteers on a scientific expedition to explore the country north of the Orange River. They reached...
Warmbad on the 5th October and moved on to the Lion River. The banks were well-wooded, they reported, apart from rhino, also giraffe, buffalo, zebra, quagga, kudu, eland, hartebeest and wildebeest were seen (Vedder 1938). This is the earliest record in literature of the occurrence of rhinoceroses in South West Africa.

In 1791 Willem van Reenen set out on a hunting and exploration expedition and travelled into South West Africa. He reached Swartmodder (Keetmanshoop) in November 1791. After crossing the Fish River his party had difficulty in crossing a waterless stretch of country. At the Leber River they shot rhino, giraffe and buffalo as food for the party.

They travelled for a period of nine months and during this time shot 65 rhino, 6 giraffe and large numbers of other game.

The Dutch Government despatched the MEERMIN from Cape Town to the South West African coast in 1793 to forestall occupation by foreign powers. A landing party went ashore on the 23rd January, 1793. They saw great numbers of animals in the Swakop River. Animals recorded by them were elephant, rhino, gemsbok and springbok (Vedder 1938).

In his “An expedition of discovery into the interior of Africa” J. E. Alexander (1838) described his journey from Cape Town, across the Orange River, along the Fish River and down the Kuiseb River to Walvis Bay, returning past present-day Windhoek. His party left Cape Town on the 8th September, 1836. He came across his first rhino at Kopunnaas, or “Bulls Mouth Pass”. He reached this mountainous terrain after crossing the “Kei Kaap or Great Flat”. According to his map the “Bull’s Mouth Pass” is situated north of the 24th Latitude – possibly in the region of the present-day Naukluft mountains and with little doubt the present-day “Bilsport”.

During his travels Alexander came across a few Bushmen (near the abovementioned Bull’s Mouth Pass) and he records the following:

“I asked him what was that of all other things he wished for in the world – was it plenty of wives, of children, of cattle, of sheep, of clothes, or a good hut? and he (the Bushman) answered, the rhinoceros, and to get it easily!”

By now more and more travellers and missionaries travelled and settled in South West Africa. When Hugo Hahn travelled from Otjikango down the Swakop River to Walvis Bay in 1847 a rhino crossed his path. During 1850 Rath explored the north bank of the Swakop River as far north as the Erongo Mountains where he was repeatedly molested by rhinoceroses (Vedder 1938). During this time a missionary at Rooibank used the skin of a black rhinoceros, shot in the nearby Kuiseb River, as a door.

Francis Galton and Andersson travelled extensively in South West Africa during 1850 and 1851. (See map 1) The results were published during 1889. They set out from Walvis Bay during September 1850, travelling along the Swakop River. Galton records that there was not a sign of game apart from tracks several days old and mostly of buffaloes.

After visiting Ovamoland, travelling past the Etosha Pan, they reached Elephant Fountain in August 1851. At Elephant Fountain (the present day Gobabis) he records that the inhabitants:

“...talk familiarly of the rhinoceros as an everyday kind of game ... I had not yet seen a single rhinoceros” (almost a year after they set out from Walvis Bay!!) “One was shot by Andersson when they went down to the bay (Walvis Bay), but I was then not present.”

From Elephant Fountain they travelled over Twass to ‘Tounobis’. Two days journeying brought them to a picturesque gorge in the ridge (along which they were travelling) which led down to the plain, and in which was a succession of small springs:

“Rhinoceros were lying in every direction, but strangely enough not a single spoon could be seen. The whole of that night did Saul and I watch without seeing anything but a jackal. Saul had told us that the rhinoceros would begin trooping in at nightfall, and that we should continue firing at them till daybreak, and I had believed him. Forty were killed here about a month since. I could not doubt it, for I counted in a small place upwards of twenty heads; but I suppose that a vast number were also wounded, and that the whole game fairly scared from the place.”

These animals were apparently shot by Witbooi’s Hottentots who roamed through these regions.

On the 28th September, they reached a waterhole and saw a dozen fresh tracks of elephant and a few of rhino at the waterhole. That night Galton “bagged” his first rhino, and also a lion, a hyena and a wildebeest. On reaching ‘Tounobis’ they erected hides and shoot a number of rhino as they came to water. Galton did not record how many but added:

“The Hottentots shot away a great many bullets at rhinoceroses and did, I dare say, a great deal of mischief. They bagged but very few, compared to the number they fired at; the others most likely lingered on for a few days, and then lay down and died elsewhere.”

Dr. Scherz (pers. com.) made a thorough survey of the rock engravings and paintings in South West Africa. Most of the engravings portray animal figures, and in a few cases rhinos are also delineated.

Although the possibility exists that the artists may have moved long distance after observing an animal and before engraving it, it is usually considered that the artist was tended to engrave animals seen in the immediate vicinity.

Dr. Scherz found rhino engravings south of Bethanie on the farm Rooipunt, 157. There are en-
The latter are the most northern rhino engravings known in South West Africa.

Towards the east rhino engravings were found on the farm Ivanhoe 92, south of Gobabis. Dr. Scherz mentioned that no rhino engravings occur to the east of an imaginary line that may be drawn from Tsumeb and Otavi to Okahandja.

Old remains of rhino skulls and/or parts of skeletons were also found (Mr. de la Bat, pers. com.) in the Fish River, Kuiseb River, Swakop River and near Omaruru, Windhoek and Gobabis.

A little way south-east of Lüderitz in the Namib a set of rhino footprints is encased in a limestone layer. At Grullental a rhino skeleton, completely fossilized, was found. Carbon-14 dating method showed the fossil to be \( \pm 10,000 \) years old.

To determine the distribution pattern of black rhinoceros in South West Africa before 1900 the following, fully independent, factors may be used as a basis. They are:
a) Distribution pattern of rhino rock engravings and/or paintings.

b) Localities where early hunters/explorers came across rhino.

c) Localities where the remains of rhino skeletons were found during excavations.

It may be argued that the engravings/paintings only show the distribution of the artists and suitable rocks and this may be true to a certain extent. The localities, however, where early hunters/explorers came across rhino, and also the localities where remains of rhinos were found during excavations show a clear correlation with the localities of rhino engravings/paintings (see map 2). The above-mentioned factors taken by themselves seem slender and will always leave room for a degree of inaccuracy or doubt. The three taken together however, lessen inaccuracy or doubt to a point of insignificance.

No permanent rhino populations occur today on the drier side of the 100 mm. isohyet, and this may be considered an ecological barrier. It may therefore be assumed that in the era before 1900, the black rhinoceros was distributed from the Kunene River in the north, down to the Orange River in the south, and extended westwards to the eastern boundary of the Namib desert. They may have entered the Namib desert down river courses during the rainy season as is the case at present in the Kaokoveld and western Etosha National Park.

The distribution pattern on the inland plateau, to the east is much more vague. They occurred to the south-east as far as natural vegetation (for food and cover) and available surface water allowed. As rhinos are partial to acacia thorn country, it is doubtful if they ever occurred in the sandveld areas in the eastern portions of South West Africa except in limited numbers. They did occur, however, south of the Angola border in the Kunveld.

The main factor hampering their distribution in sandveld areas was, as mentioned earlier, the lack of surface water. They may have occurred down the east flowing omurambas, viz. Omuramba Omatako, Otjoosondjo, Eiseb, Epukuro, Rietfontein and probably the Black and White Nossob, during good rainfall years.

Their distribution pattern in South West Africa during the 19th century must have looked more or less as follows: one arm reaching north-west from Oitjo to the Kaokoveld and Kunene River, and the other arm stretching to the east past the present day Gobabis. Isolated localities existed in the Kunveld and Okavango. The rest of the distribution reached south past Windhoek along the 16th Longitude to the Orange River. If they ever did occur north of the Etosha pan on the Ovamboland plains, it must have been the first area in the South West Africa where they were wiped out by man.

According to the old Heikum Bushman, now resident at Okaukuejo, no rhino were ever known to them or their fathers to have occurred in their old hunting grounds to the near west and south of the Etosha pan. Galton, Andersson and also Hugo Hahn travelled in this region without reporting the presence of rhino. The rhino that frequent the waterholes at Grünwald and Gobabeb in the Etosha National Park are apparently more recent arrivals from the south and south-west, probably from the Ugab drainage system.

The pressure of man was then felt in the south as the armed bands of Hotentots and Griquas swept across the Orange River during the second half of the 19th century. By the end of the 19th century the black rhinoceros must have neared total extermination in the southern parts of South West Africa.

2.2. Distribution after 1900

As can be deduced from the above, the distribution pattern of black rhinoceros started changing long before the turn of the century. After 1900 the changing distribution pattern to the north of Windhoek gathered momentum as new areas were opened for settlement and during a period of thirty years it shrank to include only the Kaokoveld and a few localities in the mountains north of the 22nd Latitude.

References available on the distribution of rhino after 1900 are the following:

Fischer recorded in 1904 the presence of rhino at Warmquelle and Sesfontein in the Kaokoveld. The presence of rhino near Usakos is also discussed.

Steinhart (1924) wrote that during 1915 to 1919 rhino still occurred in the lower Ugab River and sometimes moved as far as Oitjo. They were also reported from the Huab River and the Hoonib River. Various other localities in the Kaokoveld are also mentioned. In 1916 Mattenklodt shot a rhino on the northern bank of the Okavango River in southern Angola. Wilhelm (1931) reported that they did not occur on the southern bank of the Okavango River but that there still were some left near the Kwanero River.

Shortridge (1934) reported that they occurred from about the latitude of Kaako-Otavi (northern Kaokoveld) northwards and that during the rainy season, while surface water was available, a few wandered as far south as the northern and north-western parts of the Oitjo district. He recorded rhino tracks near Kamanjab.

Bearing the present distribution pattern in mind, one feels that the black rhinoceros was much more widely distributed in the north-western area of South West Africa during this period than implied by the abovementioned authors. This lack of information can be attributed to the lack of roads and the resulting large inaccessible areas and also to the lack of communications at the time.

Mr. Fritz Gaerdes of Okahandja (Pers. comm., 1967) supplied invaluable information regarding the past distribution of the black rhinoceros in
northern South West Africa. Information was also gathered from farmers who originally settled on farms in the Welwitschia and Kamanjab areas in 1948. Information from these sources indicates that rhino were distributed as far south as the 22nd Latitude. They occurred in the Erongo Mountains between Omaruru and Usakos, and to the west on the edges of the Okombahe and Otjihorongo Reserves. They also occurred in the upper reaches of the Ugab River as far east as Ovitjo. From the middle reaches of the Ugab River in a north-westerly direction past Welwitschia, Francistown and Kamanjab they were more or less evenly distributed as far north as the Kunene River. A few also occurred south of the Etosha pan at Grünewald and Gobaub.

Map 2. Distribution of black rhinoceros in South West Africa circa 1850.

1. Ryk Tulbagh’s voluntary Scientific expedition, (1761) Lion River.
2. Engravings on the farm Geelpracht, 76.
3. Engravings on the farm Rooipunt, 137.
4. Engravings on the farm Aar, 16.
5. Wiltiam van Reenen and his party (1791), Leber River.
6. J. E. Alexander and his party (1838), Bull’s Mouth Pass.
7. Engravings on the farm Die Valle, 226.
8. J. E. Alexander and his party (1838), Kuiseb River.
9. Engravings on the farm Naukels, 229.
10. Anderson and his party (1850).
11. J. E. Alexander and his party (1838), Windhoek.
12. Engravings on the farm Ivunke, 92.
13. Francis Galton and Anderson (1851), Gobabis.
15. Engravings at Spitzkoppe.
16. Rath and his party (1850), Erongo Mountains.
17. Engravings at Brandberg Mountains.
19. Engravings on the farms along the Ugab River.
20. Engravings at Twyelfontein.
21. Engravings on the farm Harmonie, 97.
22. Shortridge (1934), near Kamanjab.
23. Engravings at Sossos, south of Sesfontein.
24. Fischer (1904), at Sesfontein and Warmquelle.
25. Shortridge (1934), near Kaoka-Ohavi.
26. Hunting expeditions of Jan Robberse (1898 to 1908).
III. PRESENT DISTRIBUTION

The present distribution pattern of the black rhinoceros in South West Africa was fairly accurately established from a survey which was carried out during October, November and December, 1966 and during March, 1967. The results obtained during this survey indicate that the black rhinoceros has at present a limited distribution. It occurs only in the most inaccessible, mountainous areas of the escarpment transition belt; the exception being the Etosha National Park. (See map 3).

The present distribution in South West Africa can be divided into the following distribution areas:

3.1. The area north of the Hoanib River —
3.1.1. Northern concentration.
3.1.2. Western concentration.
3.1.3. Southern concentration.

3.2. The area within the Etosha National Prk.
3.2.1. Western portion.
3.2.2. Eastern portion.

3.3. Farms along the Huab- and Ugab Rivers.
3.3.1. Farms within the Odendaal area.
3.3.2. Farms outside the Odendaal area.

3.4. Elsewhere in South West Africa.

3.1. The area north of the Hoanib River

The distribution of the rhino in the Kaokoveld correlates for the greater part with the distribution of the OvaHimba and OvaTjimba population groups. The rhino and the OvaHimba and OvaTjimba occur on the escarpment area within the 2 000 and 4 000 foot contours. The reasons why the rhino population follows this distribution pattern may be the following:

1. The extremely broken country within the escarpment zone offers a certain degree of protection against man.

2. The OvaHimba and OvaTjimba, with whom they share this area are nomadic and seldom live around permanent waterholes — thus ensuring the rhino free access to the water. The Herero on the plateau usually live at the waterholes.

3. The vegetative cover of this area includes most of the qualifying aspects preferred by rhino, viz. — cover and preferred food plants.

The rhino is not evenly distributed through this area but occurs in three more or less isolated patches.

3.1.1. Northern concentration

This concentration area lies mostly within the upper reaches of the Hoarusib River, with isolated occurrences along the Kunene River in the Baynes and Zebra Mountains. As far as is known, no rhinos utilize the water of the Kunene River between the Rucana Falls and the Epupa Falls. Individuals within the Baynes Mountains may do so, however. The individuals that utilize the waterhole at Ombombo-Ovambo sometimes wander into western Ovamboland. Permanent waterholes utilized by rhino are the following:

Enduva, Otjipembac, Otjitsanga, Epembe, Otjirekeha, Okauzuma, Otjiwero, Ekoto, Ongongo, Otjio, Kaoko-Otavi, Omeamo, Otjijenjesa and Ombombo-Ovambo. Some of these waterholes may dry up in years drier than the average.

3.1.2. Western concentration

The western concentration lies in an area around Orupembe. This area lies for the greater part in the sub-desert region. The rhino here are isolated and this area used to be regarded as the safest for them in the Kaokoveld. During the last few years OvaHimba pastoralists moved in and settled in the area. This area lacks the dense vegetative cover and broken country of the other two concentration areas in the Kaokoveld — placing this rhino population in danger of being wiped out. Permanent waterholes used here are Orupembe, Sanitas, to the east across the mountains, Otjimba (which may dry up in years drier than the average) and Okonjombo. To the west of Orupembe lies Ombabundu which may also dry up in dry years.

3.1.3. Southern concentration

This concentration lies in the middle stretch of the Hoarusib River between the waterholes Purros and Otjikondawironko. Other waterholes utilized within this area are Omai, Kotjiedenta, Maruru and Otjiakakawa. All the latter waterholes are likely to dry up in years drier than the average.

3.2. The area within the Etosha National Park

3.2.1. Western portion

This distribution area extends from the Atlantic coast, between the Ugab and Hoanib Rivers, east to the 15th Longitude. The greater part of the remnant rhino population in South West Africa is found here, with the largest concentration in the vicinity of Otjovasundu. To the east it only occurs as far as the Okawao waterhole. Westward its distribution pattern closely follows the distribution of permanent waterholes and the broken escarpment area.

Permanent or semipermanent waterholes frequented by rhino in the Hoanib drainage system are the following:
Otjihuruotswa, Kowares, Omborongbonga, Renosterfontein, Otjovasandu, Kaross, Omborongbonga, Gaimais, Numas, Kamakams, Urukamses, Kaminukos, Chungab and Mudorib.

In the Unjab drainage system the following are frequented:

Agab, Zebraquelle, Nadas, Ururenedes, Kaus, Dabbeeb, Gemsbokquelle. In the Koichab River Springbokwasser, and another small waterhole about ten miles higher up in the river are used.

3.2.2. Eastern portion

This portion includes the rest of Etosha National Park east of the 15th Longitude. In this area only a few rhino occur in isolated localities; they are the following: Grünewald, Gobaub and sometimes Okaukujejo and Ombyka.

3.3. Farms along the Huab and Ugab Rivers

3.3.1. Farms within the Odendaal area

Farms situated to the west of Grootheberg along the Etosha National Park boundary are not fenced in and movements by rhino in and out of the E.N.P. on to these farms occur. In some localities rhino home ranges extend onto the farms. The farms referred to above are Palmwag 715, Juriesdraai 709, Rooiplaat 710, Wérelsend 715, and Driefontein 716. Other farms in the Odendaal area where rhino occur are the following:

Nauwpoort 511, Rushof 509, Versteende Woud 485. The same group of rhino frequents these three farms. Rhino also occur on Twyelfontein 534, and along the lower Ugab and sometimes wander into the Bantu reserves on the southern bank. During 1967 a rhino was reported from Uis Mine. Farms higher up along the Ugab River where rhino occur are the following:

Lesuwoeck 411, and Zebaskop 410. In the upper reaches of the Huab River rhino occur at Kakatska — Onguati 256. The most southern locality where rhino occur in South West Africa is near the Erongo Mountains on the farms Erongorus 166, Omanumbera-West, and on Libertas 69, near Omaruru. A rhino used to frequent Otjimbingwe, on the Swakop River but no record could be found of its whereabouts during the last two years.

3.3.2. Farms outside the Odendaal area

The Ugab and Huab Rivers cut through several mountain ranges on their way down towards the Atlantic ocean. Farms situated in these montainous localities harbour a few rhino usually in the most inaccessible corners. Although movement does occur up and down the drainage lines, it is usually restricted due to wire fences.

In the upper reaches of the Ugab River, near Outjo, the following farms are visited by rhino:

Petersburg 151, Ombakaha 150, Folie 147, Iris 145, and Okaura 140. Lower down this river farms harbouring rhino are Minorca 71, Hankow 78, Landek 77, and Saturn 103. In the upper reaches of the Huab River rhino frequent the following farms: Garubib 188, and Ehobib 209.

3.4. Elsewhere in South West Africa

There are no other localities in South West Africa where there are resident populations of rhino. Four black rhino were found in the Western Caprivi (Tinley pers. com. 1966). They are not residents and apparently wander along the Kwando River crossing the Angola and Botswana borders. Rhino sometimes cross the Angola border to enter the north-eastern sector of Ovamboland. Since the border has been fenced in they are very seldom recorded from this area.

IV. STATUS

4.1. Past status

Not one reference could be found in all the available literature giving an estimate of the total black rhinoceros population in South West Africa before 1900. After 1900 a few tentative estimates can be found in the literature. All these estimates, however, refer only to the northern regions. As previously mentioned no real census was ever carried out prior to 1966.

Even before the interference of man the larger part of the rhino population must have occurred in the northern areas of South West Africa; the most obvious reason for this being the higher rainfall in this area resulting in more food, cover and availability of water throughout the year. Although black rhinos once occurred as far south as the Orange River they never attained large numbers in these regions owing to the relatively lower carrying capacity for this species. The reasons why they were wiped out in the south are shortly the following:

a) Low population numbers.
b) Lack of sufficient vegetation cover over large areas.
c) This area was the first in South West Africa to be invaded by men armed with firearms.

That there were still a few left in the southern regions during the first few years after 1900 can only be considered a miracle. J. A. Meyer (pers. com. 1968) relates that he heard from an old Witbooi Hottentot that after a skirmish with German troops during 1904 at Swartmodder (the present-day Keetmanshoop) they fled into the montain ranges next to the Fish River. After a few days of nearly continuous moving they camped one night in a ravine. During the night a rhino charged through the camp causing them to think that they were being attacked by the German troops.
From various other sources (eg. Dr. Schertz and Mr. P. G. L. van Blenk, pers. com.) it was learned that during the twenties and thirties rhino horns were much valued in these southern areas for hunting knives. Rhino horn was at that time already unobtainable and farmers who did possess pieces usually had obtained them years before. One may assume with some safety that the black rhinoceros in these southern regions was exterminated around the turn of the century.

With regard to the regions to the north of the 23rd Latitude the following records were found in literature:

Hugo Hahn (1843) saw several rhino tracks crossing the road between Windhoek and Okahandja. Andersson shot one rhino in the Swakop River near Walvis Bay in 1850. During 1850 Rath came across a fair number in the Erongo Mountains. Galton and Andersson found a concentration of rhino east of Gobabis in 1851. Hartmann travelled through the Kaokoveld in 1900 and came across elephant herds with more than a 100 animals in a herd, large numbers of rhino, hippo (in the Kunene River), giraffe and antelope. In the northern Kaokoveld, "Dorslandtrekkers" from Humpata in Angola frequently crossed the Kunene River to poach elephant. J. van Molle (1943) compiled a comprehensive work on the hunting adventures of these "Dorslandtrekkers". Most of his information he gathered from the living members of this group of pioneers who moved back to South West Africa during 1928. The most concentrated hunting apparently took place during the years from 1898 to about 1908, under the leadership of Jan Harm Robberse. The hunting season lasted from about June until November every year, and although they concentrated on elephant, rhino were also shot as they received about R15 for each. During these ten years they shot between 150–200 rhino viz. about 15 to 20 per year. It seems therefore that even at this stage the largest concentration of black rhinoceros was in the Kaokoveld.

Steinhardt (1924) visited this area during 1915 to 1919 and recorded that rhinos were sporadically distributed in the southern Kaokoveld but were more numerous in the north of the Kunene River. Along the Kunene River there appeared to be one to every kilometer of river. (This is the area where rhino were hunted by Robberse and his men). In 1923 Manning estimated that there were 50 black rhinos in the Kaokoveld. In 1934 Shortridge estimated 40 to 80 animals between the lower Ugab and Kunene Rivers. Haerlen (1939) reports only that rhinos occur between the lower Ugab and Kunene but are everywhere rather scarce.

After the completion of the black rhinoceros census during 1966 information was obtained that rhinos were much more numerous up to 1948, especially between the lower Ugab and Hoanib Rivers, than implied by Manning and Shortridge. As already mentioned this could be attributed to the lack of roads, to there being no white inhabitants apart from those of the police station at Kamanjab and also to the poor communications at the time, in this area.

According to farmers who originally settled to the north of the lower Ugab River in 1948, there were many rhinos in this area but they were not abundant. A farmer, looking back, said that in those years one of their first actions had been to hunt rhino systematically on their farms; the reason for this being that the Bantu who had to look after their herds and flocks refused to do so if they knew that there were rhinos on the farm. On two farms (Minorea 71, and Persialer 105) the remains of six skulls and/or skeletons were found.

On several more farms, especially in the Grootberg area, one or two remains of skulls and/or skeletons were found. On several other farms skulls were known to be lying around but could not be found. Most of this information was obtained from neighbours or from tenants who recently leased the farms from the Administration of South West Africa after the original owners had moved away and information was only seldom volunteered by the owners themselves.

Taking into account —

a) the 1966 figure of 90 (See par. 3.5.2 on Present status)
b) the fact that rhinos are known to be slow breeders
c) the undoubtedly large numbers shot on these newly settled farms from 1948 onwards, one can only reach the conclusion that the black rhinoceros must have been much more numerous at the time than the maximum of 80 estimated in 1934. A figure of about 200–250 for the whole of South West Africa would have been more accurate. Even so one wonders whether the black rhinoceros population ever reached very high numbers in South West Africa.

4.2. Present status

The figures mentioned below are those obtained during the black rhinoceros census carried out during 1966. No adjustments were made for any changes in number that must have occurred during the time lapse since the census was carried out.

Seven known births of black rhino calves in South West Africa were recorded afterwards. During 1967 and the first half of 1968 six rhinos were killed in the Kaokoveld and two were shot in the upper reaches of the Unjab River by unknown white poachers. Three other animals died during trials to translocate them to the Etosha National Park.

Black rhinos counted during this census numbered 90. These animals are distributed as follows:

25 North of the Hoanib River.
48 In the Etosha National Park (including those animals on farms adjoining the Park along the west in the Unjab drainage system, and 8 in the eastern portion of Etosha National Park — Starke and van der Westhuizen — pers. com.).

7 On other farms in the Odendaal area.

10 On the farms outside the Odendaal area.

Looking at these figures one might be lulled into a false sense of security. These figures should, however, be analysed against the background of the proposals made by the Odendaal Commission. The rhino population then shows the following distribution:

72% of the rhino population occurs in Bantu areas or proposed Bantu areas.

11% on privately owned farms.

17% within the proposed boundaries of the Etosha National Park.

V. ABSTRACT

Available information indicates that the black rhinoceros was formerly distributed from the Kunene River south to the Orange River, along the escarpment and eastwards past Gobabis. At present its distribution is limited to the northwestern corner of South West Africa. Apparently the black rhinoceros population never reached very high numbers in South West Africa. During 1966 there were only 90 animals left in the territory.

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DISTRIBUTION AND STATUS, BLACK RHINOCEROS 43


SMITH, A. 1837 "Rhinoceros heloll A. Smith (1837)". Cat. S. Afr. Mus. 7.


STEINHARDT. 1924 Von wahrhaftigen Riesen und seinem Reiche. Atler-Verlag, Hamburg.


A new species of *Linognathus* (Anoplura: Linognathidae) from the Damara didik

by

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INTRODUCTION

Within the Anopluran genus *Linognathus* Enderlein, 1905 there is a group of four closely-related species which are characterized by having most of the abdominal setae lanceolate in form. Other characters common to the group are a short, wide head and thorax, absence of a thoracic sternal plate, short and broad abdomen and typical female genitalia, with broad, leaf-like gonopophyses bearing microtrichia on their distal surfaces. This assemblage is probably of monophyletic origin, and may be called the *pithodes* species-group, the earliest species described being *L. pithodes* Cummings, 1916 from *Antilope cervicapra*. The other species included in the group are *L. bedfordi* Ferris, 1932 from *Antidorcas marsupialis*, *L. lewisi* Bedford, 1934 from *Gazella thomsoni* and *L. spicatus* Ferris, 1932 from *Connochaetes taurus*.

Certain characters found in some species of the *pithodes* group are rather anomalous for *Linognathus*. *L. spicatus*, for example, has the claws of the first pair of legs strong and stout, and only slightly smaller than those of the second and third legs; in *Linognathus* it is usual for the first pair of legs to bear claws which are much smaller and more slender than those of the other legs. *L. pithodes* and *L. lewisi* have distinct sclerotized abdominal tergal plates on some segments in the male, a character not found in any other *Linognathus* species. The available evidence suggests that the *pithodes* group was an early offshoot from the main line of *Linognathus* evolution, and probably had a wider host distribution than at present. The geographical distribution tells us little about the possible origin of the group; the four species are all parasitic on Bovidae, one is found in the Oriental region and the other three in the Ethiopian region.

The genus *Stobbella* Eichler, 1949 was erected for the *pithodes* species-group, with *L. pithodes* as type-species. Ferris (1951) rejected *Stobbella*, but it is my opinion that the name might be useful as a subgenus of *Linognathus*, should further research confirm the homogeneity of the *pithodes* group, and if the use of subgenera should prove of value in subdividing *Linognathus*, which at the time of writing comprises 48 described species.

The purpose of this paper is to describe a new species belonging to the *pithodes* group, to give diagnostic characters which distinguish the new species from others in the group, and to provide a key to the five species now contained in the group.

In the following account I use the symbols *m* (marginal) and *a* (anterior) to distinguish the double rows of setae present on some tergites and sternites.

All measurements are in millimetres; a value in parenthesis following a statement of range represents the mean.

*Linognathus damarensis* n. sp., figs. 1—8

HOST DISTRIBUTION: northern limit near Benguela in south western Angola; eastern limit near Grootfontein, southern limit Mount Bruk-caros (25° 30’ S.), both in South West Africa. In the west it occurs into Namib desert, confined here to riverine woodland and thicket of larger seasonal rivers and reaching to within about 45 km of the coast (Tinley, 1969).

FEMALE. General appearance and chaetotaxy as in fig. 1.

THORAX. 1 + 1 stout prontal setae; 3 short setae associated with each spiracle. Claws of 1st pair of legs markedly more slender than those on 2nd and 3rd pairs. Tergal plate lacking.

ABDOMEN. With lanceolate setae as in fig. 2.

DORSAL CHAETOTAXY. A single, short row of lanceolate setae on 1, two rows of lanceolate setae on II-VII and 1 + 1 long, stout setae on VIII. Tergal setal counts for holotype: 1; 4; II, 3 m, 5 a; III, 7 m, 4 a; IV, 9 m, 8 a; V, 11 m, 7 a; VI, 12 m, 8 a; VII, 7 m, 2 a; VIII, 1 + 1. Terminal tergite with a sclerotized band and 3 + 3 short setae.

SPIRAICLES. Small and rounded. On anterior segments the spiracular openings are dorsal, posteriorly they are located on the ventral surface of the abdomen. Two long setae posterior to each spiracle on IV-VIII; on III the postspiracular complex consists of 1 long, 2 lanceolate setae (fig. 3); on II, although there is no spiracle, a group of 3 lanceolate setae in the postspiracular position.

VENTRAL CHAETOTAXY. In the holotype specimen the ventral setae are arranged in single rows with the following counts: II, 4; III, 4; IV, 8;
Figures 1-3. *Linognathus damareusis* n. sp. 1. Female in dorsal/ventral view. 2. Lanceolate abdominal setae. 3. Postspiracular complex of segment III.
V, 15; VI, 12; VII, 6; VIII, 1 + 1. In some of the paratype specimens there is a tendency towards vestigial double setae rows on IV-VII, the additional setae usually appearing towards the lateral margins.

All ventral setae lanceolate.

Genitalia. As in fig. 4. Median sclerotization present, linear and slightly expanded towards the middle. Gonapophyses with lateral strips of sclerotization slightly convergent, apices convergent with finely serrated margins; 3—4 long, stout apical setae; mesal margins clearly separated, slightly cleft, with 6—8 short setae. Terminal third of gonapophyses with closely-set microtrichia.

MALE. Characters of head, thorax, spiracles and postspiracular setae as for female.

Abdomen. As in fig. 5. There are two major types of abdominal setae. Those of the ventral surface are lanceolate, as in female. A second type predominates on tergites V—VII; these are stout, with characteristic blunt tips (see fig. 6).

Dorsal chaetotaxy. Single rows of setae on I and VIII; double rows on II—VII. Blunt-tipped setae principally on V—VII, the most lateral setae on these segments tending towards the lanceolate type; short, slender setae only on VIII. Range (6 specimens: I, 4; II, 2 m, 2—4 a; III, 6—7 m, 0—2 a; IV, 9—12 m, 5—7 a; V, 9—15 m, 6—7 a; VI, 13—16 m, 6—8 a; VII, 12—15 m, 1—7 a; VIII, 6—8. Terminal segment trilobed, with short setae as in fig. 5.

Ventral chaetotaxy. Lanceolate setae throughout, usually in single rows, with the following range (6 specimens): II, 3—4; III, 4; IV, 4—8; V, 9—14; VI, 8—11; VII, 4—7; VIII, 1 + 1. In some specimens there may be one or two additional setae between rows.

Genitalia. As in fig. 7. Basal apodeme fairly short and broad; parameres long and slender, totally enclosing the pseudopenis. Endosomal piece (fig. 8) with anterior prolongation reaching into the notch formed by the bifid basal apodeme.

DIMENSIONS (6 ♂♂, 9 ♀♀)

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<tr>
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<th>Females</th>
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<td>Head width</td>
<td>0.20—0.21 (0.20)</td>
<td>0.19—0.20 (0.19)</td>
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<tr>
<td>Head length</td>
<td>0.31—0.32 (0.32)</td>
<td>0.29—0.31 (0.30)</td>
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<td>Total length</td>
<td>1.3 — 1.4 (1.4 )</td>
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HOLOTYPE. ♀ ex Madoqua kirki damaren-sis, Namutoni, Etosha National Park, South West Africa (F. Zumpt, 15. iii. 1970)

PARATYPES. 6 ♂♂, 8 ♀♀, same data as holotype.

The holotype and 2 ♂♂, 2 ♀♀ paratypes have been deposited at the South African Institute for Medical Research, Johannesburg. The remaining paratypes have been distributed as follows: State Museum, Windhoek, South West Africa (1 ♂, 1 ♀); British Museum (Natural History), London (1 ♂, 1 ♀); United States National Museum, Washington (1 ♂,

Figure 4. Linognathus damaren-sis n. sp. Female genitalia.
D I A G N O S I S

Linognathus damarensis n. sp. is closely related to L. bedfordi (see key). The characters most useful for separating the two species are the chaetotaxy of the abdomen in both sexes, and the characters of the genitalia. L. bedfordi has considerably more abdominal setae, dorsal and ventral, than L. damarensis, and the sternal setae on IV–VII are invariably arranged in distinct double rows. In L. damarensis there are normally single rows of sternal setae on IV–VII, any additional setae being scattered towards the lateral margins of the sternites, and not arranged in definite rows. The differences in abdominal chaetotaxy are illustrated by comparing the ranges of setal counts for L. damarensis, as given in the description above, with those of a sample of 5♂, 5♀ of L. bedfordi:

F E M A L E . Dorsal: I, 4; II, 4 m, 4 a; III, 12–20 m, 8–11 a; IV, 15–20 m, 13–19 a; V, 17–22 m, 16–18 a; VI, 16–19 m, 15–20 a; VII, 12–14 m, 11–14 a; VIII, 4–5. Ventral: II, 4; III, 3–4; IV, 16–17 m, 8–16 a; V, 17–20 m, 14–22 a; VI, 15–16 m, 13–19 a; VII, 9–13 m, 14–17 a; VIII, 1–3 each side.

M A L E . Dorsal: I, 4; II, 4–5 m, 3–4 a; III, 11–16 m, 0–4 a; IV, 16–20 m, 6–10 a; V, 18–24 m, 10–13 a; VI, 20–24 m, 7–14 a; VII, 17–21 m, 7–10 a; VIII, 10–17. Ventral: II, 3–4; III, 3–4; IV, 12–16 m, 4–6 a; V, 17–19 m, 10–12 a; VI, 14–18 m, 10–13 a; VII, 11–15 m, 7–12 a; VIII, 4–5.

The female genitalia of L. damarensis and L. bedfordi are illustrated in figs. 5 & 13 respectively, the main difference being that in the latter the mesal margins of the gonapophyses touch in the midline, whereas they are clearly separated in L. damarensis. The male genitalia of the two species are exceedingly similar, but there are differences in the proportions of the endomeral pieces, as illustrated in figs. 8 & 9.

It may be noted that the blunt-tipped tergal setae described for the male of L. damarensis also occur in males of the other members of the pithodes group, with the exception of L. spicatus.

D I S C U S S I O N

The Damara dikdik, Madoqua kirki damarensis, is confined to the Southwest Arid Zone of the Ethiopian region. In the Northeast Arid Zone, separated by some 2100 km from the Southwest population (Tinley, 1969) are found six further subspecies of Madoqua kirki (Ansell, 1968). This discontinuous distribution is but one example of the biotic similarity between the Southwest and Northeast Arid Zones, presently isolated but probably in contact at different times during the Pleistocene (Tinley, 1969). Further examples are quoted by Benson & White (1962), and the map of the discontinuous distribution of the weaver bird Ploceus rubiginosus given by Moreau (1965, fig. 41) is remarkably similar to the distribution map for Madoqua kirki (Tinley, 1969, map 1). A detailed comparison of the Pthiraptera of M. k. damarensis should be instructive, and might provide some useful information on the rate of speciation of lice on possibly the same host species which have probably been isolated from one another for some 11,000 years (Moreau, 1966, p. 186).

Unfortunately the Pthiraptera of Madoqua kirki are poorly known at present. The Ichnocephalor Rhynchotagrus guentheri Smithia Thomas, 1901, described from Hopkins & Clay (1952) later cited the host as a form of Rhynchotagrus kirki, but according to Ansell (1968), Smithia Thomas is a subspecies of Madoqua kirki, and the original combination given by Hopkins was correct. Turning to Anoplura, only one species of Linognathus is known from a form of the Northeastern Madoqua kirki. L. geigi Büttiker, 1949 was based on specimens taken off a dikdík in the Zoological Gardens at Basel, Switzerland.

Büttiker (1949) has described how the dikdík (which he called Madoqua salitana) was originally captured as a juvenile near Arusha, Tanzania. The ranges of Madoqua species as listed by Ansell (1968) makes it clear that the host was not M. salitana cavendishi Thomas, 1989. Mr. W. F. H. Ansell is in agreement: "... you are pretty safe I think in referring the Arusha dikdíks to M. k. cavendishi."

L. geigi and L. damarensis are not in any way comparable; the former has an elongated forehead, and certainly occupies a different niche on the body, the requirements for a valid comparison would be at least a species similar to L. geigi from the Southwest M. kirki, or a member of the pithodes group from the Northeast populations. I have before me a single female Linognathus, belonging to an undescribed species, taken from the same animal as the series now described as L. damarensis. This specimen is again not strictly comparable with L. geigi, having a somewhat short and bulbous forehead, which probably indicates a different feeding site on the host. Previous experience indicates that we can expect anything from one to five different species of Anoplura on the same host species (five Linognathus species have been recorded from Antidorcas marsupialis, see Kleynhans, 1968). Clearly, further collecting must be done to provide more knowledge of the Pthirapteran fauna on Madoqua kirki in both the Southwest and Northeast regions before we can take advantage of the opportunities provided by the discontinuous distribution of the host to shed some light on the possible rate of speciation in the lice.
**KEY TO SPECIES OF THE pithodes GROUP**

1. 1st claw similar in form and size to 2nd and 3rd claws. Abdomen in both sexes thickly beset with lanceolate setae dorsal and ventral, the normal pattern of two rows per segment being obscured, particularly towards lateral margins. Female genitalia as in fig. 10; male lacking blunt-tipped tergal setae  
   *L. spicatus*

   — 1st claw small and slender, abdominal chaetotaxy in both sexes less dense; males with blunt-tipped setae on some tergites

2. Median sclerotization of female genitalia as in fig. 11 or fig. 12, not linear. Males with distinct tergal plates on III—VII

   — Median sclerotization of female genitalia linear, males without tergal plates

3. Female genitalia as in fig. 11; median sclerotization elliptical, gonapophyses tapering and convergent towards apices, mesal margins not touching  
   *L. pithodes*

   — Female genitalia as in fig. 12; median sclerotization widened at vulval margin, gonapophyses broad, lateral sclerotizations divergent apically, mesal margins touching  
   *L. lewisi*

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4. Female genitalia as in fig. 13; mesal margins of gonapophyses touching. Sternal setae on IV—VII in both sexes always in two full rows. Endomeral piece of male genitalia as in fig. 9.

— Female genitalia as in fig. 4; mesal margins of gonapophyses not touching. Sternal setae in both sexes usually in single rows; if additional setae are present, they are not arranged in definite rows. Both sexes with distinctly fewer setae, dorsal and ventral, than bedfordi. Endomeral piece of male genitalia as in fig. 8.

*L. damarensis*

**MATERIAL EXAMINED**

The following specimens from the collections of the Veterinary Research Institute, Onderstepoort (OP) and the South African Institute for Medical Research, Johannesburg (SAIMR) were examined during the preparation of this paper: *L. bedfordi*: 1 ♂, 1 ♀ ex *Antiloceras marupialis*, Onderstepoort, from Northern Transvaal (25.vii.1930. OP); 8 ♂♂, 15 ♀♀ ex *Antiloceras marupialis*, Bloemhof, Transvaal (J.A. Ledger, 18.iii.1968. SAIMR).


*L. pithodes*: 1 ♂, 1 ♀ ex *Antilope cervicapra*, London Zoo (1938. OP).

*L. spicatus*: 2 ♂♂, 2 ♀♀ ex *Gorgon taurus*, Maasstrom, Northern Transvaal (15.viii.1930. OP).

**SUMMARY**

A new species named *Linognathus damarensis* is described from the Damara dikdik. The new species belongs to the *pithodes* species-group, and a key to the latter is provided. Because of the discontinuous distribution of the host, a detailed examination of the lice on the isolated populations might provide useful information on the rate of speciation of the parasites.

**ACKNOWLEDGEMENTS**

Research on Arthropod parasites of Vertebrates in South West Africa is conducted with the co-operation and support of the Department of Nature Conservation and Tourism, the State Health Department and the State Museum, Windhoek. I thank Mr E. M. Nevill for providing material from the Ondersteapoort collection, Mr W. F. H. Ansell for advice on dikdik taxonomy, Dr F. Zumpt for supervising my work and the Director of the South African Institute for Medical Research for library and research facilities.

This paper is based in part upon the experience which I gained during a study trip to the British Museum (Natural History), London, during 1969; the financial support of the South African Concil for Scientific and Industrial Research for this purpose is gratefully acknowledged.

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**KLEYNHANS, K. P. N.**


**MOREAU, R. E.**


**TINLEY, K. L.**

A new species of *Prolinognathus* (Anoplura: Linognathidae) and a redescriptions of *P. leptoccephalus* (Ehrenberg, 1828) from the Hyrax.

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INTRODUCTION

The genus *Prolinognathus* Ewing, 1929 comprises seven species which are ectoparasites of hyraxes (Hyracoidae: Procaviidae). Useful characters for separating species are the shape and size of the head, and the presence or absence of long lateral setae on certain abdominal segments. The latter character may be used to divide the genus into three species-groups. *P. leptoccephalus* (Ehrenberg, 1828) has long lateral setae on abdominal segments IV, V and VI; *P. faini* Benoît, 1961, *P. ferrisi* Fahrenholz, 1939 and *P. foleyi* Fahrenholz, 1939 lack such setae on V and VI, while *P. caudacephalai* (Pallas, 1767), *P. arcuatus* Fahrenholz, 1939 and *P. aethiopicus* Fahrenholz, 1939 lack long lateral setae on IV, V and VI. All species have single long lateral setae on II and III, and paired long lateral setae on VII and VIII.

Recently I received specimens, taken from hyraxes in the Cape Province and South West Africa, which resemble *P. leptoccephalus* in the chaetotaxy of the abdomen, and hereby describe the form as a new species. The opportunity is also taken of providing a short redescriptions of *P. leptoccephalus*, and designating a neotype for this species.

**Prolinognathus schulzi** n. sp., figs. 1a, 2a, 2c, 3a.

**TYPE- HOST**: *Procavia capensis capensis* (Pallas, 1766) (*sensu* Ellerman et al., 1953).

**FEMALE**. General appearance and chaetotaxy as in fig. 1a. Total length 1.6—2.6 mm.

**Head**. As in fig. 2a, length 0.51—0.63 mm, width 0.24—0.27 mm. Head index (length/width), 2—2.4.

**Thorax**. As for other members of the genus; 1 long, 1 short setae associated with each thoracic spiracle. Sternal plate lacking.

**Abdomen**. Long lateral setae on segments II—VI, paired long setae laterally on VII & VIII. Medially, 9 pairs of stout tergal setae, 6 pairs of stout sternal setae. Spiracles small.

**Genitalia**. As in fig. 2e. Gonopophyses V-shaped, somewhat broader, more rounded apically and with lateral sclerotizations more strongly developed than in *P. leptoccephalus* (compare fig. 2d).

Gonopophyses appear trilobed in some specimens; three long apical setae, 3—4 medium setae on outer margin and 10—14 short setae on inner margin.

Median sclerotization well-developed and larger than in *P. leptoccephalus*, 82—105 μ long, 58—71 μ wide. Apical lobe with stout spine, 51—78 μ long.

**MALE**. General appearance similar to female, total length 1.6—2.4 mm.

**Head**. Length 0.46—0.69 mm; width 0.18—0.23 mm; head index 1.8—2.4.

**Abdomen**. Tergal chaetotaxy as for female, 7 pairs sternal setae.

**Genitalia**. As in fig. 3a. Basal apodeme longer than in *P. leptoccephalus*, 259—364 μ. Parameres long (101—147 μ), convergent at apexes.


**PARATYPES**. 2 δ, same data as holotype; 1 ♀ ex *Procavia capensis*, Niekirkhoop, Hay District, Cape Province (7.iii.1969); 1 δ ex *Procavia capensis*, Robertson District, Cape Province (26. xii.1968); 1 δ ex *Procavia capensis wuidwoek*, Erongo Mts, Omarru, South West Africa; 3 δ ex *Procavia capensis wuidwoek*, Onguito, Erongo Mts, South West Africa; 1 δ ex *Procavia capensis*, Brulkeros Mountain, South West Africa (6.iii. 1937); 1 ♀ ex *Procavia capensis*, 80 miles West of Windhoek, South West Africa (F. Zumpt, 6.iii. 1970); 1 δ, 3 ♀♀ ex *Procavia capensis*, Lake Mentz, Vrolijkheid, Cape Province (24.ii.1970).

The holotype has been deposited at the South African Institute for Medical Research; paratypes at the same institution and at the British Museum (Natural History), London; United States National Museum, Washington; Veterinary Research Institute, Onderstepoort and the State Museum, Windhoek.

The new species is named for Dr. K. Schulz, Predator Control Research Farm, Robertson, Cape Province, who collected part of the material studied.

**Prolinognathus leptoccephalus** (Ehrenberg, 1828), figs. 1b, 2b, 2d, 3b.
Pediculus leptocephalus Ehrenberg, 1828, Synoeca Physicae, Mammalia, Decas Prima : f.

Haematopinus leptocephalus, Giebel, 1874, Insecta Epizoia : 47 (partim)


TYPE-HOST: Procavia capensis syriaca (Schreber) (sensu Ellerman & Morrison-Scott, 1951).

FEMALE. General appearance and chaetotaxy as in fig. lb. Total length 1.2—2.0 mm.

HEAD. As in fig. 2b, length 0.46—0.69 mm, width 0.23—0.36 mm, head index 1.8—2.1

THORAX AND ABDOMEN. As in P. schulzi.

GONITALIA. As in fig. 2d. Gonapophyses more acutely pointed than in P. schulzi; 3 long apical setae, 3 medium setae on outer margin, 12—15 short setae on inner margin. Gonapophyses may sometimes appear trilobed, and in general are more weakly sclerotized than in P. schulzi. Median sclerotization pear-shaped, poorly defined, often difficult to see; length 58—61 μ, considerably smaller than in P. schulzi. Apical lobe with a stout spine 21—33 μ long, considerably shorter than in P. schulzi.

MALE. General appearance similar to female, total length 1.0—1.4 mm.

HEAD. Length, 0.34—0.41 mm, width 0.14—0.22 mm, head index 1.8—2.4.
Figure 2. Heads and genitalia of *Prolinognathus* females, drawn to same scale. a) *P. schulzi* n. sp., head. b) *P. leptcephalus*, head. c) *P. schulzi* n. sp., genitalia. d) *P. leptcephalus*, genitalia.
Genitalia. As in fig. 3b. Basal apodeme shorter than in P. schulzi, length 147—175 μ. Parameres short.

NEOTYPE. 9 ex Procapia capensis syriaca, Karthu, Lebanon (S. I. Atallah, 1911,1965).

NEOPARATYPES. 2 $\delta$, 1 $\varphi$, same data as neotype; 1 $\varphi$ ex Procapia capensis syriaca, near Tyr, Lebanon (25.xii.1959); 2 $\delta$, 2 $\varphi$ ex Heterohyrax s. syriacus, Safad, Galilea, Palestine (R. S. F. Hennessey, 12.iv.1953); 3 $\delta$, 2 $\varphi$ ex Procapia capensis syriaca, Wadi Sajal, Palestine.

The neotype will be deposited at the British Museum (Natural History), neoparatypes at the same institution, the South African Institute for Medical Research, Johannesburg and the United States National Museum, Washington.

DISCUSSION

No type material of P. leptocephalus is known to be in existence, and it has been considered advisable to designate a neotype series from the adequate material available to ensure the stability of the name. P. leptocephalus and P. schulzi are separated from all other Procapia by the presence of long lateral abdominal setae on segments IV—VI. The two species appear to be closely related, and may be separated by the characters of the genitalia in both sexes, and by the shape of the head. Geographically, P. leptocephalus appears to be confined to the eastern Mediterranean part of the Palearctic region. The status of the host form syriacus Schreber is open to question — Ellerman & Morrison-Scott (1951) have included it as a subspecies of Procapia capensis. P. schulzi has been collected from Procapia capensis in the western and southern parts of Southern Africa. The close relationship of P. schulzi and P. leptocephalus may be an indication of the affinities of the southern and north-western forms of the host — further collecting and a better knowledge of Procapia may provide useful information on the relationships of the Procapia and the Cape Province. The new species is closely related to Procapia capensis (Ehrenberg), which is parasitic on hyraxes in the Middle East. The latter species is redescribed and a neotype designated.

SUMMARY

A new louse named Procapia schulzi is described from hyraxes in South West Africa and the Cape Province. The new species is closely related to Procapia capensis (Ehrenberg), which is parasitic on hyraxes in the Middle East. The latter species is redescribed and a neotype designated.

ACKNOWLEDGEMENTS

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