

# MADOQUA

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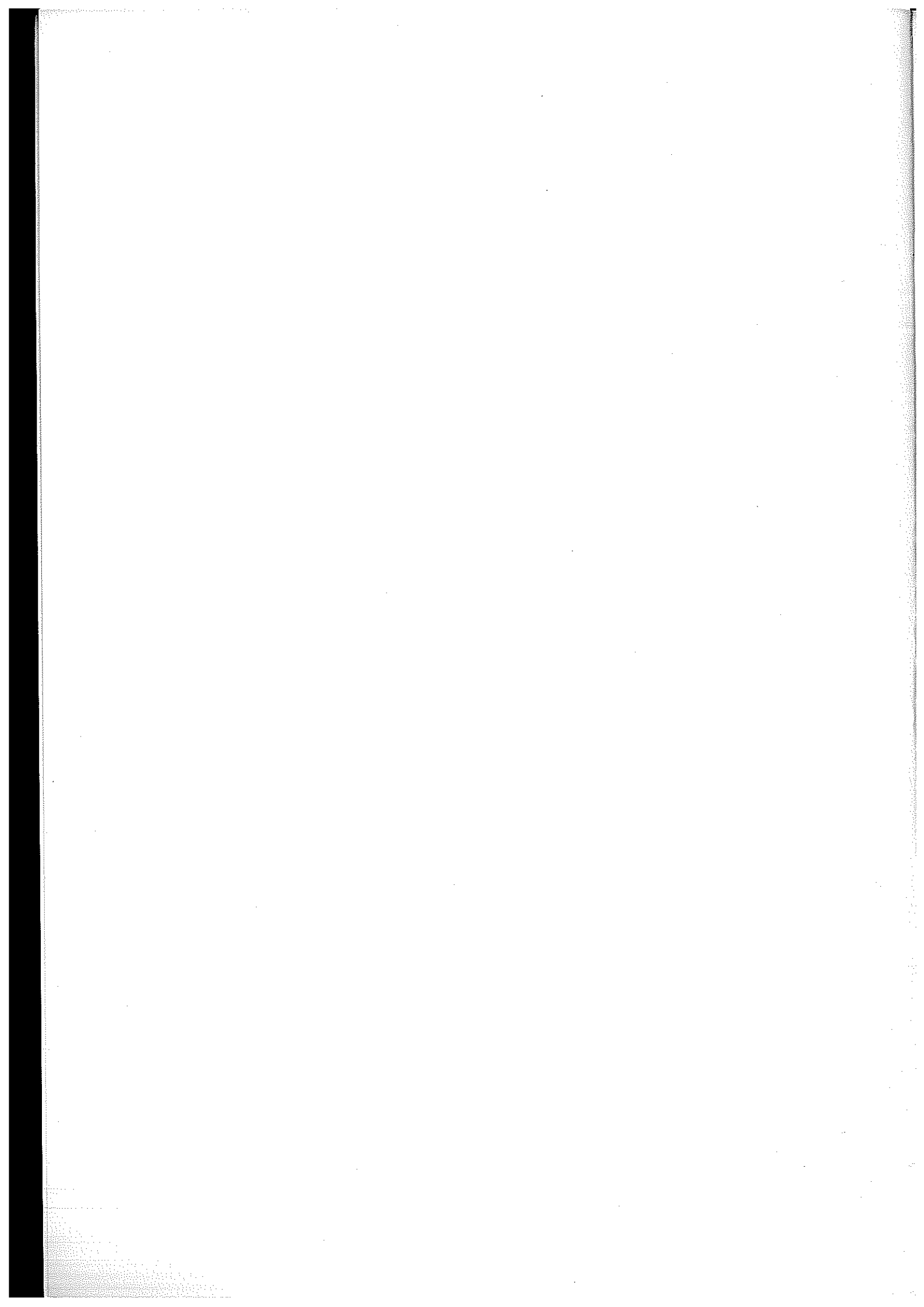
# MADOQUA

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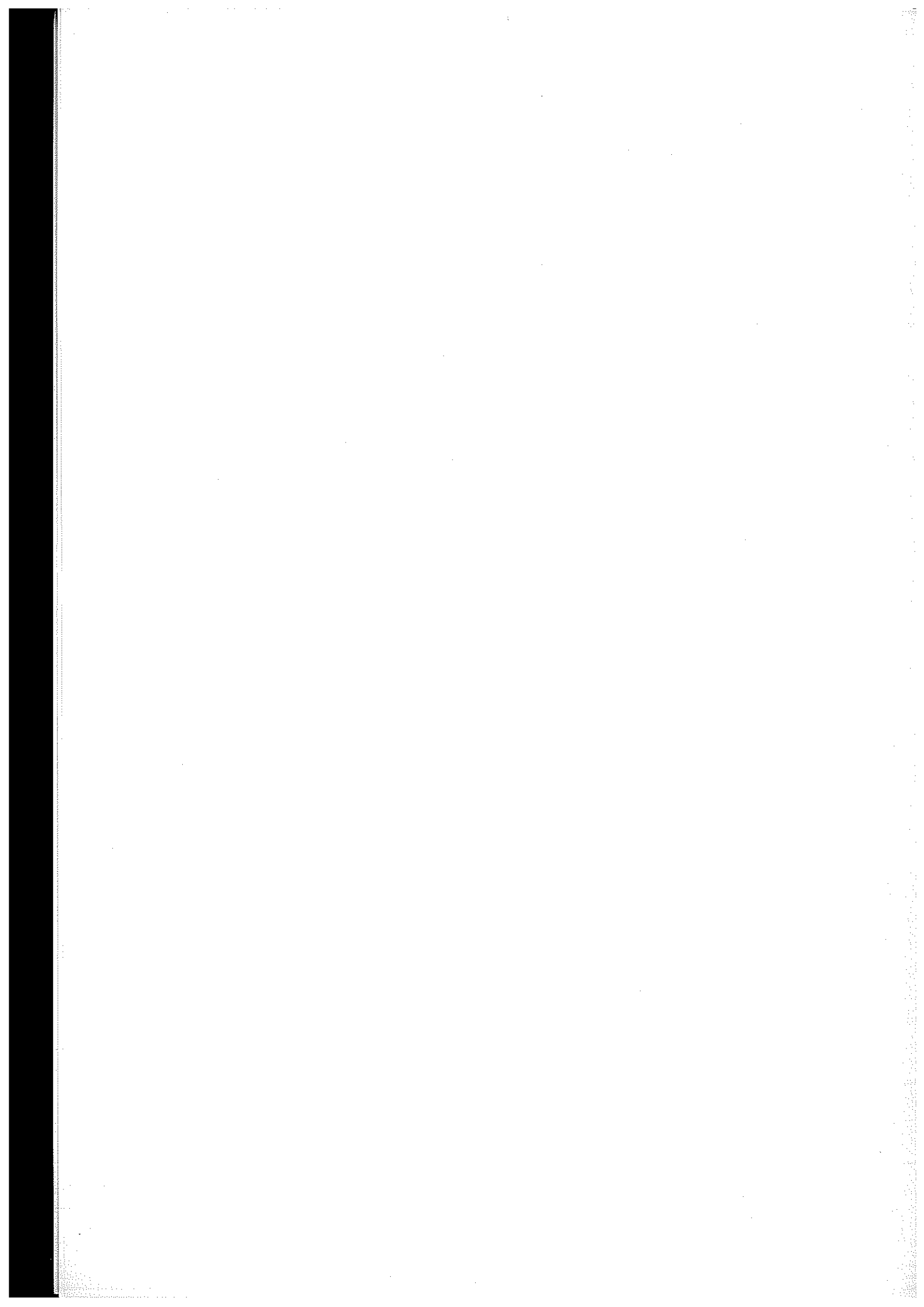


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# A preliminary report on the genus *Commiphora* in South West Africa

by  
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## ABSTRACT

The genus *Commiphora* which is represented by at least 24 species in South West Africa, forms an important component of the flora of this country. Twelve species, mainly from the north-western part of South West Africa, a number of which are endemic to this area, are described. A description is given of the habit, appearance of the bark, morphology of the stems, leaves and fruit of each species. Photographs serve to illustrate the text. The geographical distribution of each species is given in detail.

## I INTRODUCTION

The genus *Commiphora* Jacq. belongs to the family Burseraceae. This family consists of 16 genera (Lam, 1932) and 600-700 species, which are mainly concentrated in tropical regions of America, Africa and Asia. Since ancient times, the resins and gums which occur in members of the Burseraceae, have been known to mankind. Frankincense from the genus *Boswellia* and myrrh from *Commiphora* are of biblical fame.

*Commiphora* is the largest genus of the Burseraceae and the only genus represented in South Africa and South West Africa. It includes more than 200 species which occur mainly on the continent of Africa and surrounding islands. Only eight species are found in Arabia and West India.

The genus *Commiphora* forms a very important component of the flora of South West Africa due to the large number of species being well represented and widely distributed over this geographical area. The majority of species are adapted to arid areas and rocky places are favoured by most species.

A few species grow in the Namib Desert itself, but it is especially on the edge of the Namib or Escarpment Zone (Vegetation Type 4; Giess, 1971), that a large number of species are well represented. This area stretches from Neisip in the south, past Naukluft and Usakos to the Brandberg in the north. The genus is, however, as well represented in the Kaokoveld, especially in the western mountainous areas east of the northern Namib. This area reaches from the Brandberg, past Welwitschia and Sesfontein to the Kunene River in the north. Throughout the rest of the Mopane Savanna (Vegetation Type 5; Giess, 1971), *Commiphora* species are to be found on mountains, kopjes and stony outcrops, with only a few species occurring on the planes in the mopaneveld itself. It is noteworthy and interesting that many of the species which occur in the western zone of the country as described above, are endemic to South West Africa. It has also been established that three of the four species growing on the mountains near the Orange River, are endemic to this area.

The species represented in the eastern part of South West Africa, are also found in South Africa. Such species occur in the Mountain Savanna and Karst-

veld (Vegetation Type 6; Giess, 1971) near Tsumeb, Grooifontein and Otavi. This is also true of the Tree Savanna and Woodland (Northern Kalahari), Camelthorn Savanna (Central Kalahari) and Mixed Tree and Shrub Savanna (Southern Kalahari), respectively Vegetation Types 11, 12 and 13 (Giess, 1971).

The following species of *Commiphora* have been recorded from South West Africa and South Africa:

From SW Africa

1. *C. anacardiifolia* Dinter & Engl.
2. *C. crenato-serrata* Engl.
3. *C. dinteri* Engl.
4. *C. discolor* Mendes
5. *C. giessii* Van der Walt
6. *C. glaucescens* Engl.
7. *C. kraeuseliana* Heine
8. *C. multijuga* (Hiern) K. Schum.
9. *C. oblanceolata* Schinz
10. *C. saxicola* Engl.
11. *C. virgata* Engl.
12. *C. wildii* Merxm.

From SW Africa and outh Africa

13. *C. africana* (A. Rich.) Engl.
14. *C. angolensis* Engl.
15. *C. capensis* (Sond.) Engl.
16. *C. cervifolia* Van der Walt
17. *C. edulis* (Klotzsch) Engl.
18. *C. glandulosa* Schinz
19. *C. gracilifrons* Dinter ex Van der Walt
20. *C. merkeri* Engl.
21. *C. mollis* (Oliv.) Engl.
22. *C. namaensis* Schinz
23. *C. pyracanthoides* Engl.
24. *C. tenuipetiolata* Engl.

From South Africa

25. *C. harveyi* (Engl.) Engl.
26. *C. marlothii* Engl.
27. *C. neglecta* Verdoorn
28. *C. schimperii* (O. Berg) Engl.
29. *C. woodii* Engl.
30. *C. zanzibarica* (Baill.) Engl.

(Another species, *C. mossambicensis* [Oliv.] Engl. has been collected in the Caprivi strip).

The major contributions to the present knowledge of the genus *Commiphora* in South West Africa were made by Engler (1931), Wild (1959), De Winter (1968), Merxmüller (1968) and Giess (1971). The above mentioned species no. 13-24 have been described in detail in a previous publication (Van der Walt, 1973b). It is the aim of this paper to increase the knowledge of the genus by a delimitation of the 12 South West African species which do not occur in South Africa.

Material of each of the species was collected in their natural habitat, in the course of three collecting trips which were undertaken recently. Specimens of these species, housed in the National Herbarium Pretoria, as well as in the South West Africa Herbarium, Windhoek, were studied. The habit, stems,

bark, leaves and fruit of each species are described, but the flowers have not been studied at this stage. The synonyms as designated by Merxmüller (1968) are listed, although the type specimens have not been examined. The geographical distribution of each species is given according to the grid reference system of the Botanical Research Institute, Pretoria. Herbaria where these specimens are housed, are mentioned in brackets after the collector's number. The international abbreviations applicable to the National Herbarium, Pretoria (PRE); the South West Africa Herbarium, Windhoek (WIND); the Government Herbarium, Stellenbosch (STE); the Compton Herbarium, Cape Town (NBG) and the Botanische Staatssammlung, München (M), are used.

## II DESCRIPTION OF THE GENUS COMMIPHORA

*Commiphora* Jacq. in Hort. Schoenbr. 2: 66, t.249 (1797)

Dioecious or polygamous but rarely monoecious many-stemmed shrubs or shrubs with the trunk branching repeatedly above soil level or trees with a single main stem of variable height; bark often peeling or flaking in papery pieces or strips; resin ducts secreting an odoriferous resin occurring in the phloem; wood relatively light and consisting mainly of septated fibres; branchlets often spine-tipped, glabrous, pilose or tomentose. *Leaves* petiolate but rarely sessile or subsessile, alternate, usually grouped at the end of the branches, simple, unifoliate, trifoliate or impari-pinnate, margins of leaflets usually crenate, serrate or lobed but seldom entire, glabrous, pilose or tomentose, leaflets dorsiventral or isobilateral; petioles of a few species with medullary vascular bundles. *Flowers* unisexual rarely bisexual, perigynous or hypogynous, male flowers usually larger than female flowers, appearing before or with the leaves and occasionally after the leaves in axillary simple or compound dichasial cymes, in paniculate cymes or singly in clusters. *Pedicels* of variable length, glabrous or pilose to tomentose. *Calyx* infundibuliform, campanulate or broadly campanulate with 4 valvate persistent lobes, usually yellowish-green or reddish-green, glabrous, glandular or pilose to tomentose, in perigynous flowers continuous with hypanthium, in hypogynous flowers inserted on receptacle. *Petals* 4, usually yellow to green, apex incurved, glabrous or occasionally pilose on outside.

*Disk* in perigynous flowers adnate to hypanthium, cylindrical, rarely fleshy, sometimes lobed; in hypogynous flowers not adnate to calyx or corolla, intrastaminal, cylindrical, usually with 4 large lobes but in some species with 8 lobes, lobes bifid or not bifid; disk in male flowers usually more fleshy than in female flowers, glabrous or occasionally pilose. *Stamens* 8 or in a few species 4, obdiplostemonous, 4 antisealous stamens longer than other 4; filaments subterete but lower part usually flattened and broadened, inserted on the outside or on top of disk; anthers introse and adnate; staminodes in



female flowers. *Gynoecium* rudimentary in male flowers; half inferior in perigynous flowers and superior in hypogynous flowers, usually glabrous but occasionally glandular or pilose; ovary ovoid, 2-locular with 2 epitropous ovules per loculus; style of variable length but usually relatively short; stigma capitate, obscurely 2-4-lobed. *Fruit* an ovoid, ellipsoid or subglobose drupe, usually asymmetrically flattened; exocarp relatively thin, glabrous but occasionally pilose; mesocarp usually fleshy, consisting of spongy tissue with resin ducts; exocarp and mesocarp splitting in ripe fruit into 2 longitudinal valves (4 valves in a few species outside our area); endocarp forming a crustaceous or bony putamen and usually also a pseudaril; putamen ellipsoid or subglobose, irregularly flattened, smooth or rugose, usually enclosing one fertile loculus and a much smaller abortive loculus; seed with a straight embryo, cotyledons much folded; pseudaril clasping putamen, usually red or yellowish, usually fleshy but in a few species thin or membranous or absent, cupular with short lobes or arms or with 2-4 relatively long arms or covering almost whole putamen without distinct arms.

### III DESCRIPTION OF THE TWELVE SPECIES

3.1 *Commiphora anacardiifolia* Dinter & Engl. in Bot. Jahrb. 48: 475 (1912); Merxm., Prod. Fl. S.W. Afr. 23: 75 (1968)

Dioecious tree 5-10 m tall with a single trunk; bark peeling in large, yellow-brownish, papery pieces to expose a pale green underlayer. Branchlets obtuse, covered with a papery bark except for the youngest ones which are pubescent to densely pubescent. Leaves relatively large (7-20 × 5-14 cm), borne in clusters at apex of branchlets, simple, dark green, sessile, narrowly to broadly elliptic, pilose, margin entire, apex obtuse, base cuneate. Fruit red when ripe, ovoid, c. 1.5 × 0.8 cm; pseudaril yellow to orange, cupular with 2 short lobes on seam of putamen. (Plates 1-3.)

This species has a restricted distribution in South West Africa. So far it has only been collected on the fringes of the Namib Desert in the Kaokoveld, from the Sanitatas area in the north to Twyfelfontein in the south.

Also recorded from Angola.

1812(Sanitatas): 9,5 km E of Omutati (-DB), *Giess & Leippert* 7401 (WIND). 1813(Ohopoho): 17 km W of Otju (-AC), *De Winter & Leistner* 5671 (PRE; WIND); *Merxmüller & Giess* 1434 (WIND). 1913(Sesfontein): 37 km E of Sesfontein on Otjovasandu road (-BD), *Van der Walt* 246 (PRE; WIND; STE). 1914(Kamanjab): near Kowares (-AB), *Esterhuyse* 402 (WIND). 2014(Welwitschia): 138 km E of Torra Bay (-AC), *De Winter & Hardy* 8203 (PRE; WIND); Twyfelfontein (-CB), *Meyer* 1150 (WIND).

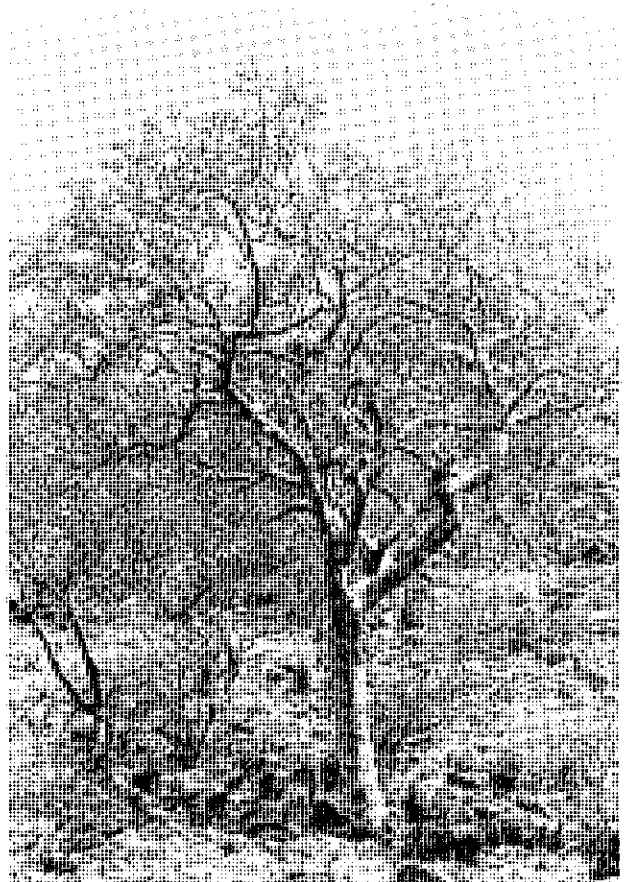


Plate 1. *Commiphora anacardiifolia* 37 km E. of Sesfontein (height  $\pm$  6 m).



Plate 2. Close-up view of the bark of *Commiphora anacardiifolia*.

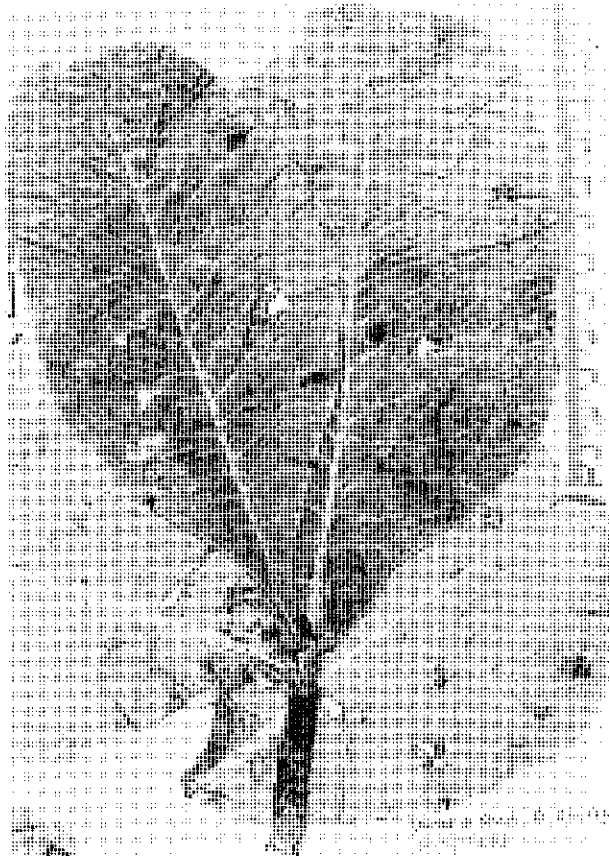


Plate 3. Leaves of *Commiphora anacardiifolia*.

*C. anacardiifolia* is a graceful tree with a round spreading crown; its attractive papery bark being typical of a commiphora, but the leaves are relatively large, a feature not typical of the genus. The midrib and larger secondary veins of the leaves are exceptionally broad and conspicuous. It has been noted that the leaves of the male trees are larger than those of the female trees, but this phenomenon must still be further investigated.

3.2 *Commiphora crenato-serrata* Engl. in Bot. Jahrb. 19: 140 (1894); Merxm., Prod. Fl. S.W. Afr. 23: 75 (1968)

Dioecious tree with a single trunk, 3-10 m tall; bark light grey to pale brown, pitted, smooth, not peeling; branchlets obtuse, conspicuously scarred, youngest branchlets with large, brown glandular hairs. Leaves impari-pinnate, 3-7-jugate but usually 5-6-jugate, with large glandular hairs especially on the petiole but otherwise glabrous, 10-25 cm but usually c. 15 cm long; petiole 4-8 cm but usually c. 6 cm long, petiolules slender, 0.5-2 cm long; leaflets narrowly lanceolate but more often lanceolate, margins crenate-serrate, apex acuminate, base truncate; terminal leaflet 5-10 × 2-3.5 cm but usually c. 6.5 × 2.5 cm; lateral leaflets 4 × 1.3-9 × 3 cm but usually c. 6 × 2 cm. Fruit ovoid, much apiculate, c. 2 × 1 cm, reddish-brown; pseudaril orange-red, cupular, covering lower 1/3 of putamen, with 2 short lobes on seam of putamen. (Plates 4-6.)

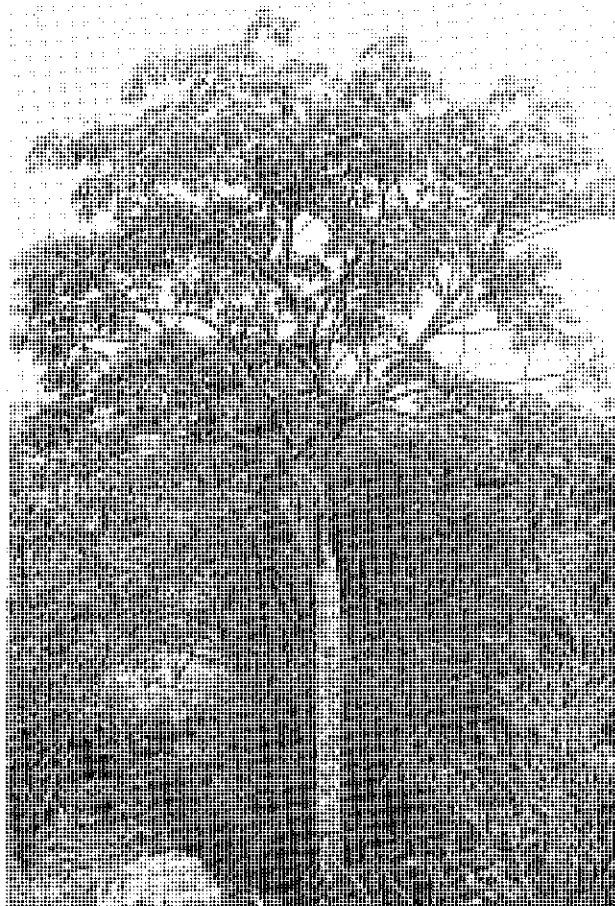


Plate 4. *Commiphora crenato-serrata* near Okorosawe, Kaokoveld (height  $\pm$  5 m).

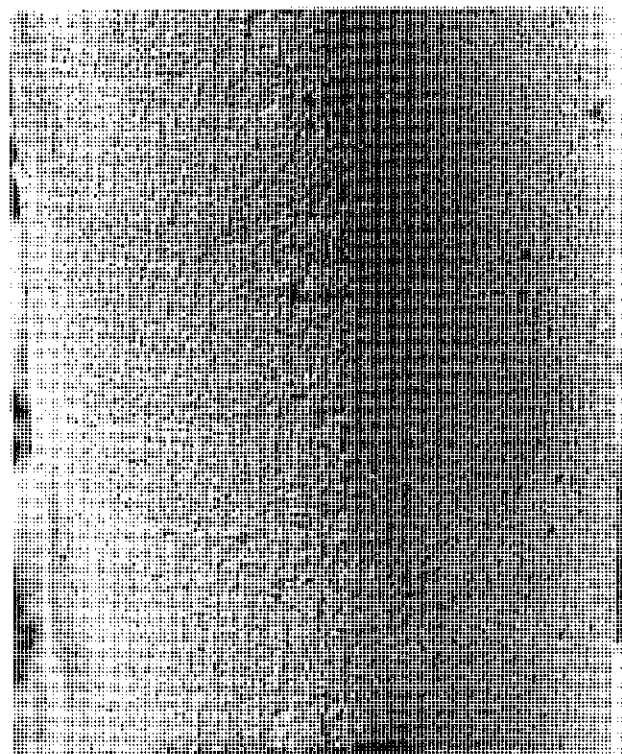


Plate 5. Close-up view of the bark of *Commiphora crenato-serrata*.

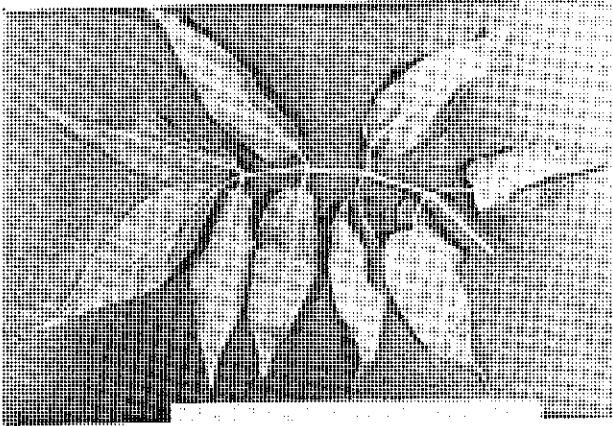


Plate 6. A leaf of *Commiphora crenato-serrata*.

*C. crenato-serrata* is apparently endemic to South West Africa and occurs in the Kaokoveld from Fransfontein in the south to the Swartbooisdrif area in the north. It is also common in rocky outcrops on the dolomite ridges near Otjovasandu in the Etosha National Park (Joubert, 1971).

1715(Swartbooisdrif): 15 km W of Otjangosemo (-AD), *Van der Walt & Giess* 295 (PRE; WIND; STE); 1813(Ohopoho): 4 km N of Ohopoho (-BB), *Van der Walt & Giess* 285 (PRE; WIND; STE); 5 km S of Okorosawe (-BB), *Van der Walt & Giess* 287 (PRE; WIND; STE). 1914(Kamanjab): 27 km N of Otjovasandu (-AB), *Van der Walt* 249 (PRE; WIND; STE); near Otjovasandu (-AB), *Joubert* 150 (WIND); Farm Hazeldene

(-BC), *De Winter & Leistner* 5121 (WIND). 1915 (Okaukuejo): Farm Teschendorf (-CC), *Walter* 1011 (WIND). 2015(Otjihorongo): Farm Hilldown (-AA), *Hardy* 2082 (PRE); 25 km N of Fransfontein (-AA), *Van der Walt* 258 (PRE; WIND; STE); Farm Pamela (-AB), *Giess, Volk & Bleissner* 6093 (PRE; WIND).

This species does not have the typical commiphora habit, and is often confused in the field with *Kirkia acuminata* which it resembles superficially. This may be the reason why it has not been collected more often. Although it occurs generally in the northern part of the Kaokoveld, it has only been collected there recently for the first time.

*C. crenato-serrata* is a fine tree, distinguishable at a distance by its whitish-grey bark. The trees bear large quantities of fruit from December to April. A whitish coloured resin with an aromatic odour is exuded when fresh leaves or branchlets are picked.

3.3 *Commiphora dinteri* Engl. in Bot. Jahrb. 44: 151 (1910); Merxm., Prod. Fl. S.W. Afr. 25: 76 (1968)

Diocious, many-stemmed and much-branched shrub. 0,5-3 m tall and up to 2,5 m in diameter: bark yellowish-green to greyish-brown with dark spots, smooth and not peeling. Branches relatively thin, branchlets glabrous. Leaves trifoliate, glabrous, 0,8-4 cm but usually 2-2,5 cm long; petiole 0,2-1,8 cm but usually 0,8-1 cm long; leaflets subsessile, apex obtuse, seldom truncate or retuse, base cuneate, margins crenate-serrate but usually finely crenate-serrate; terminal leaflet obovate 0,6-2,2 × 0,4-1,5

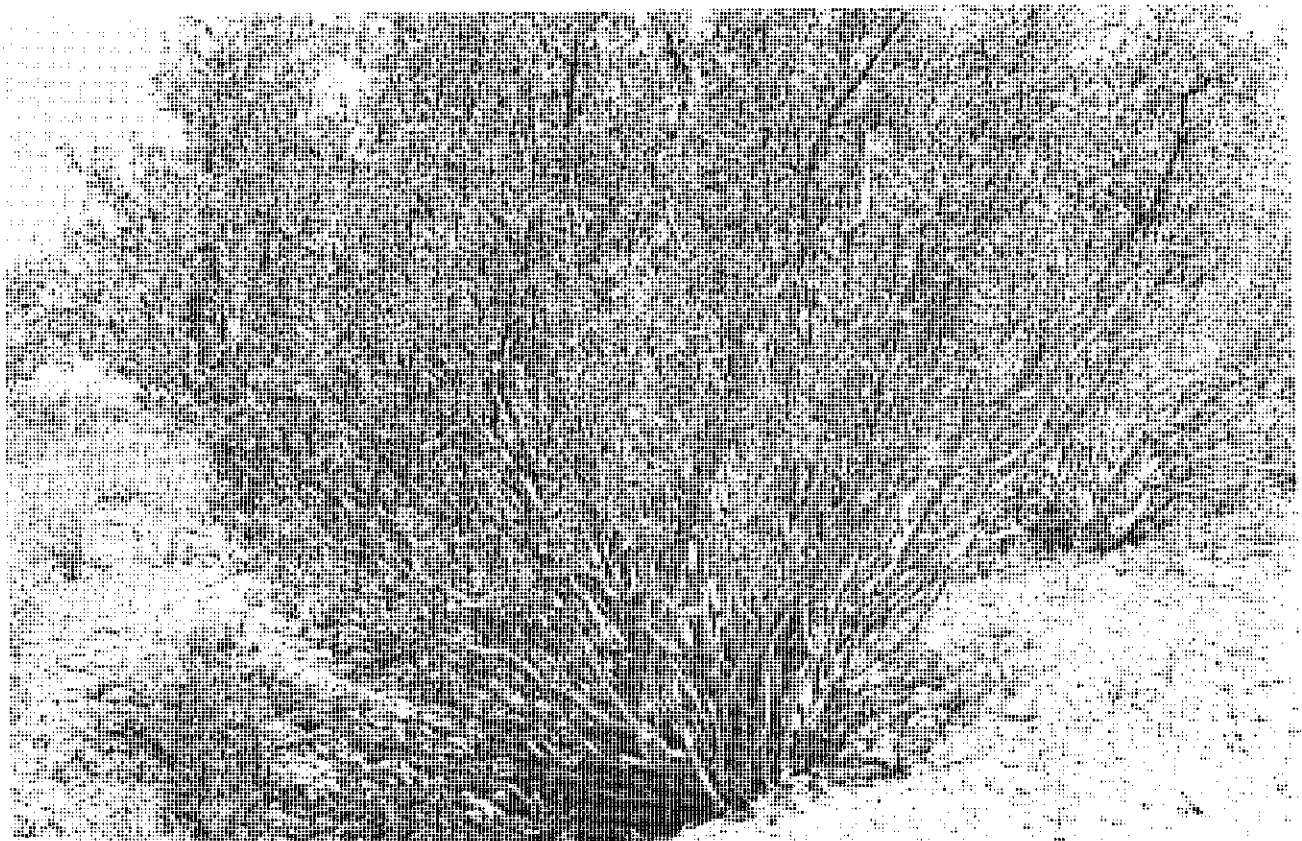


Plate 7. *Commiphora dinteri* near Karibib (height  $\pm$  1,75 m).



Plate 8. Close-up view of the stems of *Commiphora dinteri* illustrating the bark.

cm but usually c. 1,4 × 1 cm; lateral leaflets broadly elliptic, 0,4–1,2 × 0,2–0,9 cm but usually c. 0,9 × 0,6 cm. Fruit ellipsoid, apiculate, c. 1,1 × 0,8 cm; pseudaril red, cupular with 2 long arms on seam of putamen and 1 short arm on less convex face of putamen. (Plates 7–10.)

This species is endemic to South West Africa and grows in the Namib Desert itself or on its fringes, from the Karibib area southward to the Zaris Mountains near Maltahöhe. It has also been collected as far east as Rehoboth. The species usually occurs on stony hillsides or mountain slopes.

2115(Karibib): Black Range (-CC), *Van der Walt* 207 (PRE; WIND; STE); 16 km W of Usakos (-CD), *De Winter* 6035 (PRE; WIND); 3 km W of Karibib (-DD), *Van der Walt* 201 (PRE; WIND; STE). 2215(Trekkopje): Farm Nudis (-BC), *Walter* 1182 (WIND). 2316(Nauchas): Gamsberg Plateau (-AD), *Merxmüller & Giess* 935 (PRE; WIND); Farm Weissenfels (-AD), *Walter* 1719 (WIND); 2317 (Rehoboth): near Rehoboth (-AC), *Strey* 2612 (PRE). 2416 (Maltahöhe): Zaris Mountains (-CD), *Basson* 204 (PRE); *Van der Walt* 267 (PRE; WIND; STE).

Herbarium specimens of *C. dinteri* and *C. capensis* having only leaves and no flowers or fruit, could be confused because of the degree of resemblance in their leaf appearance. The stems of *C. dinteri*, however, are much thinner and more plentiful than those

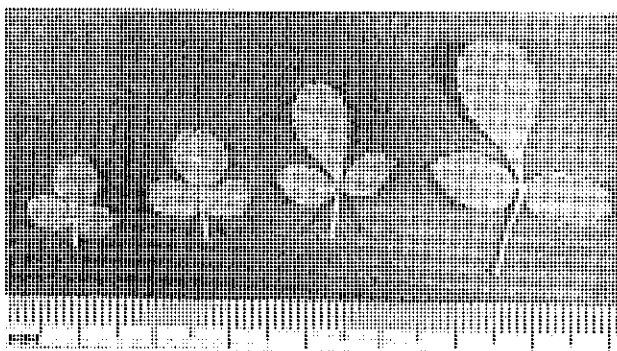


Plate 9. Leaves of *Commiphora dinteri*.

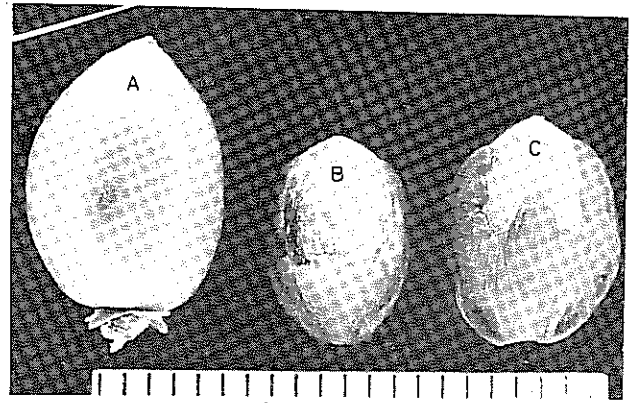


Plate 10. Fruit of *Commiphora dinteri*: A, Side-view of fruit; B, View of the more convex face of putamen with pseudaril; C, View of the less convex face of putamen with pseudaril. (scale in mm).

of *C. capensis*. The fruit of *C. dinteri* has a pseudaril which is entirely lacking in *C. capensis*.

Specimens have been collected of a commiphora (*De Winter & Leistner* 5737) growing at the Orupembe waterhole in the Kaokoveld, the leaves of which resemble those of *C. dinteri* to a certain extent, but being relatively larger. This problem still has to be investigated.

3.4 *Commiphora discolor* Mendes in Bol. Soc. Brot. sér. 2,41: 155 (1967); Merxm., Prod. Fl. S.W. Afr. 23: 76 (1968)

Diococious tree with a single trunk, 3–9 m tall; bark yellowish-white, peeling around the stem in papery trips; branchlets glabrous, occasionally spine-tipped. Leaves dark green, glabrous, shiny, on the younger branchlets usually trifoliolate with 2 much smaller lateral leaflets, on the older branchlets usually unifoliolate; trifoliolate leaves 3,3–8,3 cm long, petiole 0,3–1,3 cm but usually 6–8 mm long, leaflets sessile, elliptic to broadly elliptic, margins crenate-serrate, subentire but seldom entire, apex acute, base cuneate, terminal leaflet 2,8–7 × 1,3–4,7 cm, lateral leaflets 1,4–3,2 × 0,7–1,5 cm; unifoliolate leaves 3–6 × 2,5–4 cm, broadly elliptic to suborbicular, margins crenate-serrate but often subentire or entire, apex acute or more often truncate, base truncate or cuneate, petiole 1–3 mm long. Fruit subglobose, c. 9 × 9 mm; pseudaril with 4 arms of equal length reaching almost to apex of putamen. (Plates 11–13.)

This newly described species is apparently restricted to the north-western part of the Kaokoveld and Angola. In South West Africa it has only been collected near Otjansasemo and at Ombepera where it grows on rocky kopjes and mountain slopes.

1712(Posto Velho): Ombepera (-DB), *De Winter & Leistner* 5490 (PRE). 1713(Swartbooisdrif): 15 km W of Otjansasemo (-AD), *Van der Walt & Giess* 291 (PRE; WIND; STE).

The distinguishing features of this species are the yellowish-white, papery back which peels around the stem, and the shiny, unifoliolate or trifoliolate leaves. The leaves are designated as unifoliolate because of the apparent articulation which exists in the

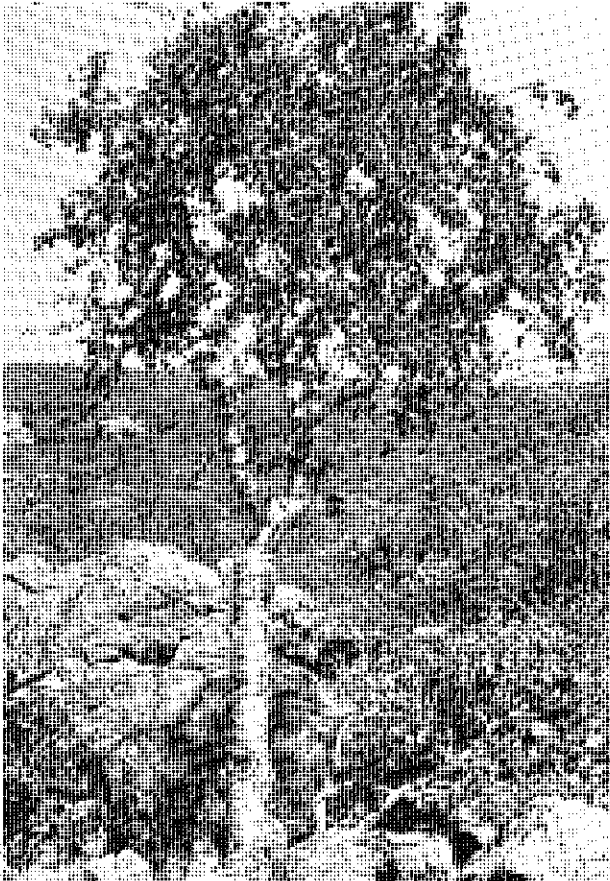


Plate 11. *Commiphora discolor* near Otjansasemo, Kaokoveld (height  $\pm$  3,5 m).

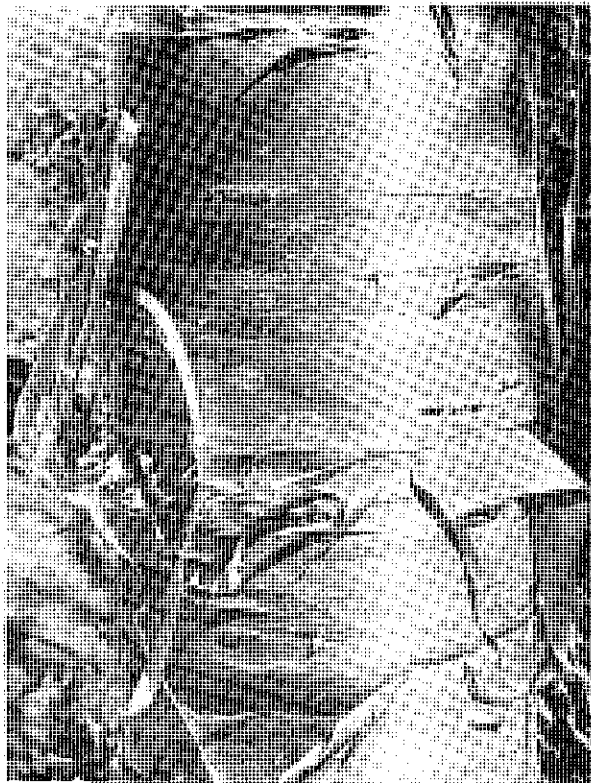


Plate 12. Close-up view of the bark of *Commiphora discolor*.

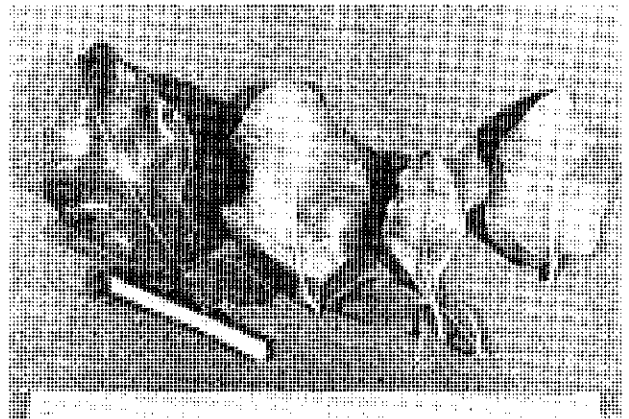


Plate 13. Leaves of *Commiphora discolor*.

petiole. Mendes (1967) mentions instances of a climbing habit in his description of this species.

### 3.5 *Commiphora giessii* Van der Walt in Dinteria 9: 23–25 (1973)

Dioecious, much-branched shrub, 1,5–3 m tall and 2–5 m in diameter; bark reddish-brown, shiny, usually not peeling, with numerous white, small, lenticular lenticels; many branches of  $\pm$  2,5 cm in diameter sprouting forth from ground level, young branchlets very slender and often drooping. Leaves trifoliate, glabrous, 1–7 cm but usually 2–3 cm long; petiole up to 2,5 cm but usually less than 1 cm long; petiolules usually less than 1 mm long; leaflets elliptic to narrowly obovate, apex acute or obtuse, base cuneate, margins entire, terminal leaflet 1–4,5  $\times$  0,5–2,5 cm but usually c. 2  $\times$  1 cm, lateral leaflets 1–3,5  $\times$  0,5–1,5 cm but usually c. 1,5  $\times$  0,7 cm. Fruit irregularly obovoid or subglobose, markedly asymmetrical, c. 6  $\times$  5 mm; pseudaril light red, forming 4 thin arms of equal length reaching almost to apex of putamen. (Plates 14–16.)

This recently described, endemic species has only been collected in the vicinity of Sesfontein and Sanitatas. It is very common north-west of Sesfontein where it grows on the slopes of the mountains, on the kopjes and also in the valleys. This area is warm and arid with an average annual rainfall of  $\pm$  250 mm.

1812(Sanitatas): 3 km W of Okonjombo (-BD), Giess & Leippert 7418 (WIND); between Otjikongo and Sanitas, Merxmüller & Giess 1446 (M). 1913(Sesfontein): 23 km NW of Sesfontein on Purros road (-AB), Van der Walt 242 (PRE; WIND; STE; M); 16 km NW of Sesfontein on Purros road (-AB), De Winter & Leistner 5713 (PRE).

A detailed study of the structure of the leaves, flowers and fruit reveals the close relationship between *C. giessii* and *C. virgata*. The differences between these two species are discussed in the paper in which *C. giessii* is described (Van der Walt, 1973a).

The habit of *C. giessii* is very characteristic and in this respect it differs completely from *C. virgata*. It is almost impossible, however, to distinguish be-

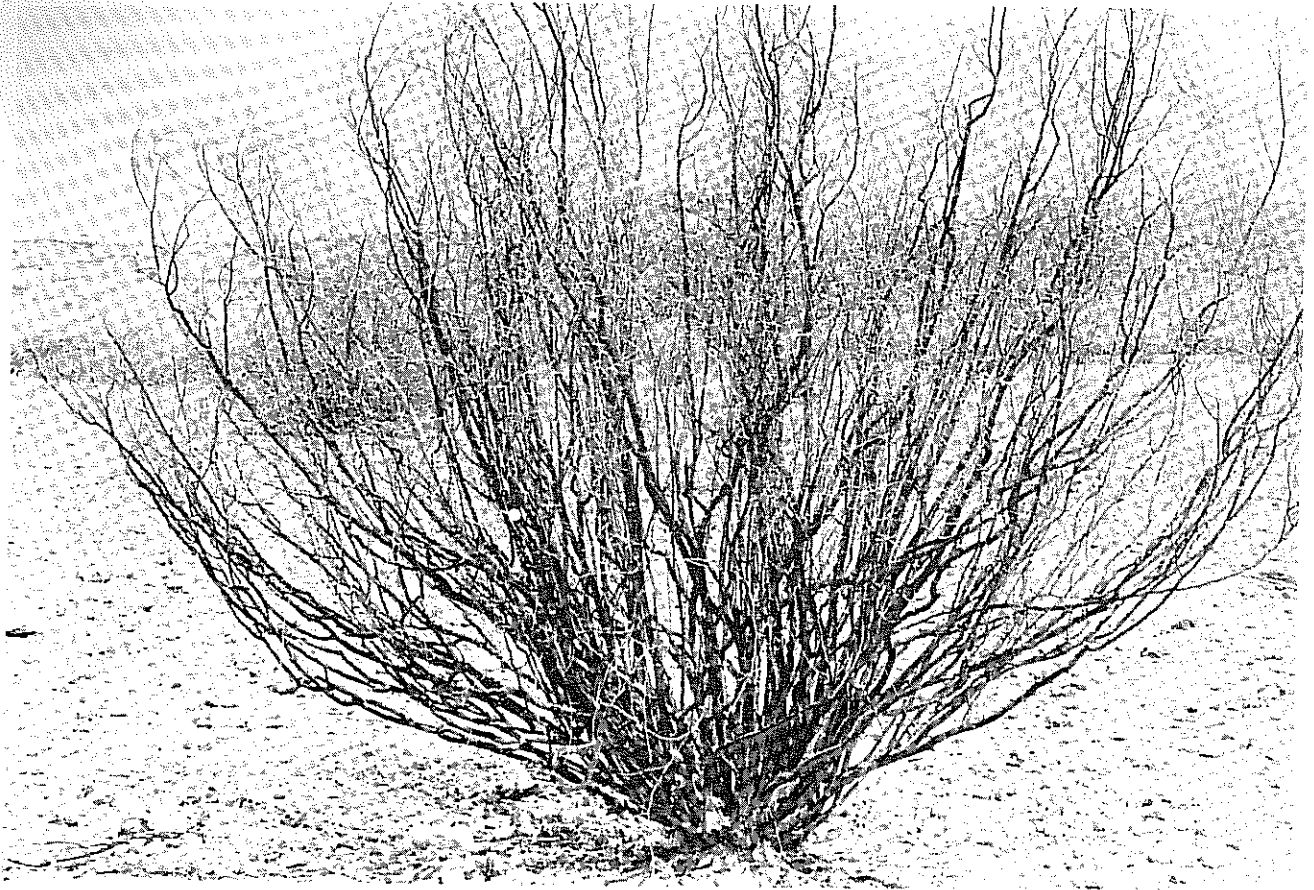


Plate 14. *Commiphora giessii* 16 km N.W. of Sesfontein (height = 2 m).



Plate 15. Close-up view of the stems of *Commiphora giessii* illustrating the bark.

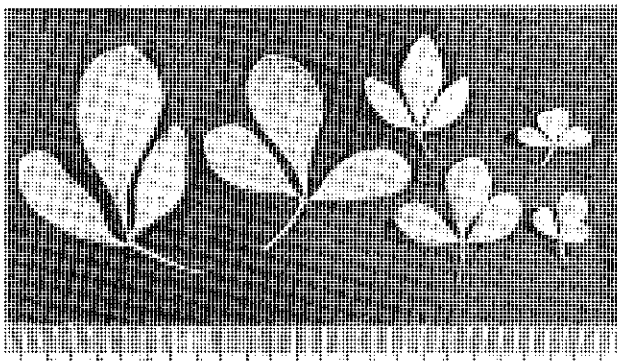


Plate 16. Leaves of *Commiphora giessii* (scale in mm).

tween the leaves of the two species, and this may be the likely reason why *C. giessii* had not been described before.

The reddish-brown bark of *C. giessii*, as a rule, does not peel off. It has been observed, however, that occasionally the bark of thicker stems near ground level, does peel off in reddish-brown papery pieces.

3.6 *Commiphora glaucescens* Engl. in Bot. Jahrb. 10: 285 (1888); Merx., Prod. Fl. S.W. Afr. 25: 76 (1968)

(= *C. pruinosa* Engl.)

(= *C. hereroensis* Schinz)

Diocious tree with a single trunk up to 8 m tall, or a shrub 1-2 m tall with a short trunk branching above ground level into thick ascending or decumbent stems, but usually a small tree 2-5 m tall and trunk up to 1,5 m long; bark yellowish brown to reddish-brown or pale grey, peeling in papery pieces or in thick discoid flakes to expose a greenish underlayer; branchlets glabrous, pilose or densely pilose. Leaves simple, glaucous or pale green, glabrous, sparsely pilose or densely pilose, 1,5-10 x 0,8-6 cm but usually c. 4 x 2,5 cm, elliptic, broadly elliptic, seldom obovate, margin entire, apex usually truncate, seldom retuse or acute, base truncate or cuneate, petiole up to 4 mm but usually less than 1 mm long. Fruit ellipsoid, laterally flattened, c. 1,1 x 0,6 cm; pseudaril red, cupular with 4 short lobes, covering lower 1/4 of putamen, 2 lobes on seam of putamen slightly longer than 2 on flattened faces of putamen. (Plates 17-20.)



Plate 17. *Commiphora glaucescens* near Otjansasemo, Kaokoveld (height  $\pm$  8 m).

Of the 12 species described in this paper, *C. glaucescens* has the widest geographical distribution and occurs the farthest eastward. It has been collected from Grootfontein in the east to near the West Coast, and from Maltahöhe in the south throughout the Kaokoveld northward to the Angola border.

This species grows in the Etosha National Park, being well represented in the vicinity of Otjovasandu. It has also been collected in the Namib Desert Park and Mountain Zebra Park.

Also recorded from Angola.

1715(Swartbooisdrif): 15 km W of Otjansasemo (-AD), *Van der Walt & Giess* 292 (PRE; WIND; STE). 1714(Ruacana Falls): near Ruacana Falls (-AD), *De Winter & Giess* 7103 (PRE; WIND). 1815(Ohopoho): near Ohopoho (-BB), *De Winter & Leistner* 5913 (PRE); *Merxmüller & Giess* 1513 (PRE; WIND); *Smuts & Pole Evans* 2252 (PRE; WIND); near Orumana (-BB), *Gibson* 122 (WIND). 1814(Otjitundua): 32 km NE of Ohopoho (-AA), *Van der Walt & Giess* 280 (PRE; WIND; STE); 64 km N of Osondeka (-CA), *Giess* 9270 (WIND); 56 km N of Otjovasandu (-CD), *Van der Walt & Giess* 275 (PRE; WIND; STE). 1914(Kamanjab): 27 km N of Otjovasandu (-AB), *Van der Walt* 250 (PRE; WIND; STE); near Otjovasandu (-AD), *Van der Walt* 254 (PRE; WIND; STE); Farm Franken (-DB), *Schwaerdtferger* 1/120 (WIND). 1915(Okaukuejo): Farm Otjitambi (-CC), *Walter* 1028 (WIND). 1917(Tsumeb): 21

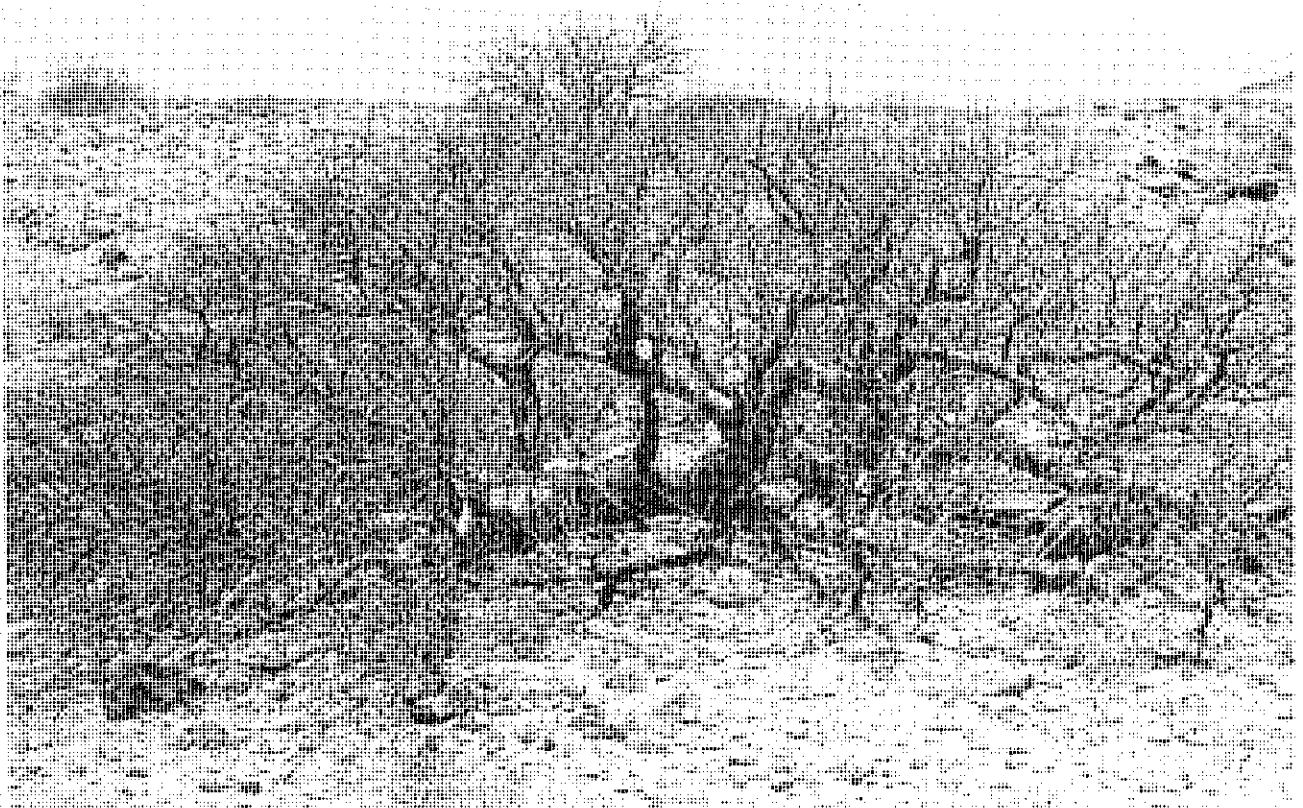


Plate 18. *Commiphora glaucescens* near Uis (height  $\pm$  1,5 m)



Plate 19. Close-up view of the bark of *Commiphora glaucescens*.

km S of Tsumeb (-BD), *De Winter* 3683 (WIND), near Otavi (-CB), *Dinter* 5276 (PRE); Elephantenberg (-CB), *Kinges* 2948 (PRE). 1918(Grootfontein): near Grootfontein (-CA), *Schoenfelder* 58 (PRE); *Le Roux* 351 (WIND). 2014(Welwitschia): Welwitschia (-BD), *Giess, Volk & Bleissner* 6129 (WIND). 2015(Otjihorongo): 4 km SE of Ugab Bridge (-CC), *Van der Walt* 231 (PRE; WIND; STE). 2016(Otjiwarongo): 7 km NW of Outjo (-AA), *Van der Walt* 236 & 256 (PRE; WIND; STE); Farm Graslaagte (-DB), *Walter* 306 (WIND). 2114(Uis): Tsisab Ravine Brandberg (-BA), *Van der Walt* 226 (PRE; WIND; STE); *Carr* B2 (PRE); *Giess* 3687 (PRE; WIND). 2115(Karibib): Klein Spitskoppie (-CC), *Van der Walt* 208 (PRE; WIND; STE); Farm Goabeb (-CD), *Giess, Volk & Bleissner* 5884 (PRE; WIND); Ameib (-DC), *Hardy* 2052 (PRE); near Karibib (-DD), *Van der Walt* 202 (PRE; WIND; STE); *Wedermann & Oberdieck* 2417 (PRE). 2215(Trekopje): Tinkas River Namib Desert Park (-CD), *Jensen* 208 (WIND). 2216(Otjimbingwe): 35 km S of Otjimbingwe (-CA), *De Winter* 2638 (PRE; WIND). 2314(Sandwich Harbour): E of Hotsas (-B), *Jensen* 83 (PRE). 2316(Nauchas): Farm Djab (-AB), *Giess & Hübsch* 11608 (WIND); *Merxmüller & Giess* 909 (PRE; WIND); *Schwerdtferger* 4289 (WIND). 2415(Sossusvlei): 18 km S of Solitaire (-BB), *Van der Walt* 268 (PRE; WIND; STE). 2416(Maltahöhe): Mountain Zebra Park (-AA), *Benseler* s.n. (WIND); Swartpoort (-AB), *Van der Westhuizen* 48 (WIND); Farm Bullspoort (-AB),

*Hardy* 1970 (WIND); Farm Friedland (-CB), *Walter* 2098 (WIND).

*C. glaucescens* is a very striking and attractive commiphora; the blue-green leaves contrasting well against the reddish-brown bark.

It has been noted that differences in habit, colour of the bark, relative size and degree of hairiness of the leaves occur among representatives from different geographical areas. It may be justifiable to distinguish two varieties.

*C. glaucescens* of the southern and eastern areas is a small tree with glabrous leaves. In the drier west the growth habit is that of a shrub, with spreading procumbent branches and the leaves small and glabrous. In the Kaokoveld to the north, the single-boled tree attains a considerable height, the leaves being relatively much larger and very hairy.

Judging by trees in the Otjovasandu area, it may be that elephants and other game browse on the young shoots and branches.

3.7 *Commiphora kraeuseliana* Heine in Senckenberg biol. 37: 493 (1956); Merxm., Prod. Fl. S.W. Afr. 23: 77 (1968)

Diocious shrub with many relatively thin and slender stems sprouting forth from the very short trunk above ground level, stems ascending or spreading almost decumbent; bark grey-brown or yellowish, peeling at the base of the stems in papery pieces; branchlets relatively short, stout, glabrous, scarred and with clusters of feathery leaves at the apex. Leaves impari-pinnate, 6-8-jugate, 3-7 cm but usually 4-6 cm long, glabrous, petiole 0,5-2,5 cm but usually c. 1 cm long, leaflets sessile, linear, subterete, margins entire 1-2,5 cm but usually c. 1,5 cm long, 0,5-1 mm in diameter, terminal leaflet usually shorter than lateral leaflets. Fruit subglobose to ellipsoid, laterally flattened, c. 2 × 1,8 cm; pseudaril absent. (Plates 21-23.)

*C. kraeuseliana* is endemic to South West Africa and occurs on rocky hillsides and stony slopes in the Namib Desert. It has only been collected in the vicinity of the Brandberg, west of Welwitschia and in the north-western region of the Kaokoveld.

1812(Sanitas): Anabib near Orupembe (-BA), *Steyn* 5729 (PRE; WIND); Orupembe (-BA), *De*

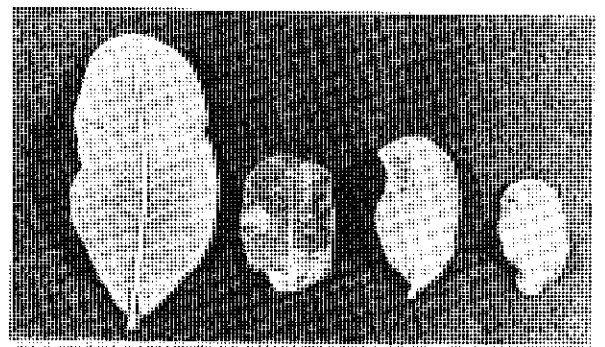


Plate 20. Leaves of *Commiphora glaucescens*.



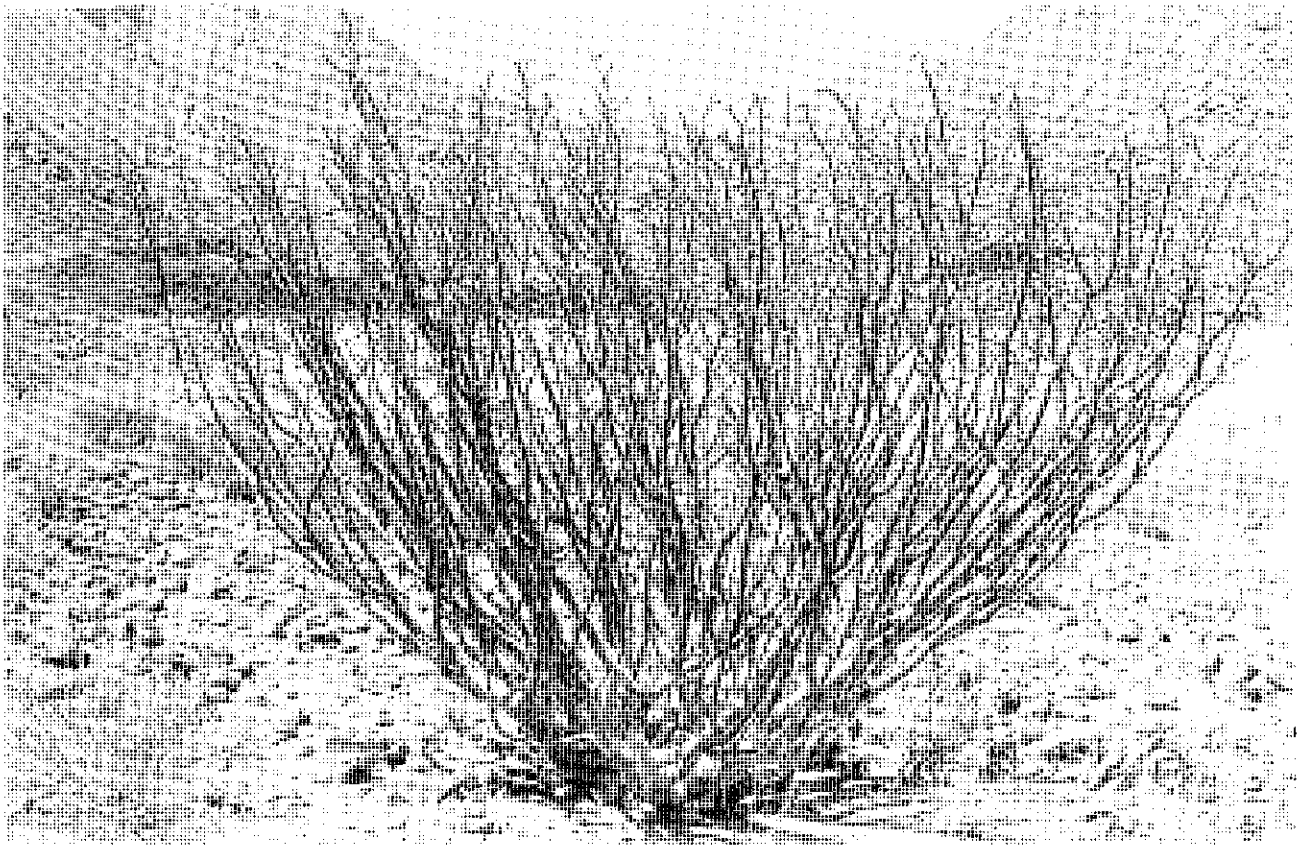


Plate 21. *Commiphora krauseliana* near the mouth of the Tsisab Ravine, Brandberg (height  $\pm$  1,5 m).

*Winter & Leistner* 5733 (PRE; WIND); 17 km E of Orupembe (-BD), *De Winter & Leistner* 5719 (PRE; WIND). 2013(Unjab Mouth): Farm Driefontein (-BD), *Giess, Volk & Bleissner* 6156 (WIND). 2014(Welwitschia): 8 km W of Petrified Forest (-BC), *Ihlenfeldt, De Winter & Hardy* 3194 (PRE); *Van der Walt* 260 (PRE; WIND; STE); Twyfelfontein (-CB), *Giess, Volk & Bleissner* 6213 (WIND). 2.114(Uis): Tsisab Ravine Brandberg (-BA), *Merxmüller & Giess* 1611 (WIND); *Carr* B1 (PRE); *Giess* 3692 (PRE; WIND); *Meyer* 1141 & 1142 (WIND); *Liebenberg* 5005 (PRE; WIND); *Van der Walt* 228 & 262 (PRE; WIND; STE); Numas Ravine Brandberg (-BA), *Giess* 3649 (PRE; WIND).

This interesting species was named in honour of the German paleobotanist, Professor R. Kräusel.

These plants, having a very characteristic growth form, must have been observed by many visitors where they grow at the mouth of the Tsisab Ravine, leading to the famous Bushmen painting of the White Lady of the Brandberg. Their feathery leaves are atypical of a commiphora. A very unpleasant odour is exuded when fresh branchlets or fruits are picked.

This is the only *Commiphora* species known of which the seeds are eaten by natives. As in almonds, the putamen is cracked open to expose the seed.

3.8 *Commiphora multijuga* (Hiern) K. Schum. in Just's bot. Jber. 27,1: 470 (1901); Merxm., Prod. Fl. S.W. Afr. 23: 77 (1968)

Dioecious tree, usually with a single trunk, 3-8 m tall; bark purplish-grey or dark grey, smooth, not peeling but in some cases cracked on the trunk; youngest branchlets sparsely pilose or pilose. Leaves impari-pinnate, 4-10-jugate but usually 6-8-jugate, pale green, 6-25 cm but usually 10-15 cm long; petiole slender, pilose or sparsely pilose, 1,5-4 cm but usually 2,5-3 cm long; petiolules slender, sparsely pilose, up to 1,5 cm but usually c. 1 cm long; leaflets drooping, irregularly elliptic, broadly elliptic to rotund but acuminate at both ends, apex acute, base cuneate, margins entire, glabrous or sparsely pilose on larger veins, 1,2-2,5  $\times$  1-2 cm but usually



Plate 22. Close-up view of the stems of *Commiphora krauseliana* illustrating the bark.

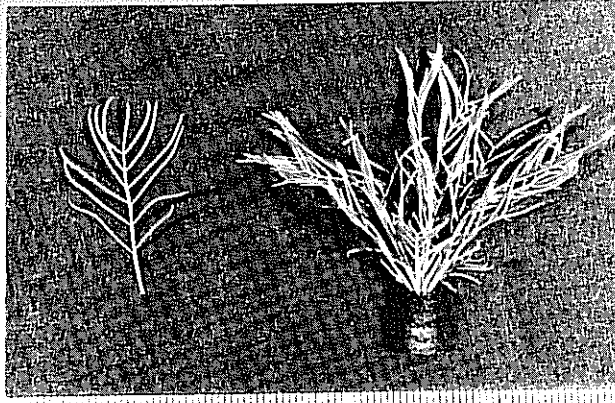


Plate 23. Leaves of *Commiphora kraeuschania* (scale in mm).

c.  $1,8 \times 1,3$  cm (excluding petiolules), terminal leaflet usually smaller than lateral leaflets. Fruit subglobose and irregularly flattened, c.  $1,5 \times 1,5$  cm; pseudaril red, 4 very fleshy arms of  $\pm$  equal length reaching almost to apex of putamen. (Plates 24-26.) This species occurs mainly in the Kaokoveld from Welwitschia northward up to the Kunene River, and is particularly common in the vicinity of the Ruacana Falls.

Also recorded from Angola.

1713(Swartbooisdrif): 17 km S of Epupa Falls (-AA), *Giess* 9547 (WIND). 1714(Ruacana Falls): near Ruacana Falls (-AC), *De Winter & Giess* 7102 (PRE; WIND). 1815(Ohopoho): 27 km W of Kaoko-Otavi (-AB), *Van der Walt & Giess* 297 (PRE; WIND; STE); 11 km W of Ohopoho (-BB), *De Winter & Leistner* 5253 (PRE; WIND); Oka-

rosawe (-BB), *Merxmüller & Giess* 1583 (PRE; WIND); 4 km N of Ohopoho (-BB), *Van der Walt & Giess* 286 (PRE; WIND; STE). 1913(Sesfontein): 23 km NW of Sesfontein (-AB), *Van der Walt* 245 (PRE; WIND; STE); 57-40 km E of Sesfontein (-BD), *Van der Walt* 247 & 248 (PRE; WIND; STE). 1914(Kamanjab): NW of Kamanjab (-DB), *Van Niekerk A* 187B (PRE); 22 km S of Kamanjab (-DD), *Van der Walt* 257 (PRE; WIND; STE); 39 km S of Kamanjab on Farm Blydskap (-DD), *De Winter* 5107 (PRE). 2014(Welwitschia): 38 km W of Welwitschia (-BC), *De Winter & Hardy* 8133 (WIND). 2015(Otjijhorongo): 56 km SE of Kamanjab (-AA), *Van der Walt* 259 (PRE; WIND; STE).

*C. multijuga* is distinguished by its typical pale greenish leaves which contrast well against the purplish-grey or dark grey bark. The graceful compound leaves with drooping leaflets and characteristic elliptic form, are also very aromatic. Large quantities of colourless, pungent and sticky resin exude when the twigs are cut.

3.9 *Commiphora oblanceolata* Schinz in Bull. Herb. Boiss. sér. 2,8: 633 (1908); *Merxm., Prod. Fl. S.W. Afr.* 25: 77 (1968) pro parte

Dioecious shrub, 1-2,7 m but usually 1-1,5 m tall, trunk very short, branching above ground level into thick succose appearing stems: bark grey to dark grey, smooth, not peeling: branchlets glabrous but youngest ones glandular. Leaves trifoliolate, glandular, 1-6,7 cm but usually c. 1.7 cm long, petiole 0,3-2,5 cm but usually c. 0.5 cm long, leaflets sessile or subsessile, narrowly oblanceolate to oblanceolate, apex obtuse, base cuneate, margins finely serrate-

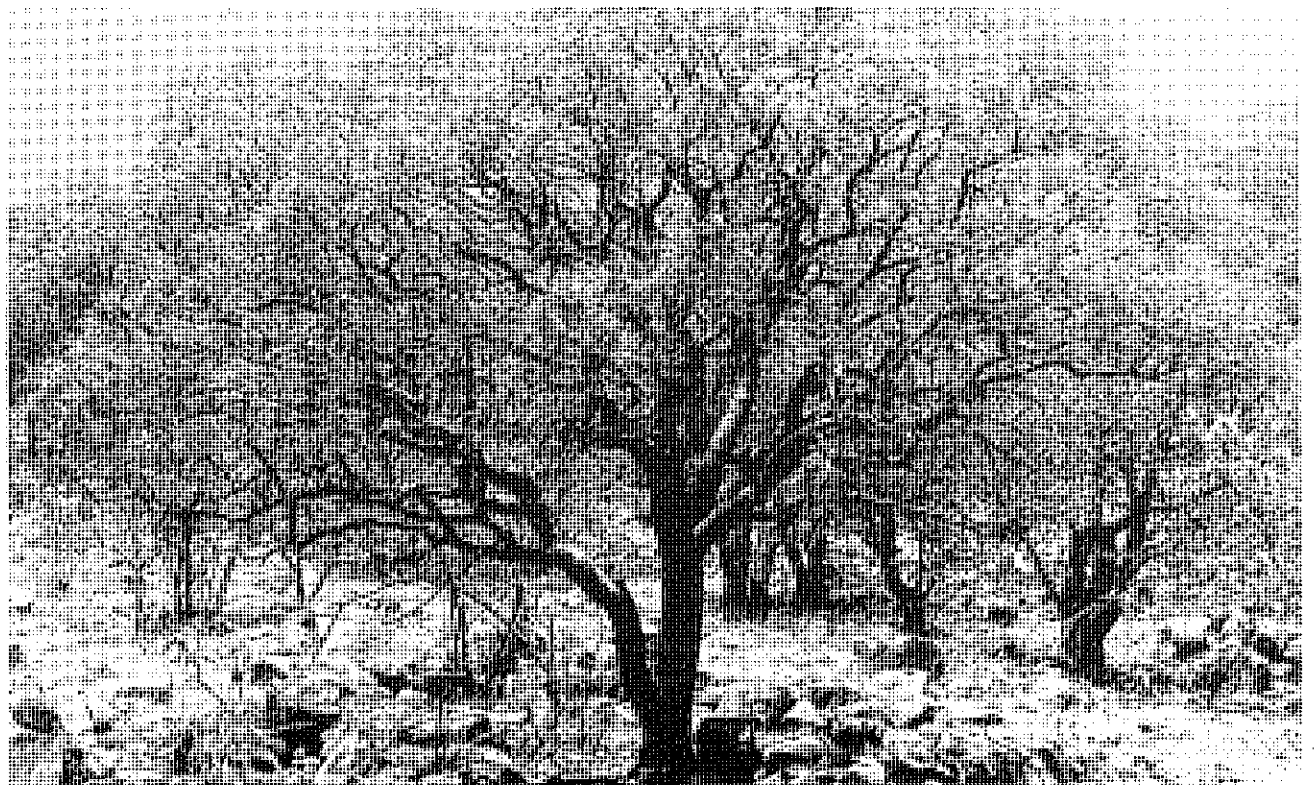


Plate 24. *Commiphora multijuga* between Kamanjab and Welwitschia (height  $\pm$  6 m).

dentate but in some cases almost entire, terminal leaflet 0,7-4,2 × 0,3-0,9 cm but usually c. 1,2 × 0,4 cm, lateral leaflets 0,8-4,5 × 0,3-0,9 cm but usually c. 1,4 × 0,4 cm. Fruit subglobose, c. 9 × 8 mm, pseudaril apparently absent. (Plates 27-29.)



Plate 25. Close-up view of the bark of *Commiphora multijuga*.

*C. oblanceolata* is one of the endemic species which is apparently restricted to the north-western part of South West Africa. It occurs on the slopes of the arid mountains near the Swakop River where it has been collected on the Farm Palmenhorst and east of the Welwitschia Flats in the Namib Desert Park. It is also recorded from the northern part of the Kaokoveld in the Swartbooisdrif area, but it is suspected to occur southward in the Kaokoveld.

1713(Swartbooisdrif): between Swartbooisdrif and Epupa (-BA), *Rycroft* 2490 (WIND; NBG); 16 km W of Enyandi (-BA), *Giess* 9342 (WIND). 2214 (Swakopmund): Farm Palmenhorst (-DB), *Mexmüller & Giess* 1751 (PRE; WIND); *Kers* 1122 (WIND); *Van der Walt* 272 (PRE; WIND; STE).

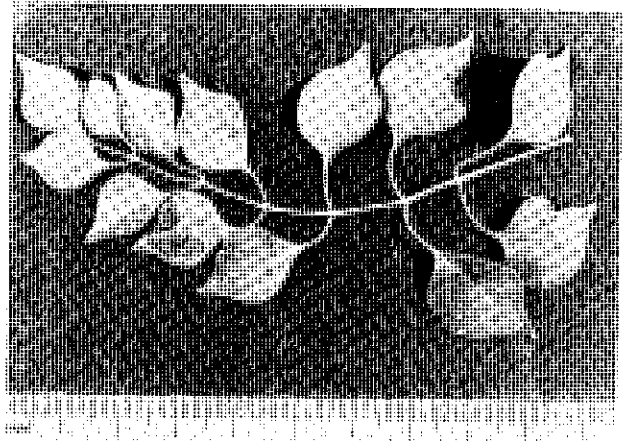


Plate 26. A leaf of *Commiphora multijuga*.



Plate 27. *Commiphora oblanceolata* on Farm Palmenhorst near Swakopmund (height ± 1 m).



Plate 28. Close-up view of the stems of *Commiphora oblancoolata* illustrating the bark.

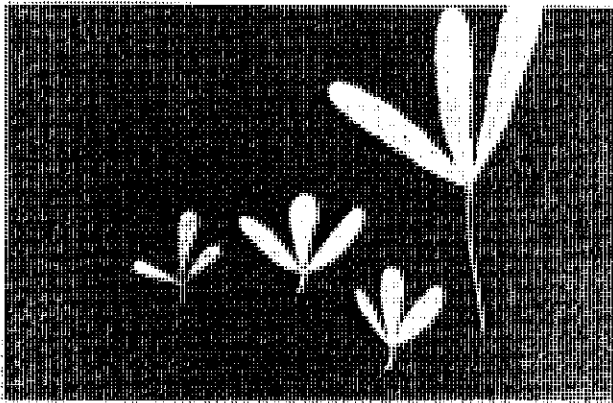


Plate 29. Leaves of *Commiphora oblancoolata*.

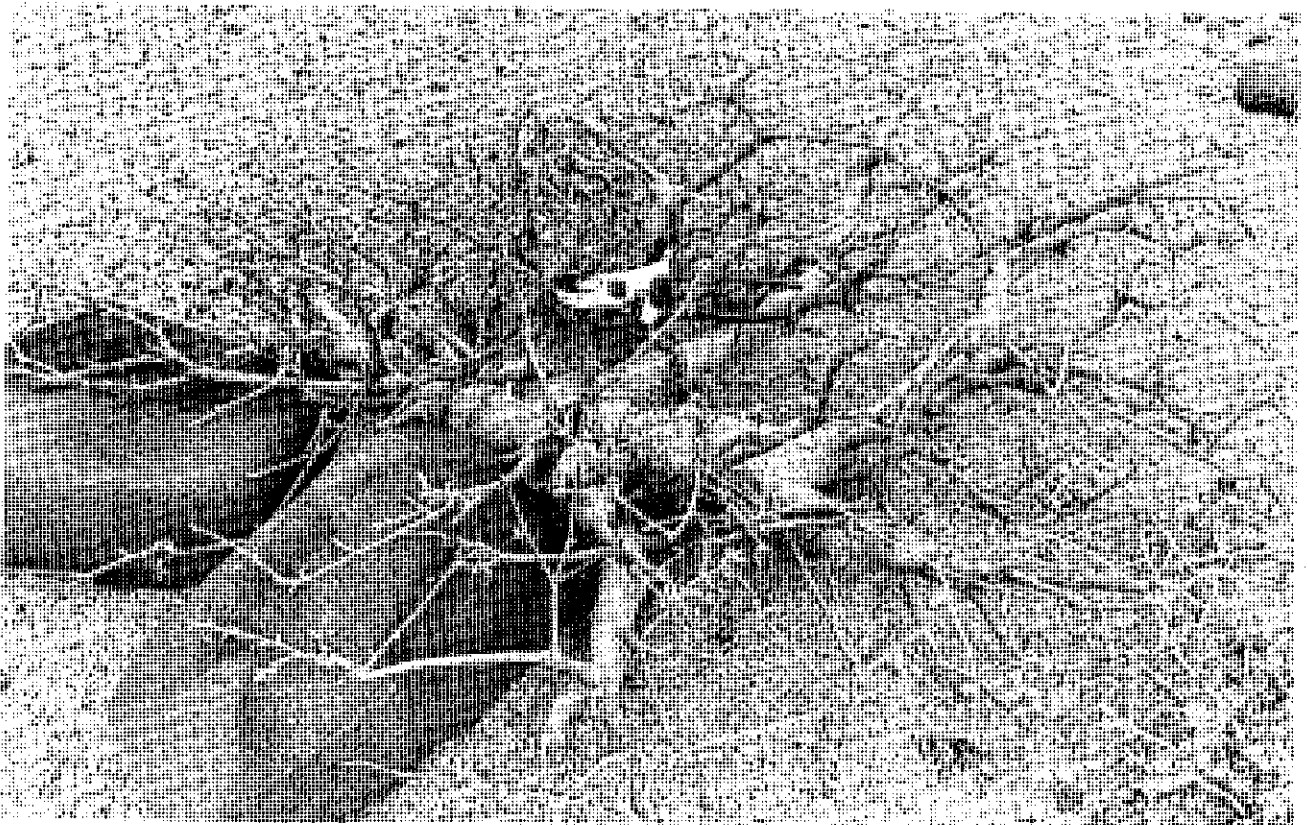


Plate 30. *Commiphora saxicola* north-east of Henties Bay (height less than 0,5 m).

2314(Sandwich Harbour): E of Welwitschia Flats, Jensen 320 (PRE).

The habit of *C. oblancoolata* is very typical for the shrubby commiphoras growing in the warm and dry semi-desert conditions in South Africa and South West Africa. Diagnostic features of this species are the greyish to dark-grey bark which does not peel off, and the presence of four stamens in the flower. *C. gracilifrons* Dinter ex Van der Walt which was formerly regarded as conspecific with *C. oblancoolata* (Van der Walt, 1971), has this feature of the presence of four stamens in common with *C. oblancoolata*. Generally the genus *Commiphora* has eight stamens.

The leaves of specimens collected in the northern Kaokoveld are decidedly larger than those of the specimens from the vicinity of Swakopmund. Due to this feature, Merxmüller (1968) held the opinion that the specimens were of different species. It has been observed, however, that the leaves of several species of *Commiphora* occurring in the northern Kaokoveld, are larger in this area than elsewhere.

3.10 *Commiphora saxicola* Engl. in Bot. Jahrb. 10: 283 (1888); Merxm., Prod. Fl. S.W. Afr. 23: 78 (1968)

(= *C. dulcis* Engl.)

Dioecious, low-growing shrub, 0,2-2,5 m tall, with a short trunk branching above ground level in thick, often decumbent stems, or small tree up to 4 m tall and trunk up to 1,5 m long; bark grey, finely pitted, smooth, not peeling; branchlets glabrous but youngest ones glandular. Leaves impari-pinnate, 2-6-

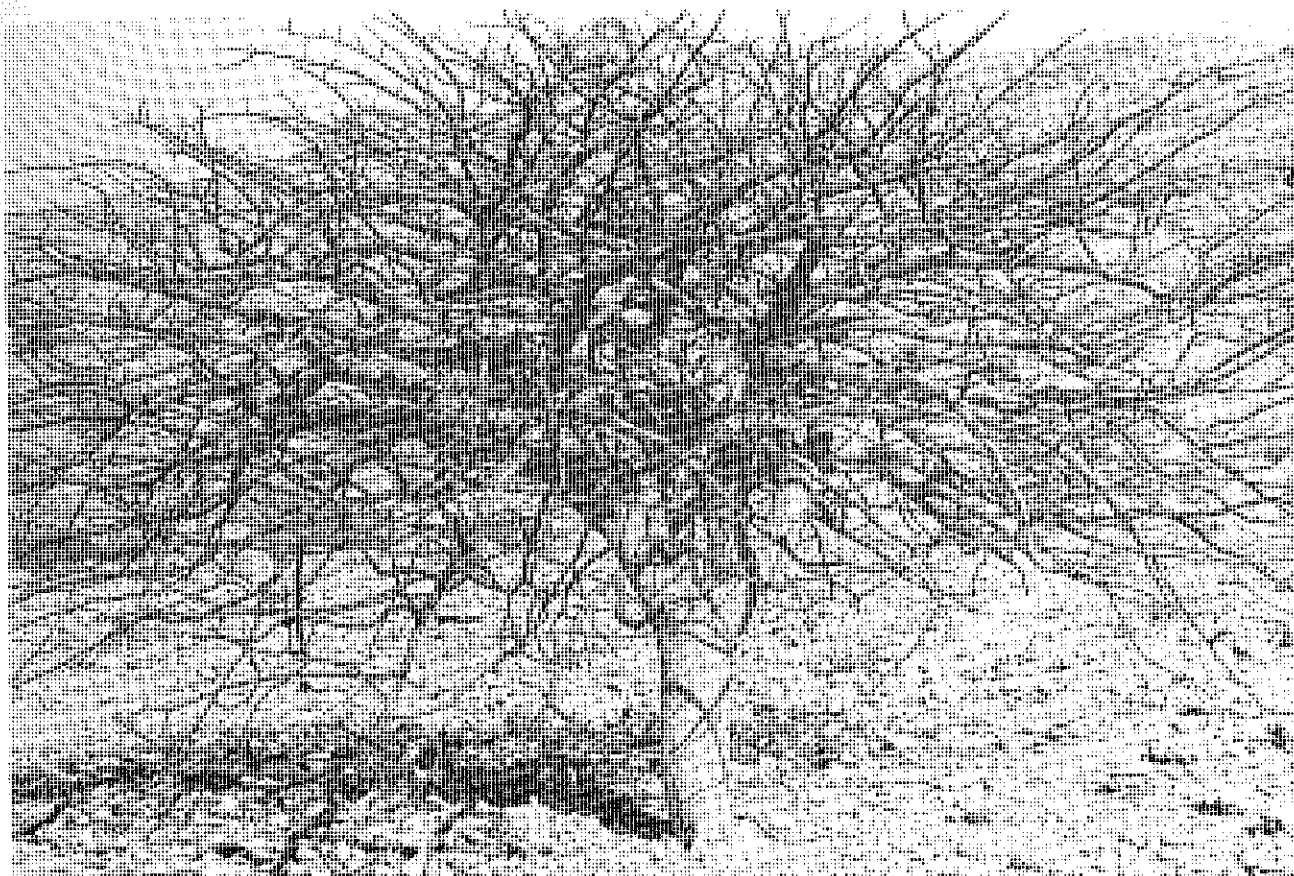


Plate 31. *Commiphora saxicola* 18 km N.W. of Sesfontein (height  $\pm$  2,5 m).



Plate 32. Close-up view of the bark of *Commiphora saxicola*.

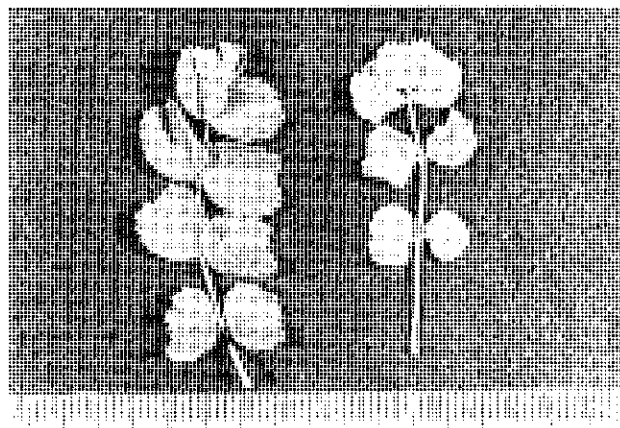


Plate 33. Leaves of *Commiphora saxicola* (scale in mm).

jugate but usually 3-4-jugate, glandular, 1,7-10 cm but usually 5 cm long, petiole 0,3-3,5 cm but usually c. 1,2 cm long, petiolules less than 1 mm long, margins of leaflets crenate-serrate; terminal leaflet 0,3-1,6 x 0,3-1,6 cm but usually c. 1 x 1 cm, suborbicular, apex emarginate or truncate, base cuneate; lateral leaflets 0,4-1,7 x 0,4-1,7 cm but usually c. 1,2 x 1,2 cm, suborbicular to oblate, apex and base truncate. Fruit oblong ellipsoid, c. 1 x 0,6 cm, apiculate, dark red to purple; pseudaril orange, cupular, covering lower  $\frac{1}{3}$  of putamen. (Plates 30-33.)

*C. saxicola* is another endemic species of South West Africa. It occurs in the Namib Desert itself, but is particularly common on the edge of the Namib from Sesfontein in the north to Nauchas in the south. It grows on rocky hills or stony slopes but is often found on sandy flats.

1913(Sesfontein): 23 km NW of Sesfontein (-AB), *Van der Walt* 243 (PRE; WIND; STE). 2013(Unjab Mouth): 57 km E of Torra Bay (-BC), *De Winter & Hardy* 8167 (WIND); Farm Driefontein (-BD), *Giess, Volk & Bleissner* 6157 (WIND). 2014(Welwitschia): 45 km N of Uis (-DD), *Tölken & Hardy* 835 (PRE; WIND). 2015(Otjihoronggo): Otjihoronggo Reserve (-CC), *Merxmüller & Giess* 1616 (WIND); *Van der Walt* 253 (PRE; WIND; STE); 15 km NE of Ossontati (-CD), *Giess, Volk & Bleissner* 5975 (WIND). 2114(Uis): 13 km S of Brandberg West (-AA), *Van der Walt* 212 (PRE; WIND; STE); 26 km E of Brandberg West (-AB), *Van der Walt* 214 (PRE; WIND; STE); Numas Ravine Brandberg (-AB), *Giess* 3650 (PRE; WIND); Messum Mountains (-AC), *Giess* 9160 (WIND); near Brandberg (-BA), *Liebenberg* 4987 (PRE; WIND); 8 km S of Tsisab Ravine Brandberg (-BA), *Giess* 3650A (WIND); *Van der Walt* 227 (PRE; WIND; STE); *Carr* B3 (PRE); 13 km N. of Uis (-BB), *Giess* 9170 (WIND); near Uis (-BB), *Van der Walt* 221 (PRE; WIND; STE); 2115(Karibib): Ameib (-DC), *Dinter* 6867 (PRE). 2214(Swakopmund): Farm Palmenhorst (-DB), *Van der Walt* 273 (PRE; WIND;

STE); 2215(Trekkoepje): Trekkoepje (-AC), *Seydel* 1208 (PRE); Farm Ubib (-BA), *Wanntorp* 1008 (WIND). 2315(Rostock): Farm Schlesien (-BB), *Merxmüller & Giess* 979 (PRE; WIND); 54 km NW of Solitaire (-DB), *Van der Walt* 270 (PRE; WIND; STE). 2316(Nauchas): Farm Djab (-AB), *Merxmüller & Giess* 911 (PRE; WIND).

The habit of this *Commiphora* species is decidedly variable. It is a small low-growing shrub with thick procumbent stems where it grows close to the West Coast, north-east of Henties Bay. South of Welwitschia, again, which is more inland, the single-boled tree may attain a height of four metres.

Specimens collected in the Kaokoveld (*Merxmüller & Giess* 1450; *Giess* 8921; *De Winter & Leistner* 5670) show leaflets, definitely larger or longer than is typical of *C. saxicola*. This problem will also be investigated.

A report from the National Chemical Research Laboratory of the CSIR mentioned that an extract made from the leaves of this species, contains the most promising antitumor properties of all South African plants analysed so far.

3.11 *Commiphora virgata* Engl. in Bot. Jahrb. 19: 139 (1894); *Merxm.*, Prod. Fl. S.W. Afr. 23: 79 (1968) pro parte

Dioecious, much-branded shrub, 0.5-3 m tall and 0.5-4 m in diameter, short trunk branches near ground level into relatively thick stems; bark peeling

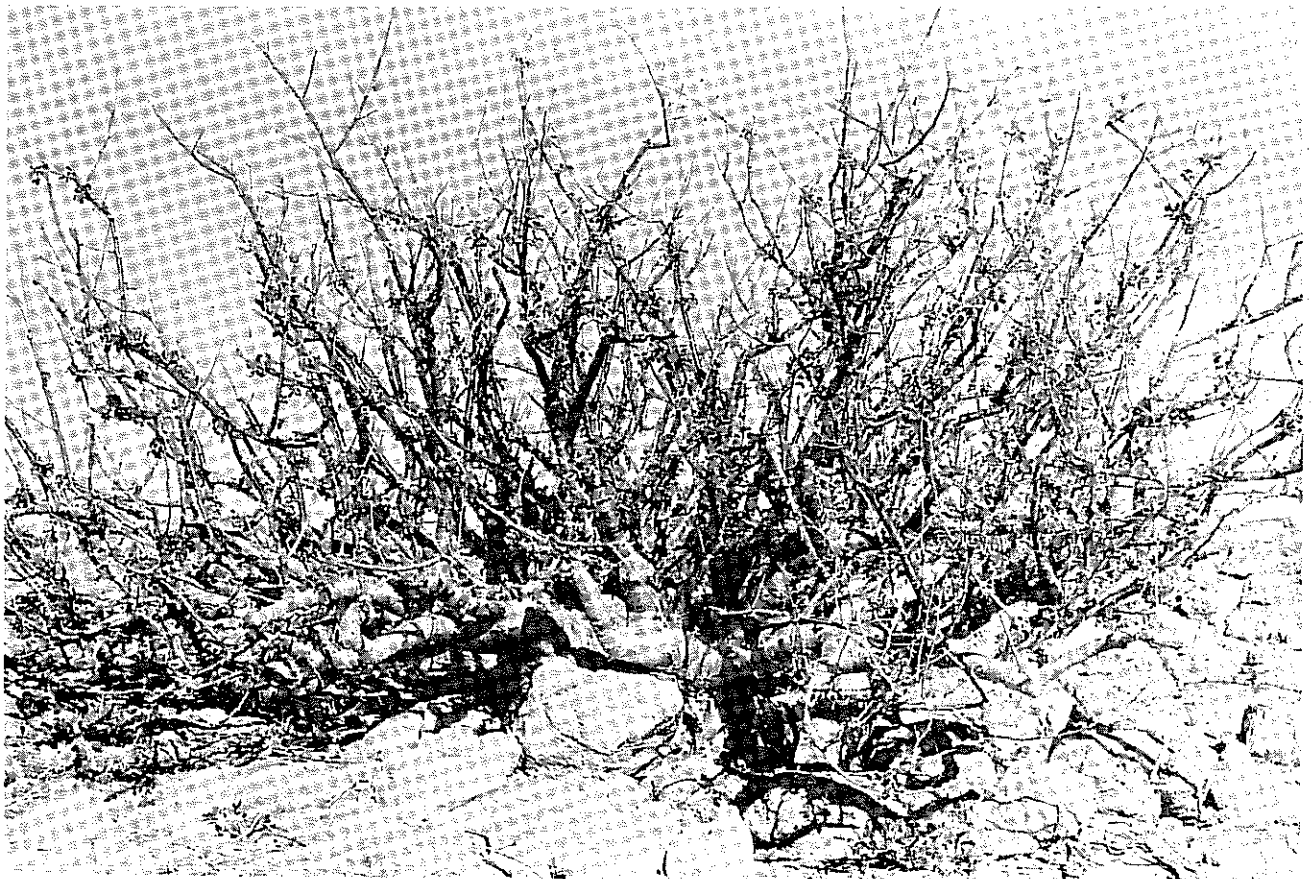


Plate 34. *Commiphora virgata* in the vicinity of Solitaire (height  $\pm$  1 m).



Plate 35. Close-up view of the bark of *Commiphora virgata*.

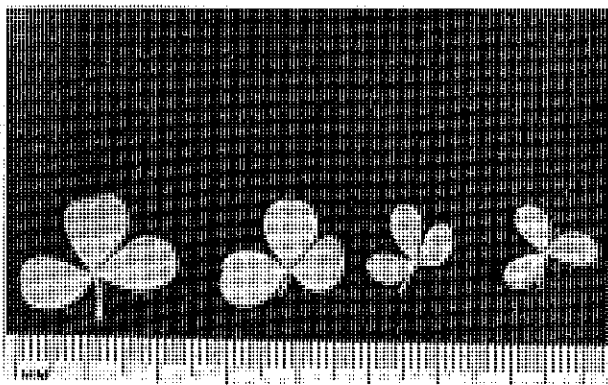


Plate 36. Leaves of *Commiphora virgata*.

around the thicker stems in yellowish-white to silvery, papery strips: stems terminating in virgate, sometimes drooping twigs, branchlets glabrous. Leaves trifoliate, glabrous, 0.5-4 cm but usually 1-2 cm long; petiole up to 1.5 cm but usually 3-5 cm long; leaflets sessile, elliptic to broadly elliptic but more often narrowly obovate, apex obtuse, seldom retuse or acute, base cuneate, margins entire. terminal leaflet 0.4-2.5 x 0.2-1 cm but usually c. 1.2 x 0.7 cm. lateral leaflets 0.4-1.5 x 0.2-0.7 cm but usually c. 1 x 0.5 cm. Fruit irregularly subglobose or ellipsoid or obovoid, apiculate, c. 8 x 7 mm; pseudaril white, greenish or light red, forming 4 arms of equal length reaching almost to apex of putamen. (Plates 34-36.)

*C. virgata* occurs on the edge of the Namib Desert and has been collected from Ombepera in the north

to Solitaire in the south. It usually grows on rocky hills or stony slopes.

Also recorded from Angola.

1712(Posto Velho): near Ombepera (-DB), *Gibson* 222 (WIND). 1812(Sanitas): 3 km W of Okonjombo (-BD), *Giess & Leippert* 7417 (PRE; WIND). 1815(Ohopoho): 17 km W of Otjihu (-AC), *De Winter & Leistner* 5663 (PRE; WIND). 1913(Sesfontein): 18 km NW of Sesfontein (-AB), *Van der Walt* 240 (PRE; WIND; STE). 1914(Kamanjab): Farm Onguali (-DC), *Schwerdtfeger* 178 (WIND). 1915(Okaukuejo): Farm Otjitambe (-CC), *Walter* 1029 (WIND). 2015(Otjihorongu): Sorris-Sorris (-CC), *Van der Walt* 232 (PRE; WIND; STE). 2016(Otjiwarongo): Farm Moselle (-BC), *Walter* 1077 (WIND). 2114(Uis): 57 km W of Uis (-AB), *Van der Walt* 215 (PRE; WIND; STE); near Brandberg (-BA), *De Winter* 3147 (PRE; WIND); Tsisab Ravine at Brandberg (-BA), *Van der Walt* 227A (PRE; WIND; STE); near Uis (-BB), *Van der Walt* 220 (PRE; WIND; STE). 2115(Karibib): Spitskoppie (-CC), *De Winter & Hardy* 8094 (WIND); Black Range (-CC), *Van der Walt* 206 (PRE; WIND; STE); near Karibib (-DD), *Wedermann & Oberdieck* 2415 (PRE). 2315(Rostock): Farm Schlesien (-BB), *Merxmüller & Giess* 928 (PRE; WIND); 48 km NW of Solitaire (-DB), *Van der Walt* 269 (PRE; WIND; STE).

The name of this species refers to the long and slender stems. Another characteristic feature is the yellowish-white to silvery bark which peels around the stem in papery strips, a feature of both *C. discolor* and *C. merkeri*.

*C. virgata* and *C. giessii* were formerly considered as conspecific.

3.12 *Commiphora wildii* Merxm. in Mitt. bot. St-Samml., Münch. 3: 609 (1960); Prod. Fl. S.W. Afr. 23: 79 (1968)

Dioecious, low-growing shrub, less than 1 m up to 2.5 m tall and up to 5 m in diameter, short trunk branches above ground level into relatively thick, often decumbent stems; bark grey-brown, shiny, mostly smooth but occasionally peeling in papery pieces; youngest branchlets frequently very short, pubescent to densely pubescent. Leaves impari-pinnately lobed or pinnately divided, (1-) 2-4-jugate, pubescent to densely pubescent, glaucous, 1-6 cm but usually c. 4 cm long; petiole up to 1.5 cm but usually 0.5-1 cm long; leaflets sessile, margins entire; terminal leaflet 0.8-2.5 x 0.6-2 cm but usually c. 2 x 1.2 cm, obovate seldom elliptic, apex usually obtuse or emarginate seldom acute, base cuneate; lateral leaflets 0.7-2.2 x 0.4-1.2 cm but usually c. 2 x 1 cm, asymmetrical, obovate or elliptic, lower margin decurrent. Fruit ovoid to subglobose, c. 1.1 x 1 cm; pseudaril yellow to orange, cupular with 2-4 short lobes. (Plates 37-39.)

This is another species occurring on the edge of the Namib Desert, and is found from the northern border of the Kaokoveld southward to Uis in the south. It has also been collected near the West Coast in the Northern Namib.

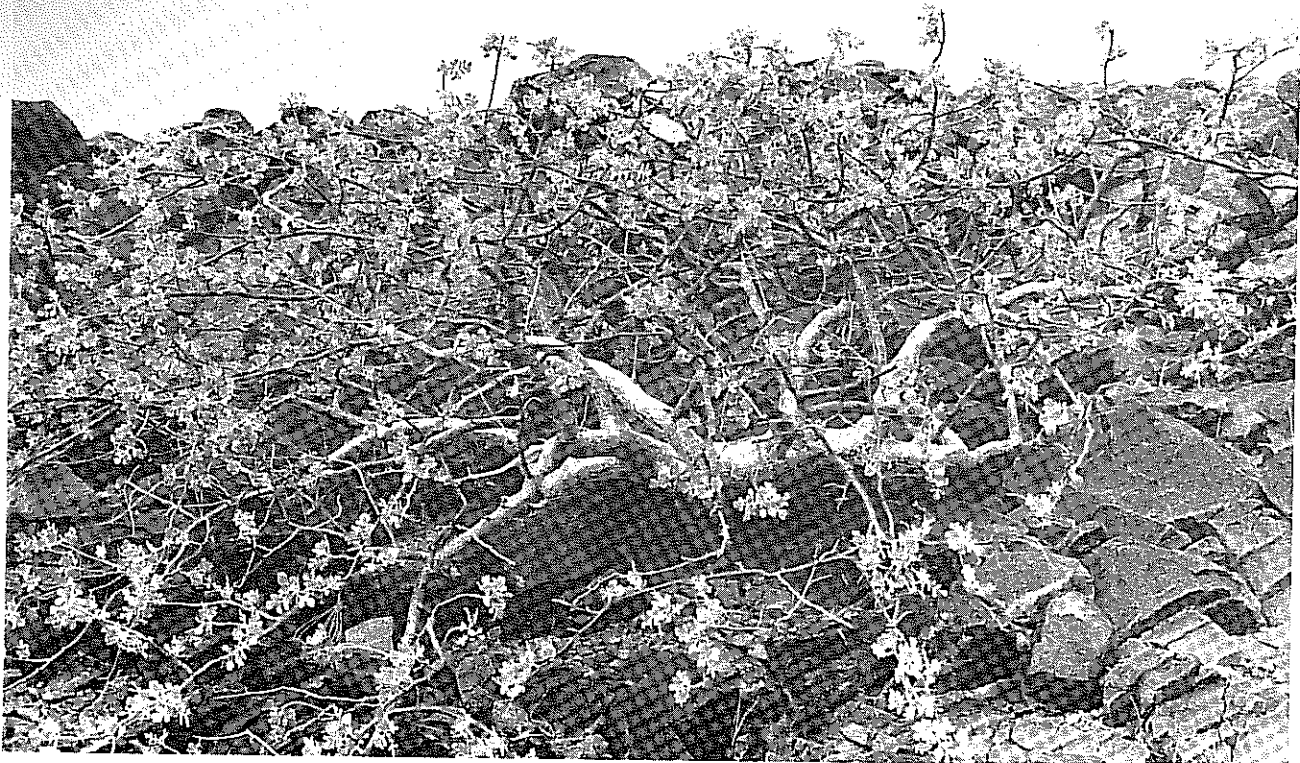


Plate 57. *Commiphora wildii* 11 km E. of Brandberg West (height less than 1 m).



Plate 38. Close-up view of the bark of *Commiphora wildii*.

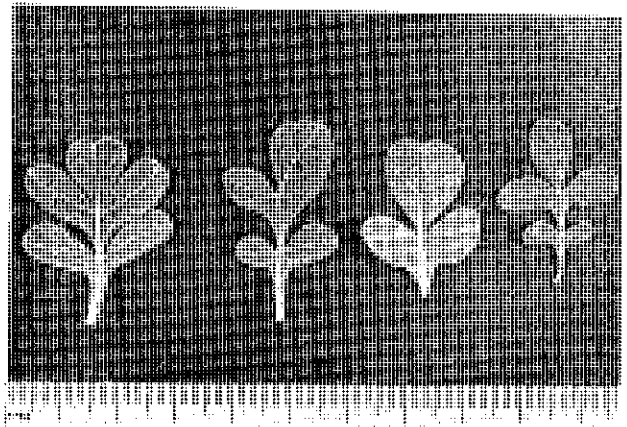


Plate 59. Leaves of *Commiphora wildii*.

Also recorded from Angola.

1712(Posto Velho): 20 km SW of Otjinungua (-AD), *Giess* 8922 (PRE; WIND); 24 km S of Ongutu (-CD), *Giess* 9400 (WIND). 1812(Sanittas): 78 km W of Otjihu (-BA), *De Winter & Leistner* 5712 (PRE; WIND); near Sanittas (-BA), *Merxmüller & Giess* 1453 (WIND); Sarusas (-CD), *Giess & Leippert* 7468 (PRE; WIND). 1913(Sesfontein): 23 km NW of Sesfontein (-AB), *Van der Walt* 244 (PRE; WIND; STE). 2013(Unjab Mouth): 44 km E of Torra Bay (-AD), *De*



*Winter & Hardy* 8170 (WIND); 8 km W of Farm Wêreldend (-BB), *Giess, Volk & Bleissner* 6170 (WIND). 2014 (Welwitschia): 90 km W of Welwitschia (-AC), *De Winter & Hardy* 8148 (PRE); Farm Bethanis (-AD), *Giess, Volk & Bleissner* 6148 (WIND). 2114 (Uis): 11 km E of Brandberg West (-AA), *Van der Walt* 213 (PRE; WIND; STE). Numas Ravine Brandberg (-AB), *Giess* 3589 (PRE; WIND); Messum Mountains (-AC), *Giess* 9159 (PRE; WIND); 33 km W of Uis (-BA), *Van der Walt* 217 (PRE; WIND; STE); near Uis (-BB), *Van der Walt* 224 (PRE; WIND; STE); Farm Sorrento (-DB), *De Winter* 6030 (WIND).

*C. wildii* is an attractive shrub with the glaucous leaves and shiny, grey-brown bark contrasting well against the black dolomitic rocks on which it is often found. The leaves are characteristically lobed and resemble those of an oak. This is the reason why the name *C. querquiloba* was proposed for this species. Eventually it was named in honour of Professor H. Wild of the University of Rhodesia who compiled the last revision of the genus *Commiphora* (Wild, 1959).

#### IV ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Messrs W. Giess and M. A. N. Muller, both of the South West Africa Herbarium, for their collaboration during collecting trips. The invaluable information and suggestions contributed by Mr Giess were a great help to facilitate matters.

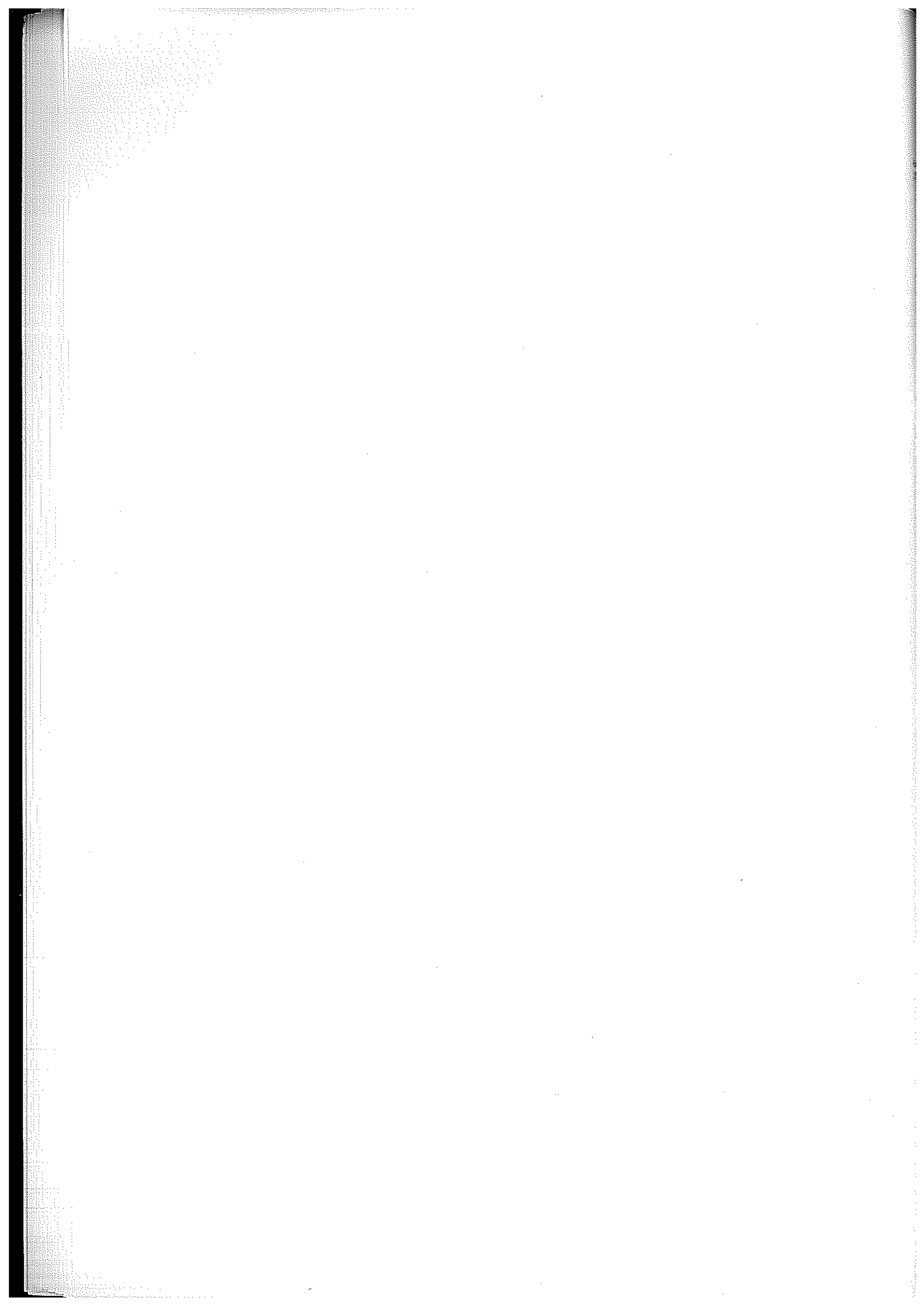
Costs incurred in obtaining the material, could be defrayed by a grant from the CSIR. For this financial support I am grateful.

I wish to extend a word of appreciation to Mrs A. E. Cillié of the Botany Department, University of Stellenbosch, who helped to finalise this manuscript. Thanks are also due to Mr E. G. H. Oliver for reading the paper.

The Nature Conservation and Tourism Branch of the Administration of South West Africa is thanked for assistance rendered in various ways.

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# Optometric examination of the Kudu *Tragelaphus strepsiceros*

by  
Stuart J. Super F.O.A. (S.A.). D. Optom.  
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## I INTRODUCTION

Motoring in certain parts of South West Africa is hazardous. A number of accidents, some with fatal results, occur each year, mainly at night, as a result of kudu jumping into or colliding with cars. These accidents occur on country roads as well as on highways.

In view of this, an investigation into the visual state of the kudu's eyes has been undertaken. Gemsbok (*Oryx gazella*), wildebees (*Gorgon taurinus*), horse (*Equus caballus*) and hyrax (*Procavia capensis*) were examined so that a comparative analysis could be made. Except for the horse, as far as is known, research of this nature has not been undertaken before.

Theories abound about the cause of these accidents; the speed of the car; the intensity of the headlights; the kudu's own shadow which it attempts to avoid; and migration to the highways in winter seeking vegetation at the shoulder of the road, have been postulated.

## II MATERIALS AND METHOD

Five kudu, two gemsbok, a horse, a wildebees and a hyrax were studied in this analysis. Examinations took place in the Etosha National Park and on a farm 90 kilometres south west of Windhoek in the Khomas Hochland. All but one of the animals, a kudu cow, were living in captivity, but for no longer than a month. The examination of these took place in animal enclosures, while the examination of the kudu cow (labelled Yellow 14, for research purposes) was performed in the open veld. Yellow 14 was darted and drugged prior to her examination, the other animals were examined in an undrugged state. Results differed somewhat due to the effects of these drugs which will be discussed later in this article.

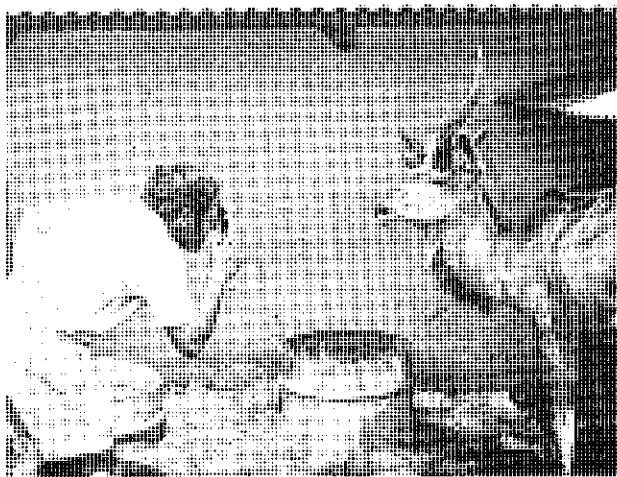
Yellow 14 was immobilized after a dart was fired into her rump by Dr Ebedes, the veterinary surgeon in the Etosha National Park. The dart contained the following chemicals: Etorphine hydrochloride 4 mg, phencyclidene hydrochloride 60 mg, acetyl promazine maleate 20 mg, and 5 mg hyoscine hydrobromide to counter the constriction of the pupil that etorphine (a morphine derivative) causes.

Some 65 minutes before Yellow 14 was hit, a herd of kudu in the vicinity of the Ombika waterhole, about 10 kilometres south of the Okaukuejo rest-camp in the Etosha National Park, was observed. Practical difficulties and the apparent extrasensory perception of our motives kept the kudus at a safe distance from the research party. (Possibly the herd had spotted us.)

When an immobilizing dart was eventually fired at Yellow 14 and a direct hit scored, she showed no reaction for 60 seconds and then, seeming to notice the dart for the first time, took fright and charged off into a wooded area. With the aid of Joseph, a Bushman tracker, we located our kudu some 60 minutes later.

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Optometric examination of kudu.

All the animals examined were held down during the examination, including Yellow 14, who was not completely unconscious. The smaller kudu and the two gemsbok were examined in a small dark cellar with only one helper holding the animal's horns. The larger kudu were examined in bright sunlight. The horse and wildebees were examined at dusk. Examinations were conducted with various rulers, high intensity torches, ophthalmoscope retinoscope and trial lenses.

### III RESULTS

The results obtained from examining five kudu, two gemsbok, one horse, one wildebees and one hyrax are summarised in Table I.

### IV DISCUSSION

#### 4.1 External examination

**Location:** The enormous eyes located at the sides of the head pointed in diverging directions and resulted in the huge interpupillary distances. The eyes being so placed would give the kudu, and the other animals to a lesser extent, a large field of vision. To a hunted animal this is obviously a distinct advantage. However, with the eyes so placed, binocular vision at most angles would be difficult to attain. Binocular vision is a prerequisite for good stereoscopic vision and distance judgement, and hence the kudu's distance judgement would be decidedly poor. This would apply to the other animals studied, but to a lesser extent as their eyes were placed more to the front of the head. The kudu would tend to look with one eye at a time.

**THE PUPIL:** The hyoscine injected into Yellow 14 more than counteracted the effects of the etorphine. However, Yellow 14's stage of anaesthesia and fright also caused dilatation of her pupils. Her pupil

size was almost double that of the kudu which were not drugged.

Pupil reactions in all but one of the kudu were negligible. This could be indicative of some ocular or nerve pathway lesion. Sustained dilatation of the pupil may have been caused by fear but as an extremely intense light was used, and in some cases in complete darkness, some sort of pupil reaction should have been elicited.

The function of the pupil is principally optical. Contraction reduces the amount of light entering the eye. It acts as an emergency mechanism, giving the retina time to adapt to the illumination. Narrowing of the pupil cuts off the peripheral parts of the refracting system. Hence it diminishes spherical and chromatic aberration and astigmatism caused by oblique pencils of light. It also increases the depth of focus — e.g. in man from  $f2.5$  to  $f13$ . The shape of the pupil has no effect on the clarity of the image provided enough light enters the eye and the eye is corrected to emmetropia. Whenever the intensity of illumination increases above a threshold value within a certain minimum time the pupil contracts, provided everything is normal. The chief factor which determines what effect a change of illumination will have on the pupil is the state of adaptation of the retina.

The kudu's pupils not reacting to light could be caused by lesions in the following pathways:— (a) The afferent pathway of the light reflex which includes structures from the rods and cones up to the pretectal region. (b) The intercalated fibres from the synapse in this region into the posterior commissure from which the fibres bifurcate and run to the Edinger-Westphal nuclei of both sides. (c) Supranuclear afferent pathways coming from undetermined regions of the brain and having to do with associated movements of the pupil e.g. near or obicularis reaction. (d) The oculomotor nucleus itself, i.e. the Edinger-Westphal nucleus. (e) The oculomotor nerves from the Edinger-Westphal nucleus to the ciliary ganglion. (f) The ciliary ganglion and the short ciliary nerves and their endings in the sphincter muscle, both cholinergic and adrenergic. (g) The myoneural junction of the 3rd cranial nerve in the sphincter muscle. (h) The cells of the sphincter muscle themselves. (i) Any part of the afferent sympathetic pathway from the hypothalamus through the brain stem to the superior cervical ganglion and thence into the eye by way of the short ciliary nerves. However, as there was also no observable consensual reaction the most likely site of a lesion, if a lesion existed at all, would be in the vicinity of the retina.

An interesting observation was made at the Okahandja Zoo. Two very tame fully grown kudu, one bull and one cow, were fed peanuts by hand while an observation of their pupils was made. The pupil in the eye which was facing a bright setting sun was contracted into a slit, the size measuring  $25 \times 5$  mm. The fact that such a marked contraction was observed with these tame kudu seems to indicate fear as being a significant factor in causing the pupil dilatation of the other kudus examined which were not tame.

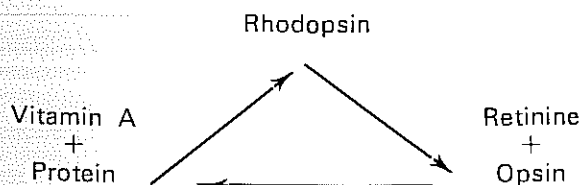
## 4.2 Internal examination

Ophthalmoscopic examinations revealed clear cornea, anterior chamber, crystalline lens and vitreous in all animals included in this analysis. A tapetum lucidum was not observed in the younger kudu and hyrax. The tapetum lucidum is an opaque membrane situated posterior to the retina. It reflects light, hence the green glow that many motorists have seen at night in South West Africa. The function of the tapetum is to re-transmit the image that has already been formed on the retina. It brightens the image without causing dazzle.

## 4.3 The retina

The retina in all the kudu showed black choroidal pigmentary patches interspersed throughout. It has been postulated that often with degeneration of rods and cones there is a migration of pigment into the retina. Pigmentary degeneration may be intimately connected with night blindness.

The retina is only stimulated by those rays reaching it. The intrinsic sensitivity of rods (and cones) is changed by the presence of retinal pigment. Rhodopsin is a magenta coloured pigment rapidly bleaching in light to become colourless. Rhodopsin = Carotene + Porphyrin. In scotopic (dark adapted) vision, the amount of energy required to stimulate vision is least with light of wave length 510 mu. This supports the contention that the primary photochemical process in scotopic vision is the absorption of light quanta by rhodopsin and a certain number of quanta must reach the retina in order to evoke a given visual sensation. Pigments which absorb light are necessary for the function of the retina and the action of light on these pigments is to break them down into one or more active products which stimulate the photoreceptors. These then discharge an impulse in the optic nerve fibres. The constant breakdown of pigment in light and its reformation in the dark establishes a "steady state" depending on the degree of illumination. This steady state is produced as a result of balance between catalysis and synthesis and exists as long as the illumination remains unchanged. The synthesis of rhodopsin from retinene and scotopsin requires no external source of energy, being a spontaneous reaction. Whenever these two substances are present together in the dark, they form rhodopsin and yield energy spontaneously. The synthesis of rhodopsin from Vitamin A plus scotopsin requires energy. The basic mechanism of rhodopsin synthesis therefore is energy demanding oxidation of Vitamin A to retinene coupled with energy, yielding condensation of retinene and opsin to form rhodopsin.



The sensitivity of the retina is at a maximum when the concentration of rhodopsin is at a maximum.

This occurs in the state of dark adaptation when the sensitivity of the eye is more than ten thousand times as great as when the eye is light adapted. Breakdown of rhodopsin occurs when light is admitted to the dark-adapted eye. The bleaching of the first molecules of rhodopsin has a relatively enormous effect on the sensitivity of the retina and results in a large fall. Much of the light and dark adaptation involves the first and the last small portions of rhodopsin that is bleached and resynthesised.

A blue-green light is absorbed strongly by rhodopsin whereas an orange light is scarcely absorbed at all. Vitamin A deficiency, liver disease, abnormalities associated with bile absorption and disorders of the large intestine are causes of night blindness.

## 4.4 Retinoscopy

This examination to determine the lens prescription was performed on all the animals. Only Yellow 14 appeared to be myopic, and in her case an arbitrary 0.75 was deducted from the prescription found, due to the hyoscine instillation.

## V CONCLUSION

In the case of the kudu examined, poor vision is indicated by their large unreacting pupils, aggravated by a small refractive error. Retransmission of the retinal image by the tapetum lucidum would tend to offset this. Unlike the findings on a survey conducted on African elephant, none of the animals in this survey exhibited any conjunctival or corneal pathology of traumatic or other aetiology. Vision must therefore be good enough to cause an avoidance of objects which might injure the eyes, such as thorn trees and bushes. However, the kudu must rely on its other senses, such as hearing, to react quickly enough to an on-coming car. (Depending on the direction from which the wind blows, this may not always be possible.)

Binocular vision and night blindness seem to be very significant factors in this survey. In the case of kudu poor distance judgement is indicated by the following facts:—

1. Collisions with kudu have taken place in daylight.
2. Kudu often become entangled in fences when they misjudge their jumps.
3. When collisions have taken place at night, the kudu have jumped on to the vehicle and not over it. It is likely that the kudu views the on-coming car with one eye only. This eye would be temporarily blinded by the bright headlights of the car. Vision would be suppressed in that eye and switched over to the other eye, which is not viewing the car, and is consequently not blinded. This eye sees its own shadow moving and the animal jumps away from it in fright, on to the car.

It is claimed that if the interior lights of the car are burning, the kudu will vault the car. This probably happens as the kudu will assess the size of the car more accurately. Furthermore, the contrast of the

headlights and the dark night would not be as great. This would shorten the time required to resynthesise rhodopsin i.e. lessen its night blindness. While the kudu is browsing in the dark, its rhodopsin balance would be in a "steady state". As soon as the headlights become visible the "steady state" is affected and rhodopsin breakdown takes place. If the kudu lacks Vitamin A (as it probably does in winter) resynthesis of rhodopsin is delayed and the possibility of a collision is increased. As the absorption maximum of rhodopsin varies in certain animals (497 mu in man) the colour of the headlights could be of significance.

## VI SUMMARY

Of the ten animals examined in this programme, the kudu's vision is undoubtedly the worst. Unreacting large pupils, small refractive errors and night blindness seem to be strong contributory factors in collisions between motor vehicles and kudu at night. Fear and hyoscine had a dramatic effect on the kudu pupil far outweighing the constriction caused by the atropine hydrochloride. Undrugged animals produced the best results as no arbitrary estimations due to the effect of the drug on the eye had to be made.











## VII ACKNOWLEDGEMENTS

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Species	Identity No.	Age Months	Sex	Inter Pupil Dist. mm	Palpebral Aperture Size mm	Pupil Size mm	Pupil Reactions	Pupil Shape	Ametropia Correction D	Pigmentary patches on retina
Kudu	Yellow 14	Adult	F	165	45x28	30x25	Nil		R. -0.25 L. -0.75	Present
Kudu	Port 1	1	M	90	43x20	15x10	Nil		R. +2.00 L. +2.00	Present
Kudu	Port 2	1	F	110	43x20	15x6	Fair		R. +1.00 L. +1.00	Present
Kudu	Port 3	15	M	160	46x25	15x6	Nil		R. +1.00 L. +1.00	Present
Kudu	Port 4	30	M	175	50x30	15x10	Nil		R. +2.50 L. +2.50	Present
Horse	Bingo	52	Mg	145	35x25	25x16	Good		R. +1.00 L. +1.00	Not Present
Gemsbok	Port 1	20	F	120	30x25	20x10	Good		R. +0.50 L. +0.50	Not Present
Gemsbok	Port 2	9	F	140	30x25	20x10	Good		R. +1.00 L. +1.00	Not Present
Wildebees	Lashes	9	M	100	30x25	25x20	Good		R. +0.75 L. +0.50	Not Present
Hyrax	Port 1	24	F	40	5x3	4x2	Good		R & L +0.50 -1.00 × 90°	Not Present

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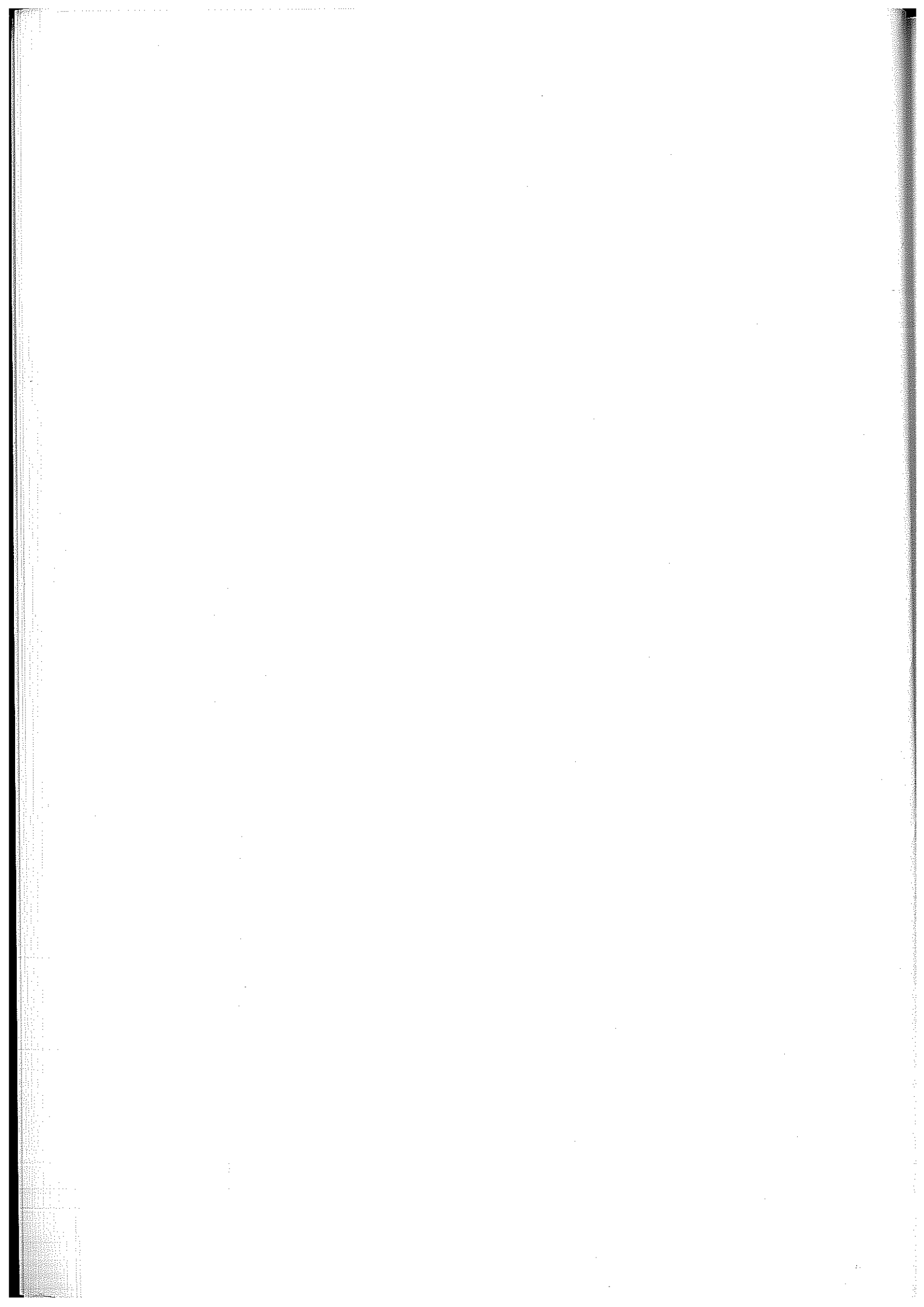
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# Notes on the reproduction in Hartmann zebra *Equus zebra hartmannae* in South West Africa

by

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## ABSTRACT

In the Hartmann zebra one finds an exclusive one-male dominance over a given number of females. The subgroup population has the reproductive advantages that it ensures selective breeding and gene flow. The oestrus cycle in young females under certain given conditions is important in the formation of new breeding units. Males without a breeding unit are psychologically castrated. Stallion groups form a gene reservoir from which old males are replaced. In the females the sexual organs have reached their full development at two years of age and the female normally drops her first foal at three years of age. A distinct breeding peak from November to April was found to exist. The gestation period is 362 days.

## I INTRODUCTION

In contrast with the domestic horse, very little is known about the reproductive cycle of the various zebra species in their natural state. Recently however, a comprehensive study by King (1965) was carried out. In this work he records field-work done on Grant's zebra (*Equus burchelli böhmi*) and Grevy's zebra (*Equus grevyi*). During a study on the ecology and behaviour of the Hartmann zebra (*Equus zebra hartmannae*) the author was fortunate enough to obtain some information on their reproductive behaviour and cycles. The results are given in the present paper as a small contribution to a better understanding of the reproduction of the wild species of Equidae.

## II CHARACTERISTICS OF THE REPRODUCTIVE BEHAVIOUR

Although this has been dealt with by Joubert (1972), certain salient points need to be stressed. The social organization of the Hartmann zebra is an exclusive one-male dominance over a given number of females. The males possess strong herding tendencies to ensure females against rivalry from fellow males. This herding behaviour has evolved as an innate behaviour pattern in the Hartmann zebra males. The social organization therefore results in a population made up of many sub-groups, comprising breeding groups and bachelor groups. Reproductively speaking this has two important advantages. It ensures selective breeding and secondly gene flow. Theoretical studies in quantitative genetics show that the structure of a population is very important in governing not only the genetic variability of the population but also the speed with which new adaptive genes may spread. Wright (1950) has shown that the optimal type of population structure is one where the population is divided into semi-isolated breeding units where a certain amount of inbreeding takes place, with the units joined genetic-

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ally by a limited amount of migration between populations.

The selection for the best breeding males takes the form of a harem, where a single male takes possession of a group of females against strong inter-male competition. As one finds with territoriality this latter phenomenon, apart from selection of males, also functions with territoriality as a means of distributing the population to ensure that all available females breed. In general the sex relationship plays an unimportant role in the social organization of the Hartmann zebra except for a limited period, in the establishment of new units or the enlargement of existing small ones. As may be assumed this happens during the oestrus cycle. The influence of oestrus on the formation of new breeding units is only important under the following conditions:

- (i) when the female which comes into oestrus is a young female. Older females which have already become an inseparable part of the breeding unit through their long association with it, do not facilitate abduction by young inexperienced males. For the young females, who are undergoing their first oestrus, this period is marked by a high degree of aggression from the females in the breeding unit.
- (ii) when the number of females in the breeding unit has reached or is close to saturation point. If the breeding unit is still small, the dominant male's own herding instincts will still be so strong that a young inexperienced male would not stand a chance.
- (iii) when there is a bachelor unit in the vicinity with sexually mature males which have had the stimulating experience of competition with fellow males and have reached a high position in the hierarchy of the bachelor unit. The oestrus period of a young female serves as a trigger mechanism to ensure keen competition amongst the young males. The oestrus female also triggers the latent herding behaviour of the young male. The male which finally succeeds in herding (abducting) her mates with her forms the nucleus of a new breeding unit. Field observation has shown that experienced males, that have lost their breeding units owing to some reason or other, or only have a small breeding unit (one or two females), do not need the triggering action of an oestrus female when forming a new breeding unit.

Constant rivalry exists between dominant males and this may be considered as the continuation of natural selection of the males. In the Hartmann zebra this intermale rivalry has taken the form of phylogenetic ritualization. Ethologists agree that ritualized behaviour's primary function is that of communication. In this context it fulfills two basic functions in the reproductive organization of the animal. The first is that it suppresses actual lethal contests which endangers the survival of the individual which is also the carrier of important genes. Secondly ritualized aggressive behaviour and mating behaviour is only shown by a dominant male with a breeding unit. The chance that a Hartmann zebra without a "harem" thus possibly an inferior animal, will re-

produce is remote. Proof was also found in sexually mature bachelor males of a behaviour which is indicative of a condition that has been called by most ethologists "psychological castration". Observations in the field showed that on occasions when oestrus females were abducted by bachelor males, mating only took place after this herding activity was carried out. The influence of psychological castration is only overcome by bachelor males when they actively engage in herding behaviour, after being triggered by an oestrus female.

Stallion groups (bachelor units) are mainly formed by immature males, most of which become sexually mature during their association with the stallion group, and old males past their prime which have been ousted by younger stallions. In the stallion group, selective pressure comes to bear and only the more worthy young males acquire their own breeding units. Stallion groups function thus both as a natural selector for the best males as well as male reservoirs for replacing dominant males that become senile, or are removed by natural causes such as diseases, accidents or predation.

The actual mating behaviour in the Hartmann zebra is relatively simple. As the dominant male and the females in the breeding unit are known to one another, courtship is peaceful with no elaborate ritualization. The first phase can be called the urination-flehmen sequence during which the male frequently exhibits flehmen behaviour as well as the tendency to urinate on the same spot as the female. During the second phase courtship takes place. This normally consist of the male rubbing the front part of his head against the female's vulva, when this is presented. This is followed by a placement of the male's head on the female's rump as a ritualized intention-mounting movement (Walther, 1958). During intromission the male lays his head, with ears laid back between the female's shoulder blades while he clamps her with his front legs. The female lowers her head with her ears also laid back and with lips pulled back. This facial expression in the Burchell zebra has been called "Rossigkeitsgesicht". Copulation normally only lasts a few seconds but is repeated almost at hourly intervals for a couple of days.

### III AGE WHEN SEXUALLY MATURE

In the Hartmann zebra, as in the Burchell zebra (Klingel, 1965, and King, 1965) the age at which the male starts showing sexual activity is no indicator of puberty. It is only when they are able to compete with older males and succeed in obtaining their own females that they show breeding activity. As can be seen in figure 1 the testis of the male starts increasing in weight from approximately two years of age. The testes however, only reach their maximum weight and size at about three and a half years of age. The average size of the testis ( $n = 24$ ) of animals older than four years is  $6,6 \times 4,9$  cm and the average weight 87,6 g. This is markedly smaller than the

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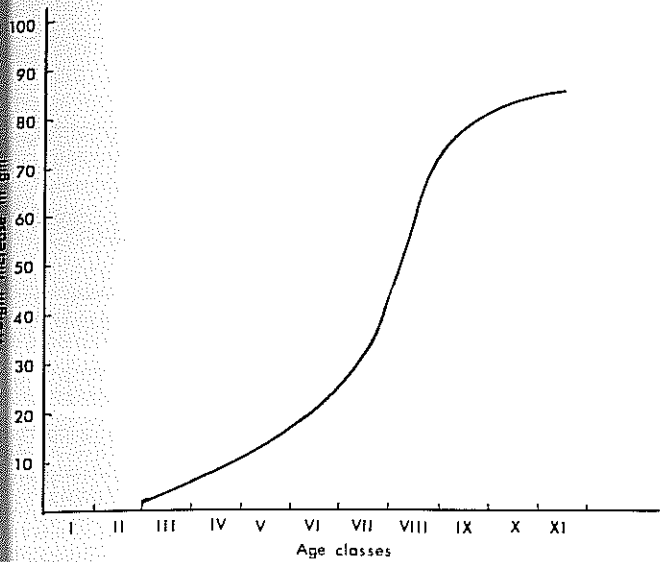


Figure 1. Increase in testis weight in the *Equus zebra hartmannae*.

size 10 × 7 × 5 cm given by King (1965) for the Burchell zebra. From post mortems carried out in the field it looks as though the testes only descend into the scrotum after the animal has reached the age of two and a half years or more.

Klingel (1965) records that the first oestrus of a Burchell zebra mare takes place at 12 to 13 months. Although it might also occur at this age in the Hartmann zebra, no opportunity arose to record this in field observations. Several females of known age dropped their first foal at three years or shortly afterwards. A female collected in the field, at an age of three years, was on the point of giving birth. With a gestation period of approximately 12 months one can therefore assume that in the Hartmann zebra female sexual organs have normally reached their full development and function from about two years of age. The ovaries show a variety of shapes according to the stages of differentiation of the maturing follicles. Usually, however, they are kidney or pear shaped. The average weight of 26 pairs of ovaries obtained from breeding females is 47,3 g. (Maximum 141,53 g — minimum 19,64 g.) The average length of these ovaries (over the median) is 45,3 mm (maximum 63,6 mm — minimum 31,0 mm). Cross-section of ovaries of sexually immature females showed them to be brown on the inside as opposed to the whitish colour of sexually active ovaries.

IV REPRODUCTIVE CYCLES

To determine reproductive cycles of the male, testes of adult animals were collected. As already mentioned, a number were collected every month throughout one year. The testes were weighed and measured. Smears were made from the epididymis to determine the number of spermatozoa. As can be seen from figure 2 only a very slight variation in the mass of the testis is noticeable during the 12 months of the

year. The average mass of the testis shows a slight decline from a peak in January (99,4 g) to the lowest point during September (83,1 g). Semen counts by the SAIMR during January gave an average figure of 4 600 000 000 spermatozoa per ml, while during September the average figure obtained was 1 900 000 000 spermatozoa per ml. The number of abnormal spermatozoa remained at an average of 9 per cent throughout the year. From the above it would appear as though the testes are more active during the rainy months than during the dry months. Despite this however, there is still more than enough spermatozoa to fertilize a female during the drier months.

Twenty-six pairs of ovaries were collected during the study-period. No differentiation in the activities of the ovaries could be detected. Follicles of Graaff were found maturing either in the left or right, or more often in both ovaries. Before rupturing, the follicle normally became so large that it projected beyond the surface of the ovary. Sometimes several of these large follicles would be found in one ovary at the same time. Even the number of developing follicles in each ovary showed a marked similarity. The outer walls of these follicles are thin and care had to be taken not to rupture them while working with the ovaries. The average diameter of these maturing follicles was 25,5 mm.

Kupfer (1928) found that donkey and horse mares show a definite periodicity of ovarian activity. Kupfer states that in South Africa, in the animals mentioned above, ovulation takes place only during the months October (second half), November, December, January, February, March and April (first half). Ovulations are thus confined to a season of six or seven months. King (1965) and Klingel (1965) detected no breeding season in Burchell and Grevi's zebra in East Africa. Klingel (1965) however, reports a main foaling season from January to March for the Burchell zebra. In the Hartmann zebra newborn foals have been recorded throughout the year, but a distinct breeding peak is noticeable. This is a

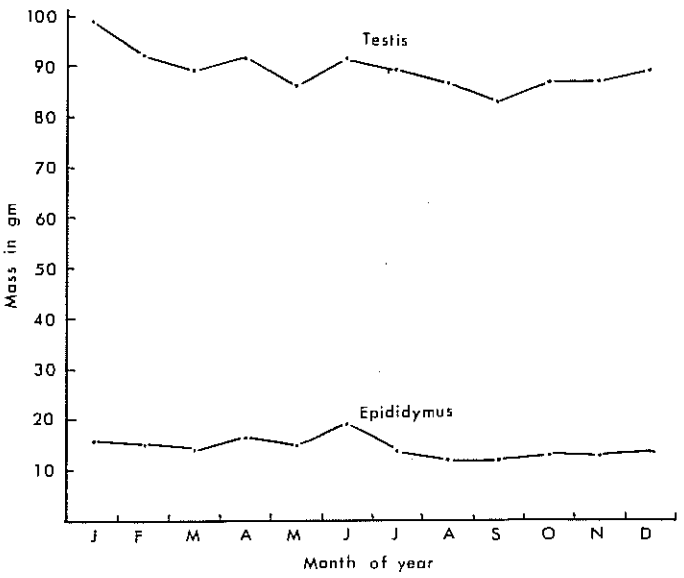


Figure 2. Seasonal changes in the mass of testis and epididymis in adult *Equus zebra hartmannae*.

clear indication that conception can take place throughout the year. During the three years of study, however, mating activities were only seen from September to April the following year, with a peak in February (for three years of observation). This indicates that mating activity during the rest of the year is very rare, which agrees to some extent with the work done by Kupfer (1928) on the donkey and horse.

One of the marked characteristics found in the ovaries investigated was the presence of a large corpus luteum even at an advanced state of pregnancy of up to five months. King (1965) found the same in the Burchell zebra.

Kupfer (1928: 1245) reports the same:

“the whole process of transformation from the ruptured follicle to the yellow body and its reduction, takes a very long time in South African donkeys (and in South African equines — horses — altogether) when compared with other animals. A rapid development and reduction of the corpus luteum, such as found in a concentrated ovulation cycle with intervals of three weeks only (for instance cattle) does not take place here.”

The average size of the corpus luteum before reduction takes place is similar to that in Burchell zebra as found by King (1965) viz. 25 mm. The colour changes of the corpora lutea were also found to be the same as described by Kupfer (1928) and King (1965). The active corpus luteum has a red-brown colour before changing to yellow. King (1965) found in ovaries three to six weeks post-partum ( $n=4$ ) remnants of a corpus luteum which appeared to be slightly larger than that seen at full term. This was found in one animal's ovaries in Hartmann zebra and suggests oestrus a week after parturition. Oestrus eight to ten days post-partum has been observed in both captive (Wackernagel, 1965) and free animals (Klingel, 1965). From observations at the Daan Viljoen Game Reserve the foaling-conception interval varied between three to seven weeks. It appears as though conception does not take place during the first oestrus following parturition.

## V SEASON OF BREEDING

As already mentioned new-born Hartmann zebra foals have been recorded throughout the year. But as Klingel (1965) found in the Burchell zebra a clear peak is noticeable. In the Hartmann zebra this peak is from November to April — thus commencing a month later and ending a month later than what Klingel found in Burchell zebra. This might be attributed to the rainfall season in South West Africa (see figure 3). Newly born foals recorded over the three year study were distributed as follows. During November to the end of April 86 per cent of all foals were born (Burchell zebra, October to March = 85,5 per cent), with 68 per cent during the main foaling season January to April (Burchell zebra, January to March = 61 per cent).

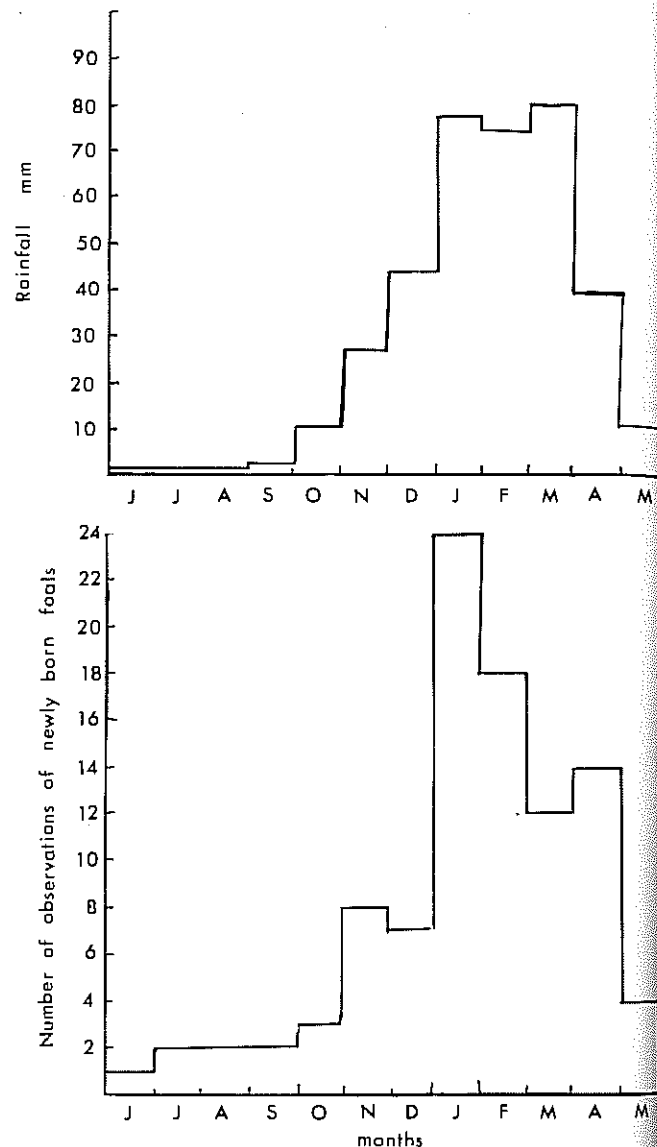


Figure 3. The correlation between rainfall and foaling in *Equus zebra hartmanniae*.

## VI GESTATION PERIOD

Wackernagel (1964) gives the gestation period of Burchell zebra as 371 days. This was determined in a zoo. Only one accurate gestation period could be recorded from the Hartmann zebra. A pair was kept in an enclosure of 14 ha next to the Legislative Building in Windhoek. On the 25th July, 1967, Mr Holtzhausen saw the pair mating and on the 23rd July, 1968 the female gave birth to a foal. This gives a gestation period of 362 days.

## VII ACKNOWLEDGEMENTS

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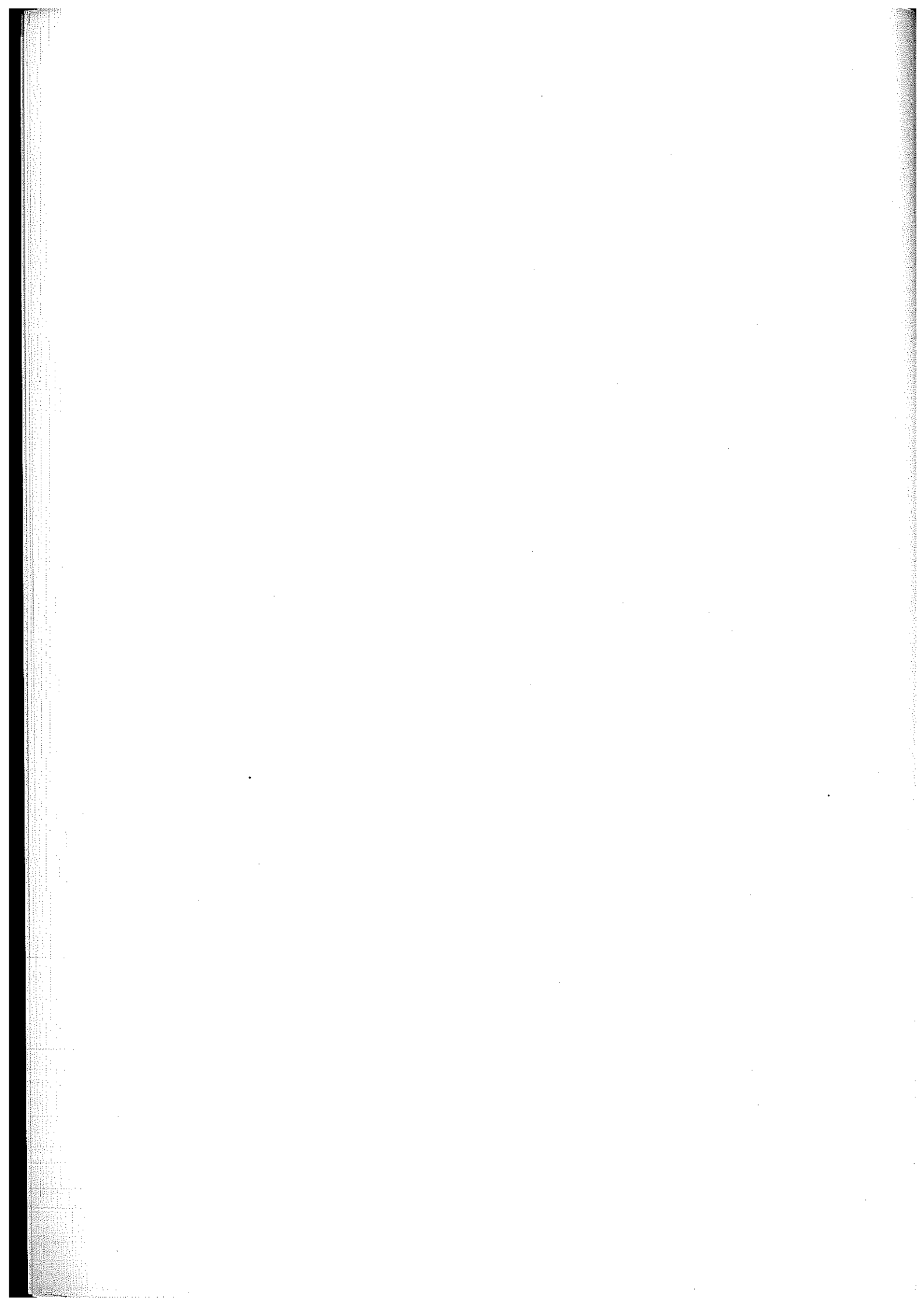
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# Developments in the capture and airlift of roan antelope *Hippotragus equinus equinus* under narcosis to the Etosha National Park

by

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(With 1 map, 1 figure, 1 table and 8 plates)

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## ABSTRACT

Seventy-four free-ranging roan antelope *Hippotragus equinus equinus* (Desmarest, 1804) were captured by dart immobilisation and successfully transported under prolonged narcosis in a C130 Lockheed Hercules airfreighter over a distance of 430 nautical miles to the Etosha National Park. Struggling and exertion during handling and transport and heat stress were effectively controlled by prolonging the period of immobilisation.

## 1 INTRODUCTION

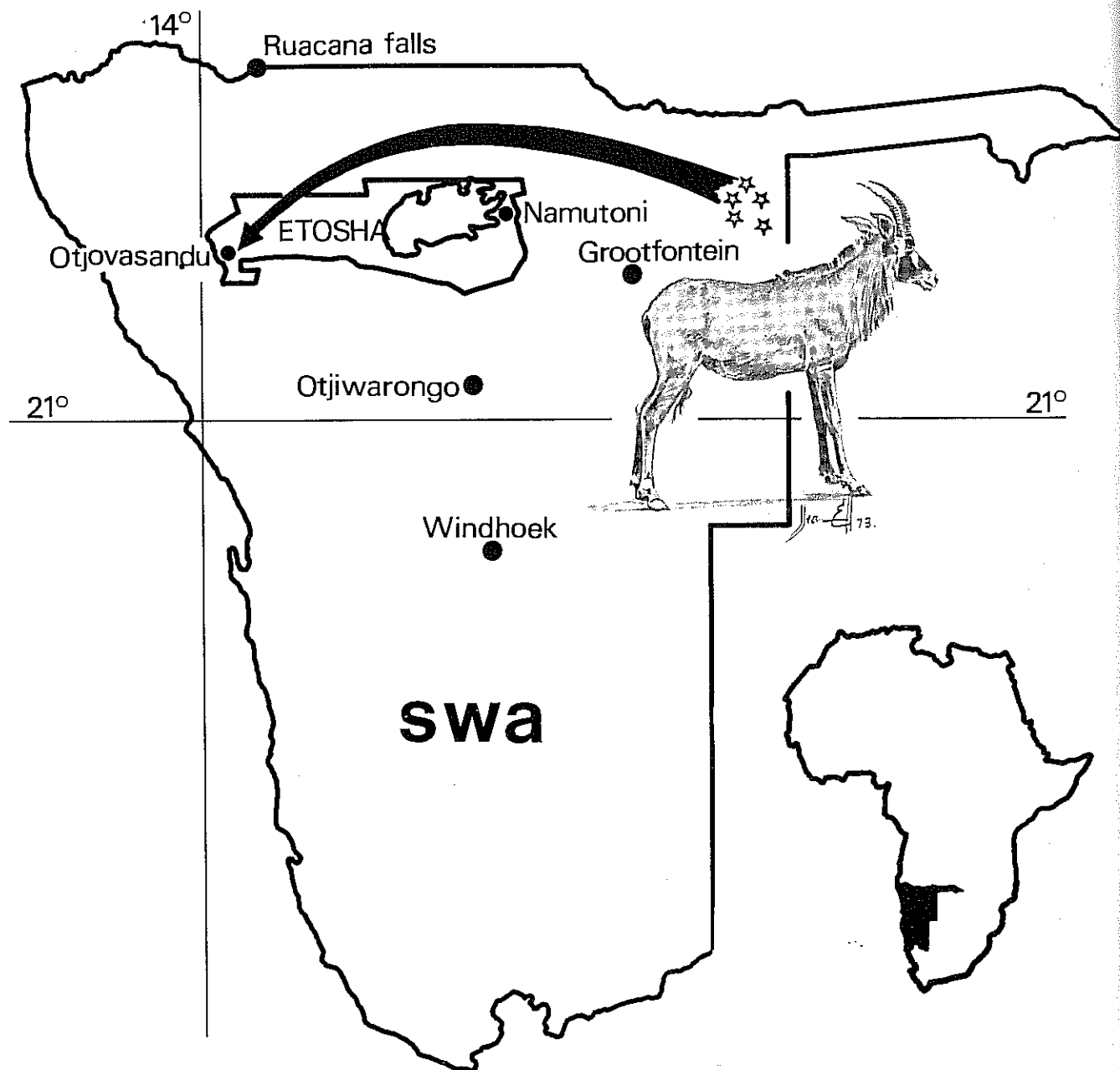
The former range of the roan antelope, *Hippotragus equinus equinus* (Desmarest, 1804) in South West Africa comprised the whole north-eastern portion of the country from the Ruacana Falls at 14° E to the Botswana border (including the Caprivi Strip) and along the eastern part, as far south as latitude 21° S. Within this area roan were widely distributed, extending as far as the eastern Namutoni area of the Etosha National Park (Shortridge, 1934). Pioneers even came across scattered roan herds in parts of the Kaokoveld, which includes the extreme western Otjovasandu area of the Etosha National Park.

In recent times there has been an alarming decline in these roan populations and they became restricted to the most north-easterly part of the country, where surveys revealed that there are no more than 400 left (excluding the Caprivi). Indeed Pienaar (1968b) points out that this antelope is now rare throughout its range in Africa. Any attempt, therefore, to capture and save it from extinction in South West Africa justified the use of the most modern technological aids and the development of new techniques for immobilisation and translocation procedures. In September and October 1970 an ambitious operation was therefore launched by the South West Africa Division of Nature Conservation and Tourism for the capture and transfer of 74 roan antelope to the Etosha National Park (Map 1) where the future of these rare animals (Southern Africa's second largest antelope) could be safeguarded.

## II CAPTURE OPERATION

### 2.1 Locality and description of area

The operation was conducted in the dry river-bed of the Khaudum Omuramba in the north-eastern corner of South West Africa, some 460 km by road from Grootfontein (Map 1). The last 160 km consisted merely of bush tracks over loose sand and could only be traversed by four-wheel drive vehicles. The greater proportion of this country is flat and featureless and during the dry season water is limited to a few scattered pans and drainage systems (omurambas). The vegetation comprises typical



Map 1. The translocation of roan antelope to the Etosha National Park, South West Africa.

woodland savanna and forest of the northern Kalahari. Trees, predominantly *Pterocarpus angolensis* DC, reach a height of 20 m. The Khaudum Omuramba, which is 200 to 1 000 m in width, is treeless and it was within a narrow 35 km stretch of this river-bed that the roan were caught.

## 2.2 Immobilisation

A survey carried out earlier in 1970 indicated that the roan were dispersed over a wide area. However by September, following a severe drought, water was limited to pools in the Khaudum Omuramba and, as roan are very dependent on water, an estimated 240 animals had congregated in the vicinity. Bushmen had recently burnt the grass, which had sprouted in the river-bed and acted as an additional attraction

for the animals. Therefore, although conditions were unfavourable climatologically (Hofmeyr & de Bruine, 1973), it was possible to launch a capture operation.

The work done by Pienaar (1968b) on the immobilisation of roan antelope and by Keep & Keep (1968) and Pienaar (1968a) on the introduction of the Butyrophenone compounds in the immobilising drug mixture served as most useful guides for this operation. The animals were darted from a Bell 47G4A helicopter. Initially nets were used with unsatisfactory consequences. The Palmer long range (pneumatic) projector and Palmer 3 cc darts fitted with NC2 needles (Palmer Chemical & Equipment Co.) were employed and proved to be very effective. Using this equipment the dart could safely strike almost any



part of the body without inflicting any undue injury. For the safe and effective intramuscular administration of the immobilising drugs the projector was aimed at a 40° to 70° angle at the rump of the animal directly in front of the helicopter. Accurate immobilisation times, taken from the moment of impact of the dart until the animal became recumbent, were recorded with a stop watch.

Initially the roan were easy to approach but they soon learnt to make for the cover of the trees when they heard the approaching helicopter and it became increasingly difficult to drive them out into the open again (Plate 1). They therefore had to be darted before they reached the forest and, being relatively small and fast-moving targets, good co-ordination between the pilot and the gun operator was an important requisite.

Altogether 81 roan antelope were immobilised. In 61 cases 4 mg Etorphine hydrochloride/M99 (Reckitt) was used as the narcotic and 200 mg Azaperone (Janssen) as the neuroleptic. Similar dosage rates were used for animals ranging from 100 to 325 kg in weight. A parasympatholytic was not incorporated in the drug mixture. The immobilisation time varied from 3 min. 12 sec. to 19 min. 49 sec. (average 7 min. 36 sec.). In 20 cases the M99 was replaced with 40 to 60 mg of Fentanyl (Janssen). The Fentanyl/Azaperone combination took 6 min. 45 sec. to 21 min. 40 sec. (average 12 min. 7 sec.) to induce immobilisation. In the writer's experience M99 was superior. Besides being swifter acting, it produced a more complete narcosis.

The first effects could be ascertained by observing the movement of the ears. This was soon followed, usually within 2 to 4 minutes after darting, by ataxia. The roan invariably went down in the sternal position. Younger animals weighing about 100 kg usually ran harder and took longer to go down despite proportionally larger dosage rates, while pregnant cows were inclined to become immobilised more swiftly.

On rare occasions the dart struck the vertebrae and this caused the needle to become occluded before the drug was discharged. It necessitated the firing of a second dart and animals that were darted twice usually ran for long distances, often 8 to 10 km, before they were finally immobilised.

Depending on climatic conditions as many as eight roan were immobilised per day. On three occasions animals which were considered too old were released.

Once the roan became recumbent, the helicopter was landed close by, usually within 100 m, so that immediate attention could be given to the animal. In order to guide the vehicles to the capture site, close contact with the aid of radio transceivers was maintained between the helicopter and the ground staff.

Once immobilised the majority of roan could be approached almost immediately. They were most tractable when immobilisation had taken less than 10 min. On the whole, their reactions were very similar to those described by Pienaar (1968b).

## 2.3 Post-capture care and clinical observations

Post-capture care proved to be the most significant aspect of the operation. Of the first six roan darted, four died as a result of overstraining or capture myopathy. Roan appear to be particularly susceptible to this condition and losses were encountered despite the prophylactic administration of drugs such as Catosal (Bayer), Vecortenol (Ciba) and Thiamine hydrochloride (Peterson).

The most significant clinical signs shown by the affected animals were the development of torticollis accompanied by general muscular weakness. The syndrome was noticed as soon as 2 hours after capture and once it was manifested clinically it became an irreversible condition which was refractory to treatment. Over-exertion, hyperthermia and psychological stress appeared to be the main aetiological factors involved in precipitating the condition. It was therefore particularly evident in roan which ran excessive distances and where exertion was further aggravated when they were transported by conventional methods using crates, in which the confined space subjected the animals to further overheating.

It was clear that, if further losses were to be avoided, radical changes in the *modus operandi* were called for. Therefore, once an animal was immobilised, every attempt was made to prevent additional exertion, alleviate and prevent hyperthermia and eliminate psychological stress. A different method of transportation which obviated the use of crates was developed and proved to be of paramount importance. In addition the prompt administration of various prophylactic and therapeutic agents, in particular the use of a vitamin E-selenium preparation, appeared to be helpful. The following regime of care and therapy prevented further clinical manifestations of the syndrome.

### 2.3.1 Drug administration and handling

Drugs such as vitamin E and selenium (E-SE S.A. Cyanamid) at the recommended dosage rate, Thiamine hydrochloride (200 to 400 mg) and Catosal (5 to 10 ml) were promptly administered intravenously. Vecortenol (75 to 150 mg according to the weight of the animal) and a long acting antibiotic were injected intramuscularly. On account of the poor nutritional value of the grazing at the time, some individuals were not in optimum condition. The injection of a vitamin ADE preparation was therefore considered advisable for all pregnant cows, animals in poor condition and in over-exerted cases while a vitamin B complex was administered to roan in poor condition. An antibiotic mastitis ointment was inserted into the dart wound.

Age was estimated by examining the teeth. Three to six centimetres of each horn tip was sawn off to prevent serious injuries should the roan fight in their captive enclosure. An ophthalmic ointment was placed on the cornea to prevent infection and desiccation and the roan were all blindfolded to pro-

Table 1. Observations on rectal temperatures, pulse and respiration rates in roan antelope.

Exercise	Rectal Temperature				Pulse/Minute				Respiration/Minute			
	Min.	Max.	$\bar{X}$	Range	Min.	Max.	$\bar{X}$	Range	Min.	Max.	$\bar{X}$	Range
* Roan captured by immobilisation (81 animals)	37,8°C (100,0°F)	42,5°C (108,5°F)	39,7°C (103,4°F)	4,7°C (8,5°F)	87	208	140	121	10	74	31	64
** Roan immobilised for translocation (74 animals)	35,4°C (95,8°F)	40,5°C (104,9°F)	37,6°C (99,7°F)	5,1°C (9,7°F)	42	77	60	35	14	44	27	30

\*Pulse and respiration rates of captured roan are averages for 45 animals.

\*\*Clinical observation done during transport approximately 1 hour after darting.

protect their eyes against dust and the glare of the sun. Rectal temperature, respiration and pulse rates were recorded in the majority of cases and the conjunctival mucous membranes were examined. The pulse was easily felt on the middle coccygeal artery at the base of the tail. The clinical findings from 45 animals are summarized in Table 1. These findings, especially rectal temperature, were closely related to the degree of over-exertion. Markedly elevated body temperatures were usually a sequel to prolonged immobilisation times and/or high environmental temperatures. To minimise hyperthermia, roan were therefore captured during the early hours of the morning and in the late afternoon shortly before sunset.

### 2.3.2 Transportation and off-loading

As crates had proved to be unsatisfactory for transporting the roan, it was decided to convey them to their holding boma (enclosure) on the back of vehicles while they were still immobilised (Plate 2). For this purpose two open, light 1¼ ton four-wheel drive vehicles were used. Employing this method struggling was eliminated during transport and animals with elevated body temperatures soon returned to normal through convection as a result of the moving vehicle and evaporation in instances where water was poured over the animal. Thus it proved possible to successfully capture roan which had run long distances and greatly exerted themselves. In one instance a roan which received a second dart after the needle of the first had become occluded showed no ill effects after it had run an estimated 10 km. Its recorded rectal temperature was 42,5°C.

The majority of adult females were pregnant and great care was taken not to injure such animals during loading, transportation and off-loading. At least five men were required to firmly lift, load and off-load an adult roan.

During transport constant supervision was maintained over the animal, which was kept in the sternal position. It was important for the head to be

held upright to allow eructation to occur and prevent the onset of tympany with possible complications of regurgitation, asphyxiation and aspiration pneumonia.

Roan were usually delivered at the holding boma within an hour after immobilisation and in some instances they remained immobilised for up to 3 hours. After off-loading the specific morphine antagonist was administered intravenously into the ear vein, either using 125 to 150 mg Nalorphine hydrobromide (Burroughs Wellcome) or 10,00 to 10,25 mg Cyprenorphine hydrochloride/M285 (Reckitt). Recovery following Nalorphine was the smoothest and quickest and, as it was advisable to get the immobilised animal to rise as soon as possible, this was preferred to M285.

Immobilised animals were placed well away from obstacles which might cause injuries and were positioned facing the far end of the boma where the rest of the herd congregated. Upon regaining consciousness they never dashed away blindly, but, though still tranquillised, walked or trotted over purposefully to join the rest of their companions (Plate 3).

### 2.3.3 The captive period before translocation

The holding boma or enclosure was erected within the catching area. It was 110 m in diameter and constructed of white opaque light plastic sheeting 2,5 m high reinforced with netting on the outside (Plates 4 and 5). Ample shade and drinking water were provided and the roan were fed baled lucerne and natural veld hay which were well distributed into several feeding lots. Antelope cubes (Epol) were provided *ad lib*.

Apart from veterinary quarantine measures it was essential for the roan to recover from the initial shock of capture. They settled down remarkably quickly in their holding pen but it took them some time (approximately 24 to 48 hours) to start feeding on lucerne. However, they fed on the grass provided

almost immediately. Once the quota of 74 roan was caught, the animals consumed 20 to 30 bales of lucerne a day in addition to the natural grass. Antelope cubs were much sought after and during hot days water consumption was considerable. Roan of different age groups and both sexes derived from several herds readily accepted one another. No serious injuries were inflicted during their mild scrimmages, which only occurred to a limited extent — mainly when the animals became excited and closely grouped while humans were present in the enclosure.

### III THE AIRLIFT OPERATION

From the outset it was clear that the translocation of the roan by road to Otjovasandu in the western part of the Etosha National Park (Map 1), a distance of over 1 000 km by road, would have been disastrous. It was originally intended to airlift them from a suitable landing strip situated 150 km from the Khaudum. After transporting the first two animals captured to this strip on an exceedingly poor, sandy bush track, it was obvious that this could not be done.

The only alternative was an airlift from the Khaudum Omuramba. The rainy season was already at hand and the possibility of a giant airfreighter landing in a river-bed not only proved to be a staggering exercise in logistics but could only be contemplated while the river was dry. A senior captain of Suidwes Lugdiens (South West Airways), Windhoek, was flown in to investigate and select a possible landing

site. After a thorough investigation a landing strip 1 800 m in length was located 5 km from the roan enclosure.

Once it was established that an airlift was possible an experiment was conducted to determine the effect of prolonged immobilisation on the roan antelope. It was estimated that during the transit operation they would have to be immobilised for as long as 5 hours.

After being darted from the helicopter, three cows were retained for clinical observations and placed under the shade of a canopy (Plate 6). Body temperatures, respiration and cardiac rates were taken at 30 min. intervals. The results from one animal (HE74) are plotted in Figure 1. A marked correlation was found between the respiration rate and body temperature. The latter decreased during transport to the boma, but later increased with a rise in ambient temperature.

While immobilised the animals were moved over every 30 min. from one side to the other, maintaining a sternal position, to relieve the pressure on their legs. Roan HE75 remained down for a period of 3 hours after which she stood up of her own accord and joined the rest of the herd. HE76 and HE74 received Nalorphine after 5 and 6 hours respectively.

Ptyalism was the only side effect noticed during immobilisation. These results were most favourable and it was felt that it would be perfectly feasible to transport the roan by air while they were under deep narcosis. For transit it was important to dart the animals at dawn when it was still cool, to minimise the effects of heat stress. In addition the pay load of

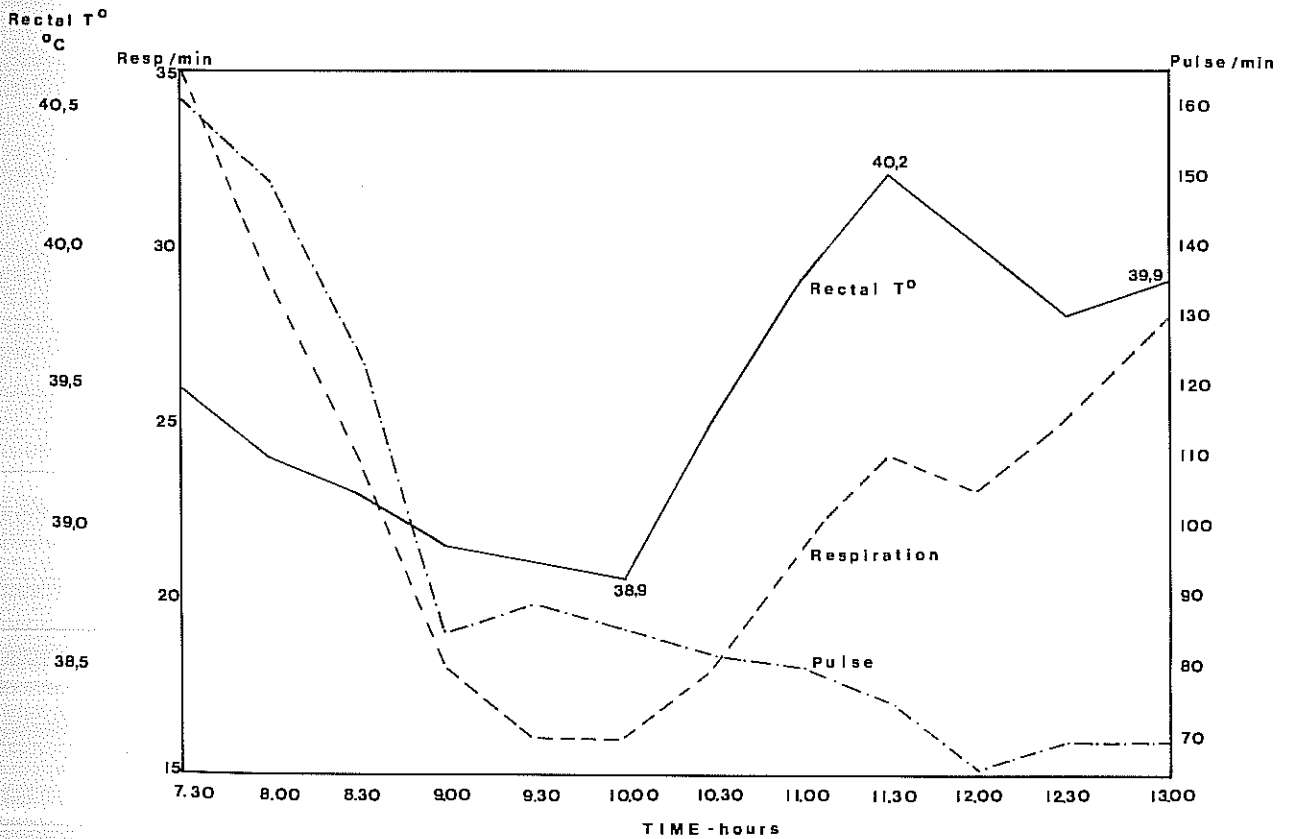


Figure 1. The effect of prolonged immobilisation on respiration, pulse and body temperature in a captured roan antelope (HE 74).

the aircraft is considerably reduced when it is operated at high environmental temperatures, especially when taking off from a makeshift landing strip.

On 20 October 1970, Safair's C130 Lockheed Hercules airfreighter touched down in a cloud of dust in the dry river-bed. The roan were reimmobilised *en masse* after groups of 10 to 15 animals had been herded into a smaller, specially constructed enclosure (Plate 5). Darts prepared with 4 mg M99 and 200 mg Azaperone were fired through slits made in the plastic sheeting. Once all the animals were down they were immediately placed on the back of open vehicles. As many as four animals per vehicle were conveyed to the plane. There they were placed three to four abreast on pallets lined with plastic and containing a layer of sawdust overlaid with hessian. Once loaded each pallet was moved into position on rollers and secured. The horns of the animals were loosely tied with ropes to suspended cross chains (Plate 7) specially constructed for the purpose. This prevented the animals from accidentally injuring one another and, with their heads raised, the air passages were kept open with no danger of bloat and asphyxiation. Nets were placed over the roan to secure them during take-off and landing. Moreover, attendants were stationed at strategic points to supervise specific groups of animals and rectify their positions whenever necessary. Ventilation and the temperature inside the aircraft could be regulated as required.

With 26 roan on board and loaded to capacity the airfreighter took off with its precious cargo. The animals only showed a temporary response to the aircraft's engines when these were started. The journey of 430 nautical miles took 1 hour 10 minutes and the roan were immobilised for a period of 3 to 5 hours. On occasions it was necessary, particularly with the animals which had been immobilised first, to administer an additional 1-2 mg M99 and/or 100-200 mg Azaperone. During transit clinical observations were made which indicated that the majority of roan were not subjected to any marked degree of stress (Table 1). They all received an intramuscular injection of 5 ml Catosal plus a long acting antibiotic (Compropen, Glaxo-Allenburys) and 100 mg Thiamine hydrochloride. Eye ointment was once again applied.

On arrival at Otjovasandu vehicles were standing by to transport the roan to their new enclosure. After the intravenous administration of 150 mg Nalorphine the disembarked animals soon returned to their normal state of consciousness (Plate 8).

In order to airlift the 74 roan, three flights were made. There were four losses shortly after delivery — two being the victims of capture myopathy, and two as a result of injuries sustained in the delivery boma.

The roan were released into a specially constructed 765 ha paddock a month later, following the termination of the veterinary quarantine period. During this period a remarkable event occurred in that a cow gave normal birth one week after the animals were translocated. Furthermore during the ensuing three months a total of 26 calves were born. The

roan have successfully adapted to their new environment and are steadily increasing in numbers (Hofmeyr, in press). In August, 1973, 159 roan were counted during a helicopter game census.

#### IV DISCUSSION AND CONCLUSIONS

During capture any animal is undoubtedly subjected to some degree of exertion and often hyperthermia when pursued by a helicopter. Although every attempt was made to limit exertion in the roan by inducing rapid immobilisation and by limiting darting to the most favourable part of the day it could not be entirely avoided. The effect of exertion is often aggravated during the handling, transport and captive phases and becomes cumulative, soon leading to an irreversible shock syndrome which cannot be treated. In the roan this was particularly evident when crates were used. Prolonging the period of immobilisation to eliminate struggling during handling and transport, and combating hyperthermia by convective and evaporative cooling, therefore proved to be most effective aids for the successful capture and translocation of the roan antelope.

The Etorphine/Azaperone combination was effective in prolonging the immobilisation period, although additional drug administration was necessary on occasions. More recently Picnaar (1973) recommends an Etorphine/Xylazine drug combination for the immobilisation of roan antelope. Experiments on gemsbok *Oryx gazella gazella* in the Etosha National Park using this drug combination showed that Xylazine has a very prolonged effect (up to 8 hours). Should the same apply to roan this combination may be useful where prolonged immobilisation is indicated provided the animals are attended to until fully recovered.

Although several anti-stress agents which appeared to be of value were routinely administered prophylactically, little is known of their real effect in limiting the onset of the shock syndrome. Until further research is done on the blood chemistry of wild ungulates in relation to stress and the use of prophylactic anti-stress agents, no definite conclusions can be drawn.

Where high environmental temperatures prevail air movement is important in regulating body temperature. In addition the effect of psychological stress is not always recognised. The provision therefore, of a large enclosure in which the roan could move about freely was a most important factor in the maintenance of their health and recovery from the initial shock of capture. Unless proper facilities are provided for the keeping of animals, management may become the most difficult part of the operation. Plastic sheeting proved to be most effective for confining the roan antelope. It was most unlikely that an animal would injure itself should it dash against the side.

Undoubtedly the most remarkable feature of the operation was the airlift of the roan. Indeed their translocation by plane over a distance of over 400 nautical miles while under deep narcosis is probably the first example of its kind involving large wild ruminants. It obviated the use of crates which would have increased the weight factor and necessitated additional flights and increased expense. Because of the fragility of the landing strip in the river-bed, a fourth landing and take-off could not have been considered. Although the roan were not adversely affected by ptyalism, it should be effectively controlled by incorporating 10 mg Hyoscine into the drug mixture. Pienaar (1973) recommends Promethazine (Phenergan, M&B) for this purpose. Noteworthy too was the successful calving of pregnant cows shortly after translocation. It shows that darting the animals twice and immobilising them for long periods had no adverse influence on either mid- or full-term pregnancy and parturition.

This operation clearly emphasises both the need for specialised equipment and the role that modern technology can play in certain capture and translocation procedures. It can probably be justifiably claimed that this operation was one of the most costly short-term game catching operations ever to have been launched in Southern Africa, as expenses were in the region of R40 000. However, in terms of saving a rare and valuable asset, such expenses are not excessive.

These immobilisation procedures for roan can be applied to other species and should provide greater scope in wildlife capture and translocation operations. Indeed they have already been successfully used for eland *Taurotragus oryx* plains zebra *Equus burchellii* and mountain zebra *Equus zebra hartmannae* in South West Africa.

## V SUMMARY

Seventy-four roan antelope *Hippotragus equinus equinus* were transported successfully under narcosis in a C130 Lockheed Hercules airfreighter over a distance of 430 nautical miles from the Khaudum river-bed in north-eastern South West Africa to the Etosha National Park.

The roan were captured by dart immobilisation from a helicopter. Post capture husbandry and various anti-stress agents administered, are discussed. While chemically restrained the roan were conveyed on the back of open vehicles to a large holding pen constructed of plastic sheeting, reinforced with netting on the outside. To transfer the roan by plane, they were immobilised with Etorphine hydrochloride/M99 (Reckitt) and Azaperone (Janssen) for a period of 3 to 5 hours. Twenty-seven calves were born in the first 3 months after translocation.

Prolonging the period of immobilisation to obviate the use of crates and thereby eliminate struggling and exertion during handling and transport, and

controlling heat stress by convection and evaporative cooling, proved to be most effective aids for the successful capture and translocation of roan antelope.

## VI ACKNOWLEDGEMENTS

Mr B. J. G. de la Bat, Director of Nature Conservation and Tourism, is cordially thanked for instigating this operation and in particular for making the necessary arrangements to ensure the successful translocation of the roan antelope.

I wish to thank the following for their valuable contribution and assistance:

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Captain J. G. Maritz of Suidwes Lugdiens for selecting a suitable landing strip, for the final arrangements and guidance of the aircraft during the first landing in the river-bed.

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Plate 1. Trees 10 to 15 metres high fringing the Khaudum Omuramba (dry river-bed) with the helicopter herding roan into open terrain.



Plate 2. A narcotised roan on the back of an open vehicle ready to be conveyed to the holding enclosure. Note that it is blindfolded, placed in a sternal position on a layer of hessian and the head is held erect. The water container was used for wetting hyperthermic animals.



Plate 3. A newly introduced tranquillised roan joining its companions in the roan enclosure. Note the calm disposition of the animals.

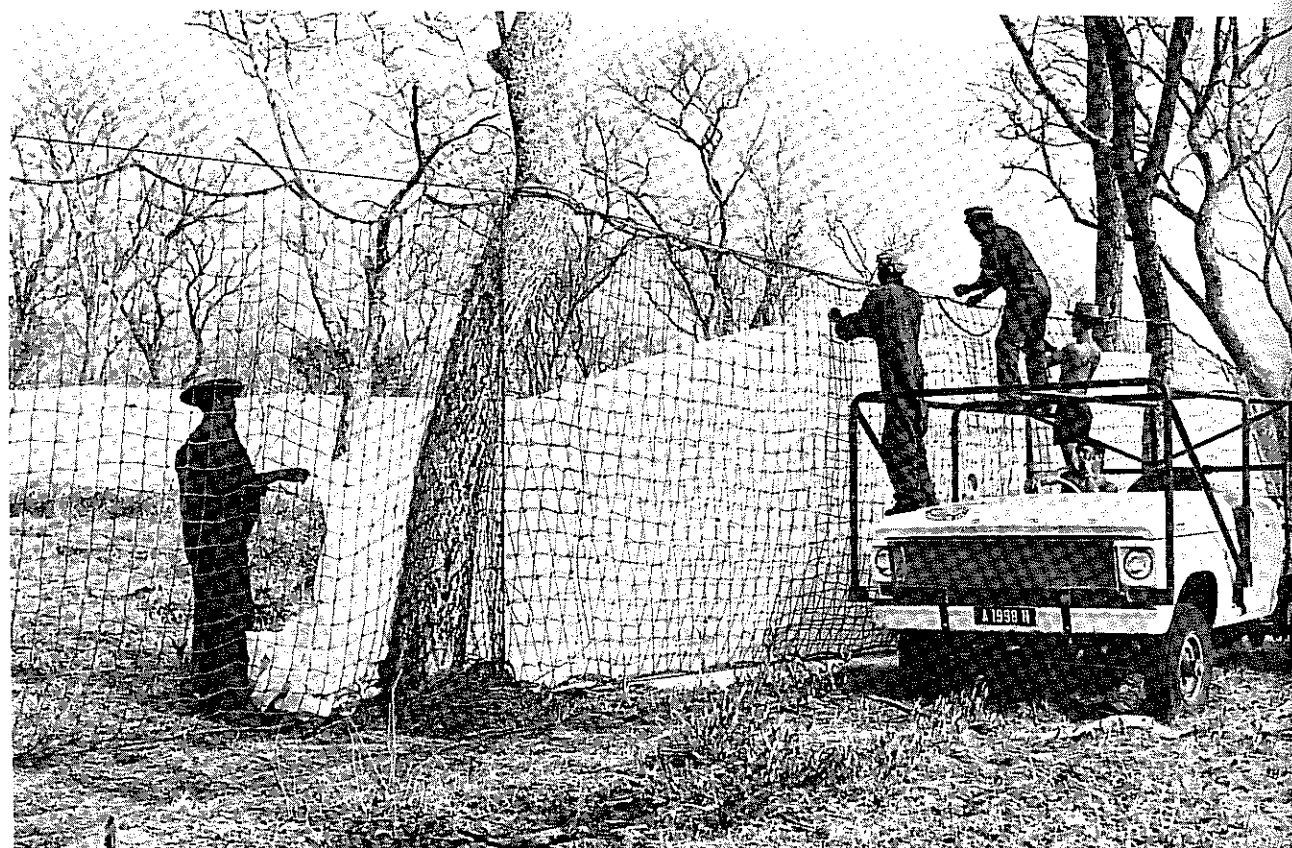


Plate 4. The roan enclosure under construction illustrating the white opaque plastic sheeting on the inside reinforced with netting on the outside.



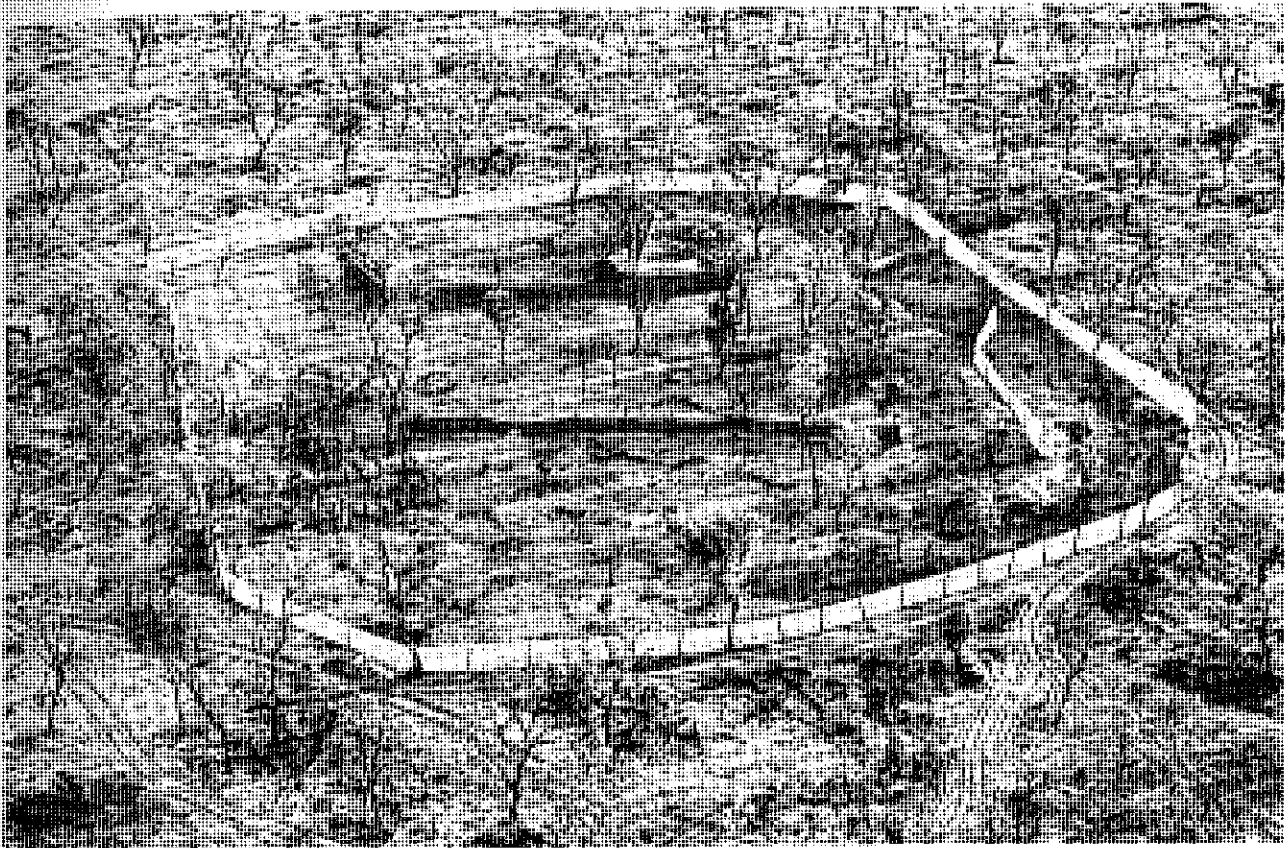


FIGURE 3. An aerial view of the open structure illustrating the capture animals, the provision of additional shade and a specially screened section on the extreme right used for rehabilitation.



FIGURE 4. Three men subjected to critical observation during prolonged incarceration. Pythons revealed by the use of a flashlight were used in restraint in the man on the left.



Plate 7. Attending to roan antelope under deep narcosis inside the aircraft. They were secured with cargo nets and their horns were loosely tied to suspended cross chains. (Photo D. van der Heever)

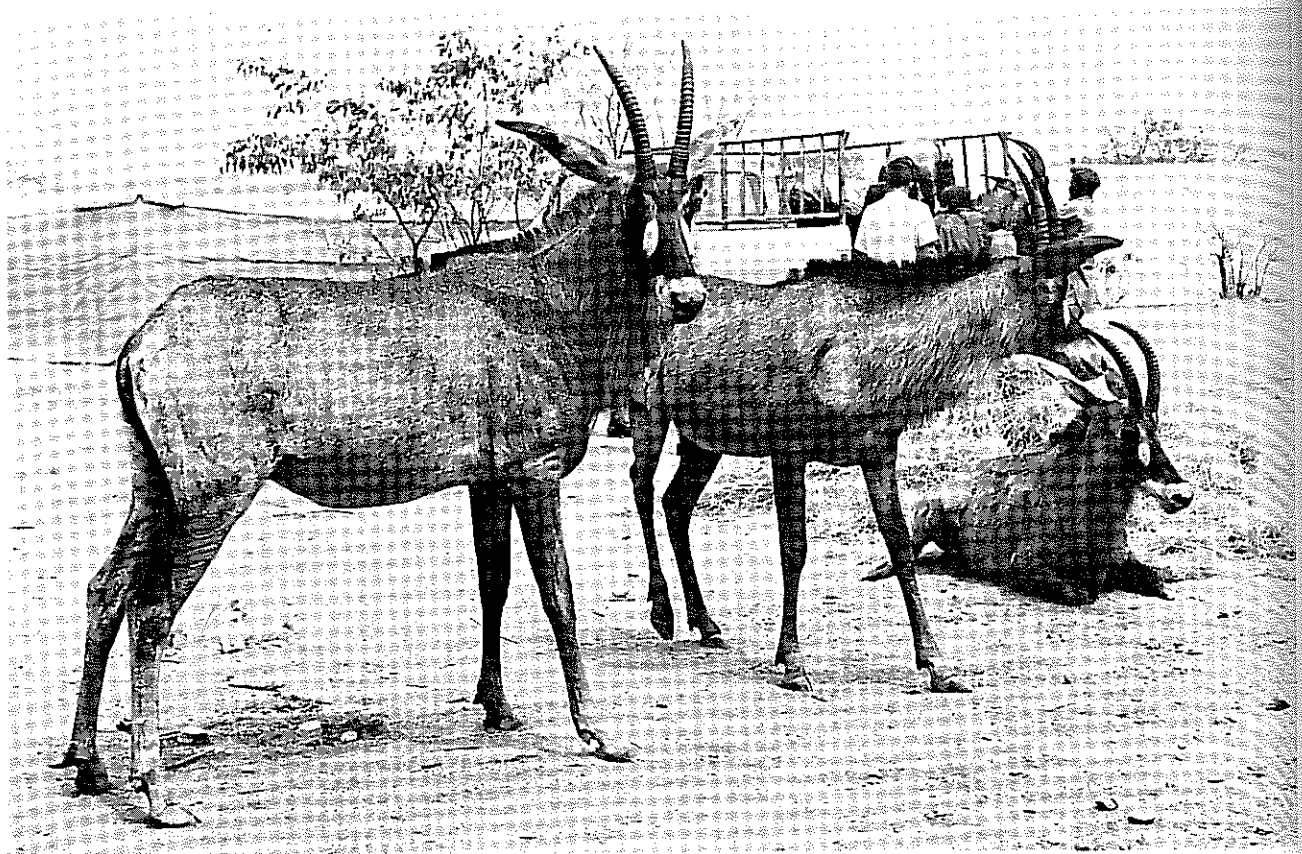


Plate 8. Following a 5-5 hour immobilisation period the disembarked roan recovering from narcosis within 2 minutes following intravenous injection of 150 mg Nalorphine hydrobromide.

# Composition and limiting factors of a Khomas Hochland population of Hartmann Zebra *Equus zebra hartmannae*

by  
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## ABSTRACT

After an aerial census of the Khomas Hochland population of Hartmann zebra, 128 animals were shot on a random basis over a period of 12 months. The population composition of the Hartmann zebra is discussed; this includes sex ratios for the various age classes, age structure and dynamics of the population. There was almost an equal distribution of sexes throughout the age classes. An age structure curve and a life table have been constructed. Various limiting factors are discussed showing that these animals are susceptible to drought.

## I INTRODUCTION

Owing to the social organization, the difficulty of quickly and accurately sexing animals in the field, as well as the habitat the Hartmann zebra frequents, it is virtually impossible to sample a population in the field. Klingel (1965) experienced similar problems with the Burchell zebra, and he gives only the sex ratios of the foals born in marked groups. In their population study of the wildebeest, Talbot & Talbot (1963) faced the same problem.

The Hartmann zebra in South West Africa are classified Specially Protected Game and under normal conditions no permits are issued to hunt them. During some years, especially drought years when they compete with livestock, permits are issued to farmers all over the Khomas Hochland. Arrangements were made with these farmers and thanks to their friendly co-operation it was possible to collect 128 animals over a period of 12 months. The animals were shot on a random basis. The method used was modified from the one devised in the Kruger National Park by Pienaar (1969). Two sets of numbers, one to five were written on small pieces of paper, one set with the prefix R and the other with the prefix L and then folded. Before a hunt took place lots were drawn to decide which animal of a breeding or bachelor unit would be shot, for example R<sub>2</sub> would mean the second animal from the right or L<sub>1</sub> the first animal on the left.

## II POPULATION COMPOSITION

During the study a reasonably accurate aerial census of the Khomas Hochland population of Hartmann zebra was carried out and found to number 5 000 animals (Joubert 1973). As already mentioned it was virtually impossible to sample a population in the field. With the abovementioned method however, a random sample of 128 animals were collected from the Khomas Hochland population. Although this sample represents only 2,5 per cent of the population in the Khomas Hochland the author is confident that the calculation based on these figures must give a picture as nearly accurate as one could hope to get of a wild population.

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## 2.1 Sex ratios

The embryos and foeti collected during the study period, and which could be sexed, showed a male : female ratio of 1 : 1.12 (n = 18). This is ratio of 47 per cent males to 53 per cent females; it is not significantly different and can be considered equal. The male : female ratio for foals up to the age class VI (two and a half years old) are 1 : 1.08 (n = 57), thus 48 per cent males, a difference which is even less significant than the figure obtained from foeti.

The sex ratios for the various age classes from age class VIII (three and a half years) onwards are given below.

As can be seen, the sex ratios in the various age classes vary; despite this, the sex ratio of the entire sample of adult animals is 1 : 1.16 — still significant. One of the reasons for this almost equal distribution of sexes in the adult animals must be the lack of conspicuous dimorphism between the sexes.

Table 1. Sex ratios of an adult *Equus zebra hartmannae* population in the Khomas Hochland.

Age class	Age	Male	Female	ratio	nn
VIII	3½	1	2	1:2	3
IX	4	9	12	1:1.3	21
X	5-6	9	7	1:0.7	16
XI	7-9	7	10	1:1.4	17
XII	9-11	4	4	1:1	8
XIII	11-12	1	0	1:0	1
XIV	13-14	0	1	0:1	1
XV	15 years plus	1	1	1:1	2
Total		32	37	1:1.16	69

Table 2. Distribution into age classes of a random sample of *Equus zebra hartmannae* collected in the Khomas Hochland

Age class	n	Age groups	Total
I	10		
II	3		
III	6		
IV	8	1 year	27
V	15		
VI	15	2 years	30
VII	2		
VIII	3	3 years	5(+30)*
IX	21	4 years	21
X	16	5-6 years	16
XI	17	7-9 years	17
XII	8	9-11 years	8
XIII	1	11-12 years	1
XIV	1	13-14 years	1
XV	2	15 years and over	2
			n = 128

\*Correction factor for the determination of a life-table — see text.

It also shows that both sexes are equally well adapted to their environment.

## 2.2 Age structure and dynamics

As Allee *et al* (1949) put it, a population has certain characteristics it shares with an organism as well as others that are its own unique possession. The latter group of characteristics are largely statistical.

This sample, as has already been mentioned, was collected at random (helped to a large extent by the absence of sexual dimorphism in the Hartmann zebra). It was also possible to identify the animals into more than two age-classes — thus fulfilling the two basic prerequisites for the application of a life-table method of population analysis. To obtain more even intervals between the age classes, several of them were grouped together in age groups (see table 2). As can be seen only 5 individuals of age classes VII and VIII were collected. This was at first thought to be due to certain defects in the method of sampling. As can be seen in figure 2, however, this corresponds to a drought period in the Khomas Hochland which had an adverse effect on the survival rate of foals during that year (see Limiting factors). A graph was plotted with the information in table 2 and smoothed out to give the theoretical figure for age group VIII (three years).

An age structure curve (figure 1) and life table were then constructed (Quick, 1963). To determine the number of foals born, the following procedure was used. The total population of Hartmann zebra on the Khomas Hochland numbers 5 000. Using the information in table 1 it follows that 54 per cent of the population must be females. Assuming that theoretically 1 675 mares of three years and older, dropped foals in a given year (1970), this gives one a figure of 33 per cent foals in the population. According to the sample collected in the Khomas

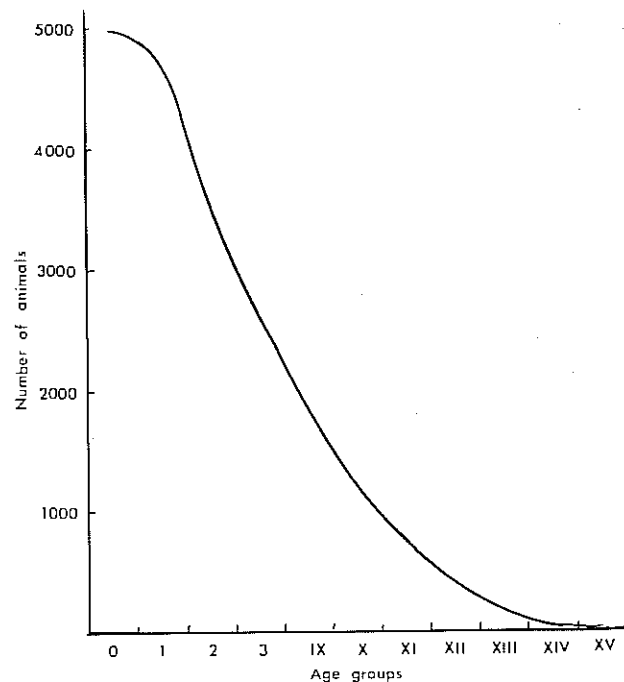


Figure 1. Age structure curve for a population of *Equus zebra hartmannae* in the Khomas Hochland.

Hochland however, one year old foals formed only 21 per cent of the population. Thus 12 per cent of the foals succumbed during their first year.

Statistical methods have been developed for the analysis of human populations and these methods have been adapted with considerable success to wildlife management. In the analysis of population dynamics the numerical and structural changes within population resulting from births, deaths and movements must be considered (Quick, 1963). For this paper, only the Khomas Hochland population of Hartmann zebra will be discussed. This population is for all practical purposes stable. As has already been mentioned 128 animals were collected on a random basis in the field. This sample was grouped into the various age classes, using tooth development and wear as parameters (Joubert, 1972). The result obtained can be seen in table 2.

The life-table above was based on a cohort of 5 000 and is thus directly applicable to the Khomas Hochland population. The headings are those commonly used in basic life-table calculations (Allee *et al.*, 1949). They are:

- x — age in appropriate units, stated as an interval;
- lx — the number surviving at the beginning of the age interval stated in the x column;
- dx — the number dying within the age interval stated in the x column;
- qx — the number dying in the age interval, divided by the number of survivors at the beginning of the interval, viz. rate of mortality;
- Lx — is the mean number of individuals alive between the stated age-classes;
- ex — life expectation, mean length of life remaining to each organism alive at the beginning of the age class, expressed in terms of age classes.

As can be seen by the age-specific mortality rates qx, as well as the structure curve, the survival rate for foals is quite high. This is in strong contrast with what Talbot and Talbot (1963) found in the wilde-

beest, but in agreement with Klingel's (1965) findings in the Burchell zebra. Up to three years of age the Hartmann zebra foals have a relative high life expectancy. This is probably due to the protection offered to the young by the breeding units.

### III LIMITING FACTORS

Owing to the broken terrain it was found extremely difficult to record mortalities in the field. Although no accurate figures are available, certain limiting factors were determined during the study period. These limiting factors are drought, accidents, predation and possibly parasites and diseases.

#### 3.1 Drought

Although drought occurs only at irregular intervals and with variable intensity, it is one of the primary causes of known mortality. During the drought of the 1968/69 season hundreds of Hartmann zebra were found dead or dying in the Khomas Hochland. At three dry waterholes in the Kuiseb River 32 carcasses were found. On another farm in the Khomas Hochland, 21 carcasses were found of animals that had been trapped in the mud of a dam drying up. As already mentioned figure 2 illustrates the effect on survival rate of foals during periods of drought.

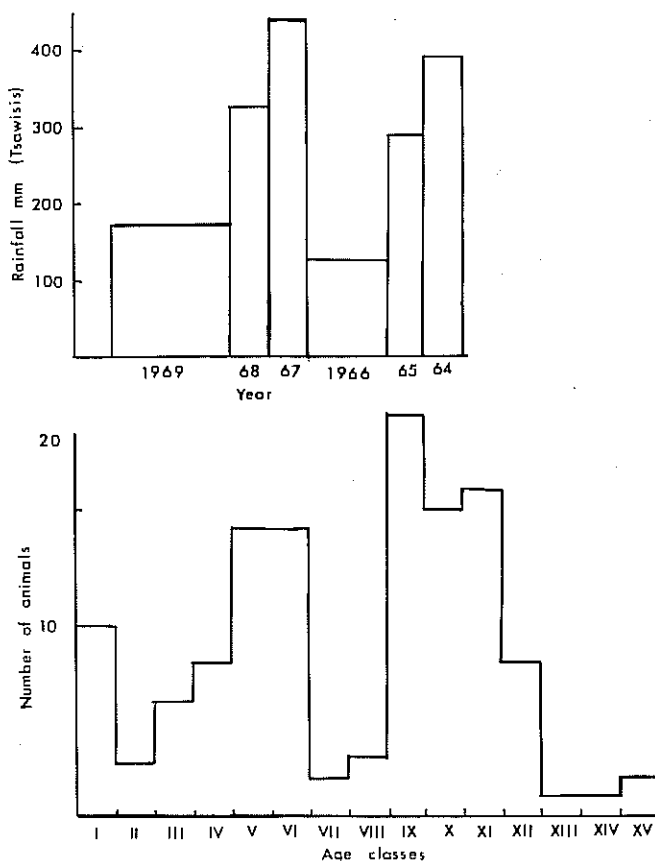


Figure 2. Population survival histogram illustrating the influence of a poor rainy season on a *Equus sebra hartmannae* population in the Khomas Hochland.

Table 3. Life-table for the *Equus zebra hartmannae* population in the Khomas Hochland

(Age class) x	lx	dx	qx	*Lx	ex
0	5000	608	608	4696	3,56
1 year	4392	750	854	4017	2,98
2 years	3642	835	1147	3224	2,49
3 years	2807	973	1753	2320	2,09
IX	1834	583	1484	1542	1,93
X	1251	445	1779	1028	1,61
XI	806	472	2928	570	1,22
XII	334	223	3339	222	1,25
XIII	111	29	1219	96	1,74
XIV	82	26	1342	69	1,18
XV	56	56	5000	28	0,5

\* Fractions are ignored.

Normally the heavily hunted Hartmann zebra on the Khomas Hochland are very wild and shy and will make off whenever they spot a vehicle. During this abovementioned drought however, they wandered aimlessly around, especially around dried up waterholes and along the Kuiseb River. One could drive to within fifty yards of them. The farmers, who during this time were also hard hit, mercilessly shot hundreds of Hartmann zebra. The primary cause for this was that these animals were in direct competition with the livestock, not only for water, but also for grazing. A second factor was that during this period, untanned zebra hides fetched prices of up to R35 apiece, that of young foals even more. Zebra hides thus ensured a ready cash income for the farmers.

The heaviest mortality in the Hartmann zebra population during this drought, occurred amongst the newly-born to young foals and pregnant females. Strange as it may seem, a dead or dying female was found on several occasions with her young (new-born to a few months old) foal standing next to her. This might be due to the drain of lactation on the female and a shortage of food. In animals weighed during December 1969/January 1970, at the height of the last drought, it was found that the contents of their digestive systems formed only 12 per cent of their body weights. In animals weighed from July 1970, onwards, after good rains had fallen, the contents of their digestive systems formed 25,4 per cent of their body weights.

Post mortems on three females revealed signs of recent abortions. No aborted foeti, however, were found in the study area — probably because they were quickly disposed of by scavengers. Mr B. J. G. de la Bat (pers. com. 1970) informed the author that he recorded several aborted Burchell zebra foeti during severe droughts in the Etosha National Park.

### 3.2 Accidents

Considering the habitat they frequent it is not surprising that accidents also cause mortality, especially among the adult population. Although no figures are available from the field, eight per cent of the population at the Daan Viljoen Game Reserve died owing to accidents, during 1969 and 1970. Several deaths owing to accidents were also recorded by P. van der Westhuizen (5) and W. Piepmeyer (2) (pers. com. 1969, 1970) from the Naukluft Mountain Zebra Park. Several carcasses with fractured bones were found under various precipices.

As already stated adults, male and female alike, are most accident prone. Accidents normally occur during play-fighting or maintenance of social hierarchy activities, probably also when fleeing from danger, real or imagined, especially around waterholes. The most common injuries are fractures of the legs and although not the actual cause of death they form the primary factor that leads to the animals death.

### 3.3 Predation

In the Khomas Hochland predators such as leopards (*Panthera pardus*) and cheetahs (*Acinonyx jubatus*)

are still relatively common. Although they may not have a marked influence on the population they certainly remove a certain percentage, especially foals. At one very secluded waterhole in the Naukluft mountains on the farm Panorama, a large number of skeletons of primarily young animals lie scattered around. Some of them were relatively fresh, and although cause of death could not be ascertained, it seemed very likely that it was due to predation. On the same farms, the owner, Mr Visagie, told the author that during the last 10 years they lost almost 75 per cent of their horse and donkey foals to predators.

In the Namib Desert Park, in the Kaokoveld and the area west of Otjovasandu, hyenas (*Crocuta crocuta*) and wild dogs (*Lycan pictus*) also assist in reducing the population. During 1967/68 three deaths owing to predation by lion (*Panthera leo*) were recorded by the author in the Otjovasandu area.

### 3.4 Parasites and diseases

Hartmann zebra, as Burchell zebra, are heavily infested with internal parasites. Apparently however, these parasites have no real detrimental effect on the animals. During years of severe drought however, the internal parasites are bound to have a certain adverse effect.

Internal parasites recorded are the following:

*Gasterophilus pecorum* Fabt.  
*G. intestinalis* De Geer  
*R. evertsi* ssp. *mimeticus* Dönitz  
*G. haemorrhoidalis*  
*Rhinoestrus steyni*

External parasites are mainly ticks situated in the scrotal area. No heavy infestations were ever found. Ticks recorded are the following:

*Rhipicephalus oculatus* Neumann  
*R. eversti* ssp. *mimeticus* Dönitz  
*Hyalomma rufipes* Kock

A new louse was also found from material collected during the study. This louse belongs to the *Damalinia*, but has not yet been described.

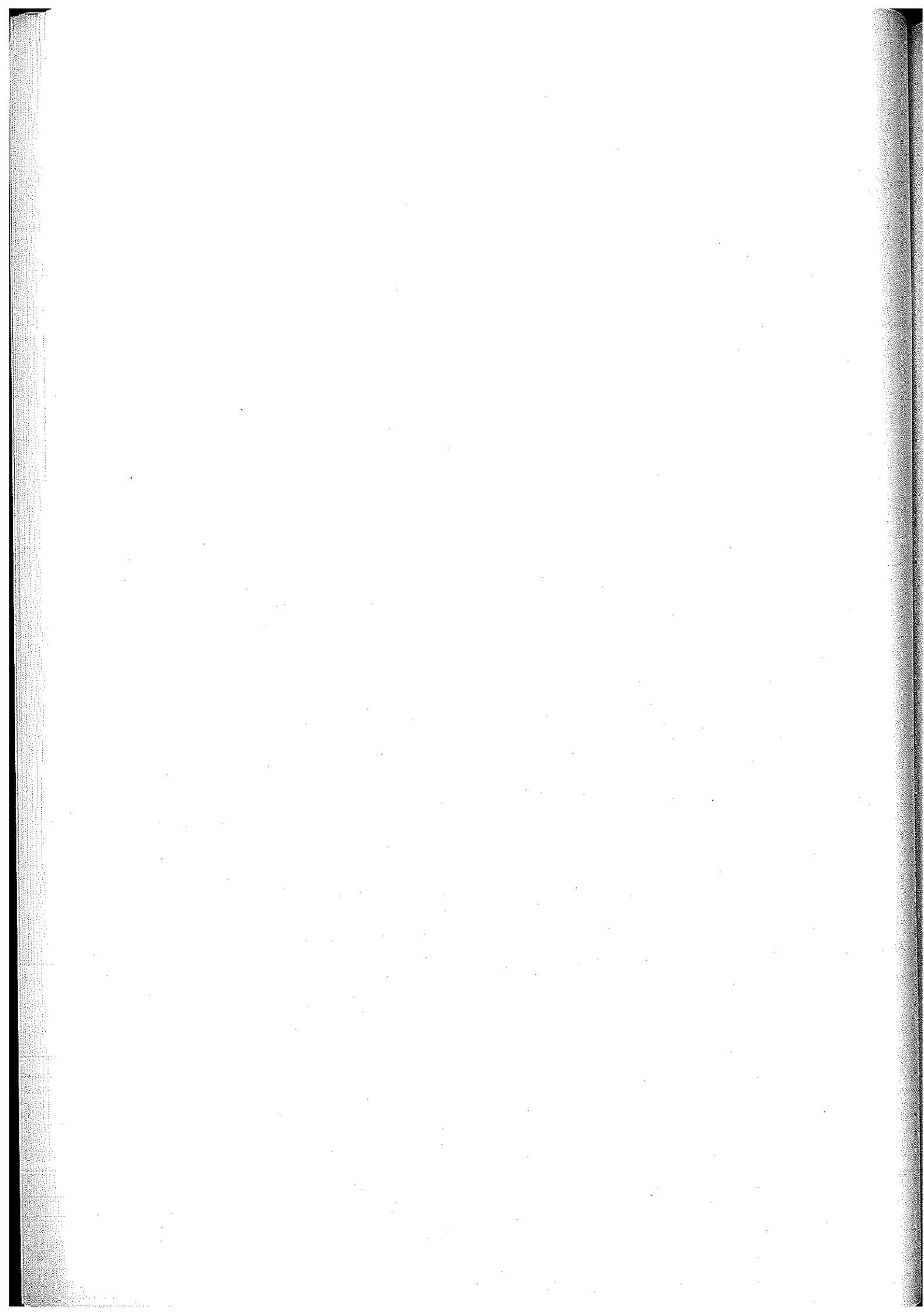
There has been several records of Hartmann zebra dying mysteriously, possibly due to diseases. Death due to disease in nature, however, is difficult to establish. In the Etosha National Park, anthrax annually kills a number of animals, especially Burchell zebra. In the Otjovasandu area, despite strict vigilance, the collection of blood smears from all fresh carcasses, not one death due to anthrax was recorded in the Hartmann zebra population.

## IV ACKNOWLEDGEMENTS

Mr C. G. Coetzee, Director of the State Museum, Windhoek is thanked for his advice and for critically reading through the paper. My sincere appreciation is due to all my colleagues mentioned in the text.

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# Size and growth as shown by pre- and post-natal development of the Hartmann zebra *Equus zebra hartmannae*

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## ABSTRACT

From a sample of 128 animals the standard samples and measurements were obtained. A description is given of the pre-natal development of the Hartmann zebra foetus. Post-natal development is also given in both size and mass gain. The average mass of the adult female being 276,5 kg while the adult males shows an average mass of 298 kg. No statistical meaningful differences in the growth rate of males and females could be determined.

## I INTRODUCTION

During a study on the behaviour and ecology of the Hartmann zebra in South West Africa permission was obtained to shoot 128 of these animals on private land where they were creating problems. Apart from all the other information and samples taken (Joubert 1974 a, b), the standard measurements of each animal were also obtained. Nothing could be found in the available literature on the development of the zebra. The pre-natal development is represented by a growth curve and table, so as to facilitate the establishment of the age of zebra foeti in the veld. This information is important when trying to determine the breeding season. There is furthermore an increased trend to incorporate game animals with livestock on farms for red meat production. It was felt therefore that the post-natal development information might be a help in ascertaining the optimum cropping age as related to size and body mass of the Hartmann zebra.

## II SCHEDULES FOR PRE-NATAL DEVELOPMENT

During the study 37 Hartmann zebra mares were collected of which 18 were pregnant. A few more mares may have been fertilized but with the blastocyst so small that it was missed during the post mortem. Eighteen embryos and foeti in different stages of development were thus collected. This material was then correlated with the characteristics of the equine foetus as determined by Richter & Gotze (1950). By comparing the state of development of the Hartmann zebra foetus with that of the horse and then comparing the weights and lengths, a strong correlation was found. Although the horse foetus and Hartmann zebra foetus showed the same growth in length, the Hartmann zebra foetus did not gain weight as fast as the horse foetus. Despite this, however, the work by Richter & Gotze (1950) was found to be a valuable guide line. The determination of the period of conception of each embryo was based on their work, using both weight and body-length as parameters. The actual description of the foetus however, was made from the specimens to hand.

In figures 1 and 2 the growth in weight and length of the Hartmann zebra foeti can be seen. According to figure 1 the foetus starts picking up weight at an

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accelerated rate from about eight months. At birth the foetus may weigh 25 kg (n = 5). The increase in body length of the foetus shows a more gentle curve. At birth a foal is on the average 120 cm long (head and body n = 5).

### III POST-NATAL DEVELOPMENT

#### 3.1 Mass

Figure 3 shows the increase in mass in the Hartmann zebra. The female mass gain curve levels off sooner

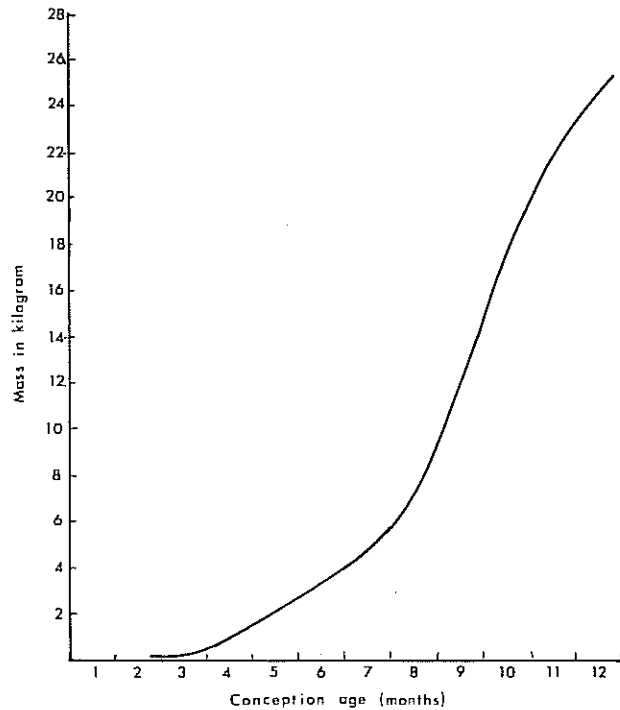


Figure 1. Prenatal increase in mass of *Equus zebra hartmanniae*.

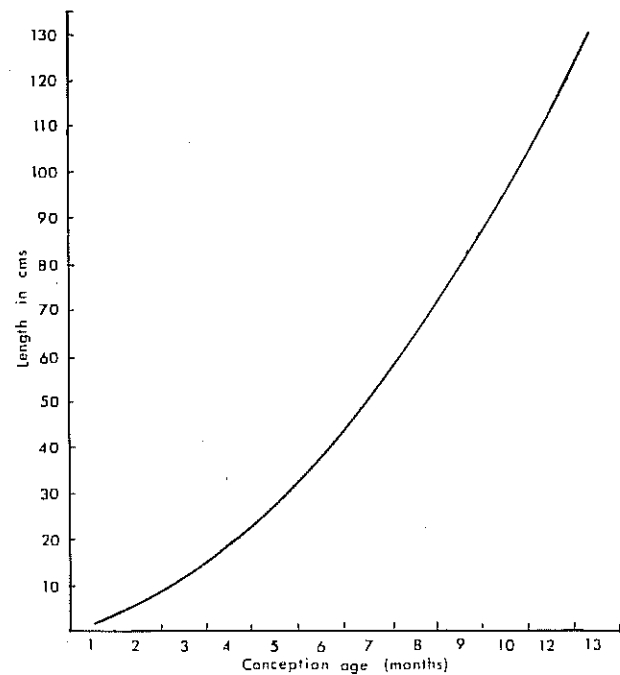


Figure 2. Prenatal increase in length of *Equus zebra hartmanniae*.

than the curve showing the male mass gain. No such marked dimorphism could be determined in the body measurements and skeletal growth of the two sexes. As can be seen from tables 2 and 3 the only measurement that does show some difference is that of body circumference which is larger in the male by an average of 5,6 cm. The average mass of the adult female, older than four years, is 276,3 kg (n = 23), with the 10 largest females showing an average of 279,8 kg. The maximum mass recorded for a female was 322,1 kg. The males only reach their maximum mean mass from (approximately) the age classes XI to XII i.e. from about seven years of age (Joubert, 1972). The average mass of adult males, older than four years, is 298 kg (n = 22). The average mass however, of the ten largest males older than seven years is 343,2 kg. The maximum mass recorded for a male was 371,9 kg.

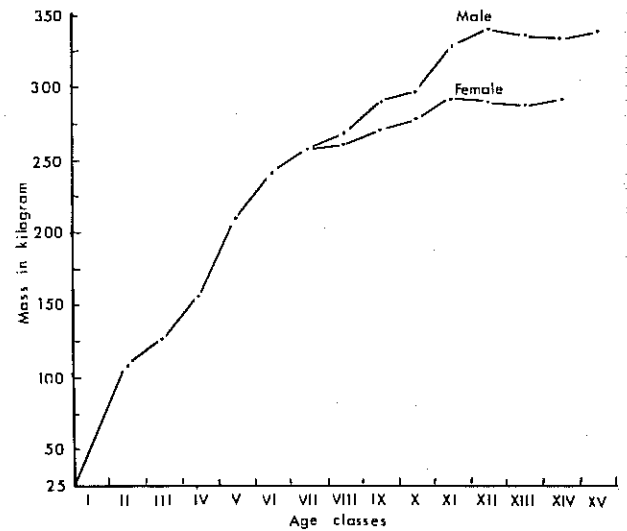


Figure 3. Postnatal mass gain in *Equus zebra hartmanniae*.

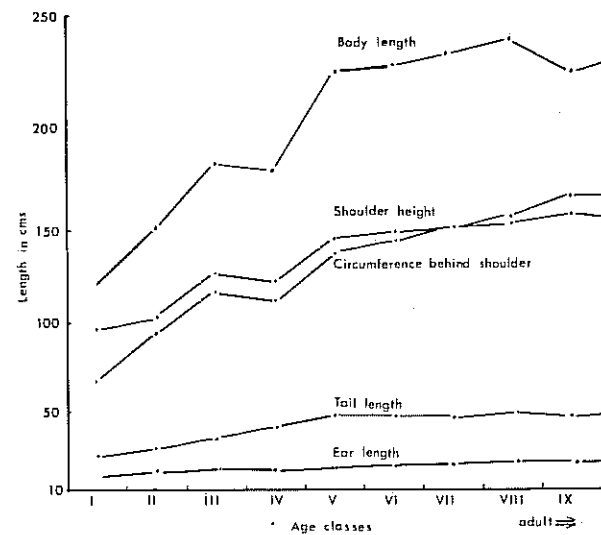


Figure 4. Growth in postnatal body dimensions of *Equus zebra hartmanniae*.

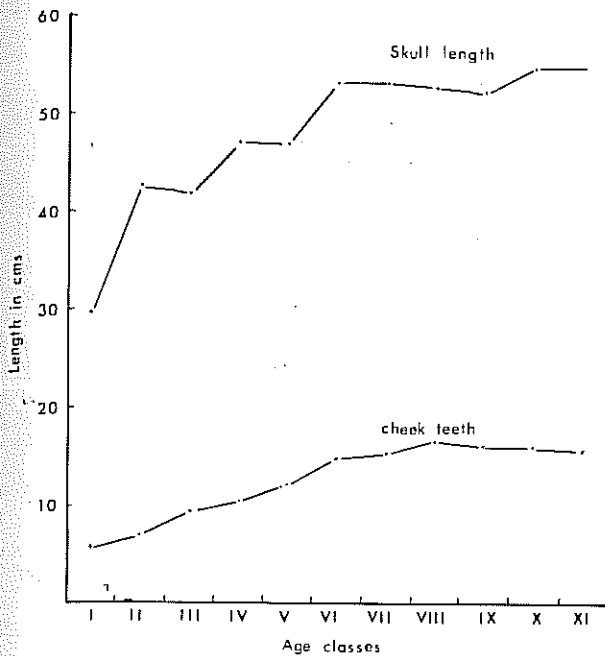


Figure 5. Growth of the skull and cheek teeth of *Equus zebra hartmannae*.

### 3.2 Body measurements and skeletal growth

Body measurements and growth are depicted in figures 4 and 5. No statistical meaningful differences in the growth rate of males and females could be determined. Even the actual differences in the maximum measurements were slight. As can be seen from figure 4 the tail and ears are the first extremities to reach their full length. In contrast to the mass gain the skeletal growth has been almost completed at age class VI — thus at 2½ years. The increase in

body measurements from here onwards is slight. As can be seen from figure 5 the same is true for the increase in skull length, as well as the length of both pre-molars and molars combined.

### IV ACKNOWLEDGEMENTS

I am extremely grateful for the hospitality and cooperation I received from the farmers of the Khomas Hochland. A special word of thanks is also due to Mr C. G. Coetzee for critically reading through the paper, Mr H. Böhme for preparing the figures and to my wife for typing the original manuscript.

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Table 1. Size and characteristics of the *Equus zebra Hartmannae* foetus during pregnancy.

Gestation period	Mass (kg)	Length (cm)	Remarks
1 month		± 2	The form of the young animal can just be made out.
2 months	± 0,027	5-7	Although still small, certain features viz. the head, body and legs are recognizable.
3 months	± 0,125	10-15	The reproductive organs are visible. The body is still transparent to a certain extent and the ribs can still be seen. The mouth can be opened and the tongue is fully developed.
4 months	± 1,0	15-23	Although the body is still naked, hairs can be seen on the upper and lower lips.
5 months	± 2,7	20-35	The nasal cavities and pinnae are formed.
6 months	± 3,6	35-60	Hairs on lips, nose, eyebrows and eyelashes.
7 months	± 4,5	40-70	Hairs on lips, nose, eyelids and tip of tail.
8 months	± 8,6	50-80	The mane starts to form.
9 months	± 13,6	60-90	Hair short and thin on body; darker and lighter bands discernible.
10 months	± 18,1	70-130	Mane and tail well-developed, complete coverage of hair on body. Hairs short.
11 months	± 21,6	76-140	Long woolly hair coverage over the body.

Table 2. Body measurements (cm) and mass (kg) of the 10 largest adult males older than seven years.

	Ear	Shoulder height	Body circ.	Body length	Tail	Front Fetlock joints	Circ. f. hoof	Hind Fetlock joints	Circ. hind hoof	Mass
	23,5	144,5	166,0	236,0	47,0	41,0	37,5	53,0	37,5	355
	23,0	142,5	154,0	224,0	55,0	43,0	39,5	52,0	39,5	350
	23,5	141,5	160,3	230,0	51,0	42,5	38,8	53,0	38,5	345
	24,0	148,0	172,0	248,0	49,0	42,0	39,0	55,0	39,5	386
	23,0	146,0	156,0	218,0	48,0	42,0	39,0	54,0	38,0	372
	22,4	145,5	157,0	226,5	50,0	44,5	37,5	52,5	37,5	331
	24,0	145,5	150,0	235,8	47,0	44,0	38,5	53,8	37,5	358
	23,5	149,5	152,5	244,5	48,3	37,6	35,5	54,5	37,2	322
	24,5	140,5	149,0	222,5	50,5	43,0	36,0	53,0	36,0	282
	22,2	142,0	163,0	235,2	49,3	44,0	37,3	49,5	38,5	331
n	10	11	11	11	11	11	11	11	11	11
Total	253,6	1445,5	1579,8	2320,5	495,1	423,6	378,6	530,3	379,5	3432
mean	23,4	144,5	157,9	232,0	49,5	42,3	37,8	53,0	37,9	343,2
range	2,5	9,0	23,0	30,0	8,0	6,4	4,0	5,5	3,5	104

Table 3. Body measurements (cm) and mass (kg) of the 10 largest Hartmann zebra females older than four years.

	Ear	Shoulder height	Body circ.	Body length	Tail	Front Fetlock joints	Circ. f. hoof	Hind Fetlock joints	Circ. hind hoof	Mass
	24,5	142,0	171,5	263,0	51,4	44,0	36,5	54,0		317
	23,5	135,0	148,0	243,0	48,5	44,5	37,8	52,2	36,8	322
	22,4	140,2	150,7	215,0	49,5	43,0	34,4	52,0	34,4	267
	23,5	143,5	150,5	214,0	46,0	42,0	32,9	55,5	33,0	285
	23,2	132,6	137,2	230,0	51,2	40,2	34,2	52,2	34,2	231
	22,0	141,2	142,0	242,0	49,7	42,5	36,5	52,5	36,3	276
	22,5	143,5	165,0	228,0	49,0	41,0	36,5	50,5	36,0	281
	22,8	146,5	152,4	226,0	50,1		36,1			285
	23,0	139,5	155,5	223,5	47,4	40,5	38,0	51,0	38,0	258
	23,4	146,5	145	230	50,3	43,0	38,3	50,5	37,3	267
n	10	10	10	10	10	9	10	9	8	10
Total	230,8	1410,5	1517,8	2314,5	493,1	380,7	361,2	468,4	286,0	279,8
mean	23,0	141,0	151,7	231,4	49,3	42,3	36,1	52,0	35,7	279,8
range	2,5	13,9	34,3	49,0	5,4	4,3	5,4	3,5	5,0	91

# The crowned race of reed cormorant *Phalacrocorax africanus coronatus* breeding underneath Walvis Bay guano platform, South West Africa

by

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## ABSTRACT

*P. a. coronatus* nests commonly underneath the Walvis Bay guano platform on Bird Rock, preferring the sheltered landward side. Breeding has been confirmed from December to April and probably takes place throughout the year. A total of 104 nests, of which 37 were occupied, existed in January 1973. Seventy-one chicks and 25 eggs were present (average clutch size 2.5). Seventeen half-grown chicks were ringed. Comparison is made between the nests and nesting sites of *P. a. coronatus* and *P. a. africanus*.

## I INTRODUCTION

*Phalacrocorax africanus coronatus* (Wahlberg) is classified by McLachlan and Liversidge (1970) as a local race of the Reed Cormorant *P. a. africanus* (Gmelin) although they mention that it forms a separate species in Roberts' original work. Rand (1960) considers the race's range to be limited to the coastline from Benguella on the West Coast to East London on the Cape Coast. Winterbottom (1971) considers *P. a. coronatus* to occur commonly along the South West African coast between the Orange River Mouth and Swakopmund.

The literature refers only briefly to breeding on the S.W.A. coastal islands of Ichaboe and Sinclair (Anon 1959, Moreau 1950, Rand 1949, 1963) although this race is known to have bred at the Walvis Bay guano platform since 1944 (Groenewald pers. comm.). Rand (1952) observed adults in breeding plumage at Walvis Bay during July and I have seen courtship displays at the nests in September. There is also a note by Hewitt (1934) concerning specimens of the Reed Cormorant *P. a. africanus* taken at Swakopmund and Walvis Bay but the date is prior to the recognition of *coronatus* as a distinct race. During January 1973 I was able to ring chicks and gather information about the race's breeding underneath the guano platform.

## II NESTING SITE, NESTS AND ACCESS

The situation and construction of Walvis Bay guano platform has been described by Rand (1952). All nests of *P. a. coronatus* are built underneath the platform, amongst the secondary struts and beams of the main supports (Plates 1 and 2). A nesting site of *P. a. africanus* comparable to this is mentioned by Benson (1946) quoting B. L. Mitchell who found that race's nests on girders under a railway bridge which crossed a dam. At the Walvis Bay platform a total of 47 supports held nests. The nests are arranged singly and in clusters of two to six amongst the supports at a height of 2.0-2.5 m above the natural rock base of the plat-

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form. At high water ordinary spring tide the nest cups would be about 1 m above the level of the sea. The nests are built mainly with sticks and dried seaweed whilst scraps of rope, wire and plastic sheeting are interwoven into the structure. The lining consists of feathers and bits of fishing line. They have obviously been added to and re-used for many seasons because some nest structures attain a height of 50 cm and addled eggs are lodged in the lower parts. The inside diameter of the nest-cup is about 12 cm and it is shallow (depth 2-3 cm). Records of *P. a. coronatus* and *P. a. africanus* nests at the Percy FitzPatrick Institute of African Ornithology, Cape Town, are brief. MacLeod *et al.* (1951) say that *P. a. coronatus* nests were "huilt entirely of dry sticks". *P. a. africanus* nests are described by Gray (1945) as "platforms of thin sticks, reed and water weed", while Patten (1952) says they are "made of twigs cemented together with the excreta of several broods of young". He adds: "These were the dirtiest nests in the heronry, and looked as if they were about to disintegrate, but were, in reality, very firm and strong".

At Walvis Bay the entire colony of *P. a. coronatus* shows a definite preference for the eastern (landward) side of the platform. All nests occupy the first four rows of struts on this side (mostly the second row) and not further towards the centre where it becomes quite dark underneath the platform. The reason for the nests being located to one side is probably to avoid exposure to the prevailing south-westerly winds. The windward side may also present difficulties in landing and taking off. The preferred landward side is in an area of calmer water because the platform's western side stands on the edge of the rock formation and in a heavy swell its underneath receives spray from the waves.

The best time to visit the colony is during the annual guano harvest in January/February when two cables are rigged between the mainland and the platform for transport purposes. Access to the nests is limited to low water, preferably during a spring tide, as the entire rock base of the platform is flooded by the incoming tide. I found it necessary to carry a light-weight, 2-m ladder to reach the nest cup.

### III NEST CONTENTS

During my visit in January a total of 104 nests existed with 37 occupied. Twenty-five eggs were present in nine nests (clutch size 2-4, average 2.5). Three eggs from different nests had the following measurements (mm): 44,0 × 31,0; 45,7 × 31,4; 46,0 × 31,2. MacLeod *et al.* (1951) give a clutch size of 2-3 eggs in a *P. a. coronatus* breeding colony in the Cape Province. Two eggs measured by them were 46,8 × 30,4 and 47,0 × 30,1 mm. At Walvis Bay there were 71 chicks in 28 nests (2-4 per nest, average 2), ranging from newly hatched to fledging. No published description of the chicks of either *P. a. coronatus* or *P. a. africanus* could be traced at the Percy FitzPatrick Institute (Rowan, *in litt.*) although Bow-

maker (1963) describes the immatures of the latter species.

*P. a. coronatus* chicks are naked, dark pink to red when newly hatched, the skin soon turning to dull black. Older chicks are covered with black down (Plate 3) except for the crown of the head which is light yellow. The bare skin of the throat next to the mandible is reddish on either side and speckled with yellow and black underneath. The legs are shiny black and the feet have sharp, hooked claws. Younger chicks remain within the nest cup, but once the wing feathers have broken through their shafts the chicks become very agile and claw their way along the beams, making it difficult to reach them. Chicks approaching the flying stage dive off the supports into the water when pursued and can swim strongly. Their head-colouring makes them easy to distinguish from the chicks of the Cape Cormorant *P. capensis* which are uniformly greyish-black around the head.

### IV RINGING

To catch chicks of *P. a. coronatus* a circular loop (diameter 1 m) was attached to a metre-long pole. The loop was loosely covered with 75 mm nylon mesh taken from a bird net. It formed a holding cup so that chicks could be caught if they fell from the nests. During the first visit 10 half-grown chicks were banded with 12,5 mm monel rings which were slightly overlapped. Subsequently 8,0 and 11,5 mm rings were tried but the former size is too small. A further seven half-grown chicks were banded with 11,5 mm rings, flattened to the shape of the tarsus. It seems inadvisable to band the older, more mobile chicks as they invariably fall from the nest and cannot regain the supports under the platform.

### V CONCLUSIONS

*P. a. coronatus* is small in number compared to the main inhabitant of the guano platform, *P. capensis*, but has established a viable breeding colony. The total number of adults present appears to be between 100-150. No Crowned Cormorant nests were found on the exposed, upper surface of the platform and the race apparently also roosts only among the sheltering supports. For these reasons *P. a. coronatus* probably has no role as a guano-producing species on the Walvis Bay platform.

### VI ACKNOWLEDGEMENTS

I thank Mr A. Groenewald of the Atlantic Guano Syndicate (Pty) Ltd. for permission to visit the platform and for providing transport for this purpose and general information.

Mrs M. K. Rowan of the Percy FitzPatrick Institute of African Ornithology kindly checked existing records of nests and chicks of the Crowned Cormorant and related forms.

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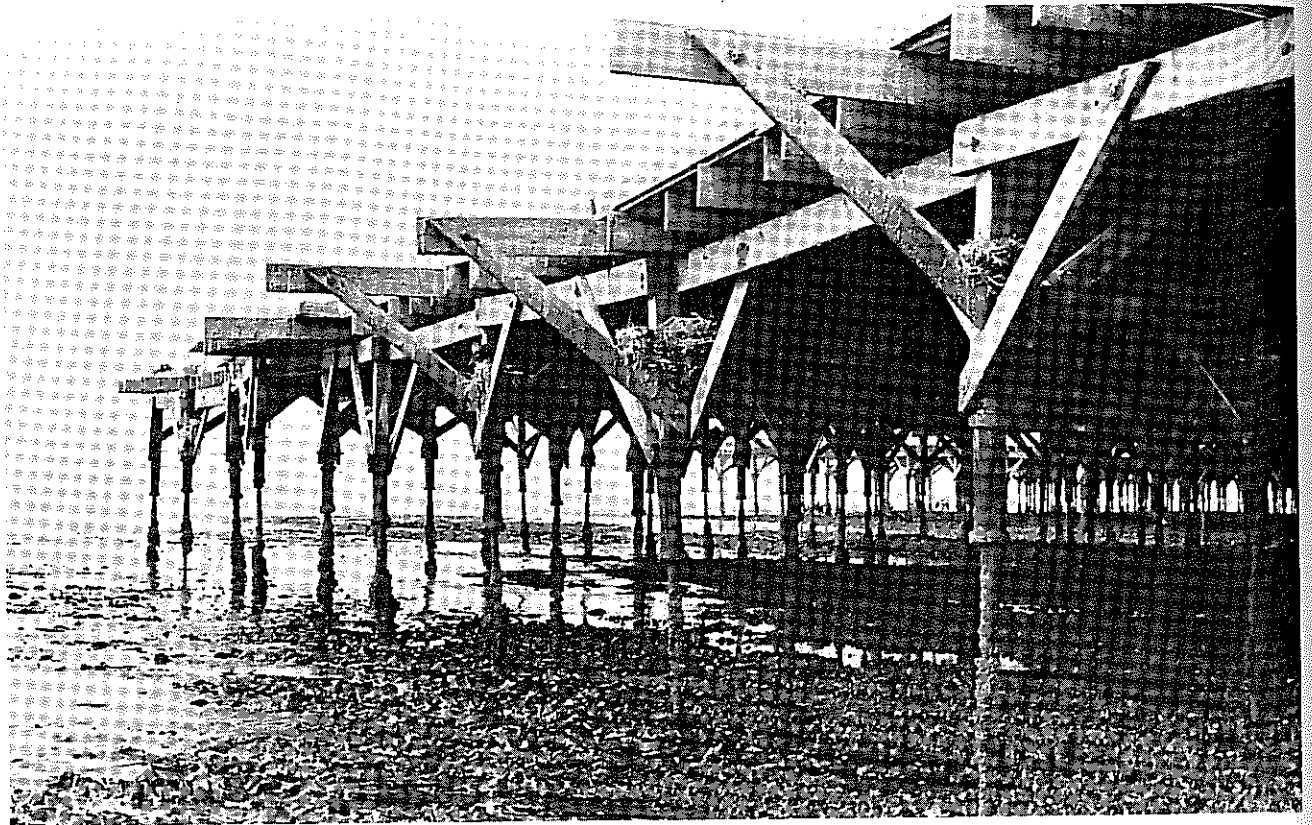


Plate 1. View of the eastern edge of the Walvis Bay guano platform at low spring tide. Nests of the Crowned Cormorant are clustered among the struts.



Plate 2. A Crowned Cormorant at the nest with its chick.

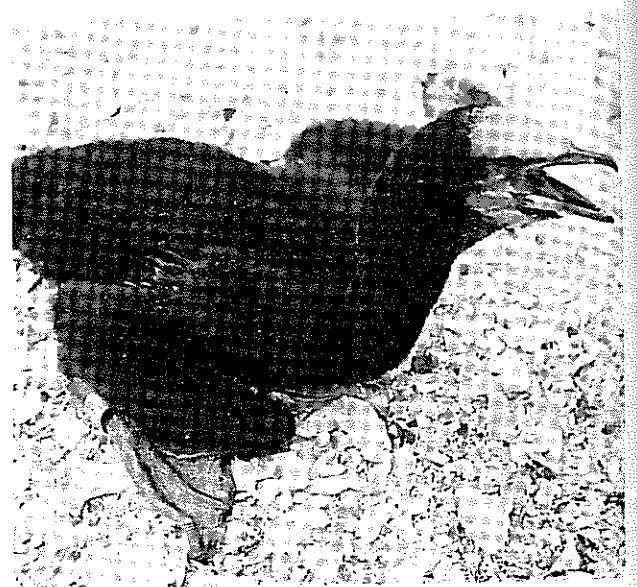


Plate 3. At this stage of growth the Crowned Cormorant chick is not quite mobile, which makes it suitable for ringing.



# Egg temperature and incubation behaviour of the ostrich

by

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## ABSTRACT

The paper reports on aspects of the physiology and behaviour of incubation in the Ostrich *Struthio camelus*. Temperatures of eggs, nest and ambient, in relation to the parent birds' incubation rhythms, and provisional estimates of the cost of energy and water to the incubating bird point up functional features of the division of labour between the parents.

## I INTRODUCTION

Large birds can inhabit warm areas only by adaptations to increase capacity for heat loss in relation to heat production (Kendeigh 1972). The Ostrich *Struthio camelus*, in addition to being the world's largest living bird, is a successful inhabitant of hot, arid country, including true deserts. Many animals living in deserts are able to do so only because of their ability to escape to protective microclimates. This strategy is denied the Ostrich — it is of too large a size.

The Ostrich employs a number of physiological adaptations in overcoming its thermoregulatory problems (Cloudsley-Thompson and El Mohamed 1967, Crawford and Schmidt-Nielsen 1967, Louw, Belonje and Coetzee 1969, Louw 1972). Significantly, these physiological mechanisms, enhanced by behavioural strategies, operate to save water; and it is clear that conservation of water is crucial to the bird's ability to survive in deserts. Ostriches are highly adaptable in responding to unpredictable local environmental conditions, and, in the desert, have been recorded breeding at all times of the year (Sauer and Sauer 1966). When sitting on their nests, Ostriches are isolated from water-holes and are directly exposed to cycling extremes in ambient temperature, wind and solar radiation.

There is little published information on the functional significance of the Ostrich's incubation performance, as an extension of its adaptations to successful desert survival. This paper presents data on aspects of the physiology and behaviour of incubation in the Ostrich.

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## II METHODS

A blind was used to observe undisturbed feral Ostriches in the Mossel Bay district, South Africa. Following Drent's (1970) method, ambient, nest-air and egg temperatures were measured continuously by means of thermistor probes and telemetry during 24-hour watches on one pair of incubating birds. The air cell of one egg in a clutch of 10 was implanted with a thermistor probe. The tip of the probe rested against the inner cell membrane. The hole in the egg was sealed with epoxy resin. Temperatures were recorded at five-minute intervals. Cooling rates of eggs were measured in accordance with the procedure and precautions advocated by Kendeigh (1973).

III RESULTS

3.1 Incubation rhythm

It has long been known that the male Ostrich tends the eggs and incubates at night, whereas the female is on the nest during the day (le Vaillant 1790). However, the shares of the sexes are not equal. Normally, in undisturbed steady incubation, each monogamous parent takes one complete shift, which is an unbroken sitting spell, every 24 hours. During a continuous 24-hour watch on one nest the male's sitting spell amounted to 14,75 hours and that of the female 9,25 hours. Thus, in this case, the male tended the eggs for about 61 per cent of the 24-hour period. Normally, the male relieves the female at the nest in the late afternoon and sits through the night until well after sunrise. Times of morning and afternoon change-overs, expressed respectively in hours after and before times of local sunrise and sunset, were recorded as 2,1 and 2,0 hours after sunrise, and 2,5, 2,5 and 2,7 hours before sunset. Change-overs took place quickly, and the eggs were uncovered for no more than a few minutes.

Aside from moving their necks and heads, it is remarkable how little the parents change position when on the nest. It appears as if the eggs are shifted relatively seldom. An undisturbed male observed incubating for 10 hours did not change position on the nest, nor did he attempt to shift the eggs. A female was observed to change position once in 10 hours of undisturbed incubation, and once, just before change-over, to use her beak in attempting to shift the eggs. According to Sauer and Sauer (1966) the parents turn and displace the eggs daily once steady incubation has started.

3.2 Nest-air and egg temperatures

The data are summarised in Table 1, and derive from a nest that contained 10 eggs which the parents had been incubating steadily for seven days (i.e., seven days after completion of laying). Under equilibrium conditions of undisturbed steady incubation, the temperature values reported here for Ostrich eggs fall within the range of temperatures at which avian eggs are held normally during incubation (cf. Drent 1973). It is remarkable how constant are the temperature regimes of the eggs and nest; and this is an expression of the parents' high degree of attentiveness, relatively stable body-temperature (see Bligh and Hartley 1965, Crawford and Schmidt-Nielsen 1967), relative lack of movement on the nest and

Table 1. Average egg, nest-air and ambient temperatures during natural incubation in the Ostrich.

Parent	Per cent attentiveness	Temperatures °C						No. records
		Egg		Nest-air		Ambient		
		mean	S.D.	mean	S.D.	mean	S.D.	
Male	100	33,85	0,48	31,88	0,25	19,48	2,33	177
Female	100	36,07	0,88	31,55	0,13	25,19	1,97	111

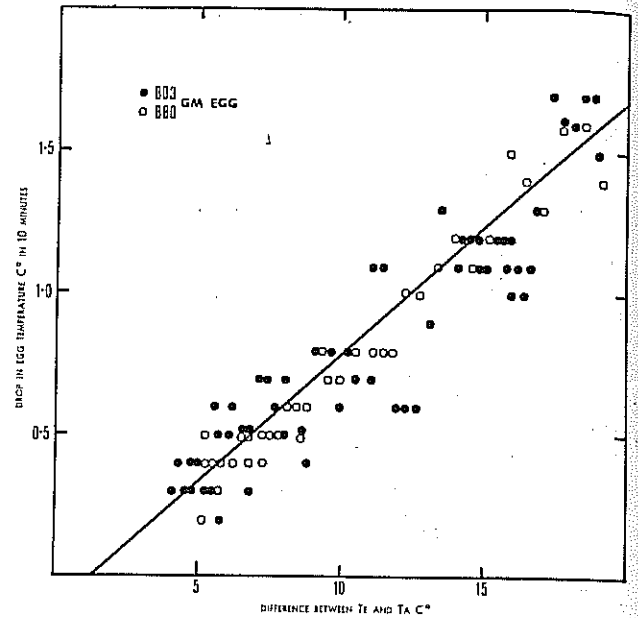


Figure 1. Relationship between fall in egg temperature and difference between egg and ambient temperature in the Ostrich.

shifting of the eggs, and the relatively slow rate at which the large eggs lose and gain heat.

The laboratory determined cooling rates of two fresh (unincubated) eggs weighing 880,6 and 803,0 g are shown in Figure 1; a cooling rate of 0,55°C/°C/h was calculated from the combined data. This figure agrees well with the expected constant extrapolated from known cooling constants for eggs of other species (Drent in prep.).

During a more or less constant ambient temperature of 25°C, an Ostrich egg, stationary in the centre of a 10-egg clutch, cooled at the rate of 2,27°C/h and gained heat at 0,94°C/h during a total period of two hours, involving the absence and presence of a parent with concomitant egg temperature changes of 1,4°C between 32,0° and 35,4°C.

3.3 Energy cost of incubation

The parameters set out below for the Ostrich have been applied to Kendeigh's (1963) equation for the calculation of the energy cost of incubation.

- $n$  = no. eggs in clutch = 10
- $w$  = mean weight of eggs = 1 000 g
- $h$  = specific heat of egg = 0,80 g—cal/°C
- $b$  = cooling rate of eggs = 0,5°C/°C/h
- $t_e$  = egg temp. maintained in nest = 35,9°C (male) = 36,1°C (female)
- $t_{na}$  = nest-air temp. surrounding eggs = 31,9°C (male) = 31,6°C (female)
- $i$  = interval in hours = 14,75 (male) = 9,25 (female)
- $c$  = % total surface egg covered by parent = 30%
- $a$  = % of time interval parent sitting on eggs = 100%

$$k \text{ cal/bird-day} = \frac{n \cdot w \cdot h \cdot b \cdot (t_e - t_{na}) \cdot i \cdot (1 - c \cdot a)}{1000}$$

On this basis, the male Ostrich parent expends 165.2 k cal/bird-day, whereas the cost to the female is 116.6 k cal/bird-day. Hence, the female saves about nine per cent of the energy she would have to expend if the energy cost were to be equally divided between the parents.

#### IV DISCUSSION

The data reported here derive from feral, monogamous Ostriches living in a relatively serene environment. Nevertheless, they are indicative of aspects of the functional significance of the Ostrich's incubation performance, as an extension of its adaptations to successful survival in hot and arid country.

Desert nights generally are cool (because of radiational loss to space), and heat flow from the incubating parent to and through the eggs is relatively high. In the Ostrich the male is responsible for this extra-energy demanding phase of incubation. Production of the clutch (approximately 10% of the Ostrich's body weight) must tax the female's energy reserves, and presumably any energy saved after that could promote quicker production of a subsequent clutch should the first one be lost. This may be important in the desert where conditions favourable for breeding occur erratically and are short-lived.

Data on productive energy (= maximum energy available minus energy required to sustain essential body processes) are not available for the Ostrich. Thus it is not possible, at this stage, to estimate the proportion of productive energy devoted to incubation. However, productive energy is related to body weight, as is basal metabolism. Crawford and Schmidt-Nielsen (1967) obtained a figure of 2 350 k cal/day for basal metabolism in a 100 kg Ostrich. This value is considerably in excess of one predicted from body size, and it is probable that 1 800 k cal/day is more realistic (see Crawford and Schmidt-Nielsen *op.cit.*). On this basis, the fractions of the parents' energy for basal metabolism devoted to incubation amount to nine and six per cent in the male and female respectively. These proportions are relatively low when measured against comparable values for a number of smaller birds (see Lasiewski and Dawson 1967, Drent 1973). The main conclusion here is that the daily energetic cost of incubation is relatively low in the Ostrich, though points to be considered are: (a) the long incubation period of 42 days, and (b) the demands of relatively low ambient temperatures typical of the desert night. Under natural conditions, birds' eggs exposed upon departure of the parent lose heat faster than their rate of heating when the parents return (Drent 1973). Ostrich eggs are no exception to this. Clearly, therefore, during relatively cool ambient temperature constant attentiveness would be advantageous in saving the Ostrich energy in addition to functioning as an anti-predator strategy.

Although the Ostrich can store large amounts of subcutaneous fat during a relatively short period

when on a high nutritional plane, it cannot store water and efficient economical use of water is crucial to the species' survival in the desert (Louw, *et al* 1969). Nesting Ostriches are often isolated and cannot visit water-holes (Sauer and Sauer 1966). By relieving the female well before sunset and by remaining on the nest until well after sunrise, the male, in addition to spending most time on the nest, permits the female two foraging spells, one during early morning and one during evening — Ostriches locate their food by sight. Louw (1972) has pointed up the importance of condensing fog and the comparatively high relative humidity of the air at night in the Namib desert, and their effects on the feeding habits of Ostriches. When grazing in the early hours of the morning the Ostriches favoured those grasses which had a high moisture content (the moisture content of these grasses had dropped by about 20 per cent at noon); direct intake of moisture, deposited as condensing fog or dew, would also have been high during the early hours of morning. The Ostrich's parental rhythm of incubation appears to be adapted to permitting the female to exploit the relatively greater availability of moisture present during early morning in hot and arid country.

Louw *et al* (1969) have demonstrated that convective and radiant cooling, through feather erection and wing drooping, is important to the Ostrich, especially in respect of water-saving. According to these authors only as a last resort, when the ambient temperature approaches 34°C, and when there is no wind, will the birds employ evaporative cooling by increasing the rate of respiration.

Crawford and Schmidt-Nielsen (1967) estimated that the critical threshold for change in respiratory rate was 25°C. Louw *et al* (*op.cit.*) pointed out that this figure (25°C) was obtained for birds kept in an artificially heated room where apparently opportunity for convective cooling was minimal. A somewhat similar condition applies to an incubating Ostrich: the bird's body is close to the ground, where wind effect is minimal, solar effect maximal and postural and ptilomotor constraints militate against efficient exposure of large areas of bare skin. We have recorded the high respiratory rate (45/min, see Crawford and Schmidt-Nielsen 1967) in females incubating in full sunlight, under still air conditions and ambient temperature at 25°C. During moderate ambient temperatures of this magnitude females have been observed to occasionally leave the care of warming the eggs to the sun, while standing guard nearby and employing convective cooling behaviour. During the night, early morning and evening, when ambient temperatures are relatively low, in the sitting male water loss due to pulmocutaneous evaporation should be minimal.

We have found very obviously heat-stressed parents sitting on their nests when surface soil temperature was greater than 55°C and air temperature 49°C at 50 cm above ground level. At these temperatures it is the heat flow from the environment to the eggs that is important, and it is necessary for the parent to sit closely to withdraw heat from the eggs. Under these conditions, we have observed a male to take over egg-tending duties in the middle of the day; the

female moved to the shade of a nearby thorn bush (*Acacia karroo*) and took up a posture designed to maximise convective and radiant cooling. After 15 minutes her respiration decreased to the normal low rate. The frequency and extent of this deviation from the usual parental rhythm of incubation are not known, but the adjustment appears functionally significant resulting in a saving of water to the female. Crawford and Schmidt-Nielsen (1967) have shown that at an ambient temperature of 45°C the Ostrich dissipates by respiratory evaporation about 100 per cent of its metabolic heat production, and in the process of doing so loses water at the high rate of 4.5 g per minute.

In conclusion, the Ostrich's incubation regime appears to be flexible and functionally well adapted to relatively severe demands caused by limited availability of water and energy, generally imposed by the desert environment. Many of the details attending the species' physiological and behavioural adaptations for successful incubation, however, remain to be worked out. While there obviously is cooperation between the members of a breeding unit, there must be also competition between the interests and investments of males and females (see Trivers 1972). For instance, very little is known about incubation in polygynous breeding Ostriches. Polygyny is common in the Ostrich, and as many as five females can lay in one nest. According to Sauer and Sauer (1966) polygynous Ostrich parents may actively help to synchronize the time of hatching of the brood through separating the eggs with the most advanced embryos; these eggs are rolled into especially dug pits surrounding the edge of the nest. Further field observations and experiments are needed to identify the relationships between egg and ambient temperatures and other cues that influence parental behaviour in incubating Ostriches.

#### V ACKNOWLEDGEMENTS

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# Broad-billed Sandpiper *Limicola falcinellus* in South West Africa

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## ABSTRACT

A number of records of *Limicola falcinellus* (Pontopp.) are reported from the South West African coast. The first records date from November 1964. Two specimens have been collected, both apparently of the nominate race from northern Europe. Mensural data are given, and identification, habitat, habits and moult in winter quarters are discussed.

## I OCCURRENCE

The Broad-billed Sandpiper *Limicola falcinellus* (Pontoppidan) is an enigmatic species breeding in the extreme northern Palaearctic Region and migrating south to largely unknown wintering grounds presumed to lie mainly in Asia Minor and northern Africa (Gooders 1969). It was first recorded in the Southern African Sub-region by H. von Schwind (pers. comm.) and colleagues in November 1964 at the Swakopmund sewage ponds on the South West African coast (22°38'S 14°32'E). One of us (P.B.) subsequently observed and photographed several examples in the Swakopmund area during the same summer, and collected one of these on 2 January 1965. This specimen appeared then to be in full winter plumage. Its race was not determined, and it has been deposited at the Landesmuseum Hannover, West Germany.

These records were accepted by Winterbottom (1971) but not by Clancey (1969) who apparently misunderstood the supporting evidence.

J. Bierberg (*in litt.*) reported a sighting at Swakopmund on 6 February 1966, but no others were observed until 1973, when R.J. saw a Broad-billed Sandpiper on 2 January, in winter plumage, at Swakopmund Salt Works evaporation pans 15 km north of the town. Shortly thereafter, H.B. mist-netted a specimen on 26 January at night, at Sandwich Harbour 72 km south of Swakopmund. This bird was photographed, preserved and sent to P. A. Clancey for confirmation and racial determination. Clancey (*in litt.*) found that the bird was apparently in "first winter dress, with traces of juvenal plumage still present". Furthermore, although comparative material was not available, he considered it to be probably nominate *falcinellus* (the western race) on the basis of measurements and plumage colour. This specimen is now in the State Museum, Windhoek.

Yet another example, in almost full breeding plumage, was observed on 28 September 1973 at a well-vegetated small pool at Swakopmund sewage works. This bird was seen and photographed by about 10 members of an ornithological symposium excursion, including Messrs P. G. H. Frost, P. F. Woodall, Prof. D. A. Zimmerman and the two junior authors.

Details of measurements and moult for the above two specimens appear in Tables 1 and 2. These specimens and sight records are the only ones of which we are aware from southern Africa, except for a

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very recent specimen collected in Rhodesia by A. J. Tree (in press). The specimens are apparently all first-year birds (see Section V), a situation not unexpected since immatures of many Palaearctic migrants have a greater tendency to "overshoot" on the southward migration than adults (e.g. Steppe Eagle *Aquila nipalensis*, vide Brooke *et al.* 1972).

## II IDENTIFICATION

The Broad-billed Sandpiper does not appear to have been illustrated in its full winter dress previously, and indeed many descriptions of this dress are inadequate (e.g. Bruun and Singer 1970). Plates 1-6 illustrate most of the identifying features adequately. The broad superciliary stripe is a conspicuous character, but the smaller upper fork of this mark, conspicuous in breeding dress, may often be quite indistinct in full winter plumage (Plates 1, 3). This species is then most likely to be confused with the Dunlin *Calidris alpina* which has a similar tail pattern, and is also a grey and white bird in winter dress. However, the Dunlin has a relatively shorter, more smoothly, slightly decurved bill while the

Broad-billed Sandpiper's is mostly straight, longer, and decurved only near the tip ("kinked"). The latter bird is slightly smaller and has shorter legs. A further good distinguishing feature in non-breeding dress is a dark carpal (shoulder) patch in the Broad-billed Sandpiper, rather like that of a Sanderling *Calidris alba*. The winter dress of *Limicola* is greyer than in Curlew Sandpipers *Calidris ferruginea* or Little Stints *C. minuta* with which they may associate. Breast marking is also more distinct in *Limicola*.

In breeding dress the blackish back and rump form a conspicuous flight pattern character.

## III HABITAT AND HABITS

The Broad-billed Sandpiper is said to be tame but secretive and to frequent well-vegetated waters both in summer (Gooders 1969, Peterson *et al.* 1966) and winter (Etchécopar and Hùe 1967). These facts coupled with its resemblance to other small sandpipers may have caused it to be overlooked in southern Africa in the past. Our own observations and

Table 1. Measurements of *Limicola falcinellus* from S.W.A.

Date	Sex	Total Length	Weight	Wing	Tail	Culmen	Tarsus
2/1/65	♂	177mm	37,5g	106mm	38mm	29,9mm	22,5mm
26/1/73	♂	167	26.0	106	39	30,8	21,0

Soft part colours: Legs: Olive, darker joints;  
Bill: Dark brown to black; olive or olive-yellow base to mandible;  
Iris: Dark brown.

Table 2. Moults of *Limicola falcinellus* from S.W.A.

Date	Primaries*	Secondaries*	Tail		Body	Neck-Head
			Left	Right		
2/1/65	Old	12 sheath, 13-14 new on both wings. Gr. Coverts moulting, left more advanced; descendant. Lesser & Marginal Coverts old.	1,6 growing, 2-5 old.	2,6 growing 1,3-5 old.	Scapulars new, dorsal and ventral contour feathers mostly new.	No moult, mostly new (winter dress)
26/1/73	1-6 new, 7 almost complete, 8 sheath, 9-10 old (both wings)	All new secondaries. Gr. Coverts new, Lesser Coverts moulting, Marginals old.	Appears all new		Few old (juv.) feathers; rump and lower back mostly old.	Mostly new (winter dress)

\* Ascendant numbering for secondaries, descendant for primaries (i.e. from carpals)

those of von Schwind (pers. comm.) indicate that the species utilizes a rather wide range of habitat in South West Africa, and may often mix with other small waders, both its own and other species. The 1964-5 birds were observed on the beach at Swakopmund (at that time the bay had become a lagoon through formation of a sandspit), at a filtering tank and vegetation-fringed ponds at the sewage works, and on brackish pools in the Swakop River bed about 6 km from the coast. Some birds were seen to commute between beach and sewage works, about 4 km apart.

Sometimes the species was observed in company with Curlew Sandpipers and Little Stints, as was the case with the 1975 sightings. Other individuals were alone. One bird observed in 1964-5 had a definite feeding territory along the beach, which it defended in interspecific encounters. Further notes appear in Becker (1974).

According to Gooders (1969) the Broad-billed Sandpiper feeds mainly on small molluscs in the non-breeding season (but cf. Tree, in press). The September 1975 bird at Swakopmund was observed probing rapidly in a mud ridge just above the waterline.

Contrary to statements in the literature, we did not find this species to be exceptionally tame, although some individuals allowed close approach in a vehicle.

#### IV MOULT

Moult patterns of the two specimens are not dissimilar, taking the time differential into account (Table 2). Tree (*in litt.*) informed us that his bird, also a first-year male, was not in moult when collected on 5 November. It would appear, therefore, that all three known specimens from Southern Africa are first-year birds, and that, as in other migrant sandpipers, this age class moults rather late.

The birds are already much duller in November with more washed-out markings, than is the case with the August passage birds in Europe. Birds observed by P.B. in November at Swakopmund rapidly assumed the pale grey dorsal colour of full winter dress. The specimen collected on 2 January 1965 was first observed on 12 November 1964, at which time it fitted the above description of November birds. On 22 November a second bird was seen on the beach, at which time the first bird appeared considerably paler than the new arrival, due to its more advanced contour-feather moult. An age-difference is possibly indicated here, since in at least some long-distance migrants of the Scolopacidae, adults begin their moult one or two months earlier than juveniles.

By the end of December 1964, the first bird appeared to be in full winter dress, almost Sanderling-like in its paleness.

#### V PARASITES

Ectoparasites were collected from the 1975 specimen by H.B., and identified by Dr T. R. Clay of the British Museum (Natural History). They comprised three Mallophaga, a female probably of *Actornithophilus umbrinus* (Burmeister 1938) from the Menoponidae, and two Philopteridae, viz. *Carduiceps* sp. (one female only) and *Lunaceps falcinellus* Timmermann 1954. Only the last-named has been previously recorded on this host (Clay, *in litt.*).

#### VI ACKNOWLEDGEMENTS

We are most grateful to: P. A. Clancey, Director of the Durban Museum for checking a specimen for us and drawing our attention to Tree's record; J. E. W. Dixon for preparing a study skin; A. J. Tree and H. von Schwind for valuable information on their respective records, and R. Liversidge for commenting on the manuscript. Dr Theresa Clay kindly identified the parasites, which were referred to her by J. A. Ledger of the S.A. Institute for Medical Research.

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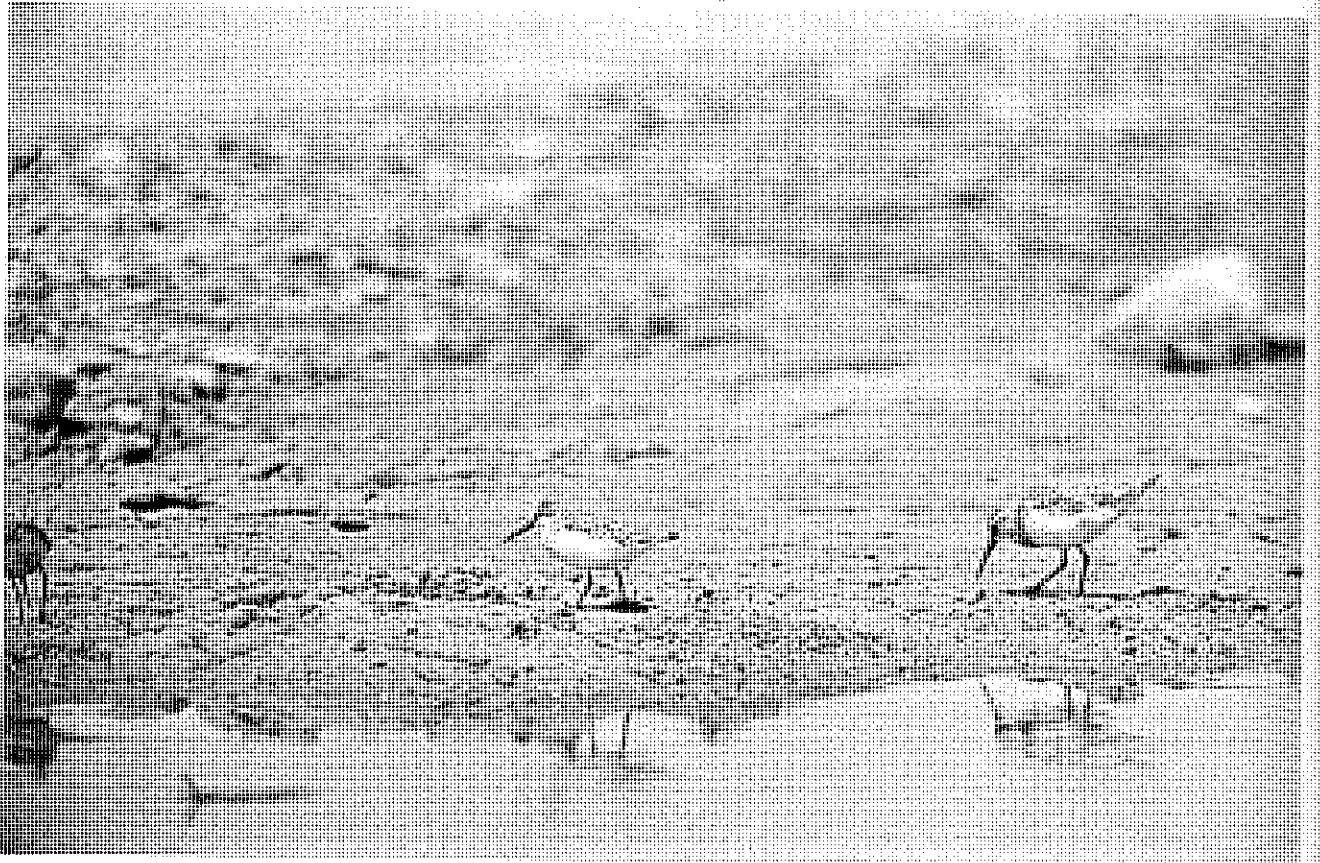


Plate 1. Broad-billed Sandpiper in non-breeding plumage, with Curlew Sandpiper on right, Southport (Jan. 1963). (Photo by P. Becker.)

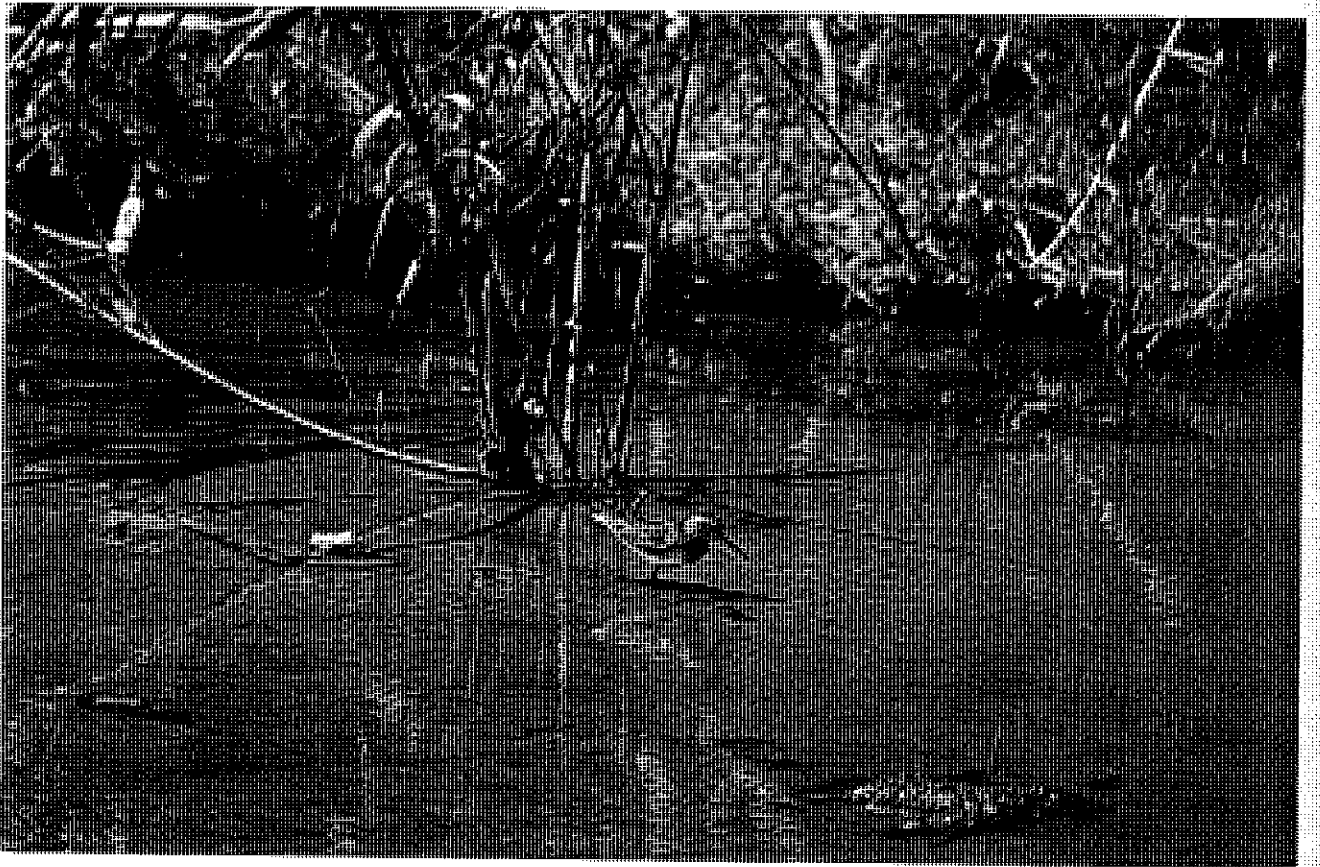


Plate 2. Broad-billed Sandpiper in breeding plumage, Southport (Sept. 1973). (Photo by H. A. C. Jensen.)



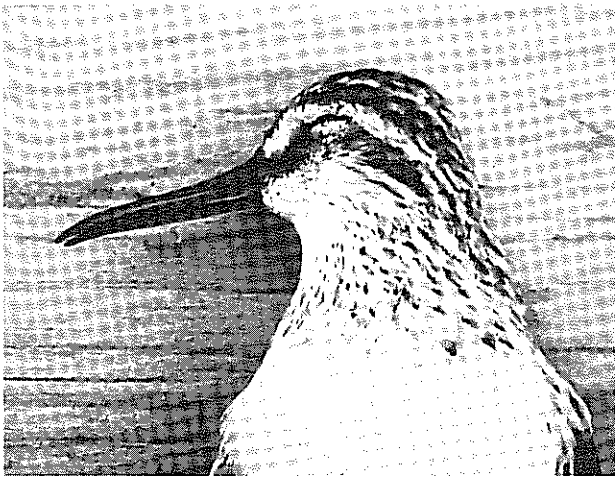


Plate 3. Head of Swakopmund specimen of *Limicola falcinellus*. Note "eyebrow" and breast markings as well as distinctive bill. (Photo by P. Becker.)

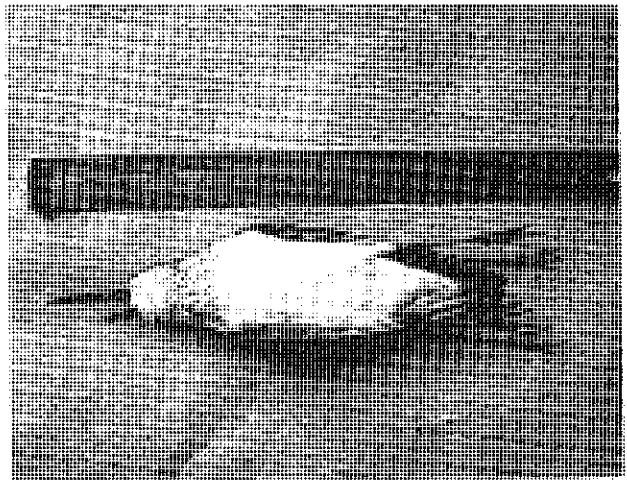


Plate 4. Ventral view of Sandwich Harbour specimen of *L. falcinellus*. (Photo by H. H. Berry.)

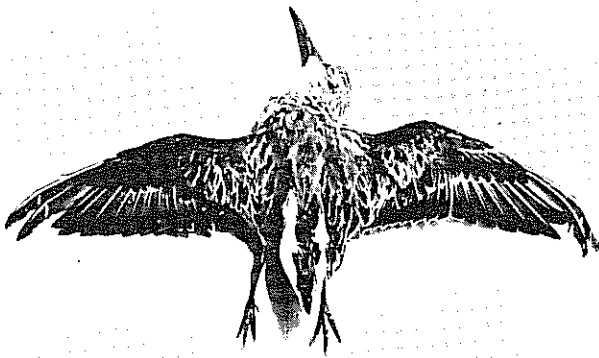


Plate 5. Dorsal view of Sandwich Harbour specimen of *L. falcinellus*, note dark rump and tail center. (Photo by H. H. Berry.)

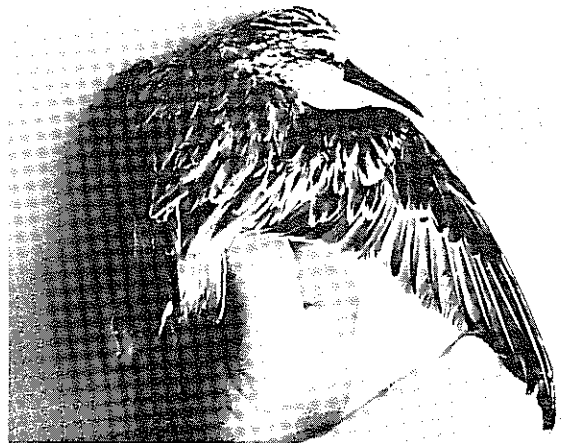


Plate 6. Another dorsal view of Sandwich Harbour specimen, note head markings. (Photo by H. H. Berry.)



## SHORT NOTE

### A "thornless" *Aloe hereroensis*

by

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It is a well-known fact that in some cases the thorns or teeth on Aloe leaves are absent. This feature is, however, quite rare since only the three Aloe species *A. karasbergensis*, *A. striata* and *A. reynoldsii* of all the Southern Africa species display this characteristic.

Thornless plants were, however, recently "discovered" in South West Africa. Upon closer investigation these plants proved to be *A. hereroensis*, but with the one difference that there were no signs of any thorns at the leaf edges. When cutting off the leaves very near the base, however, small rudimentary signs of the original thorns were found.

When first seen by the author the plant was flowering in a garden and it displayed the typical branched inflorescence of *A. hereroensis*. The possibility of cross-breeding was, however, not excluded and it was necessary to find the species in its natural habitat. Such a specimen was found, as well as an intermediate one. The latter species differed from both the ordinary as well as the "thornless" species in that most of its leaves had thorns along its entire length, although some of the leaves only had thorns near the base while the distal part was completely thornless.

The possibility of cross-breeding was ruled out since the only other species found in that vicinity was the well-known *A. littoralis*, the leaves of which are thoroughly armed with thorns.

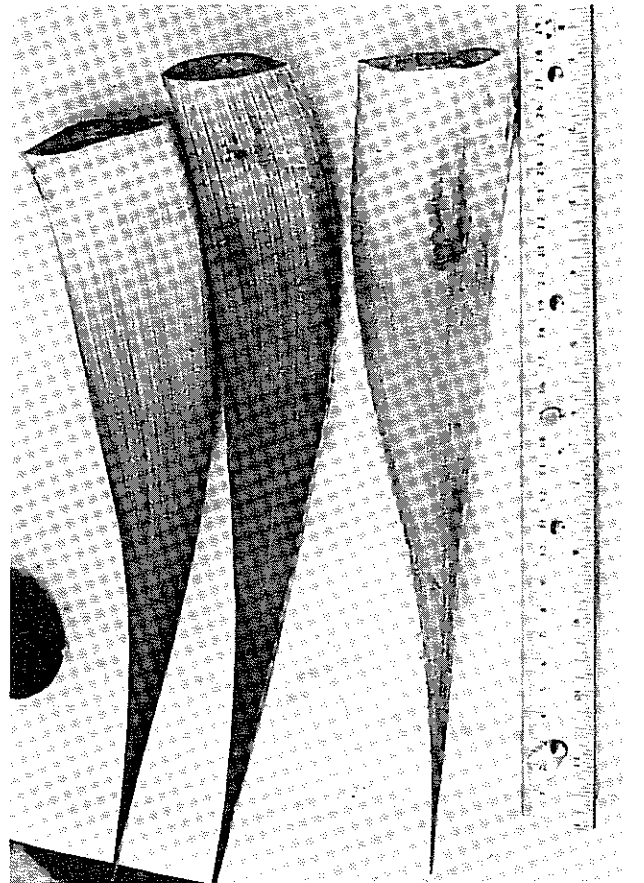


Plate 1. Note the difference between the three leaves. Photo W. Jankowitz.

This then was definitely no new species but an interesting natural mutation in the species *A. hereroensis* as shown by the intermediate specimen.

#### ACKNOWLEDGEMENTS

I wish to thank Mrs Oberholzer of Mariental for bringing these plants under my attention.

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## SHORT NOTE

### A wild Cape teal—yellowbill duck hybrid

by

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On 22 April 1973 a full-grown duck with an orange bill was seen at Walvis Bay Municipal sewage ponds, known as "Bird Paradise" (22°58'S 14°30'E). Closer examination through binoculars revealed it to have several characters of both Cape Teal *Anas capensis* and Yellowbill Duck *A. undulata*. The former is a common species in this part of South West Africa, but the Yellowbill Duck is a vagrant — one example of unknown origin had been at the sewage ponds for about a year prior to, and including, the above date. H. H. Berry informed us that he had seen the hybrid for some months previously although he had not realized its identity. The hybrid was slightly smaller than a Yellowbill Duck, but considerably larger than a Cape Teal and tending towards the former in body and head proportions. Head and body colour resembled the Yellowbill type, but the speculum was very like the Cape Teal's (Plate 2). Bill was light orange, tending to Yellowbill size but Cape Teal shape. Legs were dusky and light orange. The bird gave the loud Yellowbill Duck quack (a call exclusive to the female of that species). It associated with both parental species, although tending to occur most often alone.

A subsequent visit by R.J. on 29 October 1973 revealed the hybrid still present, but the putative Yellowbill Duck parent had disappeared.

There appear to be no previous records of this cross either in the wild or in captivity (Gray 1958, Clancey 1967) although hybrids involving both parental species have been reported (e.g. Rowan 1963, Clancey 1967, Clark 1973, Pocock 1973).

We are indebted to: H. H. Berry, then Ornithologist of our Division at Walvis Bay, for information about the hybrid and its Yellowbill Duck parent; W. Knouwds, Nature Conservator at Walvis Bay, for obtaining photographs for us. Prof. W. R. Siegfried and Mr P. G. H. Frost of the Percy FitzPatrick Institute, Cape Town, made valuable comments and supplied important information for which we are most grateful.

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Plate 1. Yellowbill Duck x Cape Teal hybrid, Walvis Bay Oct. 1973 (Photo by W. Krouwds).



Plate 2. The hybrid duck displaying its speculum (Photo by W. Krouwds).

## SHORT NOTE

The reedbuck, *Redunca arundinum* (Boddaert, 1785):  
a new record for the Etosha  
National Park

by

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During a game census in October 1973, an antelope unknown to the Etosha National Park was seen at Otjovasandu Fountain (Map 1) located at 14°28' longitude and 19°14' latitude some 200 km south of the Kunene River. Judging from the animal's size and habitat selection it closely resembled a reedbuck ewe. However, for accurate identification closer investigation was necessary. A helicopter was employed to locate and herd the animal into drop nets erected across the largely dry river course. Before the animal was netted it took refuge in a pool of water with only its head protruding above the surface. Once caught (Plate 1) it was disentangled and restrained in a comfortable position.

Characteristic anatomical features were the following: front of fore legs darker in colour; white underneath belly not extensive; single pair of inguinal glands (mountain reedbuck *Redunca fulvorufula* has two pairs).

Body measurements (in cm): ear 16; head (nose tip - occiput) 33,5; body length 144; tail 23; shoulder height 89,5; girth 87.

The findings correspond to those described by Roberts (1951) and Ansell (1968) for the reedbuck.

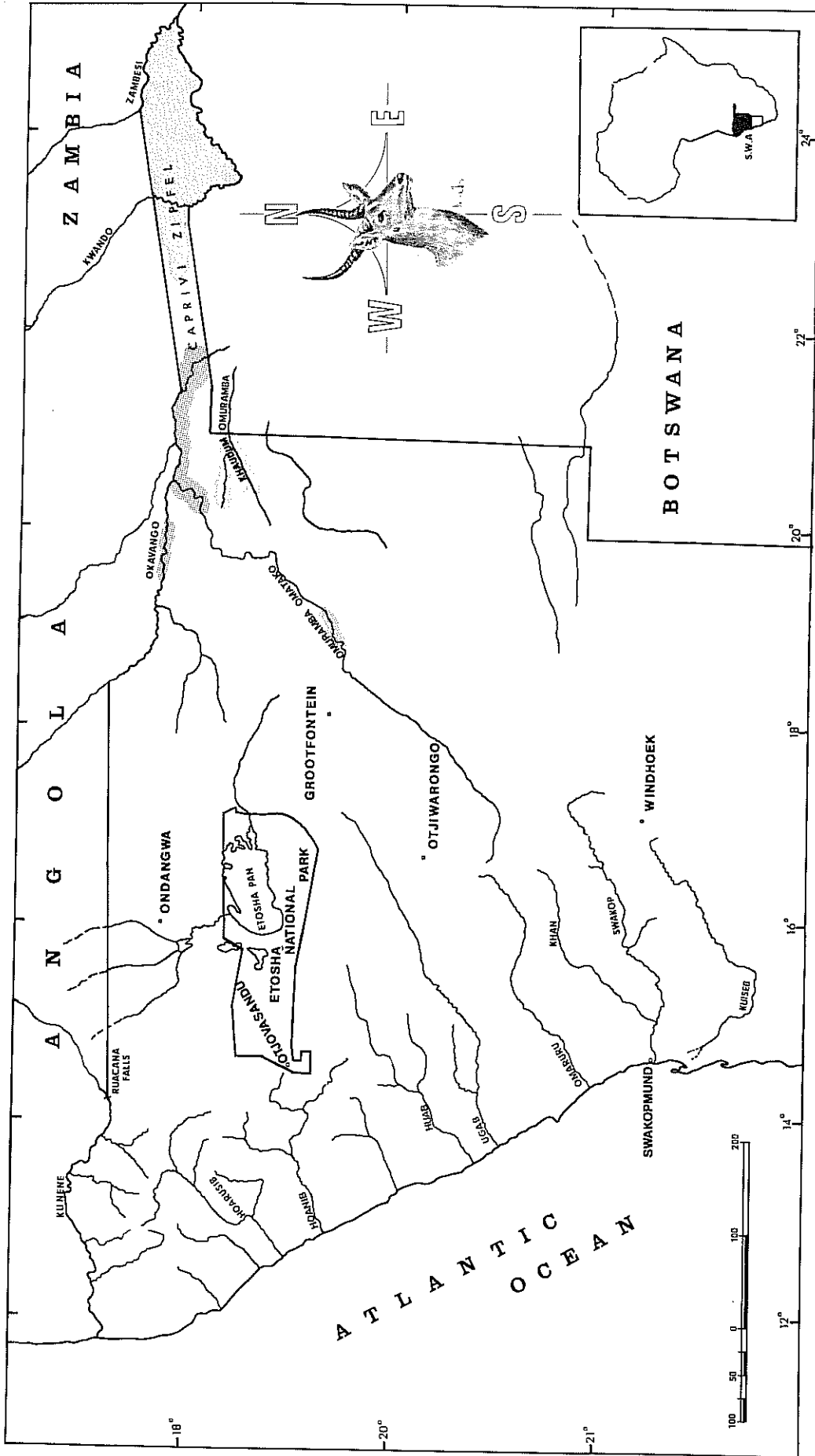
Judging from its dentition the ewe was old but nevertheless in good condition. Before being released, photographs were taken of all the characteristic anatomical features.

There is no record of the past occurrence of reedbuck in the Etosha National Park. The distribution according to Shortridge (1934) was confined to the northern parts of South West Africa along the Okavango River, the Caprivi and the Kunene - the most westerly occurrence being recorded 1,6 km below the Ruacana Falls. In more recent times it is present only along the Okavango River and in the Caprivi (Bigalke, 1958) and was recently observed in fair numbers in the Khaudum Omuramba (river-bed) and parts of the Omuramba Omatako (Map 1).

This particular reedbuck has been resident at Otjovasandu for at least three years. Its presence was recorded (unidentified) on several occasions since 1970 by one of the authors (J.P.S.). Its elusive nature was undoubtedly responsible for its survival. To date this is the only specimen known to occur in the Etosha National Park. The introduction and colonisation of a breeding herd is envisaged and although habitat suitable for reedbuck is limited and confined to the environs of the fountain, every attempt will be made to preserve and, wherever possible, improve it.

## ACKNOWLEDGEMENTS

The authors extend their appreciation to Mr C. G. Coetzee, Director, Windhoek Museum, South West Africa, for valuable comments. Mr E. Carelse of the Department of Forestry is thanked for providing useful data on the present distribution of reedbuck in northern South West Africa.



Map 1. The known present distribution of Redbuck *Redunca arundinum* in South West Africa.





Plate 1. The captured ewe restrained for identification.

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