THE ECOLOGY OF CHIEF'S ISLAND AND THE ADJACENT FLOODPLAINS OF THE OKAVANGO DELTA, BOTSWANA

by

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Dedicated to my Parents

ABSTRACT

THE ECOLOGY OF CHIEF'S ISLAND AND THE ADJACENT FLOODPLAINS OF THE OKAVANGO DELTA, BOTSWANA

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The study area lies in the central Okavango Delta, Botswana, and was proclaimed a game reserve extension on 2nd July 1976. Peoples of Khoisanoid origin first colonised the area. Bantu speaking baYei followed in about 1750 and baTawana in about 1795. The area is still completely undeveloped and pristine. The solid geology is largely overlain by Kalahari sands, but is seismically very active. Resultant faulting has given rise to the Delta. Further seismic activity, vegetation blockage formation, termitaria establishment and low density of large aquatic moving animals give rise to continual change in water distribution and output at the Delta's base. These natural factors continually cause dynamic change of flooding regimes. The climate is of summer rainfall and local Delta rainfall is considered a major factor in determining extent and duration of flooding. Five vegetation types divided into 20 plant communities occur. Five communities are dependent on a high water table and 10 on surface flooding for maintenance of specific mammalian habitat types. Floodplain vegetation types are considered most sensitive and 'normal' flooding is required to maintain the wetland flora and fauna. Sixty-three mammalian species are recorded from the study area. Twenty-two species are almost wholly dependent on flooding. Lechwe and sitatunga are completely dependent on aquatic and floodplain vegetation types and adequate flooding to conserve their habitat. Water flow in most major channels from ancient to present times has changed radically in distribution. Schemes to extract a more reliable flow out of the Delta for industry and human/stock consumption are laid out and evaluated, and a water demand made for conserved areas. Tourism should be in the form of foot and mekoro or boat safaris. Control of undesirable aquatic vegetation must be monitored. Burning as a management tool is required to enhance flow and control vegetation in some areas. It is premature and unsound to eliminate tsetse fly at this stage. Limited cropping will have to be initiated shortly. Larger tracts of Delta area are required under the direct supervision of the Department of Wildlife and National Parks to maintain the pristine conditions and ensure the conservation of fauna and flora, thereby maintaining the only reason for international tourism to the area.

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INTRODUCTION

Chief's Island is located wholly within the Okavango Delta of Ngamiland, the baTawana tribal area in northwestern Botswana (Fig. 1).

The Okavango Delta is the world's largest inland delta (Standish-White, 1972) and is fed by southern Africa's second largest river system, but one whose discharge never reaches the ocean (Brind 1954). However, this water serves to maintain a swamp system in an otherwise semi-arid environment with large quantities of water lost via transpiration and evaporation. Most other endorheic drainage systems spill into shallow lakes or inland seas, viz. Lake Chad, the Dead Sea and the Caspian Sea (Standish-White, **op. cit.**).

The vast inland Okavango Delta covers a surface area of about 16 200 km^2; and lies on Kalahari sands and alluvial soils of varying texture, with which calcrete and silcrete are associated (Wellington 1955 a). The Delta supports a high wildlife biomass, at present utilised for tourism, trophy hunting and tribal hunting; whilst stock and crop farming are encroaching from all sides into the Delta.

Various estimates of perennial versus seasonal areas of inundation exist. My own estimates are: about 3 000 km^2 comprises permanent swamp, about 5 000 km^2 seasonal swamp and the remainder dryland masses or islands. The degree of flooding at any particular time is dependent on local summer rainfall and floodwaters from southern Angola's Cuito and Cubango catchment areas.

The presence of tsetse-fly, *Glossina morsitans* excludes domestic stock from large areas of the Delta, but efforts are and will continue to be made to control and possibly eradicate this fly.

As semi-arid Botswana develops so the demand for water increases, and the Okavango River/Delta system is the only permanent inland surface source (Morse, Hadow, Hawes, Jenkins and Phillips, 1960).

The Okavango Delta drainage is very unstable due to its topographical low gradient (1 : 5 000); prevalence of seismic activity and susceptability to channel blockage, altering water flow.

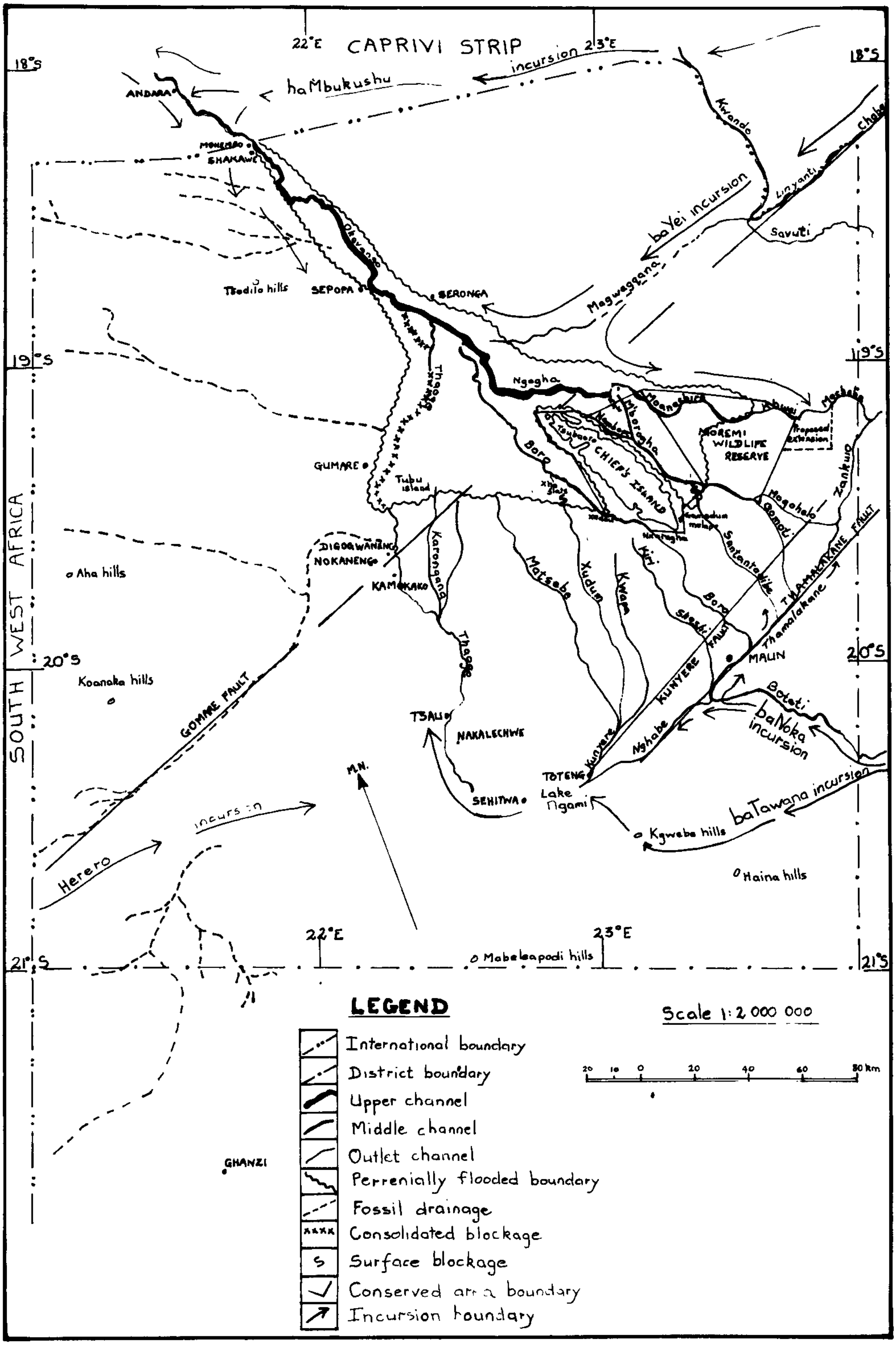

FIGURE 1 – Map of Ngamiland and Okavango Delta, Botswana, also depicting African incursion routes.

Some water manipulations to increase outflow are bound to take place. Such can be achieved with minimal alteration to the conserved areas, and hopefully, with minimal damage to this unique ecological entity.

Proposals by the authorities concerned to extend the size of the present Moremi Wildlife Reserve by including Chief's Island and parts of its adjacent floodplain systems (now a gazetted reality), plus the envisaged probable water manipulations initiated this study, which aims to document all existing ecological conditions and provide for some added water take-off and a management proposal for the Delta with minimal disturbance to the prevailing conditions.

The study area chosen was Chief's Island and its associated vegetation types, the latter being where such water manipulations will most likely take place and/or have its effect.

THE STUDY AREA

LOCALITY AND DESCRIPTION

Chief's Island and the adjacent floodplain systems now included under Tribal Game Reserve extension (Fig. 1), lies within the central Okavango Delta, Ngamiland, northwestern Botswana. The study area covers the major part of the grid formed by latitudes 19°06' and 19°36'S, and longitudes 22°45' and 23°30'E.

Chief's Island is the largest island in the Delta being approximately 850 km^2. The surrounding study area comprises islands of much smaller size varying down to termitaria. Inbetween and surrounding all these islands are the various aquatic and floodplain vegetation types forming a mosaic of plant communities, each community's existance being largely dependent on elevation or geomorphology, soil type and annual flooding pattern.

The Tribal Game Reserve extension area comprises approximately 1 812 km^2 and extends westwards from the existing Moremi Wildlife Reserve of 1 560 km^2, providing for a 116 per cent size increase of conserved Delta area. Tribal authorities may add another 358 km^2

on to the east of the existing Moremi boundary. This is mainly woodland with some Khwai and Mochaba River drainage along its northern boundary. This will provide for 21 per cent and 23 per cent of conserved Delta area respectively.

For the greater part the reserve boundaries of the study area are arbitrary and imaginary lines. Exceptions are along the Boro River in the west from Nxaragha to Xedau in the Xho flats area, and the Gamadum Melapo to the south of Chief's Island (Fig. 1). The total conserved unit is surrounded by hunting areas. This renders arbitrary imaginary boundaries difficult to define and problematic to control.

The nearest town is Maun, administrative capital of the baTawana tribe. Maun lies on the Thamalakane River draining the major Delta distributaries; and is about 75 km SE of the southern tip of Chief's Island by track. Chief's Island is only accessible by track in low flood years and possibly for a few months in medium to high flood years. Invariably some inundated areas have to be crossed dependent on the present flood regime. During high water conditions access to near Chief's Island is by water navigation up the Boro River from Maun, or from Moremi via the Moanashira and M'borogha Rivers. Light aircraft access is similarly available from Maun at present.

The name Okavango was not derived in Ngamiland. Stigand (1923) after collaboration with the German Missionary Oblate Fathers at Andara proposed the name Okavango to be derived from a corruption of the Portuguese Cubango. This is the name of the major tributary above its confluence with the Cuito. Initially, the name was probably obtained from some tribe living in that area. As Stigand (*op. cit*) further points out, the Delta's rivers have various names along their course. These are named by the local inhabitants and it is often still difficult to define where one starts and the other stops. The whole Delta is divided into areas, islands or tracts varying in size but all named. However, very few guides still exist who are fully conversant with these over any large area.

Chief's Island itself is a European-derived name designated about the 1930's to the largest island in the Delta. Theoretically, it was always for the sole hunting rights of the chief or his nominees. *Campbell (pers. comm.) states that the area actually only included Tshubaoro. This comprises a group of small to medium sized islands and an extensive surrounding floodplain at the northern tip of the current Chief's Island.

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*A.C. Campbell, P.O. Box 114, Gaborone, Botswana

Chief's Island is at present classified as non-hunting area. Locally it is still subdivided into at least eight tracts or areas. As with Tshubaoro there is some evidence that these may have been separate islands or island complexes in the past. With increased dessication and altered flow in this area all are virtually now united as a single island.

The Okavango Delta, roughly shaped as an equilateral triangle with 180 km sides, covers approximately 16 200 km^2. Of this about 50 per cent is dryland masses and islands, only partially flooded under extreme circumstances; 31 per cent are subject to seasonal flooding and 19 per cent more or less permanently flooded.

HISTORY

This section involves the historical background of the Okavango Delta and Ngamiland.

The indigenous human population of the Delta would appear to be the baNoka (people of the river, so-called river bushmen or maSarwa) (Tlou, 1972). This is the collective name for several discrete swamp groups of Khoisanoid origin (Van Hoogstraten, In Cowley, 1969). The homogeneous parent stock were the baTeti, living along the Boteti River from Lake Xau in the east to the Delta's base, and named after that river.

Migration then took place up the various distributaries – probably not far, and establishment of several discrete groups occurred. Further migration upstream probably occurred as a result of new mobility in the form of mekoro, (dugout canoes), introduced in c. 1800 by baYei and haMbukushu, and from the baTawana and maKololo incursions (Tlou **op. cit.**).

Small remnants of these groups remain today but largely intermarried with baYei and will probably soon become extinct as distinct ethnic groups. Such groups did exist and their remnants formed the basis for study expeditions viz Van Hoogstraten (1966), Heinz (1969), for baQanikhwe (northern delta), baKakhwe (southern and middle delta) and baGumahii (scattered). The large number of areas still carrying names of Khoisanoid origin in the Delta attest to their early colonization.

The baYei (derrogatory maKuba) were the first bantu speaking group to enter Ngamiland. They migrated from Diyei, just off the confluence of the Chobe and Zambesi Rivers in about 1750 (Stigand, 1923; Tlou, 1972). Today they are numerically the strongest group but are subservient to some of the other groups (Pole Evans, 1948). Initially they settled in localised spots but are now widespread.

Initially the baYei had no knowledge of Lake Ngami but stumbled on it during hunting expeditions. They named it Ncama, later corrupted to Nghabe and eventually Ngami by baTawana and Europeans respectively. At Lake Ngami they encountered hippopotamus *(Hippopotamus amphibius)* in abundance (Tlou, *op. cit.*) These were occasionally thrown ashore by wave action, attesting to the size of the Lake in those days (eighteenth century).

The baYei migrations resulted from northern incursion and local overpopulation (Fig. 1). Tlou (*op. cit.*) accentuates the latter cause but all took place gradually between approximately 1750 and 1800.

About 1795 a quarrel took place between the two sons of the baNgwato chief Mathiba. Tawana, the younger son, fled with a section of his tribal followers. They followed the Boteti River upstream and branched off at the Kgwebe Hills. The baKgalagari resident at Kgwebe Hills were driven off and Tawana established himself there (Nettleton, 1934; Sillery, 1952). They were aware of Lake Ngami and the baYei under Hankuzi (Sankose of earlier literature) with their mekoro. Possibly fear of the water mass and malaria curbed the baTawana from moving there. The Khoisanoid groups were brought into subjection by the baTawana, but not the baYei.

Tawana was killed by his son Moremi I in about 1820. During Moremi I's reign, Sebetwane and his maKololo successfully attacked the baTawana in 1825 (Nettleton, *op. cit.*) or 1828 (Sillery, *op. cit.*) and took most of their stock. The baYei escaped into the swamps, whilst the baTawana fled and settled in the Caprivi Strip near the Chobe River. The baTawana were later followed north by Sebetwane, (after he was repulsed in Damaraland) who brought them into subjection. The young heir apparent Letsholathebe and his mother disappeared during this attack. Later, during a plan of violence by Sebetwane, some baTawana fled whilst others remained. Of the latter some notables were murdered, whilst others were left untouched (Kgabo and Meno, sons of Moremi I) and continued to live with the maKololo (Sillery, *op. cit.*). Mogalakwe and his followers who fled this violence towards Lake Ngami, met up with a man of the baSubia tribe whom they wished to kill. They spared his life when he promised he would lead them to a boy who appeared to him to be one of their kinsmen. This boy turned out to be the lost Letsholathebe whom this party took to the present day Toteng and installed as Chief in about 1840 (Sillery, 1952). These remnant baTawana had no possessions and took over the cattle of the baYei and baKgalagari living at the Lake. This occurred under threats of duress without actual warfare, and the subjection of the baYei who had hitherto been treated as equals stems from this date.

The haMbukushu originally resident at Katima Mulilo first emigrated to the Kwando valley. They later moved to Andara where they established themselves, only trickling down into northwest Ngamiland in the nineteenth century (Tlou, 1972).

The haMbukushu migrations from Andara into Ngamiland resulted from dissatisfaction to their king's attitude. Subjects of his were being sold to the mambari slave traders from Angola. The major migrations took place after the baTawana established their state. These began during the reign of Letsholathebe I (approximately 1847-74), and increased during the reign of Moremi II (1876-90) (Tlou, *op. cit.*).

During 1970, a further haMbukushu migration took place. Fleeing refugees from southern Angola and part of the Caprivi Strip moved into Etsha (near Gomare) in the wake of colonial warfare. These peoples have settled permanently in Ngamiland, having taken out citizenship in preference to returning to a decolonised Angola.

The first Europeans to reach Lake Ngami were Wilson, Oswell, Murray and Livingstone on August 1st, 1849 (Le Roux, 1939). The next decade followed with many notable naturalist, hunter, trader and missionary visits to Lake Ngami, viz Edwards: 1850, Viljoen: 1851, Petrus Jacobs: 1851, Green brothers: 1851, Swartz: 1851, Leyland: 1851, Anderson: 1853, Chapman: 1853, Wahlberg: 1855, Baldwin: 1858, Mackenzie: 1861, and Baines: 1861 (Tabler, 1973).

Very limited penetration of the Delta took place initially. Probably all the requirements in hunting and trading could be obtained near Lake Ngami. They also mention fear of subjecting themselves to "noxious effluvia" caused by stagnant waters and responsible for various dreaded diseases. Andersson (1856) and Green (1857) published accounts of upstream navigation of the Thaoge River from Lake Ngami. Andersson reached the vicinity of Tubu Island for trading purposes with the baYei. Green, in 1855, equipped with a custom-built boat, transported up from Cape Town, apparently navigated further upstream. Green was accompanied by Wilson and the trip's objective was an attempt to find navigable channels to the west coast, and to visit Andara. The river trip was abandoned due to lack of progress.

During this decade, Kgabo and Meno rejoined the baTawana from the Chobe maKololo. About 1860, Sekeletu, son of Sebetwane raided the baTawana, who fled to the Kgwebe Hills. Here, they repulsed Sekeletu's attack, but lost some of their stock to him. The loot consisted mainly of small stock which necessitated the building of a crude raft to get them accross the Thamalakane River. The site chosen was above Matlapaneng at a drift still known as Lekawen or Sebetwane's drift.

In 1875 and 1877, two parties of Dorsland trekkers passed Lake Ngami on their way to Angola. They consisted mainly of Transvaal farmers and Doppers, (Reformed Church) dissatisfied with President Kruger's religious leanings and the doings of his government; and were so-called due to the waterless tracts they had to cross. H.M. van Zyl, an early and the first white Ghanzi resident, probably influenced the Dorsland trekkers to migrate in the direction they did (Tabler, 1973).

In 1882, the Matebele from Rhodesia attacked the baTawana, who suffered large stock losses and had to take refuge in the Delta. This was followed up by a second Matabele attack in 1884 or 1885. This time, the baTawana herded all their cattle onto a large island in the Delta, entering through Tsau and losing none (Sillery, 1952). The Matebele sustained heavy losses, supposedly 2 500 out of a raiding party of 4 000 when ambushed at a river crossing.

The baTawana cautiously kept their capital well up river after this; firstly at Digogwaneng till 1888, then at Kamokako until 1891. On both occasions floodwaters pushed them southwards. In 1891, they moved to Nakalechwe, but later, due to drying-up back to Tsau (Sillery, *op. cit.*).

Moremi II died in 1891 and chieftainship was taken over by Sekgoma. During 1894 or 1895 Sekgoma led a very successful foray into southern Angola, returning with many cattle and captives.

In 1896, rinderpest broke out causing heavy mortalities to domestic stock and wildlife. The reduction and absence of blood meal reduced the tsetse fly distribution to limited "pockets", probably all within the Delta.

The present-day Ghanzi farms were created in 1897 (Chirenje, 1971) as a result of C.J. Rhodes' effort to prevent German expansion eastwards from German South West Africa. The baTawana chief Sekgoma agreed to this provided that a tribal reserve was demarked for his people. This was declared in the High Commission Proclamation No. 9 of 1889 (Stigand, 1913).

During 1902, the Mababe Marsh dried up resulting in the baSubia moving up to the Chobe system.

The German/Herero war of 1904/5 resulted in the arrival of Herero refugees from German South West Africa.

During 1906, Chief Sekgoma was removed by the then Protectorate Government due to possible tribal bloodshed and replaced by the more favoured Mathiba (Sillery, 1952).

From 1910 to 1923, Captain A.G. Stigand surveyed and produced a map of Ngamiland and the Delta. This well-annotated map, together with his published notes, is a valuable contribution to early knowledge of this area.

The baTawana tribe moved their capital from Tsau to Maun in 1915.

During 1918, Professor E.H.L. Schwarz (1920) put forward his ideas on thirstland redemption by recreating massive open water bodies viz Makgadikgadi Pan, Lake Ngami, Etosha Pan and Mababe Marsh. This focused southern Africa's attention on the Okavango and Chobe systems and other fossil drainage nearby.

Schwarz's theories resulted in such public acceptance of increased precipitation over southern Africa, that the then Union Government sent out an investigation team. This gave rise to the Department of Irrigation's report of the Kalahari Reconnaissance led by A.L. du Toit in 1925, (Du Toit, Shalto Douglas, Noaks, Buckland & Stegmann, 1926). The report discounted most of Schwarz's proposals. The year 1925, itself, was a year of great floods in Ngamiland.

From August to October 1931, the acting resident magistrate of Ngamiland, Ellenberger, made a boat trip from Maun to Mohembo and back to Maun. This trip was made to inspect river channels and blockages.

Ellenberger (1931) left important and detailed notes of this trip. Partially as a result of this trip, Drotsky and Naus were independantly involved in blockage clearance and channel improvement. Drotsky worked mainly on the Thaoge and Ngokha Rivers, whilst Colonel Naus worked on the M'borogha, Gomoti, Santantadibe and Thamalakane River systems.

During 1933, Chief Mathiba died. In 1934, the first recorded outbreak of foot and mouth disease occurred in Ngamiland, (Falconer, 1971).

During 1937, J.L.S. Jeffares was engaged by the then Bechuanaland Government to carry out a survey of the Okavango Delta. This involved suitable gauging, levelling and blockage removal and provides good hydrographic data existing then (Jeffares, 1938). Moremi III was installed as chief during this year.

In 1944, another foot and mouth outbreak occurred as well as plague (Falconer, op. cit.).

In 1945, a further expedition resulting from Schwarz's theories visited the Delta. The so-called Conroy expedition then published their findings (Mackenzie, Amer, Kokot, Oldfield, Mech and Midgley, 1946); these confirming with the findings of the 1925 expedition. However, local improvement of irrigation and development of navigable waterways were possible but of no value to South Africa.

Chief Moremi died in 1946 and the tribe installed Mrs Moremi as regent during her son's minority.

In 1949, Wellington proposed a new irrigation development scheme for the Okavango.

A three-year survey was conducted by Brind (1954) from 1951 to 1953, carrying out levelling traverses to establish land and water gradients, beacons and bench marks. He also developed a papyrus cutting machine, studied water movement through various channels and took some soil samples. No action was taken on his recommendations for water development at the base of the Delta.

During the late fifties, crocodile-hunting commenced on a commercial basis. Lurie and Wilmot operating from Shakawe and Matlapaneng respectively, cropped large numbers of crocodile *(Crododylus niloticus)*. Commercial crocodile-hunting ceased during the late sixties.

In 1959, an economic survey mission led by Morse, examined the country's water resources, and concluded that long-term water development would have to rely on the Okavango system.

Game hunting has always played a role and took place virtually anywhere prior to 1962. In 1963, safari companies were leased hunting blocks. Jao, Santantadibe and Khurunxaragha areas, nos. 17, 18 and 21 respectevely, all embraced part of the study area. At the end of 1973, these blocks' boundaries were altered to prevent hunting in the study area, but this was not gazetted until 1976. In 1965, Letsholathebe II became chief of the baTawana.

On the 30th September, 1966, Bechuanaland became the independent Republic of Botswana.

In 1967, the Republic of Botswana Government requested United Nations assistance for power, water and transportations economic provision to enable development of ore deposits in eastern Botswana. Sir Alexander Gibb and Partners (1969) were engaged as consultants, and a UNDP team carried out various disciplines of research in the Delta.

B G A Lund and Partner (1969) proposed improvements to some of the Delta channels to assure sustained water supply to Orapa Diamond mine.

In March, 1971, Anglo-American Corporation introduced a dredger and dredged a small section of the Thamalakane River as commenced activities to improve water flow. During late 1971, and 1972, this work continued about 7 km up the Boro River from its junction with the Thamalakane River. The Boro River dried up in early 1973, and improvement work to this channel continued with front end loaders. In total, about 15 km of channel was improved and sideways (off-stream) drainage to surrounding floodplains was blocked by means of bunds. All this work was terminated by the Botswana Government at the end of 1973.

During late 1973, a follow-up UNDP team recommenced research in the Delta.

HUMAN UTILISATION

Historical

In this section, the emphasis is on the study area where the baNoka groups lived mainly as hunter/gatherers since their movement was dictated by their search for game and edible plants. The baNoka had certainly been resident in the study area, albeit sometimes only seasonally. Game was obtained mainly via game pits and traps. Plants utilised included waterlily *(Nymphaea* spp.), bullrush *(Typha latifolia),* papyrus *(Cyperus papyrus),* palms *(Phoenix reclinata, Hyphaene ventricosa),* African mangosteen *(Garcinia livingstonei),* sourplum *(Ximenia* sp.) and donkeyberry *(Grewia* spp.).

Initially, no crop cultivation was practised by the baNoka. A crude form of papyrus raft (huzenje or lekawa) was used for downstream transportation only by the baNoka. These rafts are made of chunks or blocks of living papyrus with additional papyrus stacked above this and were one of the greatest initial factors leading to channel blockages (Naus, 1936 b). Fishing methods and cultivation techniques were introduced to the baNoka by the baYei and the haMbukushu (Tlou, 1972).

The baYei cultivated and stock farmed where they could in tsetse fly free areas. The baYei were good fishermen, producing their own nets from mokgotse *(Sansevieria* spp.). Fish traps including baskets, weirs and fences with baskets were all utilised. The baYei excelled at hippopotamus hunting, either by setting weighted harpoon traps across hippopotamus paths (Anderson, 1856); or by hunting hippopotamus from papyrus rafts which they could not capsize (Tlou, *op. cit.*).

The baYei and the haMbukushu differentiate agriculture on the basis of floodwaters and rain; the former is referred to as tshimo ya bokgola (moisture fields) and the latter as tshimo ya pula (rainfields).

Crops such as sorghum, millet and maize were introduced by the baYei, who also introduced sheep, goats, fowls and dogs. The baYei learned their hunting techniques from the baNoka. All these residents consumed wild honey and their belief until recent times, was that a certain type of honey produced sleeping sickness (Naus, 1935).

From verbal evidence, the majority of past residents in the study area were probably baNoka and baYei. Stock and crop farming were most definitely practised on a small scale.

The baTawana established cattle posts at Tshubaoro between 1904 and 1912. Both Chief Sekgoma and Chief Mathiba hunted this top end of Chief's Island extensively in the early 1900's, (*Smith, **pers. comm.**). The baTawana informants agree that there were many maSarwa and maKuba (baNoka and baYei) living near these areas. Most informants' agree that the northern and southern ends of Chief's island were tsetse fly free in the early 1900's but that tsetse flies were present in the middle sector.

The baTawana chiefs left representatives in the Tshubaoro area to look after their cattle and game. Apparently, even after all the cattle had died of ngana or were removed, some sort of game custodian was left there for some period (Smith, *op. cit.*). The baTawana informers claim that in about 1917, cattle in the Tshubaoro area started dying. After fairly heavy losses, the baTawana withdrew and sold what cattle remained.

From baYei living near Tshubaoro about that time, a similar sequence of events occurred. These informers could however, give no dates but after losing all their cattle, remained living in the area, hunting and cultivating crops. In the 1940's several human deaths occurred, whereupon the remaining baYei moved further west and north of Chief's Island to tsetse fly free areas.

Several baYei/baNoka groups had villages on islands in the M'borogha floodplains. These groups re-established themselves in three villages on islands just off the north-eastern tip of Chief's Island. Two villages were on Sezita Island and one village on a small island known as Moretu. No domestic stock was kept, but cultivation of maize, millet, pumpkin and watermelon was practised on a small scale.

Calculating from my informant's estimated age, it would seem that the above villages were only established there after the villages on the western side had been abandoned. All three villages were abandoned in about 1958, when three villagers (from separate villages) were killed by 'man-eating' lions *(Panthera leo).* As a result of the above incidents, these villagers moved to Jao and Morije outside the study area, and established new villages. Morije is where Magau, a local headman, still has his village tody.

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*P. Smith, P.O. Box 107, Maun, Botswana.

These most recent sites of cultivation revealed no signs of agricultural scarring; nor could visual vegetation composition changes be detected against similar non-cultivated areas.

The crocodile hunting operations from 1957 – 1969 covered all navigable channels within the study area. Estimated take-off for the Delta varies from about 500 to 2 000 crocodile per annum; the lower figure probably being more acceptable as an annual average for the period. It was fairly common practice to use hippopotamus as bait and to collect crocodiles feeding off the carcass. Local tribesmen also destroyed hippopotami when these were deemed a hazard to mekoro navigation or for meat. It is impossible to gauge how many hippopotamus were destroyed in these ways, or what the effect of these actions was on the flow of some of the more critical channels. Since by physical movement, both adult crocodile and hippopotamus tend to prevent establishment of rooted aquatic vegetation where physical conditions would otherwise be suitable for such establishment, their role in maintaining open channels must not be underestimated. Likewise, hippopotamus are capable of creating and opening up new channels in poorly-drained swamp conditions.

Since many local swamp dwellers were involved in crocodile hunting operations, the hippopotamus probably suffered additional persecution. The hazard of mekoro or boat navigation due to hippopotamus are well documented by several early European travellers in the Delta (Stigand, 1923; Ellenberger, 1931). Chances do exist that many of these aggressive hippoputamus were previously wounded due to the antiquated firearms and ammunition in use by most tribesmen.

The result of this history of crocodile use was that today small crocodile are fairly numerous but that large specimens are rare, and that hippopotamus in most non-conserved areas are only present in low numbers.

Although Chief's Island was for the sole use of the baTawana chief or his nominees during the latter 1800's and up until the 1960's, after which time it was declared a non-hunting area, lack of control could not enforce this. However, most wildlife populations have by no means been severely decimated in the study area.

PRESENT SITUATION

The North-West District Council contemplated enlarging their tribal game reserve during the 1960's. As a result of this proposed size increase, a survey to demarcate new boundaries to the west of the existing Moremi Wildlife Reserve boundaries was conducted with Tawana Land Board officials during 1971 (*Tudor, pers. comm.). This was basically done to establish that no existing villages would be included within the new extension. This satisfied, boundaries were demarcated by **Verner and Tudor (pers. comm.). Since then, however, it was established that one village consisting of about 20 residents, was or is now within the inclusion area at Moretu.

Seasonal migrations of hunting/gathering parties enter the M'borogha floodplains from various areas upstream and downstream of the new reserve's northern and southern boundaries respectively. This pattern has been followed by these inhabitants for many years now, and they will not easily abandon it, since wildlife, edible fruits and honey are more readily obtained here. To a lesser extent the same pattern occurs on the western floodplains of the conserved area where sausage tree *(Kigelia africana)*, Maroela *(Sclerocarya caffra)* and ebony *(Diospyros mespiliformis)* are occasionally found chopped down for mekoro manufacture, and *Terminalia sericea* is used exclusively for making ponting poles.

The M'borogha floodplains, following minor channels just off Chief's Island and then entering the Santantadibe River in the vicinity of N'tamine Island, is a main access route between Maun and the northern and north-western Delta areas. This access route will always have to remain open.

To the west of Chief's Island, the Boro floodplains also form a main access route between Maun and the north-western Delta. However, the main route is largely outside the reserve or along its actual boundary.

Tourists are and will always be able to enter the M'borogha River through two access routes without entering the Moremi Wildlife Reserve. The first is via the Moanashira River in the north, and the second up the Santantadibe River from the south east. However, the

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**P. Verner, Department of Surveys and Lands, Maun, Botswana.

lower Santantadibe River is blocked and navigation there is difficult. The most popular tourist access is up the Boro River from Matlapaneng.

During low flood years, viz. 1973, access to Chief's Island by vehicle is reasonably simple. Under similar conditions most of the new reserve's western floodplains can be traversed, and the most northerly islands above Chief's Island can be reached. The eastern floodplains are completely cut off from vehicle access during low or high flood years.

Two tourist camps and airstrips exist at present east of the Boro River within the new reserve boundaries. These are in the process of being relocated to the west of the Boro River and are bases for conducting organised tours of the new reserve.

The proclamation of the study area with slight amendments to the existing Moremi Wildlife Reserve appear in Supplement C of the Botswana Government Gazette dated 2nd July 1976 under Statutory Instrument No. 93 of 1976, "Moremi Wildlife Reserve" (Amendment) Declaration, 1976.

GEOLOGY

The whole of northern Botswana falls within the great Kalahari sand-covered plain, or Kalahari Beds of the Tertiary System, which were formed during the Eocene to Pliocene periods between 1×10^6 and 60×10^6 years ago (Du Toit, 1966). This system covers more than three-quarters of the land surface of Botswana concealing much of the older geological formations. Geological surface remnants of the Pre-Cainozoic Era remain as inliers, inselbergs or outliers providing the key to the solid geology of the Okavango Delta, and these clearly point to a vast inland drainage depression covering a large portion of northern Botswana.

Scattered outcrops of rock delimit indefinite margins of the Okavango and Makgadigadi basins. These are: to the north and north-east, the Goha, Gubatsaa and Shinamba Hills; to the northwest, the Tsodilo Hills and other outcrops towards the South West African border; to the west, the Aha and Koanaka Hills; to the south, the Mabeleapodi, Kgwebo and Haina Hills; and to the east of the Makgadikgadi Salt Pans the outcrops of Basaltic and Rhyolitic Lavas, and of the Stormberg Series forming the east-west rain divide and belonging to the Karroo System of the Mesozoic Era (Fig. 2).

The oldest rocks are granitoid gneisses of the Archaen Basement Complex, with outcrops occurring in the Xangwa Valley and again near the Chobe River. Geophysical evidence suggests that these rocks extend in a wide belt north-eastwards from near the Aha Hills through the northern or upper Delta areas, north of the Gomare fault (Hutchins, Hutton, Hutton, Jones and Loenhert, (1976).

The variably metamorphosed strata of the overlying Damara supergroup form the Tsodilo Aha and Koanaka Hills. They comprise quartz schists, quartzites and dolomitic marbles of late Pre-Cambrian Age. To the south a fairly expansive stretch of relatively unmetamorphosed Ghanzi Formation comprising quartzites, shales, and limestones and overlying the Kgwebe Formation is reasonably well exposed.

The Kgwebe Formation comprises two members, one a quartzfeldspar porphory which gives way laterally, northwards to the Toteng diabase. The Goha and Gubatsaa Hills are also composed of the quartz-feldspar porphory, which radiometric dating has given an average age of a little over 900 x 10^6 years (Boocock, 1968). The Ghanzi Formation bears statiographic similarities and possible structural relationships with the Katangan rocks of the Zambian copper belt and the copper-bearing Tsumis Formation of South West Africa, and also form the Haima and Shinamba Hills to the north-east (Hutchins *et al.*, 1976).

Faulted outliers of Karroo supergroup strata (Late Palaezoic to Mesozoic) occur in the region south of Lake Ngami and geophysical evidence suggests that they occur extensively below the Central and lower Delta areas. This formation consists of sandstones, shale and coal seams of Ecca Age underlying Stormberg Basalts.

Post-Karroo volcanic activity has given rise to the Kimberlite pipes of the recently discovered Orapa and related diamond fields south-west of the Makgadikgadi salt Pans. These penetrate the Karroo Basalt and provide direct geological evidence of Post-Karroo volcanism close to the axis of present day seismicity (Reeves, 1972). This contradicts the theory of diamonds being water transported to the east of the present Karroo outcrops divide, but the first diamonds were discovered from this locality (Civil Engineering Equipment Digest, 1972).

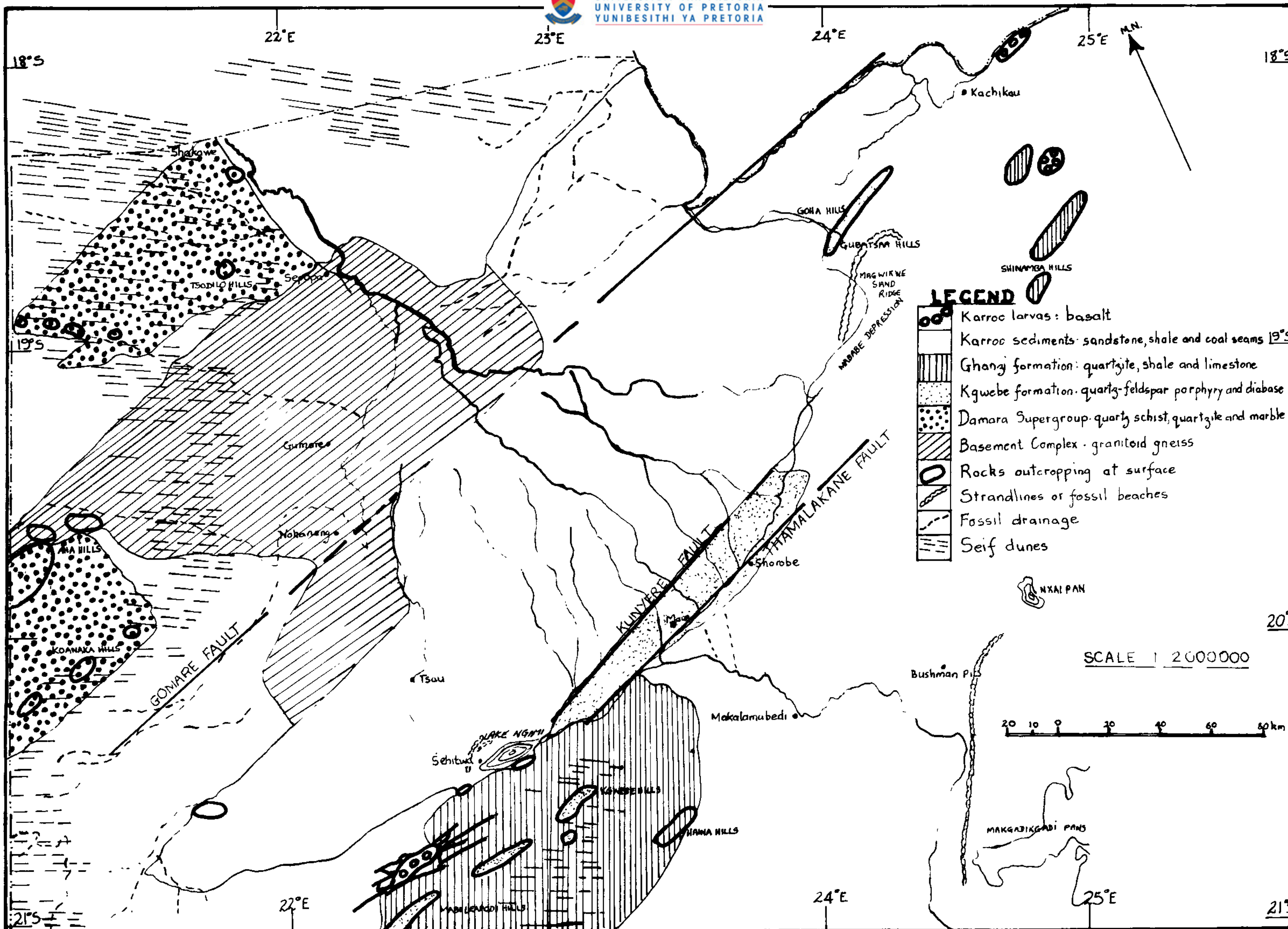

FIGURE 2 – Solid geology and geomorphology of Ngamiland and part of Northern Botswana showing surface features and interpreted bedrock geology after Hutchins, Hutton, Hutton, Jones and Loenhert (1976).

A great inland basin existed at this stage which was much larger than the present drainage system (Van Straaten, 1963; Grove, 1969). King (1963) has postulated that the Miocene epeirogenic uplift of this internal drainage basin by approximately 100 m may be responsible for shallowing and consequent lessening by evaporation of the free water surface area of the Okavango and Makgadikgadi basins.

Overlying the bedrock, except where exposed, are vast expanses of wind and water-borne sand in various thicknesses averaging about 50 m to 150 m, with a maximum of 300 m. These are medium to fine-grained sands and silts of Cenozoic Age, collectively known as the Kalahari Beds. Concretionary lenses of calcrete and silcrete are associated with these Kalahari Beds. (Hutchins *et. al.* 1976).No surface outcrops occur in the study area, the only surface structure being Kalahari Beds with associated concretionary lenses of calcrete mainly in the Xho Flats Area.

GEOMORPHOLOGY

The Kalahari Beds are the result of aeolian sands probably derived from broken down Stormberg Sandstones, and water-borne deposition (Wellington, 1955; Van Straaten, 1963; King, 1963). Poldervaart (1957) has produced petrographical evidence that the older Kalahari surface sands were derived from the northwest and blown in easterly to south-easterly directions. Numerous seif dunes exist to the northeast of the Delta's "sleeve" and to the west of the Delta (Grove 1969). These comprise rolling longitudinal sand ridges about 1,75 km wide trending approximately 102°, except south of the Aha Hills where the trend veers to 80°, but all formed during Tertiary times. Grove *(op. cit.)* states that the dunes were formed under prevailing easterly winds in a drier climate than the present. Satellite imagery provides evidence that tributaries of the larger fossil drainage to the west of the Delta have cut through these dunes. The dunes have also been eroded by former flood-waters on the western Delta margins providing evidence of increased flooding during former years in this area. The delimitation of seif dunes between the Delta's "sleeve" and the Kwando/ Linyanti system are in the extreme north only. Evidence of old drainage channels (Hutchins *et al., op. cit.*) and vegetation patterns show that this area between the Delta's "sleeve" and the Linyanti formed an extension of the Delta to the north in former days.

The strandlines located mainly on the western shores of the now fossil lakes, viz. Makgadikgadi, Mababe and Lake Ngami, are clear evidence of previous extensive bodies of water where prevailing winds and consequent wave action have given rise to these landforms (Grove, 1969). The sands are dominantly white or grey to beige in the Delta, differing markedly from the red aeolian sands of parts of the central and southern Kalahari and show the relatively recent importance of water-borne deposition.

Study of satellite imagery of Ngamiland provides a basis for establishing a sequence of geomorphological events (Hutchins, *et. al.* 1976). The longitudinal seif dunes were formed during the Tertiary Period in a desert regime with winds from the east. The state of the Okavango River flow during this period is not known. Northeast trending faulting, with downthrow on the northwest side, interrupted dune formation and the ridges created by the faults held back and diverted waters to Lake Ngami, the Mababe Depression and possibly further afield to the Zambesi System. A wetter climate is indicated at this time cutting through parts of these dunes and giving rise to a more extensive Delta and lake system. A drier climate followed giving rise to fossil drainage to the west and south and the strandlines marking the former extent of shrunken lakes. Dessication of the Delta may have been additionally aggrevated by infiltration of waters within the Delta along the lines of neotectonic activity. The topography is extremely level with gradients in the order of between 1 in 4 000 and 1 in 5 000.

SEISMICITY AND FAULTING

The tectonically active nature of Ngamiland was only recently realised from the high incidence of earthquakes (Gane and Oliver, 1953; McConnell, 1959). Jones (1962) conducting photogeological investigations in the region, led to the recognition of tectonic control lines affecting the superficial formations and revealing the structural conditions responsible for the Delta. Green (1966) first plotted the northeasterly trending impounding faults at the distal end of the Delta on a geological map. These distal faults have given rise firstly to the Delta's existence and secondly probably to impeded flow, with the more proximal Gomare fault possibly initiating the impending of flow down the Theoghe River.

The Okavango Delta and Ngamiland lie within an area of continuing earthquake activity (Reeves, 1972). From 1950 to August 1965 a total of 44 seismic events occurred in Botswana, the highest on the Richter Scale being 6,7. The exact number occurring in the vicinity of the Delta are unknown but probably most did. From September 1965 to August 1974, 38 events were recorded with epicentres in the Delta or in the vicinity of Ngamiland. The epicentral plot is to within an accuracy of 50 km radius, and Table 1 gives the magnitude distribution.

Table 1. Magnitude distribution of 38 seismic events in the vicinity of the Okavango Delta, Ngamiland, Botswana during the period September 1965 to August 1974.

RANGE ON RICHTER SCALE	EVENTS	PERCENTAGE
5,0 – 5,9	1	2,6
4,0 – 4,9	4	10,6
3,0 – 3,9	26	68,4
Less than 3,0	7	18,4

A swarm of seismic events during 1952 (27 events ranging from 4,3 to 6,7 on the Richter Scale) has been postulated to have caused a major change in drainage pattern in the Delta (Pike, 1970) or more specifically in the northern central Delta and also increased the flow of the Boro River (Scholtz, Koczynski and Hutchins, 1975). Several of the later events are plotted as occurring on the northeastern and southwestern tip of Chief's Island and in the region of the Gomoti and Mokhokelo River headwaters. The majority of epicentral plots, however, occur in the vicinity of the Mababe Depression.

A micro-earthquake investigation during 1974 (Scholtz, *et al., op. cit.*) revealed the most seismically active region to be the Maun-Toteng area, and this is associated with the Thamalakane and Kunyere faults. The Mababe Depression area yielded considerable activity whilst the central and upper Delta region was virtually inactive during this above study.

There is thus strong seismic evidence for rifting in the Okavango Delta and the focal mechanism is similar to that of the largest Kariba event (Grupta, Rastogi and Narain, 1972). This in conjunction with the persistent northeast trends of seismicity and faulting suggest that the Delta's activity is the southern extension of the Luangwa Valley – Kariba Gorge zone of seismicity and may mark an incipient arm of the East African Rift System (Scholtz *et al.*, 1975).

SOILS

Previous soil classification systems in Botswana were described by Van Straaten (1959); Van Straaten and De Beer (1959); Bawden and Stobbs (1963); d'Hoore (1964); Blair-Rains and McKay (1968); Mitchell (1968) and Siderius (1972). Tinley (1966) described soils of the Moremi Wildlife Reserve. The present description largely follows Siderius (*op. cit*) and partly Tinley (*op. cit.*).

The soils of Ngamiland and the Okavango Delta are predominantly sandy soils of the Kalahari basin. On the low ridges north of Maun and east of the Thamalakane fault pale brown sand capped with silcrete predominates. South of Maun the sand is fine to medium-grained and very white, whilst at Maun itself it is overlain by a metre of grey sand. The Delta islands, where not salt encrusted with evaporites, are formed of white sand. The Ngami lakebed deposits are dark grey, infertile silts with a low phosphorus content. (Hutchins *et. al.*,1976).

Siderius (*op. cit.*) recognises five soil complexes for northern and eastern Botswana, viz. the Limpopo Complex, the Makgadikgadi Complex, the Kalahari Complex, the Chobe Complex and the Okavango Complex, in total divided into 27 series. His Okavango Complex comprises five series which are present over the Delta and all are represented in the study area.

Molapo Series

Characterised by a Melanic A horizon overlying a gley horizon. These are deep poorly drained soils of a sandy clay loam to sandy clay texture. The gley horizon develops as a result of periodic saturation and varying groundwater levels. Seasonal flooding is necessary for the development of this profile. The parent material is classified as alluvium. The pH is neutral but increases slightly with depth to mild alkalinity. The colour varies from black at the surface through very dark grey, with brown encountered at about 1,5 m.

These soils support a mixed grass and sedge vegetation under normal seasonal inundation (Floodplain vegetation types). If inundation no longer occurs they evolve to carrying *Acacia nigrescens – Croton megalobotrys* marginal vegetation types, *Acacia tortilis* dryland vegetation type or *Colophospermum mopane* Woodland if clay predominates, or the other marginal or dryland vegetation types if sand predominates.

The local population utilises these soils for "melapo farming" but yields are generally low.

Boteti Series

Characterised by an Orthic A overlying a Regic sand (85 per cent or more sand). They are deep, very dark greyish brown fine sands excessively drained. Structural development is weak, horizonation is ill defined and natural fertility low. Carbonates are common in the deep subsoil Clay is extremely low (about 2 per cent) and silt about 11 per cent.

The parent material has been influenced by both aeolian and alluvial action. The presence of calcretes in the deep subsoil is associated with former lacustrine deposits, and the soil redeposited Kalahari sandstone over the calcrete formation. These soils support *Terminalia sericea – Combretum collinum* Communities or *Acacia erioloba* Communities. They are of no value for cultivation and when devegetated are subject to severe wind erosion.

Shorobe Series

Characterised by an Orthic A horizon overlying a dark brown calcareous B horizon. The texture is loamy fine sand with hard calcrete encountered at between 1,5 and 2,0 m depth. This soil is somewhat excessively drained, structural development is weak and horizonation is gradual.

The surface colour is dark greyish brown, and the clay percentage about 10. At the surface pH is neutral, but goes strongly alkaline with increasing depth. Depressions in this soil surface are common due to the solution of calcrete in the subsoil, and rain pans commonly form on this series. The soils support *Colophospermum mopane* Communities or *Acacia tortilis* Communities. The soil is low in fertility and arable cultivation unsuccessful.

Motopi Series

Characterised by an Orthic A horizon overlying a dark brown B horizon of a loamy fine sand texture. Structural development is weak and horizonation ill defined. These soils are somewhat excessively drained in the top 1,2 m, but their drainage may be restricted in the deep subsoil due to compaction and cementation of carbonates. The colour varies from very dark greyish brown up to about 1,2 m after which it lightens to a dark greyish brown. The clay percentage is very low (3 per cent) but may rise to 7 per cent in the deep subsoils. The silt fraction varies between 20 and 30 per cent with fine sand being dominant.

These soils occur commonly on old river terraces with a strong alluvial component and mainly support Closed Riverine Woodland and some of the marginal riverine woodland vegetation types. They are of low to medium fertility and have a limited capacity for arable farming.

Mababe Series

Characterised by being non to slightly cracking very dark grey clay soils, deep, poorly drained, highly alkaline and saline. The colour becomes paler with depth. The texture is clay to sandy clay; with the clay content ranging between 40 and 60 per cent. Silt fraction is about 8 per cent and the remainder mainly fine sand. Calcium carbonate, calcium and magnesium sulphate and sodium chloride are the common salts.

These soils support *Sporobolus spicatus* Island Grassland Communities where halomorphic and just above normal present floodlevels, but where removed from annual surface flooding support *Colophospermum mopane* Woodlands and Pyrophytic Scrub Savanna. Small or large pans are commonly associated with this series. These soils are of no value for arable cultivation.

CLIMATE

The Okavango Delta and northern Botswana is subject to the same general circulation and interaction of air masses from the north and southeast being responsible for the prevailing climate. During the winter months Superior air dominates the climate of this area. It is warm and exceedingly dry, and gives rise to warm, dry, sunny days with temperatures rising by about 20°C, followed by cold, clear nights during which terrestrial radiation occurs, and temperatures fall rapidly, occassionally to below freezing point. This weather is prevalent from April to September. During the summer months of October to March, Equatorial air from the north dominates the weather pattern. It is generally warm and moist, and gives rise to conditions conducive to the development of thunderstorms.

Due to the late establishment of a full meteorological station in the Central Delta only limited recordings of short duration were obtained. Climatic data for the study area is thus accepted as some intermediate between conditions prevailing at Shakawe (18°22'S and 21°51'E) and Maun (19°59'S and 23°25'E) where established weather recording stations exist. The study area and environs occur in the African Climatic Region of Köppen's classification referred to as Dry (B) Steppe (S) with an average annual temperature above 18°C (h), and with the dry season occurring during the low-sun period (w), abbreviated to BShw.

Rainfall

Table 2 presents the comparative precipitation data for the two stations during the period 1953/54 to 1973/74.

The highest total annual rainfall recorded for Maun (January to December) is 923,4 mm in 1974 and the lowest 221,5 mm in 1927 (over a record period of 51 years). However, a rainy season should be recorded on an annual basis from the beginning of October of one year to the end of September of the following year as this realistically effects the local flood regime. This is based on the fact that the rains from October of one year to April of the next year directly effect the magnitude pattern of the next flood; whereas heavy rains from October to December of any year have no effect on that year's previous flood pattern already experienced. On this basis the 1973/74 annual rainfall amounted to 1195 mm being the highest on record and the 1932/33 annual rainfall to 192,3 mm, being the lowest on record. The mean annual

Tabel 2 – Comparative precipitation data (in mm) for Maun and Shakawe on the peripheries of the Okavango Delta, Botswana for the Period October 1953 to September 1974 (from Gaborone Meteorological Office).

MONTH	MEAN		AVERAGE DAYS OF RAIN		MAXIMUM RECORDED		YEAR		MINIMUM RECORDED		YEAR		RANGE	
	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe
January	129,8	134,8	13	16	342,0	352,4	1974	1974	30,5	53,7	1960	1969	311,5	289,7
February	117,6	137,0	11	11	365,0	292,1	1974	1956	12,4	12,4	1971	1964	352,6	279,7
March	71,9	79,4	8	10	292,9	185,7	1961	1972	5,9	25,0	1965	1962	287,0	160,7
April	33,8	35,7	5	4	120,4	134,3	1967	1974	0,0	0,0	1964	–	120,4	134,3
May	4,0	2,6	1	1	33,8	17,8	1968	1960	0,0	0,0	–	–	33,8	17,8
June	1,1	0,7	0	0	17,1	11,3	1966	1955	0,0	0,0	–	–	17,1	11,3
July	0,3	0,1	0	0	5,8	2,0	1961	1961	0,0	0,0	–	–	5,8	2,0
August	0,6	0,2	0	0	9,6	2,3	1969	1962	0,0	0,0	–	–	9,6	2,3
September	4,0	5,7	1	1	29,2	35,9	1966	1960	0,0	0,0	–	–	29,2	35,9
October	15,5	13,5	3	3	99,7	66,5	1973	1954	0,0	0,0	–	–	99,7	66,5
November	51,6	65,8	9	9	111,9	291,5	1967	1954	2,0	0,0	1972	1972	109,9	291,5
December	89,4	98,8	9	11	264,0	229,0	1973	1954	13,0	28,2	1969	1961	251,0	200,8

rainfall for Maun from 1922/23 extended up until the 1973/74 season is 509,6 mm. The mean annual rainfall thus appears to be on the increase under present conditions since the figure for 1931 to 1950 is 457 mm (Tinley, 1966), for 1922/23 to 1968/69 is 491,1 mm (Pike, 1971) and for 1922/23 to 1973/74 is 509,6 mm.

The Shakawe station was established during late 1953 and since that period the highest mean annual rainfall recorded was 1134,9 mm during 1954/55 and the lowest 275,2 mm during 1969/70. Pike (*op. cit.*) records the mean annual rainfall as 520,3 mm (from 1953/54 to 1968/69), whilst from the period 1953/54 to 1973/74 it is 557,4 thus also showing an increasing tendency at present.

Temperature

Table 3 presents comparative temperature data for the two stations during the period 1964 to 1974.

The highest daily maximum recorded is 43,3°C (November 1930), and the lowest daily minimum recorded is – 4,4°C (August 1930) for Maun (Tinley, *op. cit.*).

During more recent times (1964 to 1974) the highest daily maximum recorded for Maun is 41,2°C (November 1966), and the lowest daily minimum is 0,1°C (June 1972). During the corresponding period Shakawe's highest daily maximum recorded is 39,6°C (November 1972) and the lowest daily minimum is 0,0°C (August 1972).

Relative humidity

Table 4 presents comparative relative humidity data for the two stations, Maun and Shakawe during the period 1965 to 1973. Relative humidity increases during the summer months when more moisture is available. However the annual surface flooding from Angolan rainfall usually arriving in early winter provides for higher winter relative humidity than would otherwise exist.

Evaporation

Table 4 also presents comparative evaporation data for the two stations, Maun and Shakawe during the period 1963 to 1968 taken from standard U.S. Weather Bureau Class A pans.

TABLE 3 – Comparative maximum and minimum temperature (^{o}C) on a monthly basis for Maun and Shakawe on the peripheries of the Okavango Delta, Botswana for the Period 1964 to 1974. (from Gaborone Meteorological Office).

MONTH	MEAN MAXIMUM		MEAN MINIMUM		RANGE ^{o}C		HIGHEST MONTHLY MAXIMUM		YEAR		LOWEST MONTHLY MINIMUM		YEAR		LOWEST MONTHLY MAXIMUM		YEAR		HIGHEST MONTHLY MINIMUM		YEAR	
	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe
January	36,3	35,2	17,6	16,5	18,7	18,7	40,0	39,2	1973	1970	15,7	10,0	1972	1969	28,4	27,7	1974	1974	19,1	18,6	1966	1974
February	34,7	34,1	15,7	16,8	19,0	17,3	37,6	37,5	1965	1964	11,5	11,5	1972	1972	28,3	28,5	1974	1974	19,1	19,3	1974	1974
March	34,7	33,6	14,4	14,8	20,3	18,8	39,5	36,4	1970	1970	11,1	10,3	1970	1967	28,3	29,2	1974	1974	16,7	17,3	1974	1974
April	33,3	32,6	10,7	11,9	22,6	20,7	37,1	36,0	1964	1964	7,2	8,5	1972	1965	27,2	27,5	1974	1974	15,2	16,1	1974	1974
May	31,1	30,9	5,2	4,9	25,9	26,0	32,4	32,6	1970	1973	0,3	1,0	1972	1973	26,5	25,6	1974	1974	9,4	9,8	1968	1974
June	28,5	29,0	2,6	3,1	25,9	25,9	30,6	30,6	1972	1968	0,1	0,7	1972	1972	25,5	24,8	1974	1974	6,6	7,5	1974	1968
July	28.6	29,2	2,4	2,6	26,2	26,6	31,3	31,9	1968	1973	0,6	0,5	1967	1973	24,9	24,7	1974	1974	6,1	5,8	1974	1974
August	32,3	32,7	5,3	4,0	27,0	28,7	34,5	34,7	1968	1968	1,0	0,0	1970	1972	28,2	29,2	1972	1974	12,0	9,6	1968	1974
September	35.9	36,1	9,1	7,4	26,8	28,7	37,5	38,0	1972	1973	5,0	2,0	1969	1973	30,1	31,1	1974	1974	13,3	11,1	1974	1974
October	38,2	37,9	13,8	11,0	24,4	26,9	39,9	39,5	1966	1968	11,0	2,0	1965	1973	34,5	33,6	1974	1974	18,2	16,9	1974	1974
November	38,2	37,2	15,5	14,5	22,7	22,7	41,2	39,6	1966	1972	11,1	10,0	1972	1972	31,5	31,7	1974	1974	19,5	18,5	1968	1974
December	36,6	35,8	15,3	15,4	21,3	20,4	39,5	39,1	1969	1972	11,2	11,4	1971	1970	30,7	31,2	1974	1974	18,7	18,4	1974	1974

Table 4 – Comparative per cent relative humidity (1965 – 1973) and evaporation (mm) (1963 – 1968) data for Maun and Shakawe on the peripheries of the Okavango Delta, Botswana, (from Gaborone Meteorological Office).

MONTH	MEAN RELATIVE HUMIDITY				EVAPORATION						
	08h00		14h00		Evaporation pan Class A		Pan coefficients factor	Evaporation open water		Evaporation after correction factor 0,7 for advection effect	
	Maun	Shakawe	Maun	Shakawe	Maun	Shakawe		Maun	Shakawe	Maun	Shakawe
January	74	80	45	51	237	236	0,80	190	189	133	132
February	75	79	44	49	221	221	0,84	186	186	130	130
March	71	77	38	47	235	221	0,74	174	164	122	115
April	68	71	35	39	225	206	0,64	144	132	101	92
May	60	68	25	29	214	188	0,54	113	100	79	70
June	62	69	27	28	186	153	0,48	89	73	62	51
July	59	67	23	25	207	170	0,49	101	83	71	58
August	51	57	19	19	242	198	0,57	138	113	97	79
September	37	50	17	21	296	256	0,59	174	151	122	106
October	42	48	21	25	359	280	0,60	215	213	151	149
November	53	62	30	36	276	252	0,76	210	204	147	143
December	66	73	40	45	260	255	0,81	211	204	148	143

These figures are reduced by the given average class A evaporation pan coefficients for Maun to give mean evaporation from an open water surface. These latter figures are further reduced by a factor of 0,7 to compensate for possible advection effects of the "station climate" (UNDP/FAO, 1972). On this basis mean annual evaporation still exceeds mean annual rainfall sixfold. Evaporation is high throughout the year but shows peaks during September, October and November. Due to the vast expanses of open surface water in good flood years evaporation losses which maintain the diversity of vegetation types ecologically, remain a direct water loss to engineers and agronomists.

Mist

During approximately 30 per cent of the early mornings of winter months, a light low mist is seen to rise off the open water bodies in the Delta. This only lasts for one to two hours after sunrise and dissipates rapidly.

Dew

Light dew was recorded within the study area on a few occasions after still, cloudless nights mainly during the months of April, May and June.

Frost

On average frost is recorded for 5 days during the winter months from Maun's meteorological station. Within the study area it was recorded close to the proximity of water on the moist soils of the floodplain systems. As Tinley (1966) has noted, no ground (white) frost was found away from the surface water verges, but then temperatures were never below freezing point. (Table 3).

Wind

From the Maun meteorological station data and personal observation in the study area, it was clear that easterly, northeasterly and southeasterly winds predominate. The early mornings before sunrise are characterised by a light to medium easterly wind. Westerly winds are of low occurrence compared to easterly winds, but northwesterly winds occur during the summer months and bring some rain.

Small whirlwinds known as dust devils are common during midday periods, and cause some erosion especially over relatively freshly-burnt areas.

Cloud Cover

Personal observations for the study area and Delta in general show that during the winter months slight to total absence of cloud cover occurs. A small build-up in cloud cover usually commences during September or October with a peak in cloud cover percentage occurring during the afternoons of December, January, February and March.

Summary of Climate

Rainfall predominates during the summer months. Precipitation may commence during September but more usually during October or November. The bulk of rain falls during November, December, January and February with January and February showing the highest mean monthly recordings. The rainy season usually ends during April but rare light showers may occur during the period of May to September.

Daily temperatures are high throughout the year, reaching peak temperatures during October or November. If precipitation is late in commencing these peak temperatures extend into December or January. Lowest night temperatures are recorded during May, June, July or August when temperatures may drop to freezing point.

Relative humidity increases during the summer months as does cloud cover. Evaporation is high throughout the year but shows peaks during early summer months. Mist, dew and frost are rare, but occasionally are found in the proximity of open surface water mainly in the winter months.

Winds are predominantly easterly throughout the year and summer droughts are common.

VEGETATION

Early contributors to the vegetation types of Ngamiland include Passarge (1904), Lugard (1909), Seiner (1912)and Pole Evans (1948). Miller (1952) classifies the northern portion of Botswana, bounded in the south by the Mopane limit *(Colophospermum mopane)* as one vegetation region. This is divided into five sub-types. Four of these are present in the study area namely; Mopane country, Mogonono country *(Terminalia sericea),* Delta country and *Acacia* country; with Miller's Mokusi country *(Baikiaea plurijuga)* absent.

The latest vegetation map of Botswana (Weare and Yalala 1971) shows the Okavango Delta to contain three of their nine physiognomic types; Tree Savanna, Aquatic Grassland and Riparian Forest. Under these vegetation types the plant communities identified are Ngamiland Tree Savanna, Swamp Grassland and Okavango Fringe Forest. They have drawn heavily on work done by De Beer (1962) for producing their provisional vegetation map.

Tinley (1966) defined four main vegetation types for the Moremi Wildlife Reserve, with two of these subdivided into eight plant communities. All Tinley's vegetation types and plant communities occur in the study area. This classification is based on soil types.

In this study the vegetation of Chief's Island and the adjacent floodplain systems is divided into five main vegetation types based on water availability, and subdivided into 20 plant communities based on physiognomic species composition, physical water parameters and/or soil types. The dryland classification types follows closely that of Tinley (op. cit.). Figure 3 presents a vegetation map of the study area showing major plant communities.

A. Aquatic vegetation types:

1. Filter Communities
2. Middle Channel Communities
3. Outlet Channel Communities
4. Madiba Communities
5. Flats Communities
6. Shallow Backwater Communities
7. Sump Communities

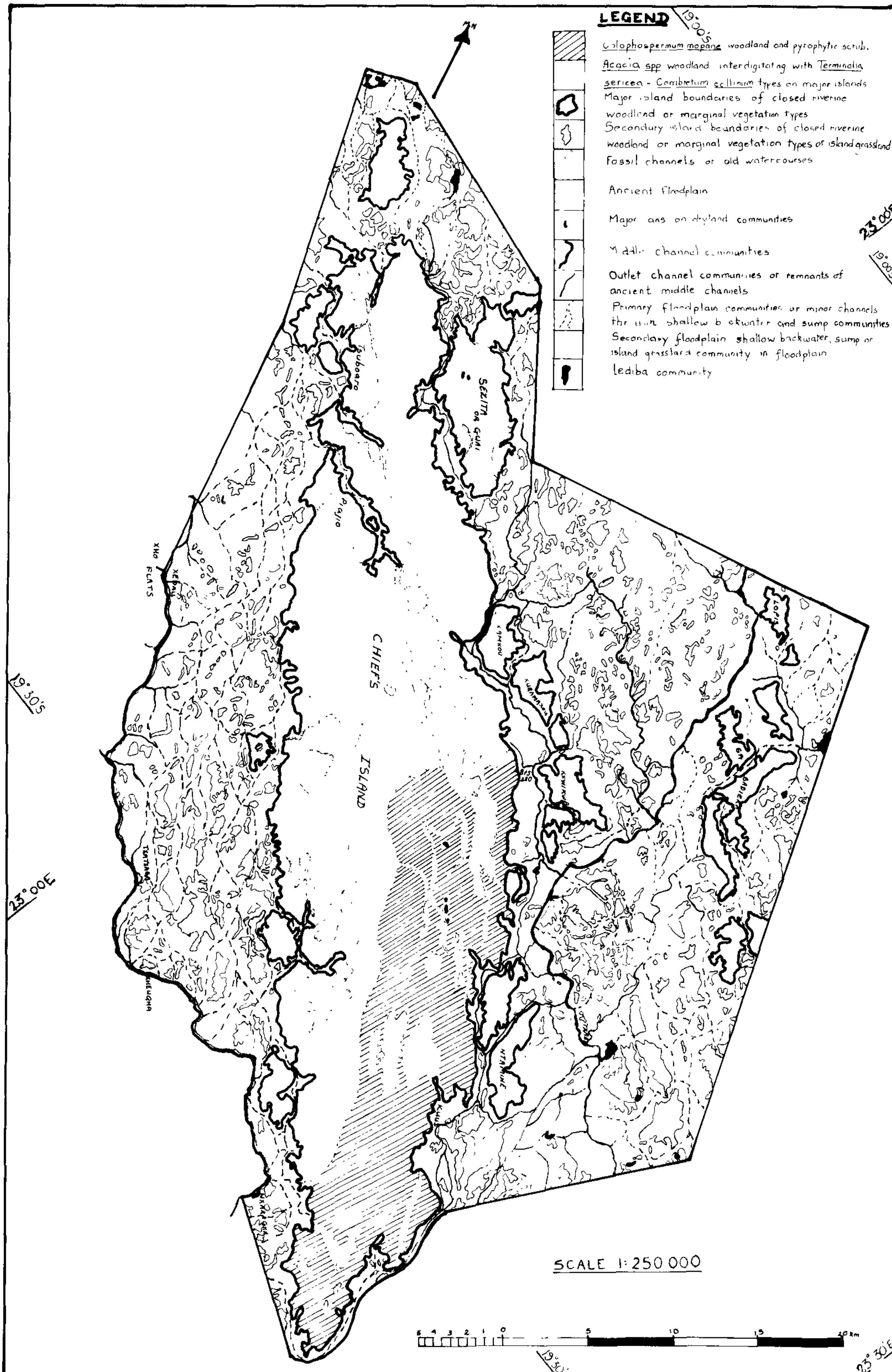

FIGURE 3 – Vegetation map of the study area showing major plant communities, Okavango Delta, Ngamiland, Botswana.

B. Floodplain vegetation types:

1. Primary Floodplain Communities
2. Secondary Floodplain Communities
3. *Sporobolus spicatus* Island Grassland Communities

C. Riverine vegetation types:

1. Closed Riverine Woodland
2. *Phoenix reclinata – Syzygium* spp Termitaria

D. Marginal vegetation types:

1. *Acacia nigrescens – Croton megalobotrys* Woodland and Savanna Woodland
2. *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland and Palm Savanna Woodland
3. *Combretum imberbe – Croton megalobotrys* Woodland and Savanna Woodland

E. Dryland vegetation types:

1. *Acacia tortilis* Savanna Woodland
2. *Acacia erioloba* Woodland and Savanna Woodland
3. *Terminalia sericea – Combretum collinum* Savanna Woodland and Scrub Savanna
4. *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna
5. *Grewia* spp – *Croton megalobotrys* Scrub Savanna.

Okavango Delta Description

The Okavango River enters northwestern Botswana almost as a single channel but then immediately spreads out to form the "sleeve" of the Delta. This "sleeve" tends northwest to southeast for approximately 100 km and is 10 to 12 km wide, comprising upper channels, small islands and inundated floodplains. Below this "sleeve" lies the true Delta with its expanded distributaries, floodplain systems and varied-size islands.

The northern sectors of the Delta comprise upper channels with vast expanses of inundated swamp studded with small to medium-sized islands. The currents in thse channels are fast but slow in the madiba and heavily vegetated swamp areas.

Proceeding to the mid-Delta, channel size and flow is decreased, more backwaters, flats and areas of generally slower-flowing water are encountered. Distributaries and madiba are more numerous and islands increase in both size and number. Here floodplains subject to seasonal flooding are encountered.

In the lower-Delta dryland masses and islands increase whilst channels become narrower, blocked or dry. Seasonal water discharge and flooding pattern continuously change in this area.

Proceeding from the upper to the lower-Delta areas there is a marked increase in vegetation species. The collection of all the Delta's distributries discharge is at right angles to their main flow, along a northeast to southwest tending drainage line as a result of faulting in the area (Reeves 1972). About 45 km ENE of Maun in this latter drainage line a critical height exists which divides flow. The main discharge proceeds down the Boteti River towards "Lake Xau". "Lake Ngami" receives a lesser discharge via the Nghabe River.

Methods

Vegetation types are based on visual physiognomic classification of the more important characterising species, and for some communities on sampling methods as discussed in the following chapter on vegetation status and trends. Some physical water parameters i.e. depth and velocity were obtained by measurement. Light penetration, turbidity, depth, velocity and some chemical composition of waters was obtained from work by Reavell, Lee and White (1973), Thompson (1975), Smith **(pers. comm.)** and *Wilson **(pers. comm.)** Soil types are based on observation and tied in with comparitive types from work done by Tinley (1966) and Siderius (1972).

Quantitative vegetation analysis work was conducted in floodplain, riverine, marginal and dryland vegetation types (See Chapter on methods and tables for description of status and trends in the vegetation types). This also served to substantiate some physiognomic vegetation communities described. The description of vegetation types and their present status and possible future trends, are described and predicted seperately since this was required in the terms of reference by the Sponsors.

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Definition of terms

Terminology largely follows Tinley (1966) for vegetation and work done in the Delta by Wilson (1974) for hydrology.

Upper channels – Largest channels from 15 to 130 m wide and usually 5 to 7 m deep. Perennial flowing watercourses with average velocity of 0,6 m/s and discharge exceeding 25 m^3/s. Relatively stable to vegetation changes and usually not subject to blockages. Riverbed formed of Kalahari sand with no submerged aquatic vegetation. Marginal vegetation prodominantly *Cyperus papyrus* with much lesser quantities of *Phragmites mauritianus* and *Miscanthidium junceum* eg. Nqogha River.

Middle channels – separated from upper channels which feed them either via 'filters', blockages or 'restricted take offs'. They vary considerably in width and flow rates from almost zero upwards. Perennial watercourses generally free of floating or emergent aquatic vegetation except at blockages. Seasonal rise and fall usually small (0,2 m). Middle channels are less stable than upper channels in preventing vegetation changes due to their lower water velocities, depth, width and variable discharge eg. M'borogha River.

Outlet channels – carry water away from perennially flooded areas and are most variable in width, depth, overall vegetation composition and flow rates in both time and space. Perennial to annual watercourses which feed the seasonal swamps during flood times. These outlet channels are most subject to change in discharge and vegetation composition are often characterised by *Ficus verruculosa* eg. Santantadibe River.

'Restricted take-off' – a minor channel leaving an upper or main channel to feed a middle or lesser channel, the nature of take-off being at right angles or an obtuse angle to the main channel when measured between the downstream and take-off axes. Such a take-off allows very little or no sudd or floating debris to enter the lesser channel, when compared with the quantity of such floating down the major channel, eg. Boro River headwaters from Nqogha River.

Filters – level area of slightly impeded drainage, covered by tall grasses and sedges. Vegetation sufficiently dense to prevent sudd or floating debris from passing through it. Filters feed overflow water from upper channels to middle channels or madiba. eg. between upper Boro and Nqogha Rivers.

Madiba (si. lediba) – Setswana term frequently and incorrectly called 'lagoons'. Body of open water probably formed from old oxbow lakes and relicts of ancient river channels. Madiba vary in size, shape and depth but most surface water is open, eg. Xadikwe lediba.

Flats – level areas of impeded drainage showing no proper channel. About 1 m or less deep. Minor channels are kept open by hippopotamus, crocodile and/or outboard engine propellors. Flats appear to undergo little change and are covered by emergent sedges, grasses and floating aquatic vegetation, eg. Xho flats.

Sumps – small to medium-sized inundated areas, surface water partially open, rest covered with short emergent sedges and surface floating aquatic vegetation. Occur as slightly depressed areas within shallow backwater communities comprising tall aquatic grasses and sedges.

Blockage – (a): Consolidated or permanent blockage. Closure of a channel via loss of flow, consolidation of vegetation and deposition of silt. Sudd or floating debris may often appear to be the initiating factor, eg. Old Nqogha blockage.

(b): Surface blockage. Temporary blockage on the surface comprising mainly *Cyperus papyrus* sudd and debris or *Rotala myriophylloides* with other sedges or other aquatic vegetation establishing itself on this base. Temporary blockages are continually added onto by addition of sudd and floating debris and may become permanent. Water flow continues below a surface blockage, eg. Nqogha blockage.

Primary floodplain – depressed floodplain which is the first floodplain type to receive flood-waters overflowing from outlet channels in the seasonal swamp areas. Surface water generally covered with emergent or floating aquatic vegetation. Known in Setswana as melapo.

Secondary floodplain – higher-lying floodplain of grassland elevated above primary floodplains by 1 m or less. Annual duration of flooding dependent on present flood regime. Dry throughout the year in poor flood seasons.

Island grassland – A short grassland dominated by *Sporobolus spicatus* and characterised by the presence of evaporites. Occurs adjacent to small or medium-sized islands or almost enclosed by a circular periphery of Closed Riverine Woodland. Depending on the Island grassland's locality in the Delta and the magnitude of the reigning flood, surface inundation may be absent or up to 0,4 m. A high water table exists below this community but this has dropped in areas where this community is evolving to a dryland vegetation type.

Parkland – island-like patches or clumps of trees in floodplain grassland and/or sedge. Appearance due to available high ground above flood levels, i.e. formed as a result of termitaria.

Thicket – very dense almost impenetrable tree and/or shrub cluster, climbing plants common, grass discontinuous or absent.

Woodland – usually two-layered (tree and grass/forb community). Stands of savanna trees with crowns almost adjacent to overlapping, with a grass and/or forb ground layer. Shrubs may be present. Trees must not be greater than one half of a crown diameter apart.

Savanna woodland – stands of trees spaced from about twice their crown diameters apart to crowns overlapping where aggregations occur, with a grass and/or forb ground layer. Shrubs may be present.

Shrub savanna and scrub – Woody plant cover from approximately 0,30 m to 3 m in height. Individual plants may be single or multiple stemmed, scattered or aggregated with a grass and forb groundlayer. The term scrub will be used for secondary, short, woody growth which occurs in relatively small patches. The term shrub savanna is preferred where the shrub and/or scrub cover, whether of a primary or secondary nature, occurs over a large expanse of country.

Aquatic vegetation types

These include rooted submerged, free-floating (submerged and surface) and rooted emergent water-dependent plants. Short periods may be experienced when surface water is absent from the more marginal areas supporting some plant communities listed under this vegetation type. This may occur after a poor rainy season before the annual flood arrives, viz. May – June or after a poor flood before the commencement of the rainy season, viz. October – November. The quantity of water available is dependent on local rainfall and floodwater from the Cuito/Cubango catchment in Angola.

The aquatic vegetation components establish themselves probably as a function of various physical and chemical water conditions, viz. flow rate, water depth and thus light penetration, duration of flooding, water turbidity and nutrient availability. These conditions can be altered by plant succession, increased or decreased precipitation and thus flood extent or alteration in base levels resulting from seismicity. All are natural factors and except for increased or decreased precipitation (on a long-term basis), are very much in action in the unstable Delta conditions. Debenham (1954) and Thompson (1975) agree that aquatic vegetation is the dominant factor determining pattern of water flow in the Okavango Delta. Standish-White (1972) however is of the opinion that seismicity is the dominant factor.

Filter Communities

Filter communities occur in the upper portions of the Delta on the northern margin of the study area. The vegetation comprises mainly *Miscanthidium junceum* and *Cyperus papyrus. Phragmites* spp. patches or *Cyperus papyrus* are encountered on old channels within the filter communities.

Filter communities are medium to shallowly flooded areas of large cross-section and short axial length. Water is able to pass through this vegetation community in quantity with little loss of head (Wilson 1974), but sudd or floating debris is prevented from passing through and is thus passed on downstream in the upper channel. Besides receiving inflow from 'restricted take-offs', the headwaters of middle channels are supplemented from water passing through filter communities viz. the upper Boro River (or the Jao River as it should properly be called). In certain instances consolidated blockages have resulted in the main headwater supply being cut off. Such systems viz. the M'borogha River headwater are now supplied almost exclusively through filter communities.

The importance of this community is in keeping its water supply to middle channel headwaters free of sudd and floating debris.

Middle Channel Communities

The M'borogha and Nambope Rivers of the eastern floodplains are representative types being the only true middle channels in the study area in accordance with the definition. (Fig. 4). Within the study area in general (as within the Delta) the width and depth of any channel decreases as one proceeds downstream; however any channels may be interrupted by flats or madiba.

FIGURE 4 – Middle Channel Community, M'borogha River, Okavango Delta, Botswana.

Depth varies between 1 and 3 m with the average tending towards the higher limit, and width usually from 2 to 6 m, again with the average tending towards the higher limit. Where the channels are deep, viz. the M'borogha River for the major part of its passage through the study area, the central channel is free of all aquatic vegetation. Gibbs Russell and Biegel (1974) report similar conditions for the Moanashira River near Dassakao lediba, and state that the uncolonised conditions are the result of combined action of water velocity and hippopotamus movement. In areas of insufficient water velocity or depth (viz. parts of outlet channels) continual passage of hippopotamus alone will maintain an uncolonised central zone. Middle channel bottoms are comprised of Kalahari sand with some deposition of silt especially where flow is reduced and submerged aquatic vegetation well established.

From the submerged middle channel margins, and extending in towards the uncolonised zone, common submerged aquatics comprise *Ottelia muricata, O. ulvifolia, Ceratophyllum demersum, Lagarosiphon ilicifolius* and *Rotala myriophylloides.* On the channel verges the marginal vegetation consists mainly of *Cyperus papyrus* and *Miscanthidium junceum. Cyperus papyrus* may dominate the marginal vegetation over large areas. However, it only forms a narrow band marginally from 1 to 4 m which then gives way to *Miscanthidium junceum* in shallow backwater areas. In the marginal zone of *Cyperus papyrus* and *Miscanthidium junceum* ferns such as *Thelypterus dentata, T. totta* and *T. quadrangularis* are common. *Cladium mariscus* is also fairly common in patches of this marginal zone but appears absent on the Boro River channels to the west of Chief's Island. Forbs collected along these channel margins include *Commelina scandens, Hibiscus* spp. and the twiners *Mikania cordata* and *Vigna lateola.* Extending onto the channel surface from the margin *Vossia cuspidata* (Hippo grass) establishes itself in suitable protected conditions of slower velocity. In middle channels these form V. cuspidata mats (small) as opposed to the V. cuspidata beds (large expanse); more characteristic of the middle and lower-Boro River verges, i.e. outlet channels. Also in these protected situations, after the inner curve of a river bend *Nymphaea lotus* or *N. caerulea* may be present; the former being more tolerant of higher water velocity.

Woody vegetation species of the Middle Channel Communities margins include the figs *Ficus verruculosa* and *F. pygmaea.* Both fig species are more common on the outlet channels, and especially so on the Gomoti River. *Ficus verruculosa* probably prefers slightly acidic conditions and is therefore encouraged in areas of reduced water velocity (Thompson 1974).

Outlet Channel Communities

These communities are represented by the Boro River from where it commences to form the western boundary (in the Xho flats vicinity) until it leaves the study area just below Nxaragha Ledibo; and also by the small section of the Santantadibe River headwaters after the M.borogha River bifurcation below Xaba Island on the eastern floodplains (Fig. 5).

All outlet channels within the study area are perennial watercourses. Sand banks and sand bars are often exposed during low water conditions, and the channels are generally narrower, shallower and have a decreased water velocity. *Cyperus papyrus* is only present in the outlet channel's headwaters or as isolated patches proceeding a short distance downstream. The southern limit of *Cyperus papyrus* is approximately in the vicinity of the new reserve's southern boundary with only isolated patches occurring outside of it. Outlet channel beds are also formed of Kalahari sand with parts covered by substantial amounts of silt.

Aquatic vegetation in these channels includes *Rotala myriophylloides, Ottelia ulvifolia, Lagarosiphon ilicifolius, L. major, Potamogeton thunbergii, Elodea densa, Najas pectinata, Ludwigia stolonifera* and the water lillies *Nymphaea lotus, N. caerulea* and *Nymphoides indica. Vossia cuspidata* and/or *Echinohloa colona* in either bed or mat form are common.

Emergent aquatic vegetation species occur in parts of these outlet channels and the marginal species increase in number compared to middle channels. Grasses such as *Miscanthidium junceum, Oryza longisteminata, Leersia hexandra, Panicum repens* and *Sacciolepus typhura* are common on the channel verges. Sedge species such as *Cyperus articulatus, Scirpus corymbosus, S. cubensis, S. inclinatus* and *Pycreus lanceus* occur on the verges or extend into the channel. Pure stands of *Phragmites australis* or *Typha latifolia* occur in more open sluggish channel conditions.

The twiners *Mikania cordata* and *Vigna luteola;* ferns *Thelypterus* spp. and aquatic woody vegetation species of *Ficus* are common excepting for *F. verruculosa* in the Boro system below Xho flats. Plant specimens collected from exposed sands bars and sand banks included *Alternanthera sessilis, Crassocephalum picridifolium, Pentodon pentander, Plectranthus* sp. cf *P. cylindraceus, Ludwigia octovalis, Limnophila indica* and *Hemigraphis prunelloides.*

FIGURE 5 – Outlet Channel Community, Boro River, Okavango Delta, Botswana.

Rotala myriophylloides becomes dominant in patches and has emergent stems and leaves floating on the water surface. These serve to trap floating sudd or debris, as well as to serve as a base for the establishment of some sedges viz. *Pycreus lanceus. Rotala myriophylloides* where dominant is a major surface blockage commencing agent.

Phragmites australis tends to prefer shallower water than *Typha latifolia* and *Phragmites australis* spreads more rapidly in static water than in flowing water, whereas the converse is true for *Typha latifolia* (Haslem 1971). The absence of *Ficus verruculosa* in the middle and lower Boro system is possibly due to the presence of limestone ($CaCo_3$) outcrops in the Xho Flats area raising the alkalinity of the water below this region. Where *Ficus verruculosa* is present it is also capable of trapping sudd or floating debris and is also a surface blockage forming agent.

The isolated stands of *Cyperus papyrus* occurring in these lower velocity outlet channels appear unhealthy and reduced in size. Thompson (1974) terms them as relict patches and initially I was in agreement. However, during the field study period small patches of *Cyperus papyrus* were found to be establishing themselves in this area of the Boro River. Increasing flow down this channel may well be improving conditions for healthy *Cyperus papyrus* establishment.

Madiba Communities

Madiba occur in two major localities within the study area, viz the extreme northern tip of the new reserve above Chief's Island and the headwaters of the Gomoti River offtake from the M'borogha River. These two localities show the presence of several madiba whilst isolated single lediba occur within other parts of the study area. (Fig. 6).

These open water bodies of varying shape and size appear to have originated from oxbow lakes as relicts of old upper and middle channel flow. The largest existing madiba are either on or just off upper and middle channel flow. Numerous smaller madiba are well off present upper and middle channel flow, but island and vegetation patterns in the vicinity of these madiba show up former major watercourses.

Water velocity across madiba is slow to almost stagnant. Madiba on the main channels exhibit deltaic fans at the entrance point of the channel. These fans occur as a result of

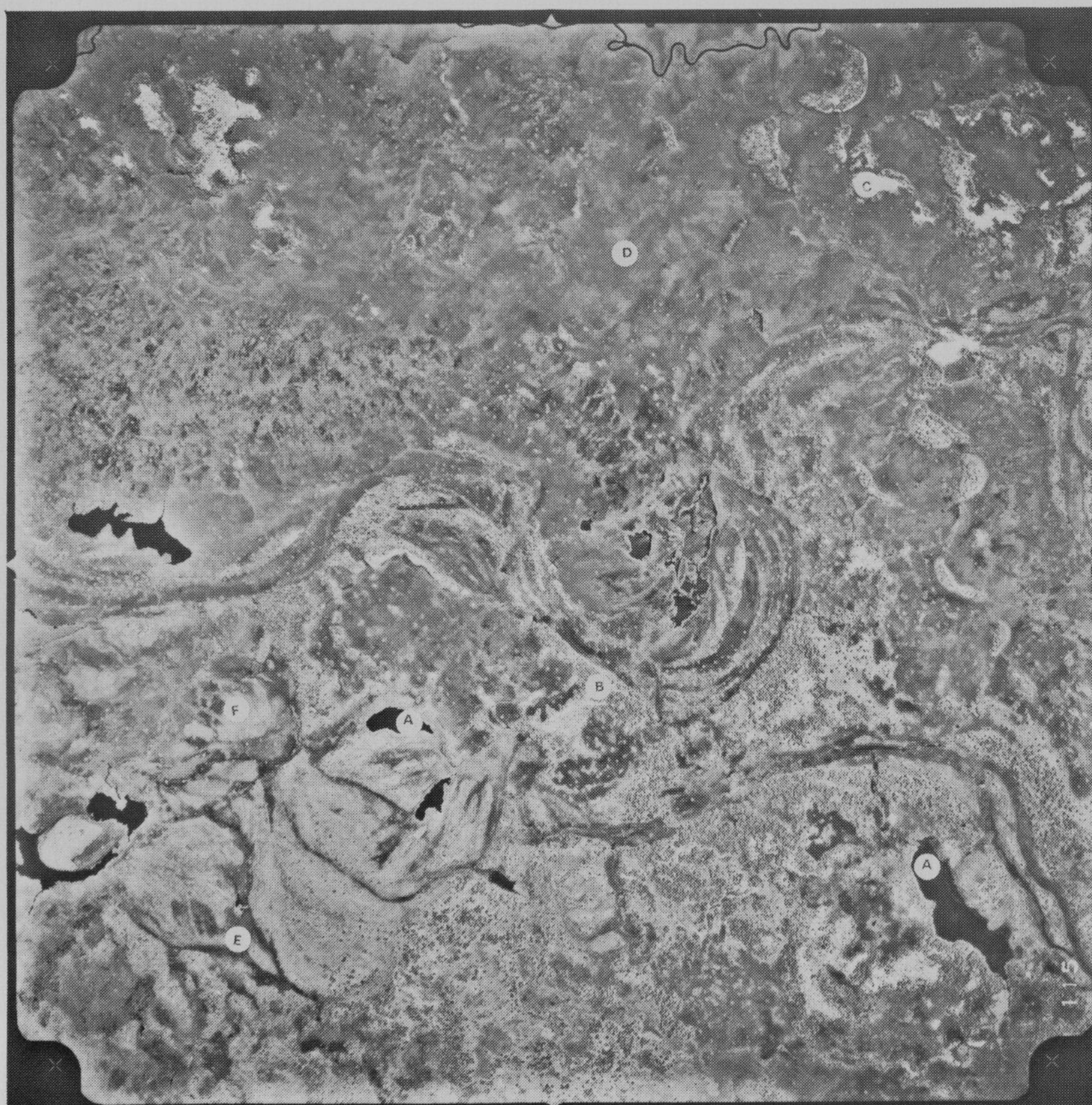

FIGURE 6 – Aerial photograph of section of the Okavango Delta to the north and northwest of Chief's Island, showing various plant communities and remnants of old Middle Channel Communities

A. Madiba Communities
B. Closed Riverine Woodland
C. *Sporobolus spicatus* Island Grassland Communities
D. Shallow Backwater Communities
E. Primary Floodplain Communities
F. Secondary Floodplain Communities

velocity decrease and subsequent deposition of the sand load. The deltaic fan so formed provides a suitable substrate for colonisation by some aquatic vegetation species, the natural evolution of which leads to a cut off of the major channel entering the lediba. Where velocity is very reduced through an on channel lediba, silt load may also be deposited.

Zonation of vegetation on madiba is present as a function of water depth and flow (Gibbs Russell and Biegel 1974). Submerged aquatic plants include *Lagarosiphon ilicifolius, Najas pectinata, Ottelia ulvifolia, O. muricata* and *Websteria confervoides.* Rooted floating-leaved plants include *Trapa natans, Brasenia schreberi, Nymphaea caerulea, N. lotus* and *Potamogeton thunbergii.* Rooted emergent plants include *Cyperus articulatus, Eleocharis acutangula, E. dulcis, Scirpus inclinatus* and *Typha latifolia.* Margins of *Cyperus papyrus* are common. Large thicket clusters of *Ficus verruculosa* occur centrally in some madiba or as smaller thicket clumps on the verges. *Azolla pinnata* and *Eichornia natuns,* free-floating aquatic plants were also collected.

These *Ficus verruculosa* thickets form nesting colonies for openbill stork *(Anastomus lamelligerus),* Marabou stork *(Leptoptilos crumeniferus),* wood stork *(Ibis ibis),* sacred ibis *(Threskiornis aethiopicus)* and darter *(Anhinga rufa).* Where plant succession leads to cut-off of a channel feeding a lediba from formation of a deltaic fan, alternative channels may be commenced by hippopotamus. The information of an alternative water route leads to the lediba now becoming off-channel and fed only by minor channels and/or overflow water. Islands in the vicinity of madiba often support a very luxuriant Closed Riverine Woodland on higher ground or *Sporobolus spicatus* Island Grassland Communities on lower ground due to high water conditions.

Flats Communities

None of the large expanses of flats occur wholly within the study area but Xho Flats adjoins the boundary and extends partly into the reserve. The Jao Flats and the Xho flats are the largest while the Xaralous Flats are fairly extensive.

Flats comprise extremely level areas usually flooded to 1 m and less in depth, dotted with occasional termitaria and small to medium-sized islands supporting woody vegetation growth. The passage of water flow through flats is greatly impeded and very little open water exists. Flats communities with their associated islands thus form a parkland type of vegetation.

Common rooted emergent aquatic vegetation comprises *Eleocharis dulcis, E. acutangula, Cyperus articulatus, C. Longus, Scirpus inclinatus, S. cubensis, Echinochloa colona, E. stagnina, Miscanthidium junceum, Polygonum limbatum, P. pulchrum* and *Phragmites australis.* Rooted submerged or with floating leaves and free-floating plants include *Ottelia ulvifolia, Nymphaea caerulea, Nymphoides indica, Ludwigia stolonifera, Potamogeton thunbergii, P. octandrus, Najas pectinata* and *Ultricularia* spp. In the upper and mid-Delta areas the termitaria and small islands support the woody species *Phoenix reclinata, Syzygium* spp., *Diospyros mesiliformis, Ficus* spp., *Capparis tomentosa, Euclea divinorum* and *Acacia nigrescens* spp. predominantly.

Minor water channels are kept open by hippopotamus, crocodile and outboard engine propellor via boat travel. These channels and flats areas are important since due to impeded water flow through them any man-made channel improvements are likely to take place here.

Shallow Backwater Communities

Shallow Backwater Communities occur in the study area on the M'borogha and Nambope floodplains, and along the reserve's western boundary above the Xho flats on the Boro River floodplain system. (Fig. 7). These communities occur either adjacent to the middle channels or displaced well off them but usually in close proximity to the perennial swamp area.

The Shallow Backwater Communities are dominated by tall grasses and sedges occurring on slightly elevated ground, but flooded for about six to nine months of the season. These communities are linked to Sump Communities covering the more depressed areas. Water flow is very slight to stagnant and the surface is covered by large amounts of deposited silt.

Miscanthidium junceum forms the major vegetation component. Other grasses such as *Oryza longisteminata, Leersia hexandra* and *Panicum repens* and the sedges *Cyperus articulatus C. longus, Scirpus inclinatus, S. corymbosus* and *S. uninodis* make up the bulk of this community. *Utricularia* spp are usually present. Numerous small termitarium islands occur usually with a single tree and shrub-thicket growing on it.

FIGURE 7 – Shallow Backwater Communities adjacent to a Middle Channel Community (M'borogha River), Okavango Delta, Botswana.

Sump Communities

Sump communities occur in the same localities given for the Shallow Backwater Communities. The former form a mosaic with the latter community, with the Sump Communities covering the more depressed areas. Sump Communities may also occur adjacent to Middle Channel Communities.

In appearance, Sump Communities are similar to madiba but are much smaller in expanse, much shallower and have far less open surface water. Vegetation comprises submerged, surface-floating, emergent and free-floating aquatic plants. Sump Communities are characterised by the absence of water velocity and no definite drainage, with soils comprising large quantities of silt. In exceptionally dry seasons Sump Communities may show no surface water but these sump communities dry out after the Shallow Backwater Communities.

Sump Communities adjacent to middle channels are characterised by sedges namely *Cyperus* spp., and *Scirpus* spp., whilst those occurring within Shallow Backwater Communities are characterised by other sedges, viz. *Eleocharis* spp. Rooted aquatic plants with floating leaves are common to both. The Sump Communities adjacent to middle channels are dominated by *Nymphaea caerulea* and *Nymphoides indica* closer to the open channel with some *Brasenia schreiberi* closer to the dryland verge. *Potamogeton thunbergii, P. pectinatus, Ottelia ulvifolia* and *Najas pectinata* are commonly submerged throughout this community. Emergent aquatic plants includes *Cyperus articulatus, C. tenuifloris, Scirpus inclinatus, S. corymbosus, Fimbrystylis hispidula* and *Fuirena* sp. *Utricularia* spp. and *Lemna purpusilla* were encountered in the almost stagnant waters and *Aeschynomene fluitens* was also collected from this area.

Sump Communities within Shallow Backwater Communities support *Brasenia schreiberi, Nymphoides indica, Najas pectinata, Potamogeton octandrus* and *Utricularia* spp. Common emergent aquatic plants from this locality are *Eleocharis dulcis, E. acutangula, E. atropurpureus, Cyperus denudatus* and *C. fastigratus.*

Floodplain vegetation types

Floodplain vegetation types are intermediary between wetland and dryland types, but is more closely associated to the wetland type, and can be divided into Primary and Secondary

Floodplains Communities and *Sporobolus spicatus* Island Grassland Communities. The Primary Floodplain communities (Setswana = melapo) are inundated virtually throughout the year, but do dry out in poor flood years for periods of up to seven months. This, however, only happens in an exceptionally dry season, viz. 1972/73. Primary Floodplain Communities in the lower-Delta dry out for longer periods (one to two months) than Primary Floodplain Communities in the mid-Delta. Secondary Floodplain Communities are characteristically open grasslands (classified as secondary from order in receiving surface inundation) which should be inundated for at least two or more months per annum to prevent species alteration and encroachment of woody plant species. The *Sporobolus spicatus* Island Grassland Communities should receive annual inundation for at least two months or more per annum but due to the locality and insufficient annual inundation of some of these areas they are evolving towards marginal or dryland types.

Primary Floodplain Communities

Primary Floodplain Communities are located west of Chief's Island on the Boro floodplain system mainly within the seasonal swamps in the study area. They also occur east of Chief's Island within the M'borogha and Nambope River systems where decreased quantities of floodwaters are progressively leading to drier prevailing conditions in central parts of this perennially classified swamp (Fig. 8).

Primary Floodplain Communities are inundated between 0,5 m and 2 m during the flooding periods. Water depths are up to 2 m in exceptional seasons at the deepest central part, but usually 1 m or less on average in the same locality. The topography here is that of a shallow trough with no marked banks and soils are of a sandy clay loam nature (Siderius 1972). The Primary Floodplain Community distribution follows the course of lowest levels in the seasonal floodplain, flooding subsequently onto Secondary Floodplain Communities and *Sporobolus spicatus* Island Grassland Communities and around the margins of islands. The vegetation is primarily aquatic grasses and sedges with very little open surface water.

The vegetation centrally comprises mainly the aquatic species *Cyperus articulatus, Scirpus inclinatus* and *Miscanthidium junceum*. *Cyperus longus, C. denudatus* and *Rhynchospora cyperoides* are fairly common. Within the lower lying central area the grasses *Sacciolepus typhura, Leersia hexandra, Panicum repens* and *Sorgastrum friesii* are common; whilst towards the shallower margins *Setaria sphacelata, Cymbopogon*

FIGURE 8 – Primary Floodplain Community to the west of Chief's Island, Okavango Delta, Botswana, with an adult male reedbuck centrally.

excavatus, Ischaemum afrum, Eulalia junciformis, Eragrostis patentissima and *Digitaria eriantha* are found. Common aquatic forbs include *Ottelia kunenensis, O. ulvifolia, Nymphoides indica, Alternanthera sessilis, Polygonum salici folium, Ludwigia octovalvis, Neptunia oleracea* and *Potamogeton thunbergii.*

Primary Floodplain Communities show a good silt deposition and are used lower down in the Delta as moisture cultivation fields when dry (see section on utilisation). In the mid-Delta areas and parts of the lower Delta they form very important habitat types for red lechwe *(Kobus leche leche)* when inundated and for many mammalian species when almost dry or completely dry. These shallow drainage floodplains are linked to middle and outlet channels and after drying up in poor flood seasons, are reflooded from both upstream and downstream junctions during the following season's flood arrival. When these two advancing flood water heads join up, a general slow flow then takes place towards the lower junction. This gives a strong indication of the small gradient and the slowness in flooding pattern. Primary Floodplain Communities are of great importance to this ecosystem and are unquestionably a source to engineers to prevent water loss from the outlet channels. The method of bunding (blocking off the entrance of floodwaters from outlet channels to primary floodplain systems by means of an earth wall) was used by Naus in the 1920's on the Santantadibe and Gomoti River headwaters. Bunding was also suggested by early authors for drying up parts of the western half of the Delta (Jeffares 1938, Brind 1954). During 1972/3 the Anglo American Corporation adopted bunding in conjunction with channel improvement for manipulations on the lower Boro River.

Natural factors such as seismicity and blockages cause water diversion, with more water becoming available to Primary Floodplain Communities, which in conjunction with large scale hippopotamus movement may result in the evolution of such a Primary Floodplain Community to a channel. Stigand (1923) quotes the haMbukushu natives telling him that during the reign of Letsholathebe I (c. 1840–1874) " . . . the Ng-gokha River (Nqogha) was formed. Prior to this it was just a 'molapo' or shallow swamp channel or channels and that the Thaoge River was the Okavango River's continuation. Hippopotamus in great numbers breaking through and trampling a big 'hippo path' created the initial Ng-gokha River and the inflowing water did the rest . . ."

Termitaria are of great importance in all floodplain and aquatic vegetation communities which dry up for part of any year. In Primary Floodplain Communities termitaria are established during dry times. These have become eroded by weather and animal usage often to the point where they form slightly elevated circular areas in these floodplains. They are usually free of woody vegetation, are covered with lawn-like *Cynodon dactylon* and *Sporobolus spicatus* and form vantage points or resting up areas for red lechwe.

Secondary Floodplain Communities

Secondary Floodplain Communities occur on the lower Boro River floodplains and in some suitable areas between the M'borogha and Nambope River floodplains within the study area (Fig. 9). Secondary Floodplain Communities are more common in the seasonal swamp areas and are more extensive lower down in the Delta out of the study area.

They comprise either uniform, short (0,2 m) or medium-height (1,0 m) open, grassland areas probably depending on flooding frequency and utilisation and occur on level sandy soils with small amounts of clay or silt present. Forbs and sedges are present in varying densities again possibly as a function of animal utilisation and flooding frequency and duration.

In poor flood seasons they receive no surface inundation whatsoever, whereas in extreme rain and flood seasons they may be inundated for periods of up to seven months. Under average conditions these areas are inundated for two to three months of the year (during the winter) from floodwaters. On average inundation depth varies from 0,01 m to 1 m. However, in poor flood seasons no surface inundation occurs. Termitaria with woody vegetation are present on some Secondary Floodplain Communities giving a parkland appearance.

Grasses dominate the plant species composition of Secondary Floodplain Communities and include *Eragrostis lappula* var. *divaricata, E. lappula* var. *lappula, E. lehmanniana, Brachiaria humidicola, Cynodon dactylon, Panicum repens, P. aphanoneurum, Setaria woodii, S. sphacolata, Imperata cylindrica* and *Trachypogon spicatus.* Sedges include *Cyperus longus, C. denudatus* var. *sphaerospermus* and *Bulbostylis burchelli.* Forbs include *Nicolasia costata, Sphaeranthus humilus, Indigofera charleriana, I. flavicans* and *Lightfootia denticulata.*

Towards the ecotone with islands or on and around raised ground, viz. termitaria, *Setaria sphacelata, Cymbopogon excavants, Cynodon dactylon* and *Imperata cylindrica* replace the above grass species. Forbs encountered in these ecotonal areas include *Nidorella*

FIGURE 9 – Secondary Floodplain Community to the west of Chief's Island, Okavango Delta, Botswana, with an isolated *Combretum imberbe* on an eroded termitarium and the western margin of Chief's Island in the background.

Blumeacaffra, Ipomoea hackeliana and *Lessertia bengurellensis.* After inundation, *Crinum* sp. cf *C. caroloschmidtii* and *Waltheria indica* were collected from Secondary Floodplain Communities.

Frequency and duration of flooding in conjunction with the dry time period which Secondary Floodplain Communities are available for animal utilisation play an important role in their vegetation composition and trend.

Sporobolus spicatus Island Grassland Communities

The *Sporobolus spicatus* Island Grassland Communities occur on both the eastern and western floodplain systems, adjacent to most islands and madiba at the extremity of the flood limits where suitable conditions exist (Fig. 10). Two types of this short island grassland exists. In general these may be separated into (i) Island Grassland Communities of the permanent swamp areas, characterised by predominantly *Sporobolus spicatus* and short sedges, the surface largely covered with evaporites, having a very high water table and inundated to a depth of 0,1 to 0,4 m in almost any flood season, and (ii) Island Grassland Communities of the seasonal swamp areas again characterised by *Sporobolus spicatus* but with other grasses dominating the species composition. The water table is lower, evaporites less common or nearly absent and these Island Grassland Communities are only flooded during high flood years to a depth of up to 0,3 m.

The most common grass species are *Sporobolus spicatus* and *Cynodon dactylon.* Where evaporites are common and flooding more regular the sedges *Juncellus laevigatus* and *Eleocharis fistulosa* occur, and the forb *Asclepias fruticosa* is often present. Under drier Island Grassland Community conditions the sedges, *Kyllinga alba, Cyperus fulgens, C. sphacelatus* and *Mariscus squarrosus* are present, as well as the grasses *Eragrostis cilianensis, E. viscosa* and on the more elevated sectors *Aristida argentea, A. meriodionalis* and *Chloris virgata.* Forb species also occur under the drier conditions namely *Cleome rubella, Hermannia modesta* and *Hirpicium gorterioides* on lower areas whilst *Pluchea leubnitziae* invades from higher ground.

The various plant associations of these Island Grassland Communities depend probably on local base levels, water table and flooding regime. The formation of termitaria on island verges is causing evolution towards island closure and the cut off of floodwaters from entering into these Island Grassland Communities. This in turn causes the plant composition to evolve towards a marginal or dryland community.

FIGURE 10 – *Sporobolus spicatus* Island Grassland Community centrally in figure with the process of "island closure" almost completed, leading to non-flooding of the community and its evolution towards a marginal or dryland vegetation type. Note Closed Riverine Woodland bottom left and arc of flooded Primary Floodplain Community above island.

Riverine vegetation types

According to Tinley's (1966) definition, no true forests exist in the Okavango Delta. Riverine vegetation types are luxuriant large tree species with overlapping crowns forming a deep shade layer in which herbaceous sciophytes predominate. These latter comprise mainly annual grass and forb species. The water table is close to the surface, and in high floods the marginal woody stem bases may become inundated for short periods.

Closed Riverine Woodland

On the slightly elevated margins of most islands, except where local lower levels exist which permit floodwaters to enter and inundate adjacent island grassland, a dense, narrow band of partially evergreen woody vegetation exists. These Closed Riverine Woodlands occur on the elevated margins of most islands throughout the study area, but their development is dependent on the proximity of surface water and thus of a high water table. The more permanent the water level in proximity to this slightly elevated dryland verge the more luxuriant is the development of this Closed Riverine Woodland. Under converse conditions the Closed Riverine Woodland is poorly developed or completely lacking. The soils consist of a sandy loam in which mature trees average 20 m in height and have a diameter at knee height (d.k.h.) of up to 1 m.

The most prominent woody species are *Diospyros mespiliformis, Garcinia livingstonei, Ficus sycamorus, F. burkei* and *Lonchocarpus capassa.* In conditions of very high water table *Syzygium* spp. and *Phoenix reclinata* are usually present with *Myrica serrata* in some localities. The low *Phoenix reclinata* population on the M'borogha floodplain islands is however not clearly understood.

Common, but less prominent woody species include *Croton megalobotrys, Hyphaene ventricasa, Rhus pyroides, R. tenuinervis, Kigelia africana, Berchemia discolor, Euclea divinorum, E. crispa, Gardenia spathulifolia, Ximenia americana, Grewia bicolor. G. schinzii, G. villosa, Vernonia amygdalina, V. colorata, Acacia nigrescens, A. sieberana* and *Ziziphus mucronata.*

Herbaceous sciophytes form a dense understorey. The most common forbs are *Achyranthus sicula, Commicarpus africanus, Celosia trigyna, Abutilon ramosum, Pupalia atropurpurea, Wissadula restrata* and *Dicliptera micranthes.* Grasses in this shade layer are mainly annuals and include *Setaria verticillata, Leptocarydion vulpiastrum, Cymbosetaria sagittifolia, Eragrostis biflora, Sporobolus fimbriatus, Panicum maximum* and *Digitaria zeyheri.* Other forbs collected include *Abutilon angulatum, A. austro-africanum, Polygonum limbatum, Chenopodium album, Solanum nodiflorum, Monechma debile* and *Dilcis petiolaris.*

Unhealthy appearing Closed Riverine Woodland indicates dessication of what was previously established. Fire devastation may also be responsible, but close examination of the stratum readily reveals this factor.

Phoenix reclinata – Syzygíum spp. Termitaria

In the more permanently flooded northern zone of the Delta and of the study area, and also in the eatern portions of Xho Flats within the study area, termitaria provide the only high ground areas for the establishment of woody species. These termitaria must have been established during drier periods or during an altered flooding pattern, and the termites were subsequently killed by rising water levels. The termitaria then became colonised by vegetation after erosion of the termitarium had commenced. Tinley (1977) stresses the importance and evolution of termitaria in floodplain systems.

These termitaria occur in almost permanently inundated Flats or Shallow Backwater Communities and combined with those communities form a parkland vegetation type. They are, however, treated solely as termitaria due to the criterion chosen in separating vegetation types. The soils are a sandy loam and during high floodwater conditions the bases of the tree stems are inundated up to 0,3 m.

In the almost permanently flooded areas and due to the high water table these termitaria are mainly colonised by *Phoenix reclinata* and *Syzygium* spp. The termitaria verges are colonised by marginal grass species i.e. *Setaria sphacelata, Cymbopogon excavatus* or *C. plurinodis, Imperata cylindrica* and *Digitaria eriantha,* whilst *Cynodon dactylon* covers part of the actual termitarium. Forb species collected from termitaria include *Rhynchosia caribaea, R. minima, Asparagus nelsii, Portulaca oleracea, Amaranthus thunbergii, Heliotropium ovalifolium, Kedrostris hirtella, Acalypha indica* and *Zehneria marlothii.*

Woody species common on termitaria in the mid and lower-Delta are *Diospyros mespeliformis, D. lycioides, Ficus sycamorus, F. burkei, Vernonia colorata, V. amygdalina,* *Phyllanthus reticulatus, Jasminum fluminense, Capparis tomentosa, Maytenus senegalensis, Grewia schinzii, G. villosa, Gomphocarpus fruticosus* and *Garcinia livingstonei.*

Under drier floodplain conditions where termitaria exists, almost any woody species occurring in the Delta is found established on these termitaria viz. *Acacia sieberana, A. nigrescens, A. galpinii, Albizzia harveyi, Combretum* spp. and *Colophospermum mopane.*

Erosion of termitaria proceeds both by rain and animal utilisation of the area, breaking down and spreading out the termitarium into a slightly elevated circular island. The degree of erosion is dependent on the death of the termites and the duration that the termitarium is subject to weathering agencies before vegetation colonisation takes place. The linking-up of adjacent eroded termitaria provides for increase in island size. Termites are one of the greatest factors in establishing raised levels and thus form suitable bases for island formation and enlargement.

Marginal vegetation types

These marginal vegetation types occur on soils slightly more elevated and slightly sandier than those supporting Closed Riverine Woodlands and thus also where a slightly lower water table exists. In certain instances only marginal woody species occur on an island; with the Closed Riverine Woodland being absent. The marginal vegetation types of the mid-Delta do not occur over extensive areas.

Acacia nigrescens – Croton megalobotrys
Woodland and Savanna Woodland

Acacia nigrescens – Croton megalobotrys Woodland or Savanna Woodland occurs in small stands on some of the small to medium-sized islands on the Boro River floodplain as well as on the M'borogha and Nambope Rivers' floodplains in the study area. On some of the larger islands of these floodplains larger stands develop but from personal observation not to the extensive size or density that this community occupies lower down in parts of the Delta (Tinley, 1966). The soils are a sandy loam and the communities are not subject to surface inundation.

Acacia nigrescens and *Croton megalobotrys* are the most common trees. Since this community usually abuts onto Closed Riverine Woodland, some of the common but less prominent woody vegetation species of the Closed Riverine Woodland extend over into the *Acacia nigrescens – Croton megalobotrys* Woodland and Savanna Woodland Community. *Kigelia africana* is often present in this community. Grasses and forbs also extend over from the Closed Riverine Woodland, but due to greater light penetration in parts more grasses (individuals and species) are present in this marginal vegetation type. *Plicosepalis* spp. of hemiparasites are common on the *Acacia nigrescens* trees. More often *Acacia nigrescens* occurs as a minor species in *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland. An *Acacia nigrescens* specimen located in Closed Riverine Woodland adjacent to a lediba was of exceptional size having a d.k.h. of nearly 2 m.

Hyphaene ventricosa – Croton megalobotrys
Palm Woodland and Palm Savanna Woodland

The *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland or Palm Savanna Woodland are very common on most small and medium-sized islands of the central and lower floodplains in the study area. Soils are classified as sandy loam and the water table is reasonably high, but surface inundation of stem bases does not occur.

Hyphaene ventricosa may occur in almost pure stands or with some *Croton megalobotrys*. *Hyhaene ventricosa* occurs either as a single-boled 20 m high palm or less commonly in a scrub form. *Kigelia africana, Garcinia livingstonei* and *Ziziphus mucronata* occur occasionally in this type of woodland. This community also abuts onto Closed Riverine Woodland and some overlap of woody and herbaceous species from the closed Riverine Woodland occurs into this marginal vegetation type. The more open canopy in this community allows greater light penetration and grasses become more prominent and forbs less prominent when compared to the Closed Riverine Woodland. *Setaria verticillata, Sporobolus fimbriatus* and *Cynodon dactylon* are common grasses in this community.

Where fire has passed through the *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland or Palm Savanna Woodland there is evidence of numerous palm seeds germinating and it is possible that fire may act as a stimulant to *Hyphaene ventricosa* germination. *Hyphaene ventricosa* sap is tapped by the Delta inhabitants for producing an alcoholic beverage, but no large scale alteration of *H. ventricosa* Woodland to Palm Scrub was detected as is reported for *H. natalensis (H = crinita)* over its range on the east coast of Zululand (Tinley 1966).

Combretum imberbe – Croton megalobotrys
Woodland and Savanna Woodland

Combretum imberbe – Croton megalobotrys Woodland or Savanna Woodland occur on some medium and large islands on the floodplains of the Boro, M'borogha and Nambope River systems in the study area (Fig. 11). The soils supporting this type of marginal woodland, probably have a slightly higher sand content than other marginal woodlands characterised by *Acacia nigrescens* or *Hyphaene ventricosa*, and surface inundation may only occur in seasons with abnormally high water levels.

The most conspicuous woody vegetation species are *Combretum imberbe*, *Croton megalobotrys* and *Lonchocarpus capassa* with *Diospyros mespiliformis*, *Grewia schinzii*, *Acacia nigrescens*, *A. tortilis*, *Dichrostachys cinerea*, *Ziziphus murconata*, *Kigelia africana*, *Maytenus senegalensis* and *Garcinia livingstonei* also present. The herbaceous layer is made up of the grasses *Cenchrus ciliaris*, *Sporobolus fimbriatus*, *Cynodon dactylon*, *Digitaria pole-evansi*, *Panicum maximum* and *Enteropogon macrostachys;* and the forbs *Blepharis diversispina*, *Tephrosia lupinifolia*, *Celosia scabra*, *Hibiscus engleri*, *Monechma debile* and *Oxygonum delagoense*.

Dryland vegetation types

Dryland vegetation types are not normally subject to surface inundation from floodwaters. Surface inundation can, however, occur under certain circumstances and this may result in the death of those species present which cannot tolerate flooding, viz. *Acacia erioloba* and *Pluchea leubnitziae*. This may occur as a result of:-

1) Some ancient drainage courses or old floodplains which have not been subjected to surface inundation for many years, and have evolved to a dryland type supporting woody vegetation, are suddenly subjected to surface inundation from extremely high flood levels or from an altered flooding pattern.

2) Some ancient floodplains which have not been subject to surface inundation for many years and due to some marginal raised levels via termitaria are now 'cut off' from surface flooding, are subjected to heavy local rainfall, the drainage off of which is now impeded, viz. some northern parts of Chief's Island during the heavy 1973/74 rainy season.

FIGURE 11 – *Combretum imberbe* – *Croton megalobotrys* Woodland on an island in the Boro River floodplains, Okavango Delta, Botswana, with Secondary Floodplain Community in the foreground.

Acacia tortilis Savanna Woodland

Acacia tortilis Savanna Woodland occurs mainly on the upper eastern and western margins of Chief's Island and centrally on some of the larger islands especially of the eastern floodplain system in the study area. These communities occur adjacent to the present floodplain extremity and on ancient floodplain where the soils comprise a compact silty alluvium. Surface inundation occurs in some parts of this community (see 1 & 2 above) in years of exceptionally high water levels.

Well developed stands of *Acacia tortilis* trees occur with lesser numbers of *A. hebeclada, A. sieberana, Albizzia harveyi, Colophospermum mopane, Ziziphus macronata, Rhus quartiniana, R. tenuinervis, Hyphaene ventricosa, Ximenia americana, Garcinia livingstonei* and *Grewia* spp. Grasses occurring in this community are *Cynodon dactylon, Sporobolus salsus, Panicum coloratum, Chloris gayana, C. virgata* and *Urochloa brachyura.*

Acacia tortilis Savanna Woodland Communities interdigitate and lie adjacent to *Acacia nigrescens – Croton megalobotrys* Woodland and Savanna Woodland Communities on higher ground, *Acacia erioloba* Woodland and Savanna Woodland where the substrate is sandy, or present-day floodplain verges.

The herbaceous layer in *Acacia tortilis* Savanna Woodland was the most heavily utilised of all the areas examined. Grasses were cropped off at ground level and maintained in this state. Some of these areas examined in 1973 showed that floodwaters did not cover the intermediate adjacent floodplains. This was also probably the case in the previous dry years and has led to a state of no rest during the flood and heavy overutilisation by game. This explains why large parts of the herbaceous layer in this community was held in the state of a barren lawn. Damage to mature *Acacia tortilis* trees caused by elephant *(Loxodonta africana africana)* was evident. *Acacia tortilis* shrubs and seedlings were hardly evident in this community, substantiating Tinley's (1966) records for the Khwai *Acacia tortilis* community. *Acacia hebeclada* occurs as localised thickets usually on the margins of rain pans in this community.

Acacia erioloba Woodland and Savanna Woodland

Acacia erioloba Woodland and Savanna Woodland occurs from the southern parts of Chief's Island northwards mainly up the western side of the island with an increasingly wider distribution as one proceeds northwards (Fig. 12). Apart from its distribution on Chief's Island some of the islands having a suitable sandy substrate support stands of *Acacia erioloba* Woodland or Savanna Woodland in the study area.

Acacia erioloba in general and throughout the study area occurs on sandy alluvium or on firmer Kalahari sands (Tinley 1966). *Acacia erioloba* is widely distributed, but dispersed, following old sandy drainage courses and some old sandy floodplains. The areas over which *Acacia erioloba* Woodlands or Savanna Woodlands occur is not subject to surface inundation except under the exceptional flood conditions mentioned also for *Acacia tortilis* Savanna Woodland.

Acacia erioloba is conspicuous in this community with other woody species such as *A. fleckii, Terminalia sericea, Grewia subspathulata, G. schinzii, G. flavescens* and *Ziziphus mucronata* present. The herbaceous layer is made up of the grasses *Brachiaria brizantha, Tricholaena monachne, Eragrostis pallens, Digitaria eriantha, Cynodon dactylon, Pogonathria fleckii, Aristida stipitata* and *Stipagrostis uniplumis;* and the forbs *Borreria paludosa, Commelina benghalensis, Pluchea leubnitziae, Cleome rubella, Blepharis diversispina, Bergia pentherana* and *Asclepias burchelli.* A common sedge in this community is *Bulbostylis burchelli.*

Acacia erioloba Woodland and Savanna Woodland occurs in patches or courses forming a mosaic and alternating with *A. tortilis* Savanna Woodland, *A. nigrescens – Croton megalobotrys* Woodland and Savanna Woodland, and *Terminalia sericea – Combretum collinum* Savanna Woodland and Scrub, depending on the pattern of substrate distribution from old flooding conditions. Numerous *Acacia erioloba* seedlings and small trees were evident and the savanna woodland type is more commonly encountered than the woodland form of this community.

Terminalia sericea – Combretum collinum Savanna Woodland and Scrub

On Chief's Island and on medium to large-sized islands *Terminalia sericea – Combretum collinum* Savanna Woodland or Scrub is established on loose pallid Kalahari sand. This community is not subject to surface inundation and appears to have established itself on the original wind-deposited sands.

The main woody vegetation species present are *Terminalia sericea, Combretum collinum, Bauhinia macrantha, Lonchocarpus nelsii, Maytenus senegalensis, Rhus tenuinervis, Acacia leuderitzii, Commiphora africana* and *Boscia mossambicensis.* Grasses recorded are

FIGURE 12 – *Acacia erioloba* Savanna Woodland northern Chief's Island, Okavango Delta, Botswana. Note heavy mammalian utilisation of herb layer.

typically tall large tufted species such as *Aristida stipitata, A. meridionalis, Stipagrostis hirtigluma, Schmidtia pappophoroides, Eragrostis curvula* and *Urochloa brachyura.* Forbs include *Barleria lancifolia, Pollichia campestris, Monechma divaricatum, Acatho-sicyos naudiniana, Blepharis diversispina, Tephrosia lupinifolia, Corallocarpus bainesii* and *Acrotome inflata.*

On southern Chief's Island this community occurs in a mozaic form alternating with *Colophospermum mopane* Woodland or Pyrophytic Scrub Savanna. In the central and northern Chief's Island areas, *Terminalia sericea – Combretum collinum* Savanna Woodland or Scrub Savanna alternates in patches with *Acacia erioloba* Woodland or Savanna Woodland and *Acacia tortilis* Savanna Woodland; each community occurring on suitable substrate. The scrub form of *Terminalia sericea – Combretum collinum* are most commonly encountered on medium to large-sized islands on the M'borogha/Nambope floodplains.

Colophospermum mopane Woodland and Pyrophytic Scrub Savanna

The largest *Colophospermum mopane* Woodland and Pyrophytic Scrub Communities occur from the southern tip of Chief's Island extending up the eastern half of the large island to an approximate northern limit in the vicinity of the primary survey beacons BPS 280 (Fig. 13). These communities also occur on some of the larger islands of both the eastern and western floodplains, but are more prevalent on the eastern floodplains and always covering the central core of all islands it occurs on. Isolated *Colophospermum mopane* trees may be found on termitaria of the central Delta areas; on island or floodplain termitaria but usually in fairly close proximity to the large *Colophospermum mopane* Woodland or Pyrophytic Scrub areas from whence the seeding probably must have come. *Colophospermum mopane* Woodlands occur on grey clay pan soils and are not subject to surface inundation.

Colophospermum mopane is dominant and occurs in almost pure stands either in the single-boled tree form or as a dense shrub form, probably as the result of fire damage to young plants (Van der Schijff, 1957) which then forms multiple coppice growth. Some interdigitation or overlap of the single-boled tree form and shrub form occur but this appears to follow and old burn pattern. Other woody species occurring in the *Colophospermum mopane* Woodlands or Pyrophytic Scrub Savanna include *Croton megalobotrys, Grewia*

FIGURE 13 – *Colophospermum mopane* Woodland southern Chief's Island, Okavango Delta, Botswana.

bicolor, G. flava, G. villosa, Commiphora africana, Acacia tortilis and *Boscia mossambicensis.* Rain pans are common in the *Colophospermum mopane* Woodlands due to the relatively impervious clay soils and localised small *Acacia hebeclada* thickets are invariably found associated with these pans. Isolated species of *Acacia tortilis, Albizia harveyi, Combretum imberbe* and *C. hereroense* may also be found locally around these rain pans, or small thickets of *Capparis tomentosa, Ximenia americana* or *Maytenus senegalensis* on old termitaria in the same locality. The herbaceous layer is generally poorly developed and includes the following species *Eragrostis curvula, Setaria verticillata, Aristida stipitata, Chloris virgata, Achyranthus sicula, Tribulus terrestris, Sesuvium nyasicum, Ruellia patula, Acanthosicyos naudinianus, Harpagophytum* sp. and *Bidens schimperi.*

Parts of the *Colophospermum mopane* Woodlands are damaged by elephant via bark stripping or "green splint" type of break. Damage is, however, no where near as serious as in the *Colophospermum mopane* Woodland southwest of the Dombo Lediba in Moremi Wildlife Reserve (pers. observ.). The thick layer of dried *Colophospermum mopane* leaves covering the soil are an ideal fuel for fire due to their high resin content.

Grewia spp. – *Croton megalobotrys* Scrub Savanna

On medium and large-sized islands with a sandy substrate, the central core of the island is often sparsely covered with tall woody vegetation. The bulk of the woody vegetation is formed by a *Grewia* spp. Scrub Savanna with *Croton megalobotrys* present. These *Grewia* spp. – *Croton megalobotrys* Scrub Savanna are present centrally on medium and large-sized sandy islands of both the eastern and western floodplain systems in the study area. This community occurs on a sandy substrate not subject to surface inundation. *Croton megalobotrys* occurs mainly as a small tree or shrub but is absent from parts of this community.

The main woody shrub species present are *Grewia flavescens, G. schinzii, G. retinervis* and *Croton megalobotrys.* Other woody species present as trees or schrubs include *Acacia erioloba, A. tortilis, Ziziphus mucronata, Lonchocarpus capassa, Hyphaene ventricosa, Commiphora african, Ximenia americana, Diospyros lycioides* and *Gomphocarpus* sp. The herbaceous layer comprises *Urochloa brachyura, Eragrostis rotifer, E. tricophora, E. biflora, Setaria verticillata, Schmidtia pappophoroides, Chloris virgata, Pseudobrachiaria deflexa* and *Cynodon dactylon* as grasses; and *Clerodendron uncinatum, Pluchea leubnitziae, Blepharis diversispina, Ipomoea mignusiana, Hermannia glanduligera* and *Gisekia africana* as forbs.

THE STATUS AND TRENDS IN THE VEGETATION TYPES AND THE EFFECTS OF PERIODIC FLOODING ON THESE TYPES

The most critical vegetation types in the Okavango Delta are those which are dependent on a varying annual period of inundation and a high water table, viz. the floodplain and riverine vegetation types. The regularity of inundation, the duration it occurs for and the pattern it assumes varies from year to year, being dependent on local Delta rainfall quantity, floodwater quantity from Angola, vegetation friction and obstruction to water flow (and thus burning of aquatic and floodplain vegetation types) and any alterations in local Delta base levels. The annual alteration and interaction of these above parameters almost assures that no two flood seasons produce the same regularity, duration or pattern of flooding over the Delta.

A massive alteration in water distribution down to the Delta will affect the distribution of the aquatic vegetation types, since these plant communities are dependent on water throughout the year. Some can however tolerate short periods of absence of surface water in dry seasons. The floodplain communities are determined to be the most sensitive to change in altering flood regimes, and as such are dealt with in more detail. The riverine vegetation types are somewhat less sensitive to change being able to endure poor flood seasons for a longer period than the floodplain vegetation types. The marginal vegetation types are even less sensitive to change than the riverine vegetation types, and appear to be expanding in distribution up the Delta. Similarly the dryland vegetation types are expanding in distribution, but their expansion is curtailed to some degree by years of excessive floods when old drainage courses and old floodplain systems, which due to the sustained absence of surface water, and a low water table, were colonised by dryland woody species, and then are suddenly reinundated.

Methods

No quantitative assessment of aquatic vegetation types' status or trend was attempted due to the lack of methodology, the difficult working conditions or the time being available to carry out such fieldwork. Some floodplain, riverine, marginal and dryland vegetation types are assessed for status using a joint combination of the "Point-centred quarter method" (Cottam, Curtis and Hale 1953), the "Step-point method" (Evans and Love, 1957) with modifications by Riney (1963) and the "Concentric-circle method" devised by Havenga (1967, In Grunow, 1971). In sampling woody vegetation strata a combination of all methods was used, whilst the "Concentric-circle method" (CCM) was omitted when sampling vegetation types comprising a herbaceous stratum only. In some instances of sampling herbaceous strata the "Point-centred quarter method" (PCQM) was also omitted due to the time factor involved. In the "Step-point method" 100 points were sampled at 1 m intervals for herbaceous and/or woody vegetation. Along this transect eight random points (selected from random number tables) were sampled via the P.C.Q.M. (for woody and herbaceous vegetation) and/or C.C.M. (for woody vegetation only). A series of such parallel transects were conducted 100 m apart, the total number depending on the extent of the vegetation community being sampled. The ratio of radii used for the CCM was 1 : 10 m. "Nearest species method" of density was calculated from the nearest individual to a strike on the "Step-point method", this being expressed as a percentage of the overall total of points sampled. Each point sampled was visually checked for grazing records of herbaceous plants. The number of grazed samples around a 0,5 m radius with sample point as centre were then expressed as a percentage of the total number of points sampled. Importance value is obtained from the average of relative percentage frequency, density and dominance.

Average densities were obtained by the following formulae for each method:

PCQM: Average density $= \dfrac{\text{No of square units of measure}}{\text{M}}$

where M = average distance from sampling point to nearest species in each quarter. (measured in cm for herbaceous vegetation and in m for woody vegetation)

m $= \dfrac{\text{sum of all distances}}{\text{number of nearest species sampled.}}$

CCM: $n = C\,(Y_2{}^{\frac{1}{2}} - Y_1{}^{\frac{1}{2}})^2$

where n = number of plants over area sampled

C $= d^2/_{\pi}\,(X_2 - X_1)^2$

Y_1 = number of plants contained in small circle

Y_2 = number of plants contained in large circle

X_1 = Radius of small circle

X_2 = Radius of large circle

where $\frac{X_2}{X_1} \geqslant 8$

$d^2 = \frac{\text{Total area}}{N}$

N = total number of sample points

From obtaining n convert by simple proportion to the unit of a hectare.

Quadrat method:

Average density = Total number of woody species in all large circles per total area of large circles and this converted to the unit of a hectare.

Conservation trend percentages (conservation trends) are based on Riney (1963), a somewhat subjective assessment based on amount of annual versus perennial grass cover, amount of bare ground, amount of litter, encroachment of undesirable plant species in that community, amount of erosion pedestal and the evolution pattern of the plot. The plot size chosen was approximately one two-thousandth of a hectare. All transects, with the exception of a series conducted on primary floodplain in the lower Delta, were conducted in the study area. However, visual comparisons are made with any of the numerous areas covered throughout the Delta during the course of other fieldwork.

Aquatic vegetation types

Thompson (1975) deals independently with the major aquatic vegetation species of the Okavango Delta, their physical and chemical water requirements and the possible effects of some alterations of flow or the introduction of some undesirable aquatic vegetation species can be deduced from his work. Since no quantitative work was conducted in aquatic vegetation types, this work will only give general status and possible trends of these communities.

Filter Communities

Filter Communities are all situated in the upper section of the Delta and as such are not subject to the extremes of flood conditions affecting the seasonal swamps. Water levels fluctuate to a small degree (0,12 m) in the adjacent river at gauge posts, but since levels appear to be lower away from the river (Jeffares, 1938), the fluctuation in water levels may be greater. The Filter Communities as such appear to be relatively stable and subject to little or no vegetation compositional change.

However, studying the aerial photographs of this section of the Delta shows a maze of ancient upper channels which have existed during the evolution of the Delta. This may well be tied up with the period of development of the Nqogha River according to haMbukushu native legend. Large scale faulting which is possible in this upper-Delta section (Scholtz *et al.* 1975) may well alter the position and distribution of present filter communities.

Middle Channel Communities

Middle Channel Communities are situated in the perennial swamps and are relatively stable to vegetation changes. However, during the Delta's evolution changes have occurred in some of these channels. Notably the Moanachira River has evolved from an upper channel to a middle channel (Wilson, 1974), and the M'borogha River carried a far greater discharge during the first half of this century as is evident from the high banks of islands adjacent to the M'borogha River channel and the major discharge of its distributaries. The consolidation of the Nqogha blockage is the primary reason for loss of discharge down the M'borogha River. The upper Boro River after the 1950's is carrying an increased discharge of water.

Continual evolution towards a decreased discharge down the M'borogha River will allow for the eventual domination of aquatic vegetation species leading to the formation of surface blockages and possibly consolidated blockages in this system. (Fig. 14). This could have far reaching effects on the ecology of southern Moremi Wildlife Reserve, Chitabe controlled hunting area and human habitation of the lower Santantadibe River.

Outlet Channel Communities

Outlet Channel Communities are located in the seasonal swamps and are subject to large scale discharge and thus vegetational changes. Ever since some form of discharge documentation has been recorded the main outlet channel discharge has varied. During the 1920's and 1930's the Gomoti River provided the bulk discharge from the Delta. Round about the 1950's the Santantadibe River filled this role, whilst from the late 1960's and till the

FIGURE 14 – Surface blockage of floating debris with sedges established further back along blocked Outlet Channel Community. Headwaters of Xudum River in the Xho Flats vicinity, Okavango Delta, Botswana.

present day the Boro River now delivers the bulk of the Delta's discharge. The redistribution of discharge water is thus a characteristic function of the Delta caused by natural phenomena and human factors occurring either independently or in conjunction with one another.

The result is that in the absence of man-manipulated control certain outlet channels are evolving towards closure, consolidation and eventual dying of those systems. However, the instability of the whole system allows for reflooding of any of these systems but invariably in an altered flooding pattern.

Madiba Communities

Madiba Communities seem relatively stable and are well represented in the upper-Delta and reasonably well in the northeastern central and lower-Delta sectors. The reason for the maintenance of these open surface water bodies is tied up with water depth and large animal utilisation. In the absence of the above two factors the madiba should evolve towards aquatic vegetation closure and thus the death of madiba as they exist today. Hippopotamus are considered to play a significant role in maintaining madiba; especially those madiba of more critical shallower depth. This will explain the persistence of madiba where hippopotamus are more stringently protected, or are less accessible to be destroyed and where water depth is a critical factor, viz. Dombo lediba on the Khwai River.

Flats Communities

Flats Communities appear to be relatively stable but those flats located in the seasonal swamps or at the junction of seasonal and perennial swamps have total or marginal areas subject to dessication for parts of poor flood years. This enables establishment of termitaria to occur leading to a higher ratio of localised, high, dry levels at the expense of the flooded flats. These termitaria are part of flats habitat which combined form a parkland vegetation type; the termitaria being significantly important areas utilised by both sitatunga *(Tragelaphus spekei)* and red lechwe.

Large-scale establishment of termitaria and their subsequent erosion and "linking up" leads to small island formation which if continuously in operation will lead to the change of this vegetation community.

Shallow Backwater Communities

Shallow Backwater Communities are well represented in the middle and lower perennial swamps. Their continued existence is dependent on surface inundation for the greater portion of any year. Since surface drying-out occurs during part of poor flood years, these areas are also subject to termitaria establishment and termitaria evolution. Being the first of the aquatic communities to dry out, termitaria play their largest role in Shallow Backwater Communities. These termitaria, whether colonised by woody vegetation or whether forming only a slightly elevated disc covered by lawn-like grass, are important to the ecology of sitatunga and red lechwe, and though ultimately the termitaria may play a role in the alteration of inundation patterns, they must be considered as part of the natural evolution of the Delta system.

Sump Communities

Sump Communities are well represented in the perennial swamps mainly as a mosaic in the depressed areas of the Shallow Backwater Communities. (Fig. 15). Since they are lower-lying areas surface water seldom dries up except undet extremely dry conditions. Provided no large scale change of flooding pattern takes place these communities are subject to little change. If localised inundation patterns change these areas are likely to develop to pan depressions surrounded by dryland vegetation types if island closure takes place around them.

Floodplain vegetation types

Primary Floodplain Communities

Insufficient sampling was conducted in this community due to the extreme flood conditions experienced from early 1974 till the termination of field work (November 1974) in this area of the Delta. Primary Floodplain Communities of the mid-Delta are dominated by sedges of *Scirpus inclinatus* and *Cyperus* spp. and the forb *Alternanthera sessilis* (Table 5, Fig. 16). Relative densities obtained from the "Point-centred quarter method" and "nearest species" are in good agreement. Herbaceous plant density for this community from the "step-point method" gave 70,26 plants/m^2 in the lower-Delta and 247,03 plants/m^2 in the mid-Delta areas (Table 6). The lower-Delta Primary Floodplain Community which was sampled had probably been receiving a below average period of flooding for the previous three years, whereas the mid-Delta community was inundated for more regular periods annually.

FIGURE 15 – Sump Community adjacent to Shallow Backwater Community, Boro floodplains, Okavango Delta, Botswana.

Table 5 – Importance values and Density Comparisons from the "Poincentred quarter Method" and the "Nearest species Method" for Herbaceous Vegetation in a primary floodplain situated off the lower Boro River, Okavango Delta, Botswana, 1973.

SPECIES	RELATIVE PERCENTAGE FREQUENCY	RELATIVE PERCENTAGE DENSITY	RELATIVE PERCENTAGE DENSITY FROM NEAREST SPP.	RELATIVE PERCENTAGE DOMINANCE	IMPORTANCE VALUE
Scirpus inclinatus	37,50	45,31	40,0	64,74	49,18
Alternanthera sessilis	25,00	23,44	17,0	8,96	19,13
Cyperus articulatus	21,87	20,31	26,0	8,96	17,05
Ludwigia octovalis	6,24	4,69	9,0	5,18	5,38
Cyperus denudatus	3,13	1,56	1,0	8,96	4,55
Unidentifie forb.	3,13	3,12	4,0	2,56	2,94
Unidentified grass	3,13	1,57	1,0	0,64	1,77
Echinocloa stagnina	0,0	0,0	2,0	0,0	0,0

FIGURE 16 – Dry Primary Floodplain Community with Closed Riverine Woodland in background, the former heavily utilised by red lechwe, Khwai River floodplain, Okavango Delta, Botswana.

Table 6 – Comparison of REGULARLY INUNDATED MID-DELTA and POORLY INUNDATED LOWER DELTA Primary Floodplain Communities (for some Riney 1963 conservation trend criteria) of the Boro River Floodplain system, Okavango Delta, Botswana 1973/74.

LOCALITY	FLOODING PATTERN	HERBACEOUS VEGETATION DENSITY	BARE GROUND PERCENTAGE		LITTER STRIKE PERCENTAGE	CANOPY PERCENTAGE	PLANT STRIKE PERCENTAGE	CONSERVATION TREND PERCENTAGE		
			Riney	Actual				Downgrading	Stable	Upgrading
Mid-Delta	Regular and good	247,03	84	21	63	74	16	0	80	20
Lower-Delta	Irregular and poor	70,26	97	86	11	48	3	25,0	56,25	18,75

The conservation trend percentages show the majority of plots assessed as stable for both mid (80 per cent) and lower-Delta (56,25 per cent) areas. However, the lower-Delta area showed 25 per cent of plots downgrading as against none downgrading in the mid-Delta communities where more sustained flooding is evident (Table 6). During 1972/73 (a very dry season) mid-Delta Primary Floodplain Communities were dry for seven months of the season, whereas during 1974/75 (an extremely wet season) these same floodplains were inundated throughout the season. The lower-Delta Primary Floodplain Communities by comparison were dry for nine to ten months of the 1972/73 season and inundated for ten to 12 months during 1974/75. The average duration of flooding in Primary Floodplain Communities should be from eight to ten months per season, during which time they serve primarily as lechwe habitat in the seasonal swamps. As Primary Floodplain Communities dry out after the winter floods they are utilised extremely heavily by a variety of large mammals. At this period they form the only non aquatic vegetation type green grazing available until the summer rains commence and fresh growth appears in the riverine, marginal and dryland herbaceous layers. If these summer rains are well below average (510 mm) following a poor flood season, the Primary Floodplain Communities are subjected to a long, dry period. In such instances these Primary Floodplain Communities are over-utilised. As dessication proceeds, the feed value of this community becomes very low and the main utilisation is from the subsurface component, viz. bulbs, tubers and rhizomes being rooted up and utilised by warthog *(Phacochoerus aethiopicus sundevalli).* Baboon *(Papio ursinus ngamiensis)* follow up the warthog, often feeding in close unison with the latter also utilising this uprooted subsurface vegetation component. When the water table has dropped sufficiently, Damara mole-rats *(Cryptomys damarensis)* move into these Primary Floodplain Communities, establish their burrows and feed on the subsurface vegetation component.

No marked erosion pedestal was detected on any of these Primary Floodplain Communities. The average depth of inundation is about 1,2 m at the lowest point in a Primary Floodplain Community but the range varies from 0,6 to 1,8 m at this lowest point and from 0,01 to 0,4 m at the verges.

Secondary Floodplain Communities

Twenty four transects were conducted in the Secondary Floodplain Communities during 1973. These were divided into three groups according to their flooding pattern and water table position during 1973. The first group was partially flooded, the second group not flooded but with a high water table and the third group not flooded and with a lower water table (Table 7, Figs. 17 and 18). All the Secondary Floodplain Communities sampled were in the mid-Boro River seasonal swamps to the west of Chief's Island and in the study area.

All the Secondary Floodplain Communities support an open grassland, but the herbaceous plant density and composition vary in accordance with flooding frequency, flooding duration and mammalian utilisation (Tables 7 and 8). The factors of prime importance are the lower local base levels and the position of the Secondary Floodplain Communities in relation to receiving inundation in poor flood seasons; or the maintenance of a relatively high or low water table. Secondary Floodplain Communities favourably located with regard to regular surface inundation or high water table show a healthier status and trend, whereas those not regularly inundated and with a low water table show a series of degrading trends (Table 7).

The density of herbaceous vegetation in the Secondary Floodplain Communities under different floodwater and water table regimes (Table 7) are different. Those Secondary Floodplain Communities showing the higher density are either located higher up in the mid-Boro River floodplains; or those lower down, closer to the Boro River itself when compared with the Secondary Floodplain Communities of lower density. The secondary Floodplain Communities of lowest herbaceous plant density are in general closest to the southwestern margins of Chief's Island; and it is in these communities that more forbs (both species and individual plants) are present, (Table 7); overutilisation is taking place and the beginning stages of bush encroachment from the verges are evident.

Table 8 compares the herbaceous vegetation components in order of relative density and importance value for the more regularly inundated Secondary Floodplain Communities with high water table. The herbaceous species composition was impossible to determine in the badly degraded floodplain as these areas were held in a short-cropped state by mammalian overutilisation.but comparative percentage composition of herbaceous species is provided in Table 7. The composition of the two Secondary Floodplain Communities under different flood regime and water table shows good comparison except that the two sub-dominant grasses differ and that forbs are starting to appear in the mid study area. Table 7 shows the increase in forb composition for non flooded, low water table Secondary Floodplain Community.

Table 7 – Comparison of three classes of Secondary Floodplain Communities (based on flooding conditions and available water) for utilisation, herbaceous plant density, herbaceous plant growth form composition and conservation trend percentage and situated in the mid-Boro River floodplains, Okavango Delta, Botswana, 1973.

1973 FLOOD CONDITIONS	GRAZING PERCENTAGE FROM SAMPLE PLOTS	DENSITY OF HERBACEOUS PLANTS PER SQUARE METRE	HERBACEOUS PLANT GROWTH FORM COMPOSITION			GRASS CONPOSITION		CONSERVATION TREND PERCENTAGE		
			Grasses	Sedges	Forbs	Annual	Perennial	Downgrading	Stable	Upgrading
Flooded some parially	77,33	220,00	85,17	14,	0,00	18,17	81,83	3,33	70,00	26,67
None flooded high water table	95,00	84,03	80,65	18,18	1,17	20,33	79,67	6,67	76,67	16,
Flooded none low water table	99,33	46,25	68,33	5,00	26,67	43,17	56,83	40,00	46,67	13,33

FIGURE 17 – Secondary Floodplain Community well inundated during 1974, but not inundated during 1973, Mid-Boro River floodplain, Okavango Delta, Botswana.

FIGURE 18 – Dry, downgraded, overutilised Secondary Floodplain Community, not receiving sufficient annual surface inundation, lower Boro River floodplain, Okavango Delta, Botswana.

Table 8 – Comparison of two Secondary Floodplain Communities from the Mid-Boro River floodplain, (the mid-study area Secondary Floodplain Community receiving less regular flooding and having a slightly lower water table than the upper-study area Secondary Floodplain Community) Okavango Delta, Botswana, 1973, for herbaceous species composition, relative density and importance value.

HERBACEOUS SPECIES	RELATIVE DENSITY		IMPORTANCE VALUE	
	Mid study area	Upper study area	Mid study area	Upper study area
Eragrostis lappula var. *divaricata*	32,50	45,00	34,88	45,12
Brachiaria humidicola	26,88	0,00	24,18	0,00
Cynodon dactylon	0,00	21,88	0,00	17,49
Eragrostis lappula var. *lappula*	10,63	10,00	12,24	11,96
Cyperus denudatus var. *sphacrospermus*	14,38	5,00	11,39	4,79
Setaria woodii	1,25	4,38	1,77	6,65
Panicum repens	0,63	5,63	0,73	5,86
Trachypogon spicatus	1,25	0,00	3,26	0,00
Eragrostis lehmanniana	3,13	3,13	3,23	2,83
Nicolasia costata	3,13	0,00	2,44	0,00
Bulbostylis burchelli	2,50	1,25	2,27	1,30
Cyperus longus	1,88	1,88	1,86	1,65
Panicum aphononeurum	1,25	0,63	1,19	1,04
Imperata cylindrica	0,00	0,63	0,00	0,65
Setaria sphacelata	0,00	0,63	0,00	0,65
Sphaeranthus humilis	0,63	0,00	0,57	0,00

Frequency and duration of flooding in conjunction with the dry time period which Secondary Floodplain Communities are available for animal utilisation, play an important role in their vegetation composition and trend. (Table 7).

The conservation trends in Secondary Floodplain Communities show a marked downgrading tendency in those communities receiving insufficient water and the best upgrading tendency is in those most regularly inundated (Table 7). Clearly a series of Secondary Floodplain Communities exist which vary in vegetation composition, density, trend and mammalian utilisation, all as a function of available water. During consecutive years of poor flood regimes the higher lying Secondary Floodplain Communities are subject to overutilisation by mammals, establishment of termitaria occurs, annual grasses increase and woody vegetation encroaches from the adjacent islands and also establishes itself on dead termitaria. The higher base levels established by termitaria are semi-permanent and contribute to the formation of islands. When the flooding cycle peaks in high floods and substantially inundates these above dessicated areas, it serves to re-establish conditions in certain instances, viz. some encroaching woody and forb vegetation species sensitive to surface flooding or a high water table, are killed. Also a period of rest and sufficient moisture allow for some recovery of this overutilised Secondary Floodplain Community. In some instances the development and erosion of termitaria may close off surface flooding access, and here the evolution of the old Secondary Floodplain Community will lead to one of the dryland communities supported by a sandy substratum. If this closure to surface flooding also affects Primary Floodplain Communities and they no longer receive floodwater inundation the evolution is towards a woody vegetation type supported by clay soils, viz. *Colophospermum mopane* woodland or *Acacia tortilis* savanna woodland.

During the 1973/74 season Secondary Floodplain Communities were inundated for a period of up to 9 months, but more generally for about 7 months. This period of inundation is abnormally long for this community and if continued seasonally would alter the herbaceous composition more towards that of a Primary Floodplain Community. The 1974/75 flood levels were also excessively high. These two seasons have served to kill some water sensitive woody and herbaceous plant encroachers onto Secondary Floodplain Communities, and provide adequate rest from mammalian overutilisation. Consequently an improvement in their conservation trend should thus result. In some central Secondary Floodplain Communities of the eastern floodplains, these two successive high flood years did not produce this excessive flooding of these communities. (Fig. 19). The overall situation of a largely altered flood pattern on parts of this eastern sector assures the evolution of these Secondary Flood-

FIGURE 19 – Secondary Floodplain Communities in the mid-M'borogha River floodplains no longer receiving surface inundation even in years of excessive high water levels (1974), Okavango Delta, Botswana.

plain Communities towards one of the dryland sandveld communities, unless further water flow changes occur and proper flooding results. (Fig. 20). A slight erosion pedestal exists on some of the more downgraded Secondary Floodplain Communities. Under extreme flood conditions these Secondary Floodplain Communities are inundated to a depth of 1 m, but more average conditions produce an inundation depth of 0,2 to 0,3 m or less.

Sporobolus spicatus Island Grassland Communities

During 1974, five transects were conducted in the study area on *Sporobolus spicatus* Island Grassland Communities of the seasonal swamps on the Boro River floodplain. The average density of herbaceous plant species is 269,54 plants/m^2 for the areas sampled. Table 9 lists the herbaceous vegetation species in order of importance values and relative density.

The trends in conservation values show the highest proportion of plots sampled as stable, but with more plots showing a downgrading than an upgrading tendency. *Sporobolus spicatus* Island Grassland Community is another floodplain vegetation community which is subject to no surface flooding in poor flood years. Flooding of island grassland communities of the perennial swamps varies between 0,01 and 0,4 m but the water table associated here is high. In the seasonal swamp these communities flooding varies between 0,01 and 0,3 m with a much lower water table and an average tendency to only slight surface inundation. In poor flood years no surface inundation occurs.

Due to the *Sporobolus spicatus* Island Grassland Communities occurring adjacent to higher lying island soils the establishment of termitaria is a constant factor operating and causing the evolution of Island Grassland Communities to proceed towards marginal or dryland vegetation types. *Sporobolus spicatus* Island Grassland Communities occur initially and usually on the off channel margins of some islands where a gentle ground slope gradient exists and no sharp altern occurs between aquatic vegetation margins and Closed Riverine Woodland. As these islands enlarge by the linking up of adjacent termitaria via erosion the riverine woodland tends to encircle the *Sporobolus spicatus* Island Grassland Community leading to a process termed island closure. When this occurs the encircled Island Grassland Community is cut off from normal surface flooding and can only be inundated by excessive local rainfall or by a rising water table. Once complete island closure has occurred the

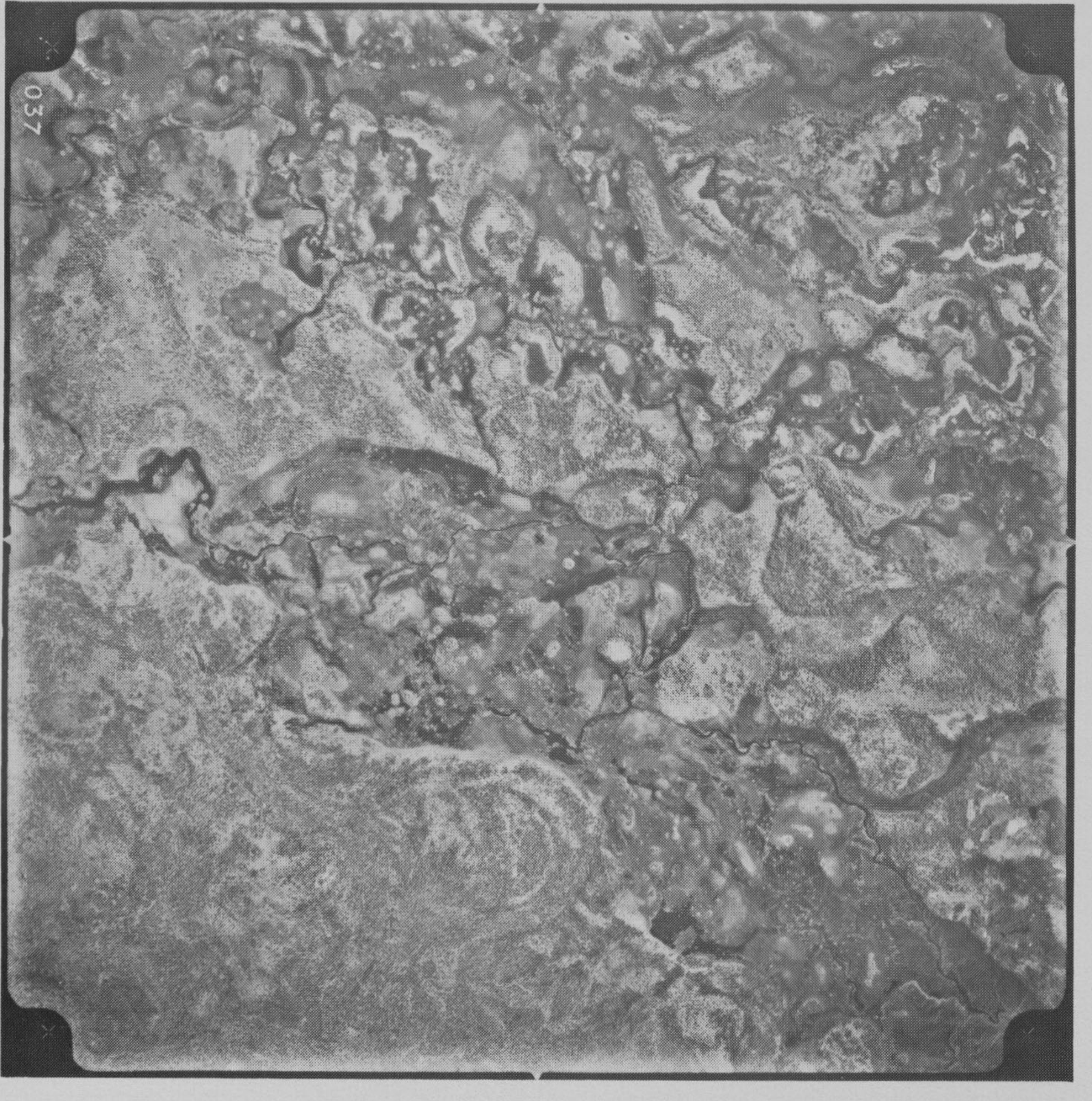

FIGURE 20 – Expansion of dryland vegetation types at the expense of floodplain vegetation types (to left and right of centre of figure) on remnants of the old Nambope River floodplain, Okavango Delta, Botswana. Note lower left hand corner of figure shows part of the north-eastern margin of Chief's Island.

Table 9 – List of herbacious plants species in order of importance value and giving relative density for *Sporobolus spicatus* Island Grassland Communities of the Mid-Boro River Floodplain, Okavango Delta, Botswana, 1974

HERBACEOUS PLANT SPECIES	RELATIVE DENSITY	IMPORTANCE VALUE
Sporobolus spicatus	29,38	28,24
Cynodon dactylon	24,38	24,30
Eragrostis cilianensis	17,50	19,35
Hermania modesta	5,00	4,91
Hirpicium gorteroides	5,00	4,48
Cyperus fulgens	3,13	4,18
Eragrostis viscosa	3,75	3,71
Chloris virgata	3,13	2,75
Cleome rubella	2,50	2,46
Pluchea leubnitziae	1,88	1,98
Aristida argentea	1,25	1,34
Unidentified forb	1,88	1,30
Setaria verticillata	1,25	1,01

central core of Island Grassland Community evolves towards a marginal or dryland vegetation type. All islands of the Delta are in varying stages of evolution, but they are all still subject to alteration and enlargement via termitaria. The encroachment of *Pluchea leubnitziae* from the verges centripitally is a manifestation of the drying-out conditions since from personal observation this herbaceous species cannot tolerate surface flooding or an extremely high water table. As base levels build up and dessication proceeds further, more forb and woody vegetation species encroach onto the Island Grassland Community changing the species composition. These Island Grassland Communities are important red lechwe habitat, whose numbers will probably diminish as this habitat type diminishes.

Riverine vegetation types

Closed Riverine Woodland

Where water tables are high and surface water is in close proximity the Closed Riverine Woodlands are best developed, viz. adjacent to some madiba and some perennial channels. Five transects conducted during May 1974 in this community gave an average tree density of 691,56 trees/ha from PCQM as against 751,56 trees/ha from the "Quadrat method". If shrubs and seedling trees are added the average woody vegetation density ranged from 1463,98 woody plants/ha from the "quadrat method" to 1584,95 woody plants/ha from CCM (Table 10). The average herbaceous plant on density from PCQM is 29,65 plants/m^2 below the tree canopies. (Table 11). Tables 12 and 13 list plant species in order of importance value for woody and herbaceous species respectively. The two sites sampled were along the Boro River verge.

Conservation trends in the Closed Riverine Woodland were either stable or upgrading but since all sampled sites were in favourable high water table conditions this is to be expected. Where water table conditions were not so high, the Closed Riverine Woodland was visually less well developed and was visually downgrading in the least favourable localities. The 1974 and 1975 flood patterns will improve these conditions due to the substantially raised water table during these years. Some woody species located on the lowest-lying areas of Closed Riverine Woodland have their stem bases inundated during parts of seasons of extreme high water levels, but remain unaffected except for isolated specimens of *Acacia erioloba* which die under waterlogged conditions. The well developed Closed Riverine Woodland along the islands adjacent to the M'borogha River is a function of the previous existing flow down this

Table 10 – Comparison of average densities (per hectare) based on the "Point-centred quarter method", "Quadrat method" and the "Concentric circle method" of various woody vegetation communities in the study area, Okavango Delta, Botswana, 1973/74.

VEGETATION COMMUNITY	POINT-CENTRED QUARTER METHOD	QUADRAT METHOD			CONCENTRIC CIRCLE METHOD
		Trees	Shrubs and tree seedlings	Total woody species	Woody species
Closed riverine woodland	691,56 trees	751,56	712,42	1463,98	1584,95
Hyphaene ventricosa - Croton megalobotrys palm woodland	973,71 woody species	600,86	716,34	1317,20	1326,60
Combretum inberbe - Croton megalobotrys woodland	202,92 woody species	84,55	90,81	175,36	163,96
Acacia erioloba woodland savanna woodland	48,65 trees	54,80	292,80	347,60	278,43
Colophospermum mopane woodland	462,75	549,97	80,25	630,22	649,88
Colophospermum mopane scrub savanna	2583,98 woody species	1753,65	1914,14	3667,79	3808,63
Grewia species - Croton megalobotrys scrub savanna	490,44 woody species	191,81	471,68	663,49	614,00

Note: Trees ⩾ 2 m Shrubs < 2 m Woody species = Trees plus shrub plus treeseedings

Table 11 – Comparison of the herbaceous layer vegetation average densities (plants per square metre) using the "Point-centred Quarter Method", and composition from "nearest species" for various plant communities sampled in the Okavango Delta Botswana 1973/74.

PLANT COMMUNITY	"POINT-CENTRED QUARTER METHOD" AVERAGE DENSITY	GROWTH FORM COMPOSITION FROM "NEAREST SPECIES"			
		Grass	Forb	Sedge	Woody Seedling or Shrub
Primary Floodplain	158,65	32,50	15,00	52,50	0,00
Secondary Floodplain	116,76	78,05	9,28	12,67	0,00
Sporobolus specatus Island Grassland	269,54	83,60	15,20	1,20	0,00
Closed Riverine Woodland	29,65	16,00	76,00	0,00	8,00
Hyphaene ventricosa - Croton megalobotrys Palm Woodland and Palm Savanne Woodland	43,45	66,00	31,00	0,00	3,00
Combretum imberbe - Croton megalobotrys Woodland and Savanna Woodland	0,00	71,00	28,00	0,00	1,00
Acacia erioloba Woodland and Savanna Woodland	18,54	82,00	6,20	10,80	1,00
Colophospermum mopane Woodland	16,88	46,30	53,10	0,00	0,60
Colophospermum mopane Pyrophytic Scrub Savanna	66,81	68,75	30,00	1,25	0,00
Grewia species - Croton megalobotrys Scrub Savanna	125,61	76,00	21,50	0,00	2,50

Table 12 – List of woody etc. species in order of importance value for Closed Riverine Woodland method by "Point-centred quarter method" and "Quadrat method" adjacent to the Boro River, Okavango Delta, Botswana 1974.

WOODY PLANT SPECIES	IMPORTANCE VALUE
Diospyros mespiliformis	*30,95*
Croton megalabotrys	*26,52*
Hyphaene ventricosa	*13,03*
Berchemia discolor	*9,71*
Euclea crispa	*5,06*
Kigelia africana	*5,00*
Garcinia livingstonei	*4,77*
Grewia schinzii	*2,48*
Lonchocarpus capassa	*2,47*

Table 13 – List of herbaceous etc. species in order of importance value for Closed Riverine Woodland by "Point-centred quarter method" and "Quadrat method." adjacent to the Boro River, Okavango Delta Botswana 1974.

HERBACEOUS SPECIES	IMPORTANCE VALUE
Achyranthus sicula	21,60
Setaria verticillata	17,40
Commicarpus africana	12,00
Celosia trigyna	12,00
Abutilon romosum	8,60
Sporobolus fimbriatus	7,50
Dicliptera micranthes	6,70
Cynodon dactylon	5,40
Seedling trees	5,40
Leptocarydion vulpiastrum	3,40

Middle Channel before the development of the Nqogha blockage when this channel still carried a greater water discharge. Should the discharge down the M'borogha River decrease further, degrading of this community can be expected. Conversely the Boro River is now carrying an increased discharge resulting in a higher water table in this area over earlier years and more luxuriant Closed Riverine Woodland is expected to develop there (See Past water regime 1849 – 1968 p. 224).

Phoenix reclinata – Syzygium spp. Termitaria

No quantitative work was conducted on *Phoenix reclinata – Syzygium* spp. Termitaria. Normally this community is well established on old termitaria surrounded by well-inundated lowerlying floodplains in Flats or Shallow Backwater Communities of the upper and mid-Delta. The almost complete absence of this community on the upper and middle M'borogha and Nambope floodplain systems remains a mystery, whilst the same community persists down parts of the dessicated ancient floodplains of the lower Thago River system (Smith **pers. comm.**). The occurrance of *Phoenix reclinata* and *Syzygium* spp. on the lower Thaoge River floodplain is a manifestation of earlier flood regimes when the bulk of water was flowing towards Lake Ngami (Stigand, 1923) and *Phoenix reclinata* thus seems able to resist sustained periods of dessication. The water table level is not known in this area, but possibly it is still relatively high and thus maintains this community; but not under optimum conditions. Under optimum conditions the water table is consistently high and surface water usually laps or floods the woody species stem bases during the high-flood months.

Marginal vegetation types

Acacia nigrescens – Croton megalobotrys
Woodland and Savanna Woodland

No quantitative work was conducted in the *Acacia nigrescens – Croton megalobotrys* Woodland and Savanna Woodland Communities. The stands of this community are common on most islands but the stands are not extensive and are nowhere developed in the study area to the extent found on the lower Khwai River margins.

The areas of occurrence of *Acacia nigrescens – Croton megalobotrys* Woodland or Savanna Woodland Communities appear to be on ancient floodplains, now raised above present flood levels and no longer subject to surface inundation. As island size increases so does this community and the *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland and Palm Savanna Woodland are expected to increase slightly in extent and distribution.

Hyphaene ventricosa – Croton megalobotrys
Palm Woodland and Palm Savanna Woodland

Hyphaene ventricosa – Croton megalobotrys Palm Woodland and Palm Savanna Woodland Communities are common in the central and lower Islands of the study area as well as in general in the mid and lower areas of the Delta. Four transects conducted in these communities, during June 1974, using the "Point-centred quarter method", provided an average density in the woody stratum of 973,71 woody spp/ha (Table 10) and in the herbaceous stratum of 43,45 plants/m^2 (Table 11). The density sampling conducted via the "concentric circle method" provided much higher density estimates per unit area (Table 10), but these are not accepted since this sampling method is unsuitable in these woody vegetation strata of the Okavango Delta (*Grunow pers. comm.). The woody species in order of importance value are *Hyphaene ventricosa* (68,93), *Croton megalobotrys* (29,12) and *Ziziphus mucronata* (1,95) and in Table 14 the herbaceous species are represented in order of importance value for this community.

Table 14. List of herbaceous layer species in order of importance value and relative percentage density from "Nearest Species" for *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland and Palm Savanna Woodland sampled adjacent to the Boro River Okavango Delta Botswana 1974

VEGETATION SPECIES	IMPORTANCE VALUE	"NEAREST SPECIES" RELATIVE DENSITY
Setaria verticillata	37,78	37,0
Sporobolus fimbriatus	14,93	14,0
Achyranthus sicula	13,78	15,0
Canodon dactylon	10,79	8,0
Unidentified forbs	8,11	7,0
Celosia trigyne	7,59	3,0
Commicarpus africanus	4,22	2,0
Abutilon ramosum	2,78	0,0
Leptocarydion vulpiastrum	0,00	6,0
Solanum spp.	0,00	4,0
Hyphaene ventricosa seedling	0,00	3,0
Aristida argentea	0,00	1,0

*Professor J.O. Grunow, Department of Plant Production, University of Pretoria, Hillcrest, Pretoria, R.S.A.

The conservation trend in the *Hyphaene ventricosa – Croton megalobotrys* Palm Woodland Communities shows 81,25 per cent of plots stable and the remainder upgrading. The absence of downgrading plots shows this community to enjoy a healthy and probably expanding trend. Within the herbaceous layer 66 per cent of the plants are grasses (two-thirds of which were annual grasses), 31 per cent forbs and 3 per cent woody plant seedlings (from "Nearest Species"). This proportion of grass plants shows over 300 per cent increase when compared with that of Closed Riverine Woodland (Table 11).

This communtiy also appears to occur on ancient floodplains now raised above present flood levels and thus no longer subject to surface inundation. All three marginal vegetation communities' dominant woody vegetation species often occur as isolated individuals or small clusters on single termitaria, the erosion of which provides suitable higher base levels for their expansion. Some degree of mixing of *Hyphaene ventricosa* and *Acacia nigrescens* occurs in both above communities.

Combretum imberbe – Croton megalobotrys
Woodland and Savanna Woodland

Combretum imberbe – Croton megalobotrys Woodland and Savanna Woodland Communities occupy the lower-lying marginal areas and appear to have a higher sand content in the substrate. Five transects conducted in this community during June 1973 using the "Point-centred quarter method" provided an average density of 202,92 woody plants/ha in the woody stratum (Table 10). Average density from the "concentric circles method" provided the lower density estimate of 163,96 trees/ha but again this latter method was unacceptable (Grunow pers. comm.). Table 15 lists the woody species in order of importance value, and Table 16 lists the herbaceous species in order of relative density from nearest species for this community.

The conservation trend in the *Combretum imberbe – Croton megalobotrys* communities showed 56,25 per cent of plots stable 31,25 per cent downgrading and 12,50 per cent upgrading. From "Nearest species" this community's herbaceous layer composition comprised 71 per cent grasses, 28 per cent forbs and 1 per cent woody plant seedlings. Possibly the high proportion of down grading plots was caused by the previous low flood years, as some of these communities appear to occur on ancient Secondary Floodplain and the sandier soils seem more prone to rapid degradation.

Table 15. List of woody species in order of importance value for *Combretum imberbe* – *Croton megalobotrys* Woodland and Savanna Woodland from marginal island areas of the Boro river floodplain, Okavango Delta Botswana,1973

WOODY PLANT SPECIES	IMPORTANCE VALUE
Combretum imberbe	45,32
Croton megalobotrys	19,51
Lonchocarpus capassa	15,78
Acacia nigrescens	3,82
Grewia schinzii	2,56
Diospyros mespiliformis	2,34
Kigelia africana	1,91
Dichrostachys cinerea	1,75
Grewia flavescens	1,55
Ziziphus mucronata	1,50
Acacia tortilis	1,44
Maytenus senegalensis	1,41
Garcinia livingstonei	1,14

Table 16. List of herbaceous layer species in order of relative density from "Nearest Species" calculations for *Combretum imberbe* – *Croton megalobotrys* Woodland and Savanna Woodland of Marginal island areas of the Boro River Floodplain, Okavango Delta, Botswana,1973

PLANT SPECIES	RELATIVE DENSITY
Cenchrus ciliaris	20,80
Sporobolus fimbriatus	19,60
Cynodon dactylon	16,40
Digitaria pole-evansi	9,60
Blepharis diversispina	8,40
Monechma debile	6,40
Tephrosia lupinifolia	5,60
Celosia scabra	4,00
Chloris gayana	2,80
Oxygonum de lagoense	2,40
Panicum maximum	0,80
Enteropogon macrostachys	0,80
Hibiscus engleri	0,80
Asparagus sp	0,40
Lonchocarpus capassa seedling	0,40
Capparis tomentosa seedling	0,40
Ximenia americana seedling	0,40

The *Combretum imberbe – Croton megalobotrys* Woodlands and Savanna Woodland are Communities subject to some slight surface inundation in high flood years but no surface flooding in average seasons. This serves to substantiate their evolution from ancient Secondary Floodplain Communities which in the past have received progressively less and less surface inundation and eventually no surface inundation except when extreme flood conditions reoccur after their establishment.

Dryland vegetation types

Acacia tortilis Savanna Woodland

No quantitative field work was conducted in *Acacia tortilis* Savanna Woodland. The stands of this community are common in the central and upper parts of the study area adjacent to Chief's Island but are all subject to heavy mammalian utilisation.

Visually the trends seem to be downgrading due to overutilisation of both the woody stratum and the herbaceous stratum; but more especially the herbaceous stratum. *Acacia tortilis* Savanna Woodland occur on relatively recent old primary floodplains as well as ancient primary floodplains. Due to their situation such communities are subject to inundation in high flood years or in instances where flooding pattern changes and ancient floodplain is reflooded after sustained dry periods.

Acacia tortilis Savanna Woodland must provide probably the most palatable grazing and browsing available for most months of the year, after summer grazing areas have dried out. The largest concentrations of non-aquatic dependent large mammals were always present in these communities during dry periods and wet periods, and remained so until Primary Floodplain Communities became available for mammals to utilise. During excessively high flood periods, when these areas are shallowly inundated, red lechwe are forced to utilise *Acacia tortilis* Savanna Woodland as their prime habitat is excessively inundated and under such circumstances prefer this habitat although this is not normally utilised by lechwe under average flood conditions.

Acacia erioloba Woodland and Savanna Woodland

Acacia erioloba Woodland and Savanna Woodland are wide-spread throughout the study area but mainly occur on parts of Chief's Island. Five transects conducted during July 1973 in *Acacia erioloba* Savanna Woodland provided an average woody vegetation stratum density of 48,65 trees/ha from the "Point-centred quarter method" (Table 10). Using the "concentric circles method" and taking shrubs and seedling trees into account the density obtained is 278,84 woody plants/ha which again is considered too high and unacceptable. However, although only 1 per cent of strikes occurred, numerous seedling trees are sprouting in this community. The herbaceous species of this community is widely spaced, providing an average density of 18,54 plants/m^2 (Table 11). The woody species in this community in order of importance value are: *Acacia erioloba* (74,87) *A fleckii* (15,72), *Terminalia sericea* (7,85) and *Grewia subspathulata* (1,56). Table 17 lists the herbaceous species in order of importance value.

Table 17. List of herbaceous layer species in order of importance value and "Nearest Species" relative percentage density from *Acacia erioloba* Woodland and Savanna Woodland on Chief's Island, Okavango Delta, Botswana 1973

HERBACEOUS PLANT SPECIES	IMPORTANCE VALUE	"NEAREST SPECIES" RELATIVE DENSITY
Brachiaria brizantha	54,11	49,2
Tricholaena monachne	7,52	6,4
Eragrostis pallens	6,60	6,4
Digitaria eriantha	5,97	3,2
Bulbostylis burchelli	5,76	10,8
Pluchea leubnitziae	4,34	1,8
Cynodon dactylon	4,24	8,0
Borreria paludosa	2,90	1,6
Aristida stipitata	1,81	5,6
Commelina benghalensis	1,44	0,8
Blepharis diversispina	1,44	1,2
Pogonathria fleckii	1,29	0,4
Stipagrostis uniplumis	1,29	1,2
Cleome rubella	1,29	0,8
Acacia erioloba seedling	0,0	1,0
Sporobolus fimbriatus	0,0	0,8
Eragrostis lehmanniana	0,0	0,4
Enteropogon macrostachys	0,0	0,4

From "Nearest species" method grasses form 82 per cent of this community with 10,8 per cent sedges, 6,2 per cent forbs and 1 per cent woody plant seedlings (Table 17). Fifty per cent of the *Acacia erioloba* community plots sampled were determined to be stable with 25 per cent downgrading and 25 per cent upgrading. Heavy utilisation occurs below mature *Acacia erioloba* trees where *Tricholaene monachne* is dominant. In the open *Brachiaria brizantha* is heavily utilised and sample plots failing into these areas were often found to be downgrading. In general the communities seem to be evolving more towards a woodland as is evident from the presence of small trees, shrubs and seedlings of *Acacia erioloba.*

Acacia erioloba Woodland and Savanna Woodland are not subjected to flooding or an excessively high water table, and when extremely high floods or altered flooding patterns occur, *Acacia erioloba* is killed by water presence. The community is well utilised by large mammals but not as excessively as *Acacia tortilis* Savanna Woodland communities.

Terminalia sericea – Combretum collinum
Savanna Woodland and Scrub

No quantitative work was conducted in *Terminalia sericea – Combretum collinum* Savanna Woodland and Scrub. The communities are wide-spread on Chief's Island and mainly on the central sectors of large islands.

In parts of this community the woody plants are damaged by elephant but nowhere was this found to be serious. This community visually appears to be in a stable trend and is not subject to surface flooding except in extreme flood years or via altered flooding patterns. Excessively long periods of surface flooding (longer than two months) will kill most dryland woody species unadapted to such Flooding; viz. the dryland types and some woody species occurring in the marginal vegetation types eg. *Acacia tortilis* and *Dichrostachys cinerea.*

Colophospermum mopane

Woodland and Pyrophytic Scrub Savanna

Large stands of *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna occur from southern Chief's Island mainly up the southeastern side and as a central core to some of the larger islands in the study area. Ten transects conducted in these communities ud during September 1974 gave an average density of 462,75 trees/ha in woodland and 2583,98 shrubs/ha in scrub savanna from the "Point-centred quarter method" (Table 10). The corresponding figures from the "concentric circles method" are approximately 40 per cent higher in each case and are disregarded as before. The herbaceous layer provided an average density of 16,88 plants/m^2 in the Woodland and 66,81 plants/m^2 in the scrub savanna from the "Point-centred quarter method" (Table 11). Table 18 lists the woody vegetation species in order of importance values.

Table 18 – **List of woody species in order of average importance value for *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna from Chief's Island, Okavango Delta, Botswana, 1974**

WOODY VEGETATION SPECIES	IMPORTANCE VALUES
Colophospermum mopane	80,91
Croton megalobotrys	8,13
Grewia bicolor	3,76
Grewia flava	2,77
Acacia tortilis	1,65
Commiphora africanus	1,41
Grewia villosa	1,38

Values in conservation trends in the *Colophospermum mopane* communities were generally stable (79,17 per cent) with few downgrading (8,33 per cent) and a slightly higher percentage of plots upgrading (12,5 per cent). This community is fairly well utilised but mainly so during the summer months when herbaceous grazing is at its best and drinking water is available in pans. Elephant and fire (Fig. 21) do some slight damage to the mature *Colophospermum mopane* trees and elephant utilise this habitat more than other large mammal species, but nowhere was excessive elephant damage found.

Colophospermum mopane Woodland and Pyrophytic Scrub Savanna are not inundated by floodwaters except in extremely high flood years or altered flooding pattern, but in either case only small parts of this community are affected for a short duration.

Grewia spp – *Croton megalobotrys* Scrub Savanna

Grewia spp. – *Croton megalobotrys* Scrub Savanna is well-developed on the central sandy cores of medium to large islands. Five transects conducted in this community during July 1973 provided an average density of 490,44 woody plants/ha from the "Point-centred quarter method", with higher estimates from quadrates method and the "concentric circle method" being disregarded (Table 10). The herbaceous stratum provided an average density of 125,61 plants/m^2 from the "Point-centred quarter method" (Table 11). Table 19 lists the woody species in order of importance value and Table 20 lists the herbaceous species also in order of importance value in this community.

This community was being well-utilised but still showed very rank growth at the time it was sampled. Trends in conservation values showed no downgrading plots with 65,63 per cent of plots stable and 34,37 per cent of plots upgrading in this community. *Grewia* spp –*Croton megalobotrys* Scrub Savanna is not subject to surface inundation from floodwaters except under perhaps exceptional circumstances.

FIGURE 21 – Fire damage in *Colophospermum mopane* Woodland with commencement of Pyrophytic Scrub Savanna development, Chief's Island, Okavango Delta, Botswana.

Table 19 – List of woody species in order of importance value from *Grewia species - Croton megalobotrys* Scrub Savanna sampled from large sandy central islands on the Boro River Floodplain, Okavango Delta, Botswana 1974.

WOODY PLANT SPECIES	IMPORTANCE VALUE
Grewia flavescens	27,05
Grewia schinzii	19,52
Croton megalobotrys	19,02
Grewia retinervis	10,93
Acacia erioloba	6,65
Ziziphus mucronata	3,96
Acacia tortilis	3,77
Hyphane ventricosa	2,28
Lonchocarpus capassa	2,25
Commiphora africana	1,62
Diospyros lycioides	1,09
Ximenia americana	1,06
Gomphocarpus species	0,78

Table 20 – List of herbaceous layer species in order of importance value and "Nearest Species" relative percentage density from *Grewia species - Croton megalobotrys* Scrub Savanna sampled from large sandy central islands on the Boro Rivier Floodplain okavango Delta, Botswana,1974.

VEGETATION SPECIES	IMPORTANCE VALUE	"NEAREST SPECIES" RELATIVE DENSITY
Urochloa brachyura	26,67	26,50
Eragrostis rotifer	22,31	21,00
Eragrostis tricophora	7,76	3,00
Eragrostis biflora	6,67	7,50
Pluchea leubnitziae	5,42	4,00
Setaria verticillata	4,66	5,00
Schmidtia pappophoroides	3,94	1,50
Chloris virgata	3,11	3,00
Clerodendron uncinatum	5,61	5,50
Blepharis diversispina	3,27	2,50
Pseudobrachiaria deflexa	2,80	1,00
Unidentified grass	1,87	4,50
Ipomoea magnusiana	1,87	3,50
Hermania glandufigera	1,76	1,50
Cynodon dactylon	1,35	0,50
Gisekia africana	0,93	2,00
Eragrostis lappula	0,00	2,00
Grewia retinervis	0,00	1,50
Unidentified forb	0,00	1,50
Andropogon huillensis	0,00	0,50
Aristida meridionalis	0,00	0,50
Dactylotenium aegyptium	0,00	0,50
Achyranthus sicula	0,00	0,50
Leucas martinicensis	0,00	0,50

MAMMAL FAUNA

The earliest contributors to information on the mammal fauna of Ngamiland and the peripheral Okavango Delta areas, comes from the published accounts of naturalist/hunter/trader missionary visits to Lake Ngami and its environs during the 1850's to 1860's (See HISTORY). Although none penetrated the actual study area, their accounts of previous large mammal distributions are of great value.

Up until the early 1900's various naturalist/hunters contributed minor written accounts of value, notably Selous (1881), Bryden (1893), Baldwin (1894) and Schultz and Hammar (1897), but again they only covered peripheral Delta areas. Following these accounts were Dollman (1910), Stigand (1923), Ellenberger (1931), Naus (1933), the Vernay-Lang Kalahari expedition of 1930 with results described by Roberts (1935) and Hill (1942); Davis (1946) and Pole-Evans (1948). Only Stigand, Ellenberger and Naus penetrated parts of the study area.

After this period, contributions were made by various members of the Smithsonian Institution, Washington, D.C. and the Mammal Research Unit, University of Pretoria; the Government Departments of Tsetse-fly Control, Veterinary Services and Wildlife and National Parks; as well as Safari and Taxidermy Companies and their staff, and the United Nations Development Programme (BOT. I) Survey 1972, either in published form, Departmental reports or personal communications.

The most comprehensive contributions came from Tinley (1966), Smithers (1971), Robbel and Child (1976) and the present FAO/UNDP Survey (1976).

Methods

Large and small mammals were recorded in the study area by direct observation, aerial survey, trapping and limited collection by shooting of some species. In some instances sight records were obtained from reliable persons resident in the study area, or from guides who were resident in the past in parts of the study area. Species not covered by aerial census population estimates were classified as rare, common or abundant according to observations during the study period.

Aerial survey utilised the method described by Jolly (1969) and referred to as "Jolly 3" – "Equal or unequal size units, selecting with probability proportional to size". This involved the use of a fixed high-wing aircraft, flying fixed units or transects and censusing a fixed strip width of 300 m; either on one but usually on either side of the aircraft flying at an altitude of 90 m and a speed of 112 to 128 km/h.

The total area censused embraces 1 812 km^2 and showed three distinctive zones governed by flooding pattern. These three zones were strip-census sampled individually, viz., the Eastern or M'borogha floodplains (670 km^2); Chief's Island and the associated northern islands (790 km^2) and the Western or Boro floodplains (352 km^2) (Table 21). The units to be sampled in any zone were selected by random pairs of co-ordinates within a grid totally embracing each zone. Only when a random point fell within one of the zones was it used for that zone. Any points outside the area, but within the grid, were discarded. This method was continued until sufficient transects were obtained for each zone in an attempt to obtain a more or less 20 per cent sample of the zone whilst remaining within the economic limitations of the excercise.

As a point fell within a zone, it was extended to the edges of that zone at right angles to the main axis of Chief's Island. Any subsequent random point on any existing line within a zone, simply allowed that unit to be used twice in the subsequent statistical treatment without the transect or unit being flown twice.

Following "Jolly 3" population estimates were computed from the following formulae:

$$\hat{Y} = \Sigma Z_i \bar{d}_i$$

$$\text{Var } \hat{Y} = \Sigma \frac{Z_i^2}{N_i} \quad Sd_i^2$$

$$Sd_i = \frac{1}{N_i - 1} \left\{ \Sigma d_i^2 - \left(\frac{d_i^2}{N_i} \right) \right\}$$

where

$\hat{Y}$ = estimated population of animals

Z_i = total area of stratum i

$\bar{d}_i$ = average density of animals per unit area in particular transect of stratum i

$\text{Var } \hat{Y}$ = variance of the estimate

N_i = number of transects in stratum i

d_i = number of animals per transect unit area (= density/transect sampled)

Table 21 – Area, (km^2) number of transects and percentage of zone sampled in aerial strip survey for the study area, Okavango Delta, Botswana, 1973/74.

STRATUM	AREA	NUMBER OF TRANSECTS*	PERCENTAGE OF AREA SAMPLED	
			One observer	Two observers
Eastern floodplains	670	14	10,26	20,52
Chiefs' Island	790	18	7,80	15,60
Western floodplains	352	26	17,41	34,82
TOTAL	1 812	58	35,47	70,94
Average	604	19	11,82	23,64

*
Note: Each stratum has one doubled up unit.

and where: the standard error of $\hat{Y}$ = Var $\hat{Y}$ = SE
the 95 per cent confidence limit of $\hat{Y}$ = $\hat{Y} \pm (1{,}96)$ (S.E. $\hat{Y}$.)

Navigation was done by pilot and navigator from a 1:250 000 map with plotted transects by observation and magnetic bearings. The aircraft was marked for strip width following the method of Pennycuick and Western (1972) from the formula:

$$W = \frac{Wh}{H}$$

where	w	=	Strip width on ground aircraft stationary (m)
	W	=	Strip width from air at H (m)
	h	=	height of observer's eye above ground with "aircraft stationary in flying attitude" (m)
	H	=	altitude above ground when flying (m)

The advantages of strip census over total census eliminates errors due to navigation and orientation – Grimsdell and Bell (1972a).

For the aerial survey conducted specifically on red lechwe in the conserved and adjacent areas a 2 x 2 km square grid was drawn up covering the total area to be surveyed. Transects were flown through the mid point of each 2 km block. The other flying and surveying conditions were exactly the same as before.

Results for this survey had to be calculated on the basis of "Jolly 2" – unequal sized units using the ratio method (Jolly, 1969), from a programme drawn up for an Olivetti Computer (Programma 101 P.203).

The population estimate is derived from

$$\hat{Y}_2 = \frac{\hat{Y}_1}{z_1} Z$$

Where

$\hat{Y}_1 \quad = \quad \sum_i N_i \bar{Y}_i$

$N_i \quad = \quad$ total number of units in the i^{th} stratum

$\bar{Y}_i \quad = \quad$ average number of animals per unit over the n_i units samples

$z_i \quad = \quad$ area of the i^{th} unit

$Z \quad = \quad$ total area under survey

$$\text{Var } \hat{Y}_2 = \sum_i \frac{N_i (N_i - n_i)}{n_i} \quad (sy_i^2 - 2\hat{R}szy_i + \hat{R}^2 sz_i^2)$$

in which

$$\hat{R} = \frac{\hat{Y}_1}{\hat{Z}_1}$$

and

$$szyi = \frac{1}{n_i - 1} \left\{ \Sigma z_i y_i - \Sigma \frac{(\Sigma z_i)\ (\Sigma y_i)}{n_i} \right\}$$

and where Standard Error of $\hat{Y}_2$ = Var $\hat{Y}_2$

and the 95 per cent confidence limit of $\hat{Y}_2 = \hat{Y}_2 \pm (1{,}96)\ (\text{SE } \hat{Y}_2)$.

Trapping of small mammals involved the use of snap traps ('Museum special' breakback traps), Sherman live traps, and 'Macabee' traps for mole rats. Collection of bats and some of the larger small mammals was by means of a 12-Gauge shotgun.

Recorded data included mass and standard measurements in accordance with Smithers (1971), date, time, reproductive data and habitat type. Measurements are all in millimetres and include total length (TL) this being the length from tip of nose to last caudal vertibra of tail. In small mammals this is taken with the mammal lying ventrally and extended along the tape, whereas in large mammals the tape is extended from the tip of the nose and follows the central dorsal midline along the natural curvature to the last caudal vertebra. Length of the tail (T) is from the base of the tail to the last caudal vertebra. The length of hind foot (Hf) is the measurement taken from heel (or hock) to the end of the longest digit including nail hoof or claw ie. "cum ungue". Ear (E) is the straight length measured from the notch to the furthest extremity of the cartilage of the ear excluding hair or ear-tufts as the tip. The Mass is obtained from freshly killed weighing of mammals expressed either in Kilograms (large mammals) or grams (small mammals).

Salter hanging spring-scales of 0-200 Kilogram and 0-1 000 pounds were used for large mammals whilst an Ohaus triple-beam balance weighing up to 2 610 gram was used on small mammals.

The length of forearm (F/a) for Chiroptera only was measured from the end of the ulna to the end of the carpus.

Where foetuses were present crown rump (CR) measurements were taken, this being the straight distance between cranium and base of tail with the foetus in natural position as removed from the uterus. The mass of the foetus was recorded in grams with the umbilical cord severed at the body of the foetus. The position and number of foetusses were recorded from all pregnant females collected. For larger mammals collected condition indices based on Riney (1955) were obtained. This involved kidney fat index, back fat index, abdominal fat index and marrow index. Batcheller and Clark (1970) fault Riney's (1955) work on kidney fat index since they maintain that kidney mass fluctuates seasonally. This fluctuation in kidney mass was not accounted for in the present work. The visual method of determining physical condition in large mammals as developed by Riney (1960) and further verified by Child (1968a) was abandoned since it is only really valid in extreme cases and not well suited in assessing wild African ungulates.

Ten lechwe were captured by darting from a helicopter and marked with "sterkolite" collars and ear tags during October 1974 to facilitate movement studies during 1975 in the lower Khwai area (Table 22). Attempts were first made to herd groups of lechwe into an "Oelofse Plastic Kraal" (Oelofse, 1970; Densham, 1974) with the helicopter. Four lechwe were successfully herded into the kraal but showed no fear of the plastic 'walls' and escaped. Due to the severe reaction and non-recovery after antidote administration on the first individual (Table 22), the tranquilising agent was excluded in all subsequent attempts and the immobilising agent or analgesic M99 was used on its own. Care has to be exercised since lechwe often became immobilised in the water. No lechwe were known to have died as a result of the exercise. A single barrel Palmer Cap-chur gun using 0,22 "Ramset" medium and heavy charges and 5 ml dart syringes were used throughout.

All collected foetuses were weighed and conception and parturition dates were calculated according to the formula of Huggett and Widdas (1951).

Table 22 – Drug immobilisation data for lechwe darted and marked on the lower Khwai River floodplain, Okavango Delta, Botswana, October 1974.

DAY	COLLAR NUMBER	EARTAG NUMBERS		SEX	DRUG DOSAGE IN MILLGRAMS			REACTION TIME (MINUTES)	
					Analgesic: Etorphine hydrochloride	Neuroleptic Rompun	Antagonist: Nalorphine hydrobromide	Immobilisation	Recovery
5	1	1797	1798	M	2 + 2*	100 + 100	6 + 5	*	*
7	11	–	–	M	2,5	–	10	7,5	1,0
7	13	–	–	M	2,5	–	10	7,0	0,5
7	15 **	1757	1758	M	2,5	–	10	7,5	1,0
7	10	1759	1760	F	2,5	–	10	8,0	1,0
8	2	1737	1738	F	2,5	–	10	7,5	2,0
8	4	1739	1740	F	2,5	–	10	8,0	1,0
9	3 ***	1779	1780	M	2,5	–	10	7,0	1,0
9	6	1769	1770	F	2,5	–	10	8,0	1,0
9	5	1789	1790	M	2,5	–	10	7,5	1,0

* No reaction after 12 minutes, thus darted for a second time. Lechwe down but up again and eventually caught by hand. Only recovered after 5,5 hours and added treatment.

** Same group as number 10 when captured.

*** Same group as number 6 when captured.

$$t = \frac{W^{1/3}}{a} + t_o$$

Where t = post-conception age (days)

t_o = constant (dependant on average birth mass and gestation period for any particular species)

W = mass of foetus

a = foetal growth velocity

and a is established from $a = \frac{W^{1/3}}{t-t_o}$

using W = mean mass of foetus at birth

t = full gestation period

Results

A total of 63 mammal species were recorded within the actual study area boundaries. Doubtless more smaller mammals exist than are recorded.

The outline of classification used in this work follows Smithers (1971) whose work is based on Ellerman, Morrison-Scott and Hayman (1953) with some exceptions where Smithers followed the 'Preliminary Identification manual for African mammals', Smithsonian Institution, Washington D.C. (1966) now revised to 'An Identification Manual' (Meester and Setzer, 1971).

The orders Insectivora, Chiroptera, Primates, Pholidota, Carnivora, Tubulidentata, Proboscidea, Perissodactyla, Artiodactyla, Lagomorpha and Rodentia were represented; thus only Hyracoidea being absent. Each species is dealt with independently giving distribution and status, movement patterns, habitat requirements, feeding behaviour and general behaviour patterns. For the larger more common species where numerous observations and limited collection of individuals was carried out, further parameters of population structure, physical condition and breeding biology are given. Seasonal population estimates from aerial surveys are given for the larger mammalian species. Some internal and external parasites are recorded from specimens collected and identified by Onderstepoort Veterinary Research Institute, Pretoria[x] (internal and external parasites) and the South African Institute for Medical Research, Johannesburg* (external parasites.)

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*P.O. Box 1038, Johannesburg, South Africa.

Small mammal identifications were confirmed by preserved specimens or study skins sent to the National Museums of Rhodesia, Salisbury** and to the South African Institute for Medical Research, Johannesburg.* This does not preclude that mammals not occurring on this checklist are absent from the study area. It is only presumed that they are absent. Where possible, comparable data are given for adjacent areas either from other works or from my own observations.

Order Insectivora

The only insectivores found present during this study were some members of the Soricidae (Shrews), all being of the genus *Crocidura.*

Crocidura flavescens (I. Geoffroy, 1927)
Giant Musk Shrew.

Fairly widely distributed along the immediate verges of the mid-Boro River but none were captured on the verges of similar Outlet or Middle Channel Communties of the eastern floodplains. All specimens were captured during 1973 in extreme low flood conditions when this would have been the only suitable habitat available. Smithers' (1971) only records are for the Upper Okavango and Chobe Rivers and the mid Khwai River. Thus *C. flavescens* appears to be spreading southwestwards down the Delta, although Smithers' work was not concentrated in this study area.

Movement appears to take place as during high flood conditions of 1974 none were captured from localities where they were previously taken. It inhabits the fringes of well-watered areas in tall grass and sedge cover on the verges of Upper, Middle and Outlet Channel Communities. Meester (1963) reports captive species to be carnivorous on small mammals, birds, amphibians, reptiles and invertebrates.

Predominantly nocturnal as all specimens were captured at night, although Smithers *(op. cit.)* reports captures during daylight hours. No breeding data are available for Botswana.

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SIZES AND MASS

Male

TL = 218 mm; T = 81 mm; Hf c/u = 23 mm; E = 9 mm; Mass = 40,7 g; N = 1.

Females

TL $\bar{X}$	=	215;	N	=	8;	Range 196 – 230
T $\bar{X}$	=	80;	N	=	8;	Range 71 – 85
Hf c/u $\bar{X}$	=	23;	N	=	8;	Range 22 – 25
E $\bar{X}$	=	11;	N	=	8;	Range 10 – 13
Mass $\bar{X}$	=	46,72 g;	N	=	5;	Range 37,4 – 63,4 g

External parasites
(Acarina)
Haemaphysalis sp.
Dermacarus sp.
Eadiea crocidurae (Lawrence, 1951)
Laelaps sp
Ornithonyssus bacoti (Hirst, 1913)

Crocidura bicolor woosnami Dollman, 1915.
Tiny Musk Shrew

This shrew appears to be localised and probably does not occur in abundance. Only one male specimen was trapped at night in *Acacia tortilis* Savanna Woodland about 200 m from the verge of the floodwater extremity.

The subspecies is doubtful as conflicting material was described by Meester (1963) and Smithers (1971) from the Okavango region.

Smithers *(op. cit.)* reports the subspecies as showing a wide habitat tolerance, being mainly nocturnal but to some extent diurnal and insectivorous. No breeding data are available.

SIZE AND MASS

Male

TL = 107; T = 39; Hf c/u = 10; E = 8; Mass = 5,4 g, N = 1.

Crocidura mariquensis shortridgei St. Ledger, 1932
Black Musk Shrew

These shrews are fairly common and fairly widely distributed in the floodplain systems, but appears more common on the Western floodplains. Four specimens were captured during daylight hours and 22 at night, all in the ecotonal areas between Middle Channel or Outlet Channel Communities and Closed Riverine Woodland or Primary Floodplain Communities. Thus proximity of wet conditions and tall aquatic to semi-aquatic vegetation appear to be essential habitat requirements.

Black musk shrews are insectivorous and carnivorous, mainly nocturnal but also diurnal. Smithers (1971) reports gravid females from August to April with an observed range of two to five foetuses.

SIZES AND MASS

Males

TL	$\overline{X}$	=	136;	n	=	14;	Range	123	–	144
T	$\overline{X}$	=	55;	n	=	14;	Range	47	–	60
HF c/u	$\overline{X}$	=	15;	n	=	14;	Range	13	–	16
E	$\overline{X}$	=	7;	n	=	14;	Range	5	–	11
Mass	$\overline{X}$	=	9,1 g;	n	=	8;	Range	7,2	–	10,0 g

Females

TL	$\overline{X}$	=	133;	n	=	11;	Range	122	–	141
T	$\overline{X}$	=	52;	n	=	11;	Range	47	–	60
Hf c/u	$\overline{X}$	=	14;	n	=	11;	Range	12	–	17
E	$\overline{X}$	=	7;	n	=	11;	Range	5	–	10
Mass	$\overline{X}$	=	8,8g;	n	=	7;	Range	7,9	–	10,6 g

External parasites

(Acarina)

Haemaphysalis sp.

Androlaelaps sp.

Ornithonyssus bacoti (Hirst, 1913)

(Anoplura)

Polyplax reclinata (Nitzsch, 1864)

Order Chiroptera

Few bats were collected due to lack of collection equipment and damage to collected specimens from a 12-Gauge shotgun.

Suborder Megachiroptera (Fruit Bats)
Epomophorus crypturus Peters, 1852
Peters' Epauletted Fruit Bat.

Commonly distributed throughout the areas of well-developed Closed Riverine Woodland in the study area, and similar areas of the Delta in general (Smithers, 1971). Movement appears to follow the abailability of fruit.

Found hanging during daylight hours in trees with dense foliage, especially *Garcinia livingstonei* and feed on the fruit of such as well as *Diospyros mespiliformis, Ficus* spp. and *Sclerocarya caffra.* No breeding records exist for Botswana (Smithers *op. cit.).*

SIZE AND MASS

Male

TL = 155; Hf c/u = 22; E = 26; F/a = 80; Mass 99,5 g; N = 1.

No female data are available as females were damaged extensively by the collection method.

Suborder Microchiroptera (Insectivorous Bats)

One specimen of the subgenus *Tadarida* was found dead in Closed Riverine Woodland, but due to decomposition the species could not be determined.

Order Primates

Family Lorisidae
Galago senegalensis bradfieldi Roberts, 1931.
Lesser Galago; Night Ape; mottwele.

Reported as fairly common throughout the Delta (Smithers, 1971); but nowhere fairly common in the study area. They occur mainly in Closed Riverine Woodland and Marginal vegetation types, and were recorded in these localities in the study area.

The subspecies is predominantly nocturnal, arboreal, largely insectivorous, and usually found occurring singly but occassionally in pairs. Smithers *(op. cit.)* suggests breeding throughout the year with one to two being the average number of foetusses present.

Family Cercopithecidae
Cercopithecus aethiops ngamiensis Roberts, 1932.
Vervet Monkey, Kgabo

Vervet monkey are fairly widely distributed on the margins of Chief's Island and the islands of the Boro floodplain system, but not common anywhere in the study area. On the M'borogha islands and floodplains, vervet monkey populations are low which can possibly only be attributed to the more permanent water levels and deeper channels of this eastern sector serving as a barrier to their expansion. The drier conditions of the lower-Delta areas show much higher vervet monkey populations and group size. Groups of 12 to 30 individuals were regularly encountered in the lower-Delta whereas a maximum of 15 in a group were found in the study area, only on isolated occasions. Movement seems localised and home ranges small.

Found to occur in all vegetation types except the aquatic vegetation types, and appears to display a dislike of wet conditions. Most commonly encountered on islands in Closed Riverine Woodland or Marginal vegetation types or *Sporobolus spicatus* Island Grassland, and Primary Floodplain Communities after seasonal inundation has ceased and the surface is dry.

The subspecies is diurnal and gregarious, but troops are small. None were found exceeding 15 individuals, but more commonly troops comprised seven to ten individuals. Vervet monkeys are predominantly vegetarian with the bulk of food material being made up of wild fruits and seeds. The abundance of fruit-bearing trees in the Closed Riverine Woodland should support higher vervet monkey populations. Termites and other insects were also observed to be fed on.

Juveniles were observed during most months and this suggests a non-seasonal reproduction for this sub-species which Smithers (1971) also suggests. Vervet monkeys give birth to a single juvenile, with no instances of twins observed.

Papio ursinus (Kerr, 1792)
Chacma Baboon, Tshwene

Widely distributed throughout the study area and commonly encountered. In some parts of the study area there appears to be an overpopulation of this species. Baboon utilise all the vegetation types, except aquatic vegetation types, but may be found utilising some of the latter communities during exceptionally dry seasons, viz. 1973. The particular plant community being utilised in time is dependent on food availability, and is thus tied up with flowering and/or fruiting of the various tree/shrub species, and with the recession of floodwaters in the floodplain vegetation types, viz. the heavy utilisation of almost dry or dry Primary Floodplain Communities.

Baboon move over a fairly small home range (5 to 6 km^2) in the study area due to the abundance of food. *(Borland **pers. comm.**). Daily movement patterns change with the availability of certain specialised food types, viz. when scale insect larvae (Coccidae) and pupae are present on *Colophospermum mopane* in August, September and October the baboon utilise this plant community heavily. During other seasons when scale insect is not available the *Colophospermum mopane* Woodland are not included in the daily feeding routine. Baboons show little fear of moving through shallow water and Child (1968a) reports that they readily take to water and are strong swimmers.

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*R. Borland, c/o Anglia Television, England.

The roosts (of which a troop may have more than one) are always located in Closed Riverine Woodland or dense marginal vegetation types. The general daily pattern was to come down from the roost shortly after light conditions prevail, and minor feeding then occurs in the roost area. They then move about slowly but feed opportunistically on their way to the major feeding area of that season. Copulation, playing and scolding may occur during progress to the site. Once reached dominance prevails over the most select feeding sites or the viance for such sites.

Baboons are vociferous and alert, and any potential danger always initiates warning barks during which time the females rapidly locate their young. During troop interaction for territory or home range, the subadult males do most of the 'performing shout' or bark (as opposed to warning), whilst adults often take to copulation.

After the main bout of feeding the baboons move towards water from 11h00 to 14h00, this usually presenting no problem in the swamp environment, where they drink and rest. Playing, copulation, nursing and scolding of juveniles by adults takes place. After this rest period at approximately 15h00 to 16h00 they again move, slowly feeding towards the roost which they reach towards sunset and enter such for the night.

The population is broken up into troops of various sizes but usually comprises 40 to 70 individuals in the study area. Stoltz (1977) reports troop sizes from the Northern Transvaal and eastern Transvaal lowveld to average approximately 40 individuals; thus showing fewer individuals comprising a troop when compared with the study area. A troop is made up of all age groups of both sexes but with a strict dominance hierarchy amongst the males. This dominance probably extends amongst the females as well; but is far less pronounced in constant expression, determination and maintenance of such. Stoltz *(op. cit.)* reports similar findings in Transvaal baboon troops. There appears to be an alpha dominant male, with several adult males of lower rank. Large males often chased non-oestrus females and treed them, only to give a characteristic bark and then leave the female; this being interpreted as a dominance show for other males. More dominant males often do the same to less dominant males. Single, large males were encountered on several occassions and would appear to be displaced old alpha dominant males. Stoltz *(op. cit.)* also reports single males, not necessarily old dominant males, but often males leaving their birth troop and trying to join a new troop, rejected, and in turn rejected by their birth troop.

Baboons are omnivorous but predominantly vegetarian. They feed on the flowers of *Acacia* spp., *Kigelia africana, Lonchocarpus capassa, L. nelsii* and *Grewia* spp. Fruits of *Diospyros mespiliformis, Garcinia livingstonei, Ficus* spp. and *Kigelia africana* are relished. The mesocarp of *Hyphaene ventricosa* is highly favoured. The seeds of *Acacia erioloba* and *A. tortilis* are consumed but the pods are bitten open and then rejected. Sedge bulbs and roots and some grasses and sedge seedheads are also consumed. Baboons eat a wide variety of invertebrates, birds eggs or nestlings and small mammals are sometimes caught and consumed, viz. *Paraxerus cepapi* which is often chased but seldom caught. If caught, the bush squirrel appears to be relished.

Visually the physical condition of baboons was fair to good, but several individuals in poor condition were seen. This appeared to be more as a result of injury or disease than lack of sufficient food, i.e. overpopulation since all troops contained individuals showing physical injury.

Baboons bred throughout the year but with a peak of births from June to September. Females displayed oestrus for about 10 days. During initial oestrus the main attention received seemed to stem from sub-adult males. After this initial period the oestrus female attaches herself to a dominant male who copulates frequently with her as also reported by Stoltz (1977). His failure to serve her leads to her copulating with any other male but usually with a less dominant one. During the last part of oestrus the female attaches herself to any suiting male, and even sub-adult to juvenile males try to mount and copulate with her. Copulation also takes place in the roost at night. On average copulation takes place up to 20 times per day and thus during oestrus a female may copulate up to 200 times (Borland, pers. comm). Immediately after copulation on the ground the female runs off making a characteristic call while the successful male grunts.

The population appears to be excessive on the Boro floodplain system during dry seasons when on average 44 troops were estimated from aerial survey, to be utilising this sector. During high flood conditions an average of 16 troops were present but when water levels dropped significantly towards the end of 1974, 33 troops were estimated to be present. The pattern on Chief's Island showed a much lower density with immigration during high flood and emmigration during dry periods, but overall sustaining the lowest density. The M'borogha floodplains showed a more stable population but with immigration during the drier periods (Appendices 1 to 17). Baboon move within the three areas as well as in and out of the study area in accordance with season and floodlevels. Some troops always remain within the study area and baboon are probably in somewhat excessive numbers and in no danger whatsoever.

Order Pholidota

Family Manidae
Manis temmincki Smuts, 1832.
Pangolin, Kgaga.

Pangolin occur within the study area but can be considered rare. None were sighted by myself, but two sightings by reliable witnesses occurred in the study area, during the course of field work, and a further one in an adjacent area. Smithers (1971) considers them to be more common in the Delta than in other parts of the territory.

Nothing is known of their movement patterns. They appear to occur in a variety of habitat types, Smithers *(op. cit.)* and were recorded on a Secondary Floodplain Community, and Closed Riverine Woodland in the study area. The species is both nocturnal and diurnal, generally encountered solitarily or as a female with juvenile or sub-adult. Single births occur and the mother-juvenile attachment is very strong (Smithers *op. cit.*).

Stomach contents from Rhodesian specimens show a diet consisting mainly of Formicidae (ants) and secondly Isoptera (termites) with traces of sand, gravel and small sticks (Smithers, *op. cit.*), probably consumed whilst feeding on prey. The large populations of termites present in the Delta may account for the higher density of pangolin in the Delta.

Order Carnivora

Family Protelidae
Proteles cristatus (Sparrman, 1783)
Aardwolf, Thukwe, mMabudu

Occurs in the drier Secondary Floodplain Communities and dryland vegetation types, but nowhere common in the study area. Sightings were in Secondary Floodplain Communities

Grewia spp. – *Croton Megalobotrys* Scrub Savanna and *Sporobolus spicatus* Island Grassland Communities. Shortridge (1934) and Smithers (1971) also record aardwolf utilising similar vegetation types, but the species is more typical of the semi-arid areas in Botswana.

They are obviously affected by flooding regimes, as one known specimen lived in an old antbear hole in a Secondary Floodplain Community which remained dry throughout 1973. The same Secondary Floodplain Community was inundated for six to seven months during 1974 and under such circumstances aardwolf are forced onto the islands. Bothma (1971a) records movements of up to 35,4 km for this species, in stock-farming areas of the western Transvaal.

Aardwolf are generally nocturnal, but one specimen was observed at 12h00, and occur singly, in pairs or in small groups. Aardwolf take refuge in old antbear holes or enlarged springhare holes.

Food preference is strongly biased towards insects mainly Isoptera (Kruuk and Sands 1972) and due to the large prevailing termite population one would expect a fairly high aardwolf population, but this is probably curtailed by partial inundation of the more favoured Secondary Floodplain Community.

Insufficient data are available from Southern Africa on breeding seasons to reach any definite conclusions (Smithers, *op. cit.*).

Family Hyaenidae
Crocuta crocuta (Erxleben, 1777)
Spotted hyaena, Phiri

Widespread and common throughout the study area, occurring in all but aquatic vegetation types. Encountered commonly in dry Primary Floodplain and Secondary Floodplain Communities, *Sporobolus spicatus* Island Grassland Communities, Closed Riverine Woodland, Marginal vegetation types and all dryland vegetation types. Robbel and Child (1976) report the species as common in the Moremi Wildlife Reserve.

Movement may be localised or wide-spread (Eloff, 1964) depending on the availability of food and on audio reception of activities of other hyaenas and their associated vocalisations.

Kruuk (1972) reports packs or clans with definite territories and aggressive defense of such in the Ngorogoro Crater. Hyaenas cross shallow water readily and will also rather reluctantly take to deeper water.

Hyaenas are crepuscular and nocturnal mammals occurring either singly, in small groups, yet on one occassion a pack of 15 was recorded at a temporary camp in the verge of Chief's Island with no associated carrion. Most sightings of hyaenas in the study area were of solitary animals or of pairs, except in the cases where a carcass was present. They actively hunt either singly or in small groups but readily take to scavenging carrion from dead animals. Reedbuck and lechwe were recorded kills made by hyaenas, but doubtlessly they accounted for many other ungulates and smaller mammals. Hyaena readily locate temporary or semi-permanent camps in the Delta where they scavenge almost any article. Hyaenas usually became active during early evening and spend the night searching for carrion or hunting prey. Vocalisations seem to play a large role in communication of individuals or groups and hyaenas could be heard nightly at almost any spot in the study area. The number of hyaena spoor encountered in the study area attested to their abundance and widespread distribution. Their activity extended until early morning when they generally retired to disused antbear *(Orycteropus afer)* holes, unless they were in the vicinity of a carcass and had not yet fed, when activity extended well into the daylight hours.

The young are born in antbear *(Orycteropus afer)* holes, usually located at the base of a termitarium with the surroundings well-inundated. Evidence from Zambia (Ansell, 1960), seems to show no definite breeding season, and whilst Botswana evidence is still too scant there appears to be a breeding peak during the winter months. Two hyaenas were shot after causing large-scale damage to my camp; one was a mature female collected in August 1973 and she was lactating. Ovulation was from both ovaries and the uterine horns were still distended and highly vascularised. This female was in excellent condition for rearing pups, having a kidney fat index of 50 per cent. The other was a mature male having a kidney fat index of 15 per cent.

SIZES AND MASS

Male

TL = 1 535; T = 274; Hf c/u = 245; E = 109; Mass = 74 kg; N = 1.

Female

TL = 1 551; T = 310; Hf c/u = 246; E = 109; Mass = 76 kg; N = 1.

Family Felidae

Acinonyx jubatus jubatus (Schreber, 1775)

Cheetah, leTlotse

A reasonably healthy cheetah population occurs in the study area but these cheetah are widespread and sparsely distributed. Cheetah were recorded from the western floodplains and Chief's Island, but none were recorded from the eastern floodplain system of the study area. Found to occur largely associated with the drier Secondary Floodplain Communities, but also encountered in *Colophospermum mopane* Woodland and *Acacia tortilis* spp. Savanna Woodland, however never distantly removed from the more open Secondary Floodplain Communities.

Little is known about cheetah movement patterns, but in the study area they appear to move over a large home range. Cheetah were also encountered crossing shallowly inundated Primary or Secondary Floodplain Communities.

Cheetah are predominantly diurnal but do show some nocturnal hunting activity. Group size varied from single individuals, either male or female, but in the latter case usually heavily pregnant or possibly with hidden juveniles; to two or a maximum of five individuals. Due to their shy nature it was impossible to assess group sex structure. Single individuals or pairs of cheetah were most commonly encountered.

Recorded skills by cheetah include one sub-adult female lechwe (single cheetah), a lechwe juvenile, and adult female impala (three cheetahs) and a sub-adult warthog and an adult male warthog (2 cheetahs). Their prey species in general consist largely of the medium to smaller-sized ungulates, small mammals and birds (Kruuk and Turner 1967, Schaller 1968, Pienaar 1969). Adult cheetah hunting in groups are known to take prey up to the size of an adult female kudu. (pers. observ.). An ostrich *Struthio camelus* was reported killed by cheetah near Tsau (Brown, In Smithers 1971).

The general visual physical condition of cheetah encountered was good. No accurate breeding data are available for Botswana but two single female encountered during April 1973 were heavily pregnant.

Panthera pardus pardus Linnaeus, 1758
Leopard, Nkwe

Leopard are widely distributed but apparently in low population density throughout the study area. From spoor evidence leopards show a preference for the dense Closed Riverine Woodlands. The assessment of the leopard situation is largely derived from spoor evidence, audio records and discussion with local hunters who had killed leopard in or adjacent to the study area.

Spoor evidence was mainly located in the Closed Riverine Woodlands, *Acacia tortilis* spp. Savanna Woodland, *Terminalia sericea – Combretum collinum* Savanna Woodland and scrub, *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna and Primary Floodplain, Secondary Floodplain and *Sporobolus spicatus* Island Grassland Communities. Leopards appear to reside in localised Closed Riverine Woodland and readily cross inundated areas.

Leopards are predominantly nocturnal and occassionally crepuscular, usually occurring singly, but occassionally in pairs. Leopard lie up during major daylight hours in Closed Riverine Woodland which affords suitable protection and large trees for resting up and storing unconsumed portions of prey species.

Recorded kills include impala (adult male and female), adult female lechwe and adult male kudu. In general leopards show a wide spectrum of prey species but largely from the smaller-sized antelope, small mammals and birds (Mitchell, Shenton and Uys, 1965). Child (1968b) records kills of duiker, baboon, impala, tsessebe, bushbuck, young roan and antbear from the Moremi Wildlife Reserve.

No information is available on breeding data or population density but judging by known numbers removed in hunting (six in or adjacent to the study area during 1974) and spoor evidence still present the population appears to be in no immediate danger.

Panthera leo (Linnaeus, 1758)
Lion, Tau

Lion are widely distributed and in fairly good population density throughout the study area. Encountered in most habitat types except aquatic vegetation types, but display no fear to move through water. Lions penetrate to some of the smallest islands surrounded by well-inundated floodplain communities. Their movement is widespread and lions constantly move in and out of the study area.

Lions are largely nocturnal and crepuscular, occassionally occurring singly, but more often in small groups or prides of two to 12 individuals. Both single males and single females were encountered. In the latter case heavy pregnancy or early parturition is involved and in one instance as a relatively badly injured lioness, being the result of porcupine *(Hystrix africaeaustralis)* quill damage. The most common pride size encountered was two to five individuals but prides of up to twelve individuals were all recorded on isolated occassions. The sex composition and age structure of prides one was able to assess accurately varied greatly.

Once the morning temperatures rise, lions apparently seek the first suitable resting place, where they laze and sleep unless disturbed till the temperatures fall during the late afternoon. Opportunistic attempts at killing, or actual killing (but mostly unsuccessful), may take place during these hot hours if a chance arises. Most recorded kills took place during the general hours of movement.

Lions appear to take any available warm blooded-prey and also include such items as tortoise *(Testudo* spp.) and python *(Python sebae)* (Pienaar, 1969). Recorded skills include adult male and female giraffe, sub-adult and adult male wildebeest; adult female and male impala, sub-adult, adult female and adult male warthog, adult female kudu, adult female zebra and adult female and juvenile lechwe. On one occassion five buffalo calves were killed in the space of approximately one-sixteenth of a square kilometre.

Visual physical condition varied from good to fair but with predators this is mainly a function of when they had last fed. The only lioness found in poor condition was that mentioned as injured above. Breeding biology showed estimated births occurring in April, June and November, but apparently births can take place throughout the year (Shortridge, 1934; Ansell, 1960). Two to three cubs were found to be accompanying a single female and this seems to be the most common litter size in the study area.

Felis libyca griselda Thomas, 1926
Wild Cat, Tibe, Phage

Wild Cat appear to be sparsely distributed and apparently nowhere common in the study area. Only recorded from the Piajio area of Chief's Island on short grassed Secondary Floodplain Community associated with adjacent *Acacia tortilis* Savanna Woodland.

Smithers (1971) records a wide habitat tolerance for this species, and probably due to their small size and mainly nocturnal habits sightings are poor and their distribution may be greater especially over Chief's Island. Wild Cat occur singly or in pairs. Their diet consists mainly of Muridae, Solifugae, Orthoptera, Reptilia and Aves (Smithers *op. cit.).*

Felis serval serval Schreber, 1776.
Serval, Tadi

Serval occurs throughout the study area, but mainly on the eastern and western floodplains and the verges of Chief's Island. Fairly common and widely distributed. The proximity of water together with adjacent dense scrub, tall grass and sedge or reed cover appear to be essential habitat requirements.

Serval are largely nocturnal and lie up in fairly thick cover during daylight hours or in disused antbear holes. Odd individuals may be encountered during daylight hours but generally when disturbed from resting up. Occurrence is singly or in pairs, but three were sighted on one occassion. Nothing is known of their movement pattern or home range.

Their diet consists largely of Muridae with lesser quantities of Solifugae, Aves, Reptilia, Coleoptera and Orthoptera (Smithers *op. cit.).* No breeding data are available for Botswana, but an all-year breeding cycle seems possible if records from all adjacent territories are taken into account.

Family Canidae
Otocyon megalotis megalotis (Desmarest, 1822)
Bat-eared Fox, moTlhose

Locally distributed but not common in the study area. Observed on the western floodplains and marginally on Chief's Island but not on the eastern floodplains. Bat-eared foxes were recorded on short to medium-height sandy Secondary Floodplain Communities and adjacent *Acacia tortilis* Savanna Woodland areas. They are essentially an open semi-arid dryland species, (Smithers 1971) and in heavy flood years their available range is restricted.

The subspecies is diurnal and nocturnal, occurring singly or in small groups. During the heat of the day they usually rest in self-excavated burrows or old antbear or springhare burrows.

They are avid diggers even in hard ground and bat-eared foxes feed largely on Isoptera, Coleoptera (adults and larvae), Orthoptera, Muridae, Scorpionidae and dry grass stems and leaves, a lesser quantity of wild fruits, Reptilia, Solifugae, Lepidoptera, Formicidae, Myriopoda and green grass is consumed (Smithers, *op. cit.*). Berry (1978) found insects (57 per cent) and fruit (33 per cent) to comprise greatest percentage of stomach content of bat-eared fox in the upper Limpopo River Valley. Carrion is also consumed. Mills (1977) is of the opinion that brown hyaena *(Hyaena brunnea)* show definite predatory instincts towards bat-eared foxes in the Southern Kalahari.

Females burrow extensively and the young are born in subterranean excavations, generally numbering four to six juveniles after a gestation period of 60 to 70 days (Asdell, 1946). The present population in the study area cannot be considered high, but this is largely due to lack of suitable habitat.

Lycaon pictus pictus (Temminck, 1820)
Wild Dog, LeThalerwe

Widely distributed and common throughout most of the study area, as well as the Okavango Delta and surrounding areas. Found in most vegetation types, except the aquatic vegetation types, but will readily take to shallow water in pursuit of prey. Wild dogs were most commonly encountered on the dry floodplains and also in the dryland communities. They move over large home ranges and are not normally restricted in movement unless juveniles are too young to accompany the packs (Van Lawick Goodall, 1970).

Wild dogs are gregarious and diurnal animals. On three occassions single wild dog were encountered, but more commonly packs varied from six to 14 individuals, with one pack of 24 and another of 31 individuals recorded. Sex composition of packs varied considerably and in one instance a pack of six wild dogs comprised five adult males and one adult female. Wild dogs were the least wary of human presence of all the predators.

The four recorded wild dog kills were adult male and female impala and adult male and female lechwe. Wild dogs seem to prefer the medium-sized ungulate prey species, but packs are capable of killing large ungulates (Estes & Goddard, 1967). If in the vicinity of a wounded mammal, they are exceptionally quick to chase and capture such, but they apparently will not take carrion.

Mating was observed in late March and pups accompanying adults were recorded in September and October, usually in the larger packs. These juveniles were estimated to be three to four months old which would correspond to a breeding season of May to July as recorded for Zambia (Ansell, 1960). The litters are born in disused antbear holes.

Canis adustus adustus Sundevall, 1846
Side-striped Jackal; raNtalaje, seKgee

Side-striped jackal are fairly common and reasonably widespread throughout parts of the study area. They are more commonly associated with the open Primary and Secondary Floodplain Communities (when dry) and with adjacent dryland vegetation types, but seem tied in occurrence to the vicinity of well-watered areas. They were recorded in dry Primary and Secondary Floodplain Communities and most of the marginal and dryland vegetation types. Nothing is known of their movement patterns, but individuals do seem fairly localised but are forced to move when some of their habitat becomes inundated. They were more commonly encountered in the dry 1972/73 season, when compared with the wet 1973/74 season, and did seem to have migrated onto Chief's Island.

Side-striped jackal are predominantly nocturnal, but were often observed moving during daylight hours, and occurred singly or in pairs. Food commonly comprises Muridae and carrion and to a lesser extent wild fruits, Coleoptera, Isoptera, Orthoptera, Reptilia and Aves (Smithers, 1971).

No breeding data are available for Botswana but gravid females have been collected from Rhodesia during August, September and November (Smithers *op. cit.*).

Canis mesomelas arenarum (Thomas, 1926)
Black-backed Jackal; Phokoje

Black-backed jackal are fairly common in the drier parts of the study area adjacent to Chief's Island and especially on the Secondary Floodplain Community enclaves forming the ecotone of potential inundated areas and dryland, and in the dryland vegetation types of Chief's Island itself. There is a definite overlap in distribution in the study area of *Canis adustus adustus* and *C. mesomelas arenarum.* Bothma (1971a) showed adult black-backed jackals capable of extensive movement in stock-farming areas of the western Transvaal.

The subspecies is diurnal and nocturnal and cocurs singly or in pairs. In the vicinity of kills larger concentrations were encountered. In Botswana food in order of preference appeared to be Insecta, small mammalia, carrion, green grass, wild fruits, Solifugae, Scorpiones, Reptilia, Aves, Myriopoda and dry grass (Smithers, 1971). Bothma (1971b) showed food preferences from stock-farming areas in the Transvaal and Cape Province to be more biased towards domestic and wild Aves, Reptilia and domestic and wild Artiodactyla.

Young black-backed jackal appear to be born during the early summer months.

Family Mustelidae
Aonyx capensis capensis (Schinz, 1821)
Clawless Otter; leNyibi

Clawless otters were only recorded from the eastern floodplains where they were found in the dry, burnt, short Secondary Floodplain Community about 1 km from the M'borogha River. Recorded by Smithers *(op. cit.)* from the main Okavango River forming the sleeve of the Delta and from the Thamalakane River at the base and its eastern extensions. Thus apparently localised and not common in the study area.

Aquatic and semi-terrestrial mammals, the clawless otter generally seems to prefer the larger river systems viz. Upper and Middle Channel Communities and their associated flood-plain and dryland vegetation types. They are nocturnal and diurnal and wander widely over dryland areas in the vicinity of floodplain systems and over swamp islands. A pair was observed at least 0,5 km away from the nearest surface water at 08h00 heading towards an isolated pool in a drying-out Primary Floodplain Community. Smithers (1971) records most sightings of two, but up to four individuals at a time. Clawless otters are fairly shy, but more inquisitive than the spotted-necked otter *(Lutra maculicollis)*.

Their food comprises fish, crabs and insects and apparently frogs, aquatic birds, eggs, mussels and rodents (Smithers, *op. cit.)*.

No breeding data are available from Botswana, but young appear to be born in Rhodesia about April (Smithers, *op. cit.*), and about July or August in Zambia (Ansell, 1960).

Lutra maculicollis chobiensis Roberts 1932
Spotted-necked Otter; leNyibi

Spotted-necked otters are widely-distributed and fairly common in both the Middle Channel Communities of the eastern and western floodplain systems; and especially more common in the Outlet Channel Communities of the western floodplain system. Spotted-necked otters appear to prefer the smaller channels and lower water velocity present in the Outlet Channel Communities, their adjacent almost stagnant Sump Communities and adjacent offtakes to Primary Floodplain Communities. They occassionally move out into dryland verges or sandbanks but usually remain close to tall *Miscanthidium junceum, Phragmites australis, Typha latifolia* or *Cyperus papyrus* beds.

Spotted-necked otters are largely diurnal but also nocturnal and almost exclusively aquatic. Spotted-necked otters were often encountered from 08h00 to 11h00 and from 15h00 to 18h00, either singly or in groups of up to three individuals. They actively swim with just the head above water and characteristically dive after prey. They are very shy and the moment that they become aware of observers they dive, sometimes to re-surface well away, but usually they move off into the tall verging aquatic vegetation margins. Observed on dry sand banks at 09h00 thence moving into tall adjacent vegetation where they have definite runs.

Feeding records are scant but they appear to feed on fish and other aquatic animal life. A specimen collected at 16h00 had a completely empty stomach with only nematodes (*Cloeoascaris spinicollis* Baylis, 1923) present.

No breeding records are available for Botswana, but a nest was observed being prepared in September/October. Ansell (1960) records a litter born in November or December from Zambia.

SIZE AND MASS

Adult male

TL = 1 046; T = 415; Hf c/u = 127; E = 17; Mass = 4,25 kg; N = 1.

Mellivora capensis (Schreber, 1776)

Honey Badger; Ratel; Matshwane

The Honey badgers are widely-distributed in the study area but not common. Less evidence of honey badgers was found on the eastern floodplain system than on the western floodplain system. They are found more associated with the dryland vegetation types, the dry Primary and Secondary Floodplain Communities, the marginal vegetation types and Closed Riverine Woodland Communities. No particular habitat preference is shown except that they avoid aquatic vegetation types. Nothing is known of their movement patterns.

Honey badgers are nocturnal and diurnal, largely terrestrial but able to do limited climbing to reach some wild bees-nests. They were encountered on several occassions during daylight hours, in some instances showing some aggression, but more usually taking off when disturbed.

Their diet consists of honey and larvae, Scorpiones, Arachnidae, Muridae, Orthoptera, Reptilia, Aves, Myriopoda and carrion; (Smithers, 1971); but they are sometimes able to catch and kill newborn and small to medium-sized mammals (Ansell, 1960) and even large mammals (Stevenson-Hamilton, 1947). They are avid diggers and much of their prey seems to be caught by this means.

Limited available breeding data for Botswana and Zambia shows births during November, December and probably adjacent months (Smithers *op. cit.*).

Ictonyx striatus (Perry, 1810)
Striped Polecat; Nakedi

The striped polecat are widely-distributed throughout the dryland vegetation types of the study area and appear to be fairly common. Found mainly on the islands, dry floodplain and Chief's Island. Nothing is known of their movement patterns.

Striped polecats are nocturnal and terrestrial. They only appear to be active during the period from 22h00 onwards till early morning (Smithers, 1971). No observation of this species was made during daylight hours, and only on one occassion were they located prior to 22h00 at night. All recordings were of a single individual or of pairs.

Diet includes Coleoptera adult and larvae, Reptilia, Muridae, Orthoptera, Scorpiones, Solifugae and Myriopoda and limited breeding data suggests a late summer period, viz. January to March. (Smithers *op. cit.)*.

Family Viverridae
Viverra civetta civetta Schreber, 1776
Civet; Tshipalore

Civet are widely-distributed throughout the study area except the main dryland mass of Chief's Island, but not common. Habitats include some aquatic, riverine marginal and floodplain vegetation types. Nothing is known of their movement patterns.

Civets are nocturnal and usually occur singly, but pairs may be found. They are terrestrial and secretive, lying up for most of the day in dense cover. Their occurrence in the study area seems largely dependent on water proximity as also for all Botswana records (Smithers *op. cit.)*.

Feeding records include wild fruits, Amphibia, Orthoptera, Coleoptera and Solifugae (Smithers, *op. cit.*). Breeding records suggest births take place in the middle of the rainy season, January or February (Smithers, *op. cit.)* whereas Ansell's (1960) records for Zambia indicate an earlier October/November season.

Genetta genetta pulchra Matschie, 1902
Small-spotted Genet; Tshipa

Small-spotted genet are widely-distributed and fairly common in the study area. The major habitat occurrence is Closed Riverine Woodland and associated marginal vegetation types and to a lesser degree in the dryland vegetation types. Movement patterns appear to be fairly localised.

Small-spotted genets are nocturnal and occur singly, in pairs or in small family parties of up to five individuals. They are terrestrial and arboreal and are sometimes recorded during late afternoon.

Feeding records include Muridae, Orthoptera, Scorpiones, Solifugae, Reptilia, Isoptera, Coleoptera, Aves, Myriopoda, carrion, green grass, Amphibia, Chiroptera, Araneae, wild fruits, Lepidoptera, Soricidae, Dictyoptera and Muscardinidae descending in order of preference from stomach samples. (Smithers, 1971).

The breeding season occurs mainly from October to February or later, with an average of two to four juveniles born.

Genetta tigrina rubiginosa Pucheran, 1855
Rusty-spotted Genet; Tshipa; Thokolo

Rusty-spotted genet are widely-distributed and fairly common within the study area. They overlap in distribution and habitat requirements with *G.g. pulchra* within the study area. *G.t. rubiginosa* is however more confined to well-watered areas, whereas *G.g. pulchra* has a wider habitat tolerance and is independent of surface water. Rusty-spotted genets occur largely in Closed Riverine Woosland and associated marginal vegetation types. Movement patterns appear to be localised.

Habits are the same as for *G.g. pulchra.* Feeding records include Muridae, Coleoptera, Orthoptera, Isoptera, Solifugae, wild fruits, Myriopoda, Scorpiones, Aves, Anthropoda, Reptilia, Araneae and carrion (Smithers, *op. cit.).* Muridae form a large percentage of their diet.

Breeding season seems to occur from September to February.

Cynictis penicillata (G. Cuvier, 1829)
Yellow Mongoose; Moswe

Yellow mongoose occurs within the study area, but only recorded on four occassions. Appears to be confined to the drier and more denuded Secondary Floodplain Communities and adjacent woodlands.

The yellow mongoose is diurnal and terrestrial. Smithers (1971) reports the species as gregarious and living in colonies, but all recordings in the study area were of single specimens.

Feeding records include Coleoptera (adult and larvae), Isoptera, Orthoptera, Muridae, Scorpiones, Reptilia, Solifugae, Myriopoda, Aves, Amphibia and carrion (Smithers, *op. cit.)*. Breeding records indicate a breeding peak from October to March with sporadic recordings outside this period. Two to five juveniles are born in underground warrens. (Smithers, *op. cit.*).

Herpestes sanguineus Rüppel, 1836
Slender Mongoose; Ngano

Slender Mongoose are fairly widely distributed and are fairly common in the study area. They occur in the riverine, marginal, dry floodplain and dryland vegetation types. Movement appears to be very localised.

Slender mongoose are diurnal and normally solitary. All observations in the study area were of single individuals during daylight hours. Feeding records include Reptilia, Isoptera, Muridae, Orthoptera, Coleoptera, Aves, Scorpiones, Lepidoptera and wild fruits (Smithers *op. cit.)* Breeding data are scant but breeding appears to occur during November to March.

Atilax paludinosis (G. Cuvier, 1829)
Water Mongoose; Tshagane

Only one specimen of a water mongoose was recorded from the well-inundated eastern floodplains. The specimen was recorded in Closed Riverine Woodland adjacent to a Middle Channel Community's verge of tall aquatic vegetation.

Water mongoose are nocturnal, terrestrial and also aquatic to a degree. They are secretive and doubtless more are present in the study area but due to their habits not located. Feeding evidence is scant from Botswana but the food of Rhodesian specimens include Amphibia, Crustacea, Muridae, wild fruits and carrion (Smithers, 1971).

Mungos mungo grisonax Thomas, 1926
Banded Mongoose; leTototo

Banded Mongoose are widely distributed and common in most parts of the study area. Found in Closed Riverine Woodland and adjacent dry floodplain and dryland vegetation types.

Banded mongoose are gregarious, diurnal and terrestrial and usually occur in troops of from eight to 14 individuals, but larger concentrations of up to 30 individuals occurred. They move fairly widely in search of food and have a colonial warren.

Feeding records include Coleoptera (mainly larvae but also adults), wild fruits, Solpugidae, Orthoptera, Acrididae and Reptilia. No breeding data exists for Botswana, but evidence from adjacent territories indicates a season of November to February (Ansell, 1960).

Order Tubulidentata

Family Orycteropodidae
Orycteropus afer afer (Pallas, 1766)
Antbear; Thakadu

Antbear are widely distributed and rare to common throughout the study area. They were recorded from all but the aquatic vegetation types and movement appeared to be widespread.

Antbears are nocturnal but they were also recorded during late evening on two occasions. They are solitary, terrestrial and lie-up in self-excavated holes. These numerous holes form important refuge and breeding sites for a large variety of mammals and some reptiles.

Feeding records indicate a diet comprising Formicidae and Isoptera, with traces of other insects. Numerous holes are excavated during the course of searching for food. Breeding data are scant, but they appear to give birth to a single juvenile from May to August (Smithers, 1971).

Order Proboscidea

Family Elephantidae
Loxodonta africana africana (Blumenbach, 1797)
Elephant; Tlou

Elephant are widespread and common throughout the study area but mainly seasonally. They were less commonly encountered on the western floodplains, but elephant did seem to be making more use of this sector as the study progressed.

They were encountered in all vegetation communities. Movement is seasonal and herds of elephant migrate into the study area from the east and north. Some single bull elephant or small groups of three to six bull elephant remain in the area all year round, mainly utilising Chief's Island and the eastern floodplain system. During and after good rains the bulk of the elephant population migrates out of the study area moving mainly towards Moremi Wildlife Reserve, the Khwai and Maxwee concession areas and thence towards Mababe or Makalamabedi. There is less evidence available but others appear to move westwards to the Sepopa and Kuki West concession areas. These movements normally follow well-defined footpaths.

The elephants in the study area were found to be very shy probably due to adjacent hunting pressure, since large parts of the study area were hunted until recent years. Although Moremi Wildlife Reserve is also adjacent to hunting areas, elephants there are far less shy, probably as a result of adaptation to heavy tourist densities.

Elephants are generally gregarious mammals and usually occur in herds of 15 to 30 individuals. These comprise mainly cows and calves, but young bulls may still be present. One or more adult bulls may be present in these herds at any stage, but they only join the herd for possible mating. These bulls wander singly or in small groups of up to six or eight individuals, either all adult or of mixed aged males. The largest concentration encountered on Chief's Island comprised 160 individuals (26 September 1973); before the summer rains commenced. Aerial surveys also give the highest population density in the study area during or towards the end of the dry season (Appendix 1–17).

Elephants are diurnal and nocturnal. They rest up during the hotter part of the day under available shade and sleep (usually on their feet but occassionally lying down); and make use of the large pans in the southeastern sector of Chief's Island for drinking and bathing. Elephants drink daily where water is freely available, but otherwise do so every second or third day. Conditions within the study area preclude water from being a limiting factor to any movement except when the Chief's Island pans dry up.

Feeding records are given in Table 23 after Tinley (1966) with modifications. No large-scale elephant damage to vegetation was noted in the study area, but this is becoming apparent in the Moremi Wildlife Reserve to the west of Dombo lediba.

Mating and births seem to take place at any time throughout the year judging by the variation seen in calf size and the observation of small calves at widely divergent times of the year. Normally a single calf is born but isolated cases of twin births have been recorded (Liversedge, In: Smithers, 1971).

One census yielded no elephant in the study area, but generally about 10 to 20 are present in most seasons and during the dry season between 400 and 500 concentrate especially on Chief's Island.

Order Perissodactyla

Family Equidae
Equus burchelli antiquorum (H. Smith, 1841)
Burchell's zebra; Pitse yanaga

A number of zebra observed within the study area show leg markings either partially or wholly striped to the hooves and thus seem to conform to an intermediate between *E.b. antiquorium* and *E.b. chapmani.* Smithers *(op. cit.)* however adopts *E.b. antiquorum* and it is retained in this study.

Table 23 – Elephant feeding records (x), Okavango Delta, Botswana, 1973 - 1975.*

TYPE	SPECIES	PART CONSUMED				
		Leaves	Stem/branch	Bark	Fruit	Roots
Herb	*Plicosepalus kalahariensis*	x	x	–	–	–
Climbers	*Capparis tomentosa*	x	x	–	–	–
	Cocculus hirsutus	x	x	–	–	–
	Jasminum fliumensie	x	x	–	–	–
Shrubs	*Bauhinia macrontha*	x	x	–	–	–
	Colophospermum mopane	x	x	–	–	–
	Commiphora africana	x	x	–	–	–
	Dichrostachys cinerea	x	x	–	–	–
	Gardenia spathulifolia	x	x	–	–	–
	Grewia spp.	x	x	–	–	x
	Maytenus senegalensis	x	x	–	–	–
	Phyllanthus reticulatus	x	x	–	–	–
	Rhus spp.	x	x	–	–	–
	Terminalia sericea	x	x	–	–	–
Trees	*Acacia erioloba*	x	x	x	x	–
	A. Fleckii	x	x	x	–	–
	A. galpinii	x	x	–	–	–
	A. hebeclada	x	x	–	–	–
	A here roensis	x	x	–	–	–
	A leuderitziae	x	x	–	–	–
	A. nigrescens	x	x	x	x	–
	A. sieberana	x	x	x	x	–
	A tortilis	x	x	x	x	x
	Adansonia digitata	x	x	x	–	–
	Albizzia harveyi	x	x	x	–	–
	Boscia mossambicenses	x	x	x	–	x
	Colophospermum mopane	x	x	–	–	–
	Combretum collinum	x	x	x	–	x
	C. hereroense	x	x	–	–	–
	C. imberbe	x	x	–	–	–
	Diospyros mespiliformis	x	x	–	x	–
	Ficus burkei	x	x	–	x	–
	F. sycamorus	x	x	–	x	–
	F. verruculosa	x	x	–	x	–
	Hyphaene ventricosa	x	–	–	x	x
	Lonchocarpus capassa	x	x	–	–	x
	L. nelsii	x	x	–	–	–
	Phoenix reclinata	x	–	–	x	–
	Berchemia discolor	x	x	x	–	–
	Sclerocarya caffra	x	x	x	x	–
	Terminalia sericea	x	x	x	–	x
	Siziphus mucronata	x	x	x	–	–

*After Tinley (1966), with modifications.

Zebra are common in localised drier parts of the study area, but are not as well represented as in the drier adjacent parts of the Delta. Zebras show a definite preference for the drier, more open northern sectors of Chief's Island and the western floodplains when dry. Zebras were encountered mainly on *Acacia tortilis* and *A. erioloba* Savanna Woodlands and on dry Primary and Secondary Floodplain Communities with limited sightings in *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna. During extremely dry seasons two large groups of zebras were noted on the M'borogha floodplain system, but following excessive flooding of the same area only two zebra could thereafter be located on the eastern floodplain system.

Zebras tend to show a dislike for water, and migrate to the dryland vegetation types during flooding seasons or out of the study area to the south. Zebras are grazers, predominantly utilising the short grass area. They are partial to utilizing freshly burnt areas and quickly move to such areas. In one instance zebras were found to be grazing on a shallowly flooded floodplain (0,05 to 0,07 m) but all other observations were on areas devoid of surface water. Child (1968a) also describes the reluctance of zebras to utilise flooded habitat.

Zebra occurred in family groups comprising one adult stallion, several mares and their offspring. Sub-adult stallions approaching puberty are soon chased out and groups of young stallions were encountered. These family units vary from three to 17 individuals (average 10,7), but where several groups congregate at a watering point or in a local migration the appearance of larger herds is given. The largest such association in the study area was of 96 individuals.

A single young zebra is born from mid-May to January after a gestation period of 12 months, but isolated births occur outside of this time interval. Smuts (1974) gives the average gestation period of 375 days with a range of between about 360 and 390 days from various studies. Aerial surveys showed the greatest overall population estimate of 744 zebras to occur in the study area during the driest period (May, 1973). During peak flooded conditions (July 1974) this population dropped to 121 zebras. The study area carries an average of 384 zebras taking all seasons into consideration (17 surveys). Detailed population estimates appear in the appendices 1 to 17.

Order Artiodactyla

Family Suidae

Phacochoerus aethiopicus sundevalli Lonnberg, 1908

Warthog; Kolobe

Warthog are widely distributed throughout the study area and in good population numbers except for the central Chief's Island areas. The mid and lower-Delta in general carries a high warthog population. Warthog occur in all vegetation types and plant communities except for those aquatic communities carrying permanently deep water; or aquatic and floodplain vegetation types whilst they are deeply inundated. Warthogs appear to move over a limited home range in the Delta, and although able to swim, they are reluctant to take to deep water and rather take refuge in their holes. Child (1968a) describes similar behaviour of warthog during island formation in the Kariba Dam, Rhodesia.

Although warthogs are encountered in numerous habitat types they show a strong preference for certain plant communities for feeding purposes. During the drier months or seasons when most of the floodplain vegetation types are dry, warthogs are found feeding mainly on the Primary Floodplain Communities. Whilst these Primary Floodplain Communities are still green warthogs largely graze there, but when these floodplains are dessicated they resort largely to rooting up sedges, tubers and rhizomes. Tracts of dry Primary Floodplain Communities are ploughed up in this way and when the subsequent floods arrive, form open pools within the tall aquatic vegetation. These form important micro-habitats for certain mammal and bird species. At the commencement of the summer rains, warthogs move quickly onto the *Sporobolus spicatus* Island Grassland Communities and the herb layer of the Marginal and dryland vegetation types where they graze largely on fresh annual and perennial grass growth. In extremely heavy flood years warthogs are limited to *Sporobolus spicatus* Island Grassland Communities and marginal and dryland vegetation types where they resort to ploughing up large tracts of grassland. However, they also utilise the verges of the flooded area grazing in water of up to 0,25 to 0,30 m deep, and they follow the receding flood levels.

Warthogs are quickly attracted to burnt areas where they either uproot subterranean growth or graze off fresh growth. Concentrations of warthog at localized burns gives the impression of small herds of warthog, but these remain discrete individuals, groups or family units (Fig. 22). During rooting and feeding on subterranean vegetation, large amounts of

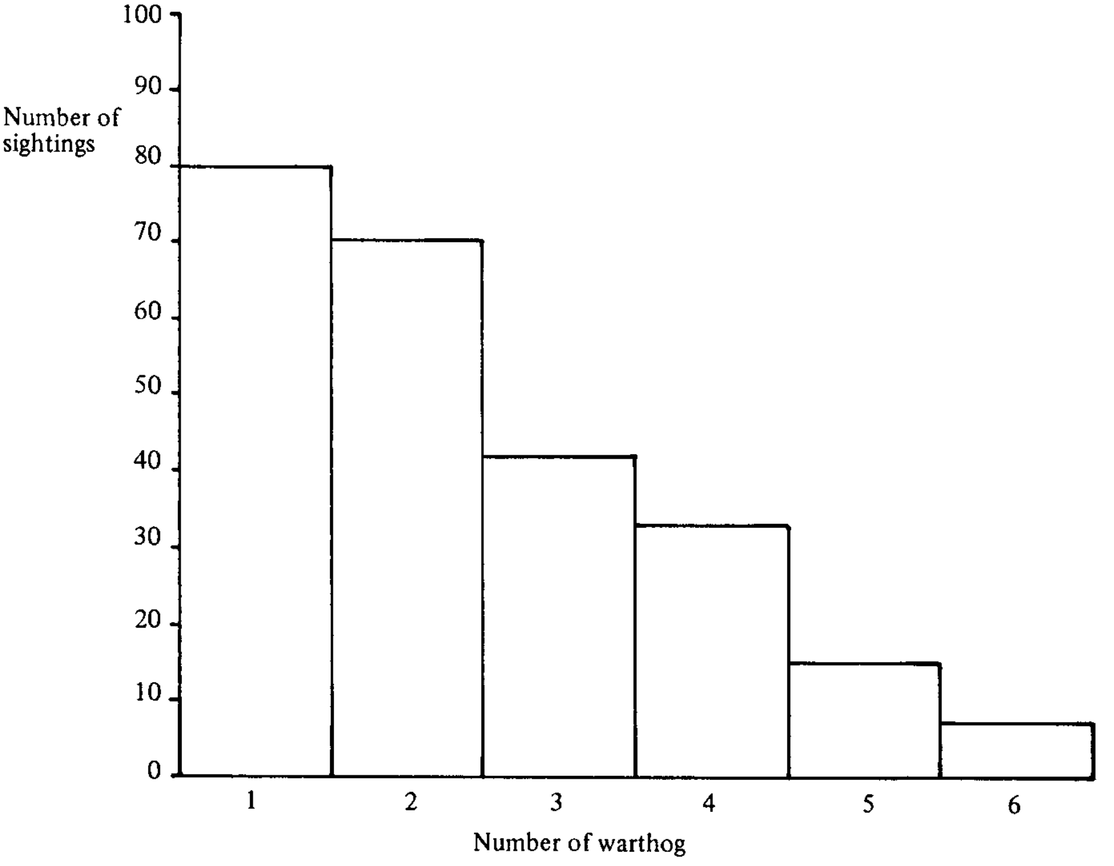

FIGURE 22 – Group size distribution of warthog in the study area, Okavango Delta, Botswana, March 1973 to November 1974.

soil are ingested. There is a definite feeding association with baboons who follow the warthogs' rooting activities and derive large quantities of subterranean vegetable and animal food material from the former's activities and in turn serve to alert the warthog to any potential danger in the vicinity. The warthogs function in creating and enlarging small pans also plays an important role in the Delta. Warthogs are grazers feeding on aerial and subterranean parts of grasses and sedges viz. leaves, culm/stem, roots, rhizomes and tubers. Recorded plant species utilised include the grasses *Chloris gayana, C. virgata, Cynodon dactylon, Digitaria eriantha, Imperata cylindrica, Leersia hexandra, Leptocarydion vulpicastrum, Panicum aphanoneurum, P. coloratum, P. repens, Sacciolepus typhura, Sporobolus spicatus* and the sedges *Cyperus articulatus, C. denudatus, C. fulgens, C. longus, C. sphacelatus, Fimbrystylis dicotoma, Kyllinga erecta, K. melanosperma, Mariscus cyperoides, M. squarrosus, Scirpus articulatus* and *S. inclinatus.*

Warthogs are strictly diurnal and occur solitarily or in groups of two to six individuals on average. Assessment of warthog group size from the study area is given in Fig. 4. One group of 10 warthogs was encountered in the Moremi Wildlife Reserve and it comprised two adult females, each with a litter of four juveniles. Warthogs rest up at night in disused antbear holes into which they "reverse" and move out soon after first light. In general they spend the morning hours grazing and/or rooting, till sufficient food is consumed and then rest up during the hotter midday periods in thickets or fairly dense vegetation. They move again during the later afternoon, actively feeding and retire to their holes before dark. Weather conditions or food availability may alter this general pattern. Warthogs drink daily and are fond of wallowing.

Table 24 illustrates warthog feeding habitat (or plant community) preference, providing for an overall 78 per cent occurrence on open, potentially flooded or dry grassland. The percentage occurrence on Primary Floodplain Community would have been higher, but due to the excessive floods of the 1974 season this habitat type could not be used by warthogs for almost the complete year. The sleeping holes are mainly located in closed Riverine Woodland or marginal vegetation types, less often in dryland vegetation types, or in a few instances on the verges of *Sporobolus spicatus* Island Grassland Communities.

Generally warthog were found to occur singly or in groups of up to six individuals (Fig. 22). Most single warthog where adult mates sightings of single adult female warthog occurred just prior to or after parturition. Approximately 25 per cent of single individuals comprised

Table 24 – Plant community (habitat) preference of warthog in the study area, Okavango Delta, Botswana, 1973 - 1974, from 954 sightings.

PLANT COMMUNITY	PERCENTAGE OCCURRENCE
Primary Floodplain Community	31
Secondary Floodplain Community	26
Sporobolus spicatus Island Grassland Community	21
Closed Riverine Woodland	8
Acacia tortilis Savanna Woodland	3
Acacia erioloba Woodland and Savanna Woodland	2
Grewia spp. - *Croton megalobotrys Scrub Savanna*	2
Acacia nigrescens - Croton megalobotrys Woodland and Savanna Woodland	2
Hyphaene ventricosa - Croton megalobotrys Palm Woodland and Palm Savanna Woodland	2
Colophospermum mopane Woodland and Poyrophytic Scrub Savanna	2
Combretum imberbe - Croton megalobotrys Woodland and Savanna Woodland	1

sub-adult males. Adult males and females were together during the May/June/July mating season but 37 per cent of pair sightings involved subadult warthog and 29 per cent and adult female accompanied by a subadult or juvenile. Fifty-eight per cent of sightings involving groups of three warthog showed an adult female with subadults or Juveniles accompanying. An all male group of three was recorded. All groups in excess of three warthog showed juveniles or subadults accompanying females.

Measurement of physical condition from Riney's (1955) internal fat parameters proved fairly successful for warthog, but warthog marrow, colour and texture visual estimates, as also noted by Child (1968a), require refinement as these differ markedly from other ungulate marrows in colour and texture. From Table 25 it is clear that adult male warthog maintain a fairly high condition index until the floods arrive in May and the majority of their prime feeding habitat is excluded from use due to high water levels. The individual collected on 20 August 1973 with high kidney fat index, was collected from a lightly inundated lower section of the study area where Primary Floodplain Community was still available or only lightly flooded. A slight condition improvement occurs after commencement of the summer rains when green grazing becomes available. (Table 25). The low kidney fat index held after this period is due to exclusion of prime habitat as a result of excessive flooding, except for the two individuals collected on 14 March 1975 and 15 June 1975 which came from areas only partially flooded. Adult female warthogs show a similar tendency to a general loss in kidney fat index during 1974, based also on excessive flooding (Table 26). Although subadults and juveniles do not build up large fat reserves, some comparable seasonal data can be derived also showing a lower condition during flooding periods. However insufficient specimens were collected in these age classes for meaningful results. In general, excessive flooding is thus detrimental to warthog condition since movement is curtailed and exclusion from their prime habitat occurs due to high water levels. Conversely the Primary Floodplain Communities require the rest from over-utilisation by warthog which flooding affords it.

Warthogs are strict seasonal breeders for approximately two months in any particular year in the study area (Table 27), and probably for the Delta in general (Robbel and Child, 1976). Almost all births take place within a two month period. During 1973 observed matings showed the rut to commence during May with a peak in rutting activity during June and no rutting behaviour after mid-July.

Table 25 – Seasonal condition of adult male warthog from the study area and surrounding areas Okavango Delta, Botswana, April 1973 – September 1975.

DATE	KIDNEY FAT INDEX (PERCENTAGE)	BACK FAT INDEX (MILLIMETRES)	COMBINED ABDOMINAL AND MARROW INDEX (PERCENTAGE)	REMARKS
4 April 1973	17,65	4,0	87	
16 May 1973	13,90	10,0	60	
24 May 1973	11,40	10,0	60	
24 June 1973	28,50	8,5	67	
25 June 1973	8,90	6,0	47	
12 July 1973	–	0,0	40	Kidneys damaged in collecting.
20 August 1973	4,40	1,0	40	
20 August 1973	21,20	12,0	53	Collected from a lightly inundated area.
21 August 1973	6,45	2,0	40	
17 October 1973	0,00	0,0	0	Old mate no trace of any fat.
28 November 1973	4,34	5,0	40	
29 November 1973	2,09	0,0	33	
19 December 1973	10,82	6,0	40	
6 April 1974	5,90	10,0	33	
15 May 1974	1,24	0,0	Trace	
11 August 1974	0,91	0,0	7	
19 October 1974	2,89	Trace	40	
14 March 1975 .	17,97	7,0	53	Area lightly inundated.
15 June 1975	14,17	3,0	40	
14 September 1975	2,79	0,0	14	

Table 26 – Seasonal condition of adult female warthog from the study area and surrounding areas, Okavango Delta, Botswana May 1973 – September 1975.

DATE	KIDNEY FAT INDEX (PERCENTAGE)	BACK FAT INDEX (MILLIMETRE)	COMBINED ABDOMINAL AND MARROW INDEX (PERCENTAGE)	REMARKS
9 May 1973	25,10	10	87	–
24 May 1973	21,20	13	67	–
20 August 1973	26,20	9	47	pregnant
9 September 1973	15,80	14	40	–
28 September 1973	6,85	0	47	pregnant
8 October 1973	11,45	11	47	pregnant
12 October 1973	23,70	17	53	pregnant
9 November 1973	3,64	Trace	33	pregnant
9 November 1973	5,40	Trace	33	pregnant
18 December 1973	10,70	4	40	given birth
18 December 1973	6,84	6	40	given birth
18 June 1974	3,60	2	40	pregnant
10 August 1974	6,19	0	27	pregnant
19 August 1974	4,27	0	40	pregnant
30 August 1974	1,99	0	13	–
10 March 1975	8,98	6	47	–
11 September 1975	1,94	0	20	pregnant

Table 27 – Warthog pregnant female and foetal data and conception and parturition dates after Huggett and Widdas (1951) for the study area Okavango Delta, Botswana, August 1973 – September 1975

DATE OF COLLECTION	FEMALE NUMBER	ESTIMATED AGE OF FEMALE (MONTHS)	NUMBER OF FOETUSES	MEAN MASS OF FOETUSES (GRAMMES)	MEAN CROWN-RUMP LENGTH OF FOETUSES (MILLIMETRES)	POST-CONCEPTION AGE (DAYS)	CONCEPTION DATE	PARTURITION DATE
1973:								
20 August	44	33	2	31,9	84,0	81	1 Jun.	20 Nov.
28 September	58	22	3	66,1	101,0	94	27 Jun.	17 Dec.
8 October	64	47+	4	510,6	218,3	152	10 May	1 Nov.
12 October	65	35	3	408,1	185,3	144	22 May	11 Nov.
9 November	76	36+	4	539,2	211,5	154	9 Jun.	28 Nov.
9 November	77	24	1	657,0	205,0	162	1 Jun.	20 Nov.
1974:								
18 June	128	43+	3	40,1	91,3	85	26 Mar.	15 Sep.
10 August	132	45+	4	243,9	167,0	126	7 Apr.	27 Sep.
19 August	136	45+	3	182,5	152,3	118	24 Apr.	13 Oct.
1975:								
11 September	209	22	3	328,6	–	136	29 Apr.	18 Oct.

Robbel and Child (1976) record the peak of rutting in the Moremi Wildlife Reserve in the second half of May and early June 1969, and extensive rutting in mid-June 1971. During the exceptionally good rainy season of 1973/74 a markedly advanced rutting season was observed, commencing in late March through April and ending in early May. This brought the 1974 farrowing season forward by 7,5 weeks and shows the influence of good nutrition on breeding season (Joubert, 1963). The first juveniles accompanying an adult female during 1973 were recorded on 20 December 1973; pointing to the fact that the first four to six weeks after birth are spent in the antbear hole prior to accompanying the female and foraging. (Tables 26 & 27).

Working on an average gestation period of 173 days (Brown, 1936; *Mason, pers. comm.) and using the formula of Hugget and Widdas (1951), Table 27 gives the conception and parturition dates for the 1973 and 1974 breeding seasons.

Multiple ovulation and multiple births occur in adult warthog. Available data from collected pregnant females point to single or double ovulation and similar implantation in subadult to young adult females. In two instances triple ovulation was recorded in females 18 to 22 months old at conception. Females of 24 to 26 months and older at conception usually show triple to quadruple ovulations with some crossing over to implantation and giving birth to three or four juveniles. In all cases the rate of ovulation corresponded with the number of foetuses present. In only one instance was one piglet of a triplet a 'runt' being approximately half the mass of the other two piglets. One adult female warhog was collected displaying neotony and on examination of the reproductive tract appeared never to have displayed ovulation or given birth. Sexual maturity thus seems to occur at 18 to 22 months of age. Table 27 gives foetal data and estimated female age.

The highest population of warthogs in the study area was found during the driest period (May, 1973) when 982 were recorded. This is considered an underestimate. During the wettest period (April to July 1974) the smallest accepted population of 305 was recorded. This figure is, however, considered a larger underestimate as most warthog at this time were occurring in marginal or dryland vegetation types where accurate aerial survey of this species is impossible. I nevertheless regard that a small but significant movement out of the area involving from 25 to 35 per cent of the warthog population occurred. A smaller total

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population for the study area of 166 individuals was recorded during December 1973 but this is not accepted due to observer error and some navigational difficulty in using a new pilot and no navigator. As conditions dried out a steady increase in warthog population size occurs, which can also be attributed to easier observation as more open warthog habitat becomes available. The study area carried an average of 511 warthog taking all seasons into account, but from ground observations this is considered to be a gross underestimate. Thus aerial survey of warhog is not reliable and can only provide a minimal population size (usually grossly underestimated).

Mass and measurements of collected warthog appear in Tables 28 and 29.

External parasites:
(Acarina)
Hyalomma truncatum Koch, 1844
Rhipicephalus simus simus Koch, 1844
R. capensis Koch, 1844
Ornithodorus moubata Koch, 1844

(Siphonaptera)
Echidnophaga larina Jordan and Rothschild, 1906
E. inexpectata Smit, 1950

(Anoplura)
Haematopinus phacochoeri Enderlein, 1908

Internal parasites:
Gastrodiscus aegyptiacus (Cobbold, 1876) Railliet, 1893
Oesophagostomum simpsoni Goody, 1924
O. mwanzi Daubney, 1924
O. eurycephalum Goodey, 1924
Cysticercus (regis) Baer, 1923
Ascaris phacochoeri Gedoelft, 1916
Paramphistomum sp.

Table 28 – Male warthog mass (Kg) and measurements (mm) from the study area, Okavango Delta, Botswana, April 1973 – September 1975

DATE	APPROXIMATE AGE IN MONTHS	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL	
								Zygomatic width	Total length
Adults									
1973:									
9 Apr.	29	52,0	1508	396	272	658	120	171	315
16 May	54+	81,0	1759	385	270	656	119	209	379
24 May	54+	83,0	1761	396	270	711	131	212	386
24 June	55+	76,5	1750	417	267	758	133	218	388
25 June	55+	81,0	1786	452	280	754	138	219	394
12 July	44	72,0	1682	431	265	745	135	207	383
20 Aug.	45	68,0	1722	415	272	765	130	–	–
20 Aug.	33	54,0	1645	460	261	633	121	–	–
21 Aug.	33	63,0	1624	434	271	701	125	187	357
17 Oct.	59+	60,0	1684	441	272	689	121	203	375
28 Nov.	36	58,0	1620	427	271	658	126	179	333
29 Nov.	60+	84,5	1753	487	262	774	133	214	384
19 Dec.	49+	78,0	1722	425	273	739	130	213	373
1974:									
6 Apr.	53+	84,0	1751	493	282	800	139	213	395
15 May	54+	75,5	1763	476	271	710	123	216	392
11 Aug.	45	66,5	1705	441	275	628	129	204	371
19 Oct.	47	70,5	1734	476	274	740	129	185	380
1975:									
14 March	66+	86,0	1762	440	276	745	134	237	399
15 June	30	50,5	1546	430	277	660	133	172	332
14 Sept.	22	48,5	1531	407	262	684	127	–	354
Sub-adults									
1973:									
24 June	19	43,5	1508	422	258	640	117	165	–
24 June	19	41,5	1478	378	260	621	120	166	328
19 Dec.	13	32,5	1426	362	252	562	121	150	294
21 Dec.	13	28,0	1392	374	269	632	109	154	300
1974:									
9 Apr.	17	42,0	1460	385	276	650	126	156	336
10 Aug.	9	16,5	1084	319	216	485	96	113	231

– = Damaged skull

Table 29 – Female warthog, mass (Kg) and measurements (mm) from the study area, Okavango Delta, Botswana, May 1973 – September 1975

DATE	APPROXIMATE AGE IN MONTHS	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL Zygomatic width	SKULL Total length
Adults									
1973:									
9 May	54+	62,0	1534	364	254	730	124	174	312
24 May	54+	61,0	1602	391	254	660	120	181	337
20 Aug.	33	48,0	1491	337	235	587	98	–	–
9 Sept.	45	59,5	1591	379	249	643	124	–	–
28 Sept.	22	40,0	1493	352	238	577	109	–	–
8 Oct.	47+	70,0	1518	350	254	694	123	–	–
12 Oct.	35	49,0	1463	348	244	633	125	–	–
9 Nov.	36+	57,0	1597	431	250	641	126	–	348
9 Nov.	24	43,5	1437	387	243	608	120	158	304
18 Dec.	49+	53,0	1516	406	249	624	115	172	342
18 Dec.	37	53,0	1445	391	243	642	109	164	324
1974:									
18 June	55+	55,5	1597	423	261	631	125	183	351
10 Aug.	45+	49,0	1500	375	246	602	120	171	354
19 Aug.	45	53,0	1638	412	248	603	116	166	331
30 Aug.	21	36,0	1402	380	251	611	118	153	306
1975:									
10 March	28	47,0	1446	406	243	548	108	156	301
11 Sept.	22	42,0	1399	412	246	570	113	158	316
Sub-adults									
1973:									
23 Nov.	12	26,5	1255	342	228	542	101	–	–
1974:									
3 June	7	16,5	1065	286	206	409	95	113	219
18 June	7	11,0	919	232	187	384	84	96	197

– = damaged skull

Family Hippopotamidae
Hippopotamus amphibius capensis Desmoulins, 1825
Hippopotamus; Kubu

Hippopotamus are widely distributed, occurring in Middle and Outlet Channel Communities Madiba and some Shallow Backwater Communities, but not in good population size except at some localised spots within the study area. Hippopotami occur seasonally on some of the larger pans on Chief's Island. Represented by a good population of approximately 150 hippopotami in the Moremi Wildlife Reserve in high flood years and at other isolated points throughout the Delta (some upper and lower Madiba Communities and parts of the Upper Channel Communities).

Hippopatami move widely in accordance with prevailing water conditions, and more locally to graze. They will move over long distances (50 to 60 km) of dryland to reach a suitable pan isolated in a total dryland vegetation type. Hippopotami are often blamed for dislodging large quantities of floating sudd and debris, but more usually this occurs as a result of human disturbance by boat when hippopotami seek a flight path to escape. They are by nature inquisitive and somewhat aggressive but the latter characteristic may largely be due to old bullet wounds. Normally hippopotami follow well-defined paths in their movement in the channels or across islands to feeding grounds. Those paths occurring on dryland are characterised by their double track with a small central raised ridge cf. a 'middelmannetjie' as compared to flat elephant paths. These paths can play a significant role in flooding relatively distant off channel depressions and in some instances result in new channel development.

Hippopotami are predominantly grazers feeding on a wide variety of grasses in Closed Riverine Woodland, marginal vegetation types, *Acacia tortilis* Savanna Woodland and the floodplain vegetation types but largely on short *Sporobolus spicatus* Island Grassland Community which they and lechwe utilise heavily. Tinley (1966) reports hippopotami feeding on water lily tubers and this was also witnessed in the Dombo lediba of Moremi Wildlife Reserve. Plant species observed to be eaten by hippopotami are *Cynodon dactylon, Sporobolus spicatus, Vossia cuspidata, Echinocloa stagnina, Imperata cylindrica* and *Oryza longisteminata.* A large number of fringe grass and sedge species are also utilised in feeding.

During daylight hours hippopotami are usually found in the water, but occasionally they are found resting up on sand banks or small Delta islands. They are semi-aquatic and amphibious. Single individuals, usually adult bulls, are encountered, but more commonly groups of hippopotami usually comprised of eight to 14 individuals are found. Concentrations of up to 36 hippopotami are encountered in the Moremi Wildlife Reserve. At night hippopotami may be encountered in the channel communities but they are usually found out of water and grazing on the numerous islands. Its bulk enables a hippopotamus to keep channels open by constant movement along them. However, once a blockage is fairly consolidated hippopotami merely move around such and thus only really play a role in the removal of early stages of surface blockage. Their numbers seem to have declined in the last 20 years, probably from local hunting pressure and the utilisation of hippopotamus carcasses for crocodile bait by the crocodile hunters during the early 1960's. Both local and crocodile hunters admitted to illegal removal of hippopotami during this period. The removal of a large number of hippopotami can have far reaching effects in drainage patterns and conversely an excessive build-up of the population under strict protection may again alter the drainage patterns especially in the north-eastern areas where the highest population sizes thrive. Delta hippopotami populations are estimated to be about one third the size of Kwando/Linyanti populations, where the human factor is far less operative. Tinley (1977) gives population estimates for Urema Lake, Gorongosa of 2 301 hippopotamus per 15 km^2 of lake area.

Juveniles were recorded in February, May and October, pointing to a possible all-year breeding season. Ansell (1960) states that young may be born at any time of the year. Females with new-born calves were encountered on their own, and would appear to rejoin the herd when the calf is about two weeks old.

The highest population estimate of hippopotami occur in the M'borogha floodplain system and this during the driest times. During May 1973 the population estimate of 331 for this sector is considered an overestimate since the census overlapped into the northwestern parts of Moremi Wildlife Reserve. Nevertheless comparison of statistical results obtained from aerial surveys numbers 1, 4, 7, 11, 14 and 17 (Appendix 1 - 17) serve to illustrate how with increased water quantity the movement is predominantly out of the study area. This migration takes place towards the lower-Delta as its water levels rise and an estimated population of 21 hippopotami remain in this eastern floodplain section of the study area. The Madiba Communities to the north of Chief's Island always maintain a small hippopotami population (10 to 20 individuals) and in good rainy seasons isolated individuals may utilise the pans on Chief's Island. The Boro floodplain system holds a low estimated population size of hippopotami in the study area with a maximum of 10 individuals. The study area probably carries on average about 30 hippopotami during high water level conditions and about 150 individuals during low water conditions.

Family Giraffidae
Giraffa camelopardalis angolensis Lydekker, 1903
Giraffe; Thutlwa

Giraffe are widely distributed throughout the study area and in good population size, but less common on the M'borogha floodplains. Movement is fairly localised and giraffe are not afraid to cross water 1,5 to 2 m deep when moving to fresh browsing areas. The largest population estimate is associated with the dryland vegetation types, followed by the marginal vegetation types and the Closed Riverine Woodland Community. Table 30 provides a breakdown of habitat preferences.

Table 30. Plant community (habitat) preferences of giraffe in the study area Okavango Delta, Botswana 1973-1975 from 584 sightings

PLANT COMMUNITY	PERCENTAGE OCCURRANCE
Acacia erioloba Woodland and Savanna Woodland	23
Acacia tortilis Savanna Woodland	21
Alterns between Closed Riverine Woodland and floodplain vegetation types	11
Closed Riverine Woodland	8
Acacia nigrescens – Croton megalobotrys Woodland and Savanna Woodland	8
Colophospermum mopane Woodland	7
Secondary Floodplain	6
Terminalia sericea – Combretum collinum Savanna Woodland	5
Combretum imberbe – Croton megalobotrys Woodland and Savanna Woodland	4
Primary Floodplains	3
Grewia spp. – *Croton megalobotrys* Scrub Savanna	2
Hyphaene ventricosa – Croton megalobotrys Palm Woodland	2

Giraffe are browsers, and feeding records observed are *Acacia erioloba, A. tortilis, A. hebeclada, A. hereroensis, A. sieberana, A. leuderitzii, A. fleckii, A. galpinii, A. nigrescens, Boscia mossambicensis, Combretum imberbe, C. molle, C. collinum, Albizzia harveyi, Dichrostachys cinerea, Sclerocarya caffra, Berchemia discolor, Terminalia sericea, Ziziphus mucronata, Grewia schinzii, G.* spp. *Lonchocarpus capassa* and *L. nelsii.* Hall-Martin (1974) shows slight use of tall grasses during the summer months and a marked seasonal change in the selection of tree utilized for feeding by giraffe in the Eastern Transvaal lowveld. Heavy giraffe browsing is locally apparent on parts of the northern third of Chief's Island.

Solitary individuals occur but more generally giraffes are gregarious, occurring in the study area in herds of two to seven individuals or less commonly from eight to 13 individuals. The largest herd observed comprised 20 individuals. The totals from all observations of adult males, adult females, sub-adults and juveniles were expressed relative to one another after each being reduced relative to the greatest total being reduced to one hundred. These figures are then compared with Robbel and Child (1976) sex and age data for Moremi Wildlife Reserve. For every hundred adult giraffe females in the study area 58 adult males, 42 sub-adults and 34 juveniles occurred. Robbel & Child *(op. cit.)* obtained figures of 65 adult male giraffe, 43 sub-adults and 36 juveniles per 100 adult female giraffe, thus providing close comparison to their adjacent study areas data.

Giraffes were generally in fair to good condition but two known adult males remained in very poor condition. One of these males was subsequently killed by lions, whilst the other never seemed to improve in condition throughout the study.

New-born giraffes were observed in May, July, August and October. The birth season appears to stretch throughout the year (Smithers, 1971) but with a peak during the winter months (May to August). Only single births are on record for Botswana after a gestation period of approximately 450 days (Dorst and Dandelot, 1970; Hall-Martin, 1975).

An average population estimate of 430 giraffe exists in the study area during all seasons and flood conditions. This provides for an average population density of 0,24 giraffe/km^2. Comparison of this with crude population densities from other regions of Africa which varies from 0,01 to 2,60 (Hall-Martin, 1974) shows a reasonable population strength. Local movement between Chief's Island and the floodplain systems exists and this occurs immaterial of floodwater levels. Chief's Island carries the bulk of this standing population, about 310 individuals, followed by the Boro floodplain system with about 80 giraffe and the largely inundated M'borogha floodplains with an average of about 40 giraffe. During the driest conditions the M'borogha floodplains carries its lowest population density of giraffe.

Family Bovidae
Sylvicapra grimmia speldidula (Gray, 1871)
Common or Grey duiker; Phuti

Only two grey duiker were observed in the study area, whereas four were seen in lower-Delta areas. Thus nowhere in the Delta do they appear to be common.

Grey duiker tolerate a wide variety of habitat types (Smithers, 1971). Nothing is known of their movement patterns in Botswana but movements are supposedly localised as elsewhere.

Grey duiker usually occur singly or in pairs or as a female and her offspring. Mainly nocturnal in Botswana and adjacent territories, (Smithers *op. cit.*), but individuals may be recorded during daylight hours. Due to its nocturnal habits, the population may be larger than expected, but it probably still occurs in low densities in the study area. Grey duiker are predominantly browsers and appear to breed throughout the year.

Raphicerus campestris steinhardti (Zukowsky, 1924)
Steenbok; Phuduhudu

Steenbok are scarce in the study area where only seven individuals were recorded, six of these from aerial surveys. Recorded from Chief's Island and the eastern and western floodplains. Occurrences were in *Acacia eriobo or A. tortilis* Woodland or Savanna Woodland or dry Secondary Floodplain Communities. Steenbok appear to be confined to a relatively small home range.

Steenbok are predominantly browsers and consume a fairly high proportion of forbs (Cohen, 1972). They are predominantly diurnal and occur solitarily or in pairs or as a female with offspring. The subspecies breeds throughout the year (Smithers *op. cit.).* The population estimate probably does not exceed 30 individuals for the study area.

Tragelaphus strepsiceros strepsiceros (Pallas, 1766)
Kudu; Tholo

Kudu are common and well distributed throughout the study area. Eighty two per cent of the occurrences were in various woodland communities, mainly on the islands of the floodplain systems. The remaining occurrences were on dry or inundated floodplain communities.

Percentage occurrence in the various woodland vegetation communities was; Closed Riverine Woodland and marginal vegetation types 27 per cent, *Acacia tortilis* Savanna Woodland 18 per cent, *A. erioloba* Woodland and Savanna Woodland 16 per cent, *Colophospermum mopane* Woodland 13 per cent and *Terminalia sericea – Combretum collinum* Savanna Woodland 8 per cent.

Kudu move widely and show no fear of crossing shallow waters. Child (1968a) remarks that in operation Kariba "kudu were amongst the first animals to take to water when men landed on an island". This lack of fear of water explains their widespread distribution in parts of the more permanently inundated M'borogha floodplains.

Kudu are predominantly browsers, and observed feeding records include *Acacia erioloba, A. tortilis, Grewia* spp., *Croton megalobotrys, Boscia mossambicensis, Combretum* spp., *Terminalia sericea* and *Commiphora africana.* The pods of *Acacia* spp. are also utilised as well as various other fruits.

Kudu are diurnal and nocturnal and usually occur singly or in small herds. Herd sizes of two to 13 individuals were recorded and single individuals were most commonly adult bulls (53 out of 56 observations) but odd single cows were also noted. Adult bulls may be with a cow subadult/juvenile herd but they were more often absent. Adult male groups comprising two to four individuals were fairly common. In the study area kudu were found to be very shy and one of the first mammals to take to flight.

Although Smithers (1971) suggests an all-year breeding season, new-born juveniles were only noted in October, December, January, February and March in the study area.

Chief's Island supports the highest biomass of the kudu population but the population estimates (Appendix 1 - 17) are considered to be a gross underestimate due to the cryptic nature of kudu in their favoured habitat. There is a marked movement of kudu from the islands of both adjacent floodplain systems onto Chief's Island during the rainy season. The average population estimate of about 190 kudu for the total study area is considered low.

Tragelaphus spekei selousi Rothschild, 1898
Sitatunga; Naakong

Sitatunga are widespread and reasonably common but only in the heavily inundated upper mid-Delta areas. Largest population estimate in the study area is on the M'borogha floodplains, and also on the mid-Boro floodplain system but chiefly in the margin and largely out of the gazetted western extension boundary of the Moremi Wildlife Reserve in the latter case. Their present distribution has diminished greatly when compared with their former range, viz. Andersson (1856) and Bryden (1893) record sitatunga from Lake Ngami. Leyland (1866) obtained the horns and skin of the "...Nakong, *(Antelope anderessoni)* .... I was informed that it had been procured a long way up the Tamunackle River" (Thamalakane) "which runs into the Zouga" (Boteti River). Selous (1881) records them from the Mababe and Thamalakane reedbanks and also the upper Boteti River.

The shrinkage of their distribution can be attributed largely to altered flooding patterns and the lack of suitable habitat in the above reference areas under present day conditions. Hunting pressure will have also played a lesser role, especially in the vicinity of Maun when a large influx of people moved in during 1915.

Habitat requirements and water levels are the most important factors governing the distribution of sitatungas. Sitatungas also require permanently flooded areas and their movement is governed by water levels. Favoured habitats are Sumps, Shallow Backwater and Flats Communities and medium to heavily inundated Primary Floodplain Communities but all studded with terminaria islands or small islands. Water levels of between 0,30 and 0,60 m are preferred. As floodwater levels recede sitatungas move northwards in the Delta, but they again move down as the floodwaters spread out, always remaining in the tall *Cyperus papyrus*, *Miscanthidium junceum* and sedge areas or in the associated open Sump Communities and small islands.

Sitatungas are largely grazers but they also browse. Feeding during daylight hours seems to take place largely in the water whilst at night they appear to utilise adjacent dryland verges viz. *Sporobolus spicatus* Island Grassland Communities. Feeding records include *Cyperus papyrus* umbels, *Nymphaea* spp. leaves and stems, *Nymphoides indica, Brasenia schreberi* leaves and stems, *Phoenix reclinata* leaf tips, *Cynodon dactylon, Sporobolus spicatus, Phragmites* spp leaves and shoots and numerous other aquatic and semi-aquatic grass species and sedge species.

Sitatungas are solitary or occur in small groups of two or three individuals. Smithers (1971) reports groups of five or six individuals in the upper-Delta, but within the study area the largest recorded group was three adult males. Sightings of two individuals include an adult male and adult female or adult female and sub-adult or juvenile accompanying. Sightings of single individuals, either adult male or adult female were the most common. Sitatungas are nocturnal and diurnal and apparently only move onto open ground at night or during very early daylight hours. During cooler daylight hours sitatungas prefer the open Sump Communities, but always those surrounded by tall aquatic vegetation. During the hotter parts of the day sitatungas retire to small thickly-wooded termitaria islands where they rest up, whence they move out to the Sumps, Shallow Backwater or Flats Communities to feed during the later afternoon. Sitatungas are shy antelopes and when disturbed issue a raucus growling alarm bark typical of the genus *Tragelaphus.* They are strong swimmers and will take to deep water on occasion, but more typically they take refuge in the tall aquatic vegetation always available in or adjacent to the favoured habitat types.

Two heavily pregnant females were observed during mid-August which looked as though they would calve before the end of September. Other records seem to indicate an all year round breeding season, with a peak during the dry season of April to September (Ansell, 1960).

An adult male sitatunga collected adjacently in Jao on a private hunting trip showed fresh crocodile teeth scar marks on the mid hing leg and Smith (pers.comm.). witnessed a crocodile unsuccessfully attempting to catch a sitatunga. Sitatunga fall prey to lions and probably to crocodile and leopard.

Sitatungas are extremely difficult to census in conjunction with other species by the methods used in this survey. A specialised type of census using low-speed and low-flying fixed-wing aircraft or helicopter covering their prime habitats would provide more accurate data. The only conclusions that can be drawn from this total studies census is that the M'borogha floodplains carry the bulk of the sitatunga population within the study area, and that the greatest concentration estimate of 62 sitatungas are recorded in it during the drier seasons. This is not totally borne out by ground observations as no sitatunga were recorded from this area during 1974 by aerial survey, but they were certainly located in the ground work. Aerial survey confirms ground work on the Boro floodplains, namely that not more than 15 sitatungas are within the western floodplains conserved area.

Tragelaphus scriptus ornatus Pocock, 1900
Chobe Bushbuck; Sekolo-botlhoko; Ngurungu

Chobe bushbuck are not common in the study area and the Okavango Delta in general. A total of only five Chobe bushbuck were recorded from the study area. All were recorded in Closed Riverine Woodland or in the adjacent Primary Floodplain Community verge, and all in the vicinity of permanent water.

Bushbuck occur singly, in pairs or as a female with her offspring, and are nocturnal and diurnal and extremely shy. Smithers (1971) suggests a long breeding season from November to June and possibly throughout the year.

Aepyceros melampus melampus (Lichtenstein, 1812)
Impala; Phala

Impalas are very common and widely distributed throughout the study area, but not occurring in flooded vegetation types. Impalas occurred in woodland communities in 57 per cent of observations preferring the more open savanna woodland; and on open grassland in 43 per cent of all observations. This high degree of occurrence on non-typical habitattype is due to the mosaic of vegetation communities and the dynamics of flooding patterns which provide green grazing in open areas when little is available on the islands. Where possible impala tend to remain in the ecotones or alterns when utilising open grazing. Smithers (1971) states that they tend to avoid open grassland or floodplains except marginally or when in transit. Impalas are quick to take to flight into wooded areas when encountered in the floodplains. Notably impala made far more use of Secondary Floodplain Communities during the dry 1973 season, but during the excessive rains and floods of 1974 they were forced to utilise *Sporobolus spicatus* Island Grassland Communities as the former was inundated. Impalas show a strong dislike for water and would only under extreme pressure cross shallowly flooded areas to escape to another island.

Table 31 indicates impalas habitat preferences from one extremely dry and one extremely wet year. Coupling the Secondary Floodplain, Primary Floodplain and Closed Riverine Woodland Communities, or marginal vegetation types, the altern of which most impalas were encountered on provides a 37 per cent utilisation. There is a strong tendency to graze on these alterns and overutilisation occurs in parts of them. Considerable movement occurs from the floodplain systems onto Chief's Island during the summer rainy season, but only for three to four months. Impalas tend to overutilise short grazing and especially so during the high floods when they were limited to the islands by high water levels.

Table 31. Plant community (habitat) preference of impala in the study area, Okavango Delta, Botswana, March 1973 – November 1974 from 1 226 sightings

PLANT COMMUNITY	PERCENTAGE OCCURRENCE
Secondary Floodplain Communities (Mainly verges) Mainly dry years	20
Sporobolus spicatus Island Grassland Communities – Mainly wet years	16
Acacia tortilis Savanna Woodland	13
Acacia erioloba Woodland and Savanna Woodland	12
Closed Riverine Woodland – Mainly wet years	10
Primary Floodplain Communities (Mainly verges) – Mainly dry years	7
Colophospermum mopane Woodland and Scrub Savanna	6
Acacia nigrescens – *Croton megalobotrys* Woodland and Savanna Woodland	4
Combretum imberbe – *Croton megalobotrys* Woodland and Savanna Woodland	4
Hyphaene ventricosa – *Croton megalobotrys* Palm Woodland and Palm Savanna Woodland	3
Grewia spp. –*Croton megalobotrys* Scrub Savanna	3
Terminalia sericea – *Combretum collinum* Savanna Woodland and Scrub Savanna	2

Impalas in the study area are largely grazers with usually an estimated 80 to 90 per cent of rumen content comprising grass and the remainder browse. Robbel and Child (1976) report similar high grazing percentages for impala in the Moremi Wildlife Reserve. During high floodwater levels when impala are limited to the islands the percentage utilisation of browse appears to increase but grass is still predominant in the rumen contents.

Recorded plant specimens fed on by impala include *Acacia erioloba, A. fleckii, A. sieberana, A. tortilis, A. hebeclada, A. nigrescens, Combretum imberbe, C. hereroense, C. collinum, Ziziphus mucronata, Croton megalobotrys, Solanum* spp., *Grewia* spp., *Colophospermum mopane, Dichrostachys cinerea, Commiphora africana, Bauhinia macrantha, Boscia mossambicensis,* seed pods of *Acacia* spp. fruits of *Solanum* spp., *Diospyros mespiliformis, Sclerocarya caffra, Garcinia livingstonei;* flowers of *Kigelia africana* and *Lonchocarpus* spp. Grasses utilised include *Panicum aphanoneurum, P. coloratum, P. maximum, P. repens, Eragrostis lappula, E. biflora, Brachiaria humidicola, Cynodon dactylon, Sporobolus salsus, S. fimbriatus, S. spicatus, Chloris gayana, C. virgata, Imperata cylindrica, Oryza longistem-inata, Urochloa brachyura, Acroceros macrum* and *Tricholaena monachne.*

Impalas are diurnal and nocturnal and occur in small or large herds, single adult males or batchelor herds. Herd size generally varies from six to 30 individuals although groups of up to 50 impalas were encountered fairly often. The largest herd encountered comprised 62 individuals, but it is thought that some of these larger herds comprise joining of two or even three smaller herds. Eighty-two per cent of single impalas observed were adult males, 11 per cent were sub-adult males and the remaining seven per cent were adult females. Batchelor herds usually comprised two to seven individuals, but larger groups of up to 22 individuals were encountered. Smithers (1971) notes larger impala herd sizes in the lower-Delta areas when compared with populations outside the Delta.

The condition of impalas as based on their kidney fat index ranged from excellent in 15 per cent of specimens to poor in 30 per cent, with 55 per cent of cases being in fair condition according to the prevailing season. Adult male impalas showed a definite peak in condition prior to the rut and a rapid decline in condition once the rutting season commenced. (Table 32). When floods are excessive and Secondary Floodplain and Primary Floodplain Communities cannot be utilised, condition indices maintain a lower level than if these habitat types were available. Adult females showed a similar trend under high flood conditions (Table 33).

Table 32 – Mean seasonal kidney fat indices (percentages) of adult male and female impala from the study and adjacent areas, Okavango Delta, Botswana, March 1973 – November 1975

YEAR AND MONTH	ADULT MALES	ADULT FEMALES	REMARKS
1973:			
Mar.	–	–	
Apr.	46,95	–	
May	–	–	Rut commences mid-May 1973.
Jun.	21,59	40,70	
Jul.	10,14	41,45	Flood-levels peak.
Aug.	6,72	47,10	
Sep.	8,92	36,70	
Oct.	22,30	15,60	
Nov.	8,22	19,35	
Dec.	24,17	5,30	Lambing commences.
1974:			
Jan.	–	12,83	Excessive rains and local floods.
Feb.	–	7,01	Excessive rains and local floods.
Mar.	–	16,74	Excessive rains and local floods.
Apr.	27,45	7,74	Rut commences mid-April 1974.
May.	7,28	7,90	Excessive floods restrict movement and vegetation types available
June	–	14,00	
Jul.	–	–	
Aug.	5,42	19,60	
Sep.	7,62	16,52	
Oct.	–	5,96	
Nov.	15,53	6,14	Lambing commences.
Dec.	–	–	
1975:			
Jan.	64,52	–	
Feb.	–	5,95	
Mar.	61,13	18,15	
Apr.	–	–	Rut commences mid-April 1975.
May	18,59	23,22	Excessive flood-levels.
Jun.	–	–	
Jul.	7,70	32,96	
Aug.	–	40,80	
Sep.	14,39	38,73	
Oct.	5,00	13,28	
Nov.	8,97	–	Lambing commences.

Note: During 1975 some impala were collected at the eastern base of the Delta where flooding does not effect their movement as it does in the study area.

Table 33 – Foetal impala data, conception and parturition dates after Huggett and Widdas (1951) for the study and adjacent areas, Okavango Delta, Botswana, June 1973 – October 1975.

DATE OF COLLECTION	MASS (GRAMMES)	SEX	CROWN-RUMP LENGTH (MILLIMETRES)	POST-CONCEPTION AGE (DAYS)	APPROXIMATE CONCEPTION DATE	APPROXIMATE PARTURITION DATE
1973:						
23 Jun.	7,5	?	44	57	27 Apr.	6 Nov.
2 Jul.	8,0	?	51	57	4 May	16 Nov.
22 Aug.	140,9	M	221	107	8 May	20 Nov.
9 Sept.	462,4	F	236	109	23 May	5 Dec.
8 Oct.	1 590,4	M	315	145	16 May	28 Nov.
9 Nov.	4 000,0	M	455	183	10 May	22 Nov.
1974:						
5 Jun.	3,5	?	35	53	11 Apr.	23 Oct.
13 Jun.	11,1	?	70	77	28 March	6 Oct.
5 Aug.	574,4	M	242	115	12 Apr.	24 Oct.
10 Sept.	1 433,3	F	350	142	21 Apr.	2 Nov.
14 Sept.	2 057,7	F	366	155	12 Apr.	24 Oct.
15 Oct.	5 750,0	M	551	195	4 Apr.	16 Oct.
19 Oct.	4 250,0	F	516	186	17 Apr.	29 Oct.
1975:						
19 Jul.	165,0	M	–	89	21 Apr.	2 Nov.
12 Aug.	486,6	M	232	111	24 Apr.	5 Nov.
12 Aug.	9,7	?	57	59	14 Jun.	26 Dec.
2 Sept.	1 193,8	M	331	136	19 Apr.	31 Oct.
12 Oct.	1 878,0	F	411	151	14 May	26 Nov.
12 Oct.	2 165,0	M	424	157	8 May	20 Nov.

Adult female impalas do not generally show condition loss during the rut, but rather show a steady condition build-up until the last month or two of pregnancy when condition drops and continues doing so in the early months after parturition. (Table 33). Robbel and Child (1976) found impala in poor condition from August to November 1969, with only 1,1 per cent of males and 2,1 per cent of females judged in better than poor condition, and in a year-round sample only one male was judged to be in good condition.

In general the population in the study area and that observed in Moremi Wildlife Reserve during 1975 should have been in better condition and should be monitored for overpopulation and habitat overutilisation, and some culling programme initiated.

Impalas are strictly seasonal breeders. The rutting takes place during April through May to June with a peak in either April or May. The commencement of rutting appears to be effected by the season and condition of the impala, and the rut only commenced about early May during 1973 whilst it had peaked during April in good seasons of 1974 and 1975 (Table 32). Robbel and Child *(op. cit.)* showed the peak of rutting in Moremi Wildlife Reserve during 1969 to occur between the 12th and 16th of May. Table 33 gives breeding data for impalas from the study and adjacent areas. Peak of births during good versus poor seasons are offset by about one month. The gestation period for impalas is 196 to 200 days (Brand 1963, Fairall 1969). All implantations occurred in the right uterine horn immaterial of whether ovulation occurred from the right or left ovary (10 left, 13 right;(pers. observ). No cases of twinning were observed. Sub-adult female impalas were found to mate for the first time at about 16 months of age and thus produce their first juvenile at approximately two years of age.

The average population density on the Boro floodplains of 2,34 impalas/km^2 is approximately double that of the M'borogha floodplains (1,23 impalas/km^2) due to the latter's potentially greater inundated areas. During the driest times the M'borogha floodplains showed its highest impala average population density of 2,56 impalas/km^2 (May and December 1973) whilst during higher floodtimes the average density of 0,44 impalas/km^2 is about one fifth of that during drier periods. These impala either move westwards to Chief's Island or southwards out of the study area, but any large channel serves as a boundary to their movement. Chief's Island carries the overall annual highest average population density of 3,83 impalas/km^2 but the area is not equally utilised, resulting in local overgrazing. The Boro floodplains carries the highest population density during driest period of 4,28 impalas/ km^2 (30 August 1973) but marked movement occurs onto Chief's Island once the summer rains have commenced. (Appendixes 1 - 17).

Mass and measurements of impala appear in Tables 34 and 35.

External parasites:
(Acarina)
Rhipicephalus evertsi evertsi Neumann, 1897
R. sanguineus (Latreille, 1906)
R. appendiculatus Neumann, 1901
R. tricuspis Dönitz, 1910
Boophilus decoloratus (Koch, 1844)
Amblyomma hebraeum Koch, 1844
Ixodes sp.

(Anoplura)
Linognathus nevilli Ledger, 1973

Internal parasites:
Agriostomum gorgonis Le Roux, 1929
Carmyerius mancupatus (Fischhoeder, 1901) Goedelst, 1911
Moniezia benedeni (Moniez, 1879) R. Blanchard, 1891
Haemonchus sp.
Stilesia hepatica Wolffhügel, 1903
Thysaniezia giardi (Moniez, 1879) Skrjiabin, 1926
Oesophagostomum sp.
Paramphistomum microbothrium Fischhoeder, 1901
Trichuris globulosa (Linstow, 1901) Ransom, 1911

Redunca arundinum arundinum (Boddaert, 1785)
Reedbuck; seBugatla

Reedbuck are widely distributed in all the floodplain systems of the study area and populations occur in good numbers. General distribution in the Delta is good. Reedbuck utilise dry or wet Secondary Floodplain and Primary Floodplain Communities, in general prefering tall open grass and/or sedge habitats. Old Secondary Floodplain Communities

Table 34 – Male impala mass (Kg) and measurements (mm) from the study and adjacent areas, Okavango Delta, Botswana, April 1973 – November 1975

DATE	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL	
							Zygomatic width	Total length
Adults								
1973:								
4 Apr.	59,0	1 755	286	459	911	153	112	280
27 Apr.	62,5	1 733	350	460	936	157	110	270
23 Jun.	52,0	1 672	285	438	925	149	108	259
23 Jun.	55,0	1 586	287	445	927	150	114	262
13 Jul.	50,0	1 620	294	445	925	155	108	266
13 Jul.	52,0	1 625	318	428	889	150	111	254
14 Aug.	56,0	1 746	354	449	931	148	114	268
20 Aug.	59,0	1 761	343	451	961	153	116	266
8 Sept.	56,0	1 650	320	445	875	148	–	–
16 Sept.	57,5	1 641	342	427	911	156	–	–
29 Sept.	56,5	1 712	347	444	872	149	112	255
13 Oct.	56,5	1 775	360	440	841	146	–	–
7 Nov.	55,0	1 692	359	441	940	154	111	264
7 Nov.	50,0	1 688	345	473	931	161	112	274
15 Dec.	57,0	1 753	372	459	995	158	115	267
19 Dec.	50,0	1 631	314	432	846	160	114	271
28 Dec.	51,0	1 614	362	446	929	146	109	270
1974:								
6 Apr.	64,0	1 736	388	481	940	159	117	283
11 Apr.	58,0	1 654	352	452	950	154	112	275
13 May	54,0	1 641	322	445	921	148	110	270
28 May	53,5	1 581	318	442	900	145	110	265
5 Aug.	51,5	1 691	346	457	960	156	115	270
8 Aug.	48,0	1 672	344	438	859	150	110	264
14 Aug.	58,5	1 720	349	447	914	152	114	273
2 Sept.	47,0	1 615	318	445	830	155	106	262
2 Sept.	54,5	1 706	359	459	911	155	111	265
13 Nov.	57,5	1 622	328	439	898	148	112	272
17 Nov.	58,0	1 721	366	451	880	150	113	269
1975:								
30 Jan.	54,5	1 589	322	419	905	156	111	259
3 March	67,0	1 683	351	454	996	153	115	279
7 March	70,5	1 794	418	463	980	151	112	286
11 March	57,5	1 644	373	433	885	153	111	270
26 March	65,0	1 732	352	469	998	159	113	277
5 May	52,5	1 688	366	437	871	149	108	263
7 May	61,0	1 786	336	456	942	162	112	275
19 Jul.	61,0	1 786	398	446	918	160	117	282
1 Sept.	59,0	1 624	352	440	911	151	116	274
8 Oct.	56,0	1 706	355	449	920	151	–	–
18 Nov.	54,0	1 775	381	459	888	154	–	–
Sub-adults and juveniles								
1973:								
24 Apr.	40,0	1 555	300	–	871	145	99	244
9 May	28,0	1 370	305	420	810	141	96	242
6 Nov.	38,0	1 505	310	431	878	150	107	257
1974:								
11 Apr.	18,5	1 190	279	371	715	135	85	186
26 May	42,0	1 620	350	466	779	150	108	262
28 May	41,5	1 583	345	439	887	151	105	256
21 May	25,0	1 331	285	405	784	144	–	–

– = damaged material.

Table 35 – Female impala mass (Kg) and measurements (mm) from the study and adjacent areas, Okavango Delta, Botswana, April 1973 – October 1975.

DATE	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL	
							Zygomatic width	Total length
Adults								
1973:								
11 Apr.	36,0	1 484	292	415	815	142	94	226
23 June	39,0*	1 535	272	417	871	136	101	249
2 Jul.	42,0*	1 547	298	420	863	141	94	241
5 Jul.	47,0	1 635	318	440	825	152	103	265
22 Aug.	43,0*	1 482	314	431	855	142	99	252
9 Sept.	40,0*	1 595	304	411	874	146	97	246
8 Oct.	40,0*	1 652	320	425	915	156	–	–
9 Nov.	42,5*	1 537	316	407	858	144	–	–
19 Dec.	37,5	1 560	328	431	800	146	96	252
24 Dec.	43,0	1 583	301	426	860	145	103	264
1974:								
9 Jan.	43,0	1 509	330	425	807	150	101	266
14 Feb.	44,0	1 575	318	422	825	155	102	259
24 Feb.	42,5	1 595	334	421	835	151	100	260
1 March	41,0	1 576	297	425	840	150	105	265
1 March	42,0	1 590	301	430	930	149	103	266
11 Apr.	36,0	1 486	300	421	860	140	93	248
9 May	40,0	1 641	345	434	865	149	101	276
15 May	43,5	1 619	333	427	874	155	106	265
5 June	45,5*	1 598	302	449	862	152	104	265
13 June	45,5*	1 703	330	432	878	149	109	270
5 Aug.	41,0*	1 607	315	427	881	148	102	258
10 Sept.	46,0*	1 612	314	433	868	151	99	265
14 Sept.	46,0*	1 601	334	440	891	149	103	258
15 Oct.	52,5*	1 684	330	441	910	159	104	273
19 Oct.	49,5*	1 611	326	436	850	158	99	261
20 Nov.	43,0	1 620	329	432	890	149	103	264
1975:								
2 Feb.	37,0	1 547	323	401	811	140	96	246
10 Feb.	43,0	1 534	320	421	826	150	100	255
7 March	42,5	1 628	332	424	802	145	91	255
26 March	40,0	1 601	305	423	898	141	100	259
5 May	40,5	1 560	314	429	835	142	96	257
12 May	40,5	1 574	311	428	870	145	99	247
19 Jul	52,0*	1 771	340	433	885	149	105	263
12 Aug.	46,0*	1 646	333	417	865	151	102	256
12 Aug.	38,0*	1 581	305	406	810	143	100	252
2 Sept.	46,0*	1 659	351	423	875	142	103	249
8 Oct.	43,0*	1 595	321	427	850	144	–	–
12 Oct.	45,5*	1 667	325	432	810	150	–	–
12 Oct.	45,5*	1 690	326	422	860	154	–	–
Sub-adults and juveniles								
1973:								
13 Sept.	28,0	1 367	265	401	704	139	90	225
1974:								
31 May	23,0	1 309	264	398	775	141	95	209
31 May	24,0	1 273	276	397	743	141	90	214
1975:								
3 Aug.	27,0	1 420	293	405	800	145	93	222

*Pregnant

– =damaged skull

in the early stages of evolving towards a savanna woodland Community, but still with tall grass, invariably contains reedbuck. Reedbuck are occasionally found in the adjacent marginal vegetation types or Closed Riverine Woodland Communities. They are localised and show little tendency to move even when floodlevels are fairly high. In Zululand reedbuck utilise either tall open grassland or woodland areas but with tall grass cover *pers. obsv.* Table 36 represents habitat preference of reedbuck in the study area.

Table 36. Reedbuck plant community (habitat) preference in the study area, Okavango Delta, Botswana, 1973 – 1975.

PLANT COMMUNITY (HABITAT)	PERCENTAGE OCCURRENCE
Primary Floodplain Community	55
Secondary Floodplain Community	22
Shallow Backwater Communities (when dry or nearly dry)	8
Termitaria in floodplain communities	6
Closed Riverine Woodland (verge)	4
Sporobolus spicatus Island Grassland Community	3
Outlet Channel Communities	2

Reedbuck are grazers and utilise grasses and sedges, and show some overlap with lechwe in habitat utilisation and grazing habits. Pienaar (1963) and Jungius (1971) report them as taking some browse including wild fruits, but this was not observed during this study.

Jungius *(op. cit.)* shows the following grasses and sedges which also occur in my study area, to be most utilised by reedbuck in the Kruger National Park: *Hyperthelia dissoluta, Panicum maximum, Trachypogon spicatus, Setaria sphacelata, Imperata cylindrica, Leersia hexandra, Cyperus fastigiatus* and *Kyllinga erecta.*

Reedbuck are diurnal and nocturnal and feed at night and during the early and later cooler daylight hours. They rest up in tall grass, termitaria verges or occassionally in Closed Riverine Woodland Communities. They occur singly, in pairs or in small groups of up to six individuals. Fifty five per cent of all observations were of single individuals, either adult males, adult females or sub-adult males, 28 per cent of the observations were of pairs, either as adult male and a female or a female with a juvenile/sub-adult, while 11 per cent of all observations comprised three individuals. The remaining 6 per cent is of group sizes of four to six individuals out of a total of 484 observations.

Reedbuck tend to 'hide' in tall grass and will only flush when one approaches closely, when they will give their characteristic alarm whistle. If utilising burnt grazing they will always lie up in adjacent cover. From visual estimates of condition parameters reedbuck were judged to be in poor to fair condition.

Mating activity in reedbuck was only once observed in mid-May and juveniles predominantly seen in August and September. One near full-term foetus was observed in a female in October. Smithers (1971) has recorded foetuses' from February, May and July and indications show a peak in births from August to December with isolated births at other times of the year. A single young is born at a time. Average reedbuck population densities of 0,12/km^2 are obtained from both floodplain systems but this is considered an underestimate due to the difficulties experienced in censusing this species, i.e. due to resting up in tall grass. Chief's Island itself does not hold any reedbuck except at the northern extremities where floodplains abut parts of this complex. The population in the study area appears to be on the increase probably due to decreased hunting activities. (*Wilmot *pers. comm.).*

Kobus ellipsiprymnus ellipsiprymnus (Ogilby, 1833)
Waterbuck; leTimoga (pl. maTimoga)

Waterbuck occur in isolated parts of the study area but nowhere in good population strengths, the total estimate being about 30 individuals. Larger numbers occur in the Moremi Wildlife Reserve and areas adjacent to it, viz. waterbuck appear to be the most abundant on the dry verges of the lower Khwai floodplain and adjacent woodlands. Apart from these areas no other waterbuck were located in the Delta.

Waterbuck were found to occur on Secondary Floodplain Communities, *Sporobolus spicatus* Island Grassland Communities, Primary Floodplain Communities, *Acacia erioloba* Woodland and Savanna Woodland, *A. tortilis* Savanna Woodland and Closed Riverine Woodland Communities and in marginal vegetation types. In the study area movement of some waterbuck males appeared to be very localised, whilst some mixed groups or female herds appeared to show much greater movement.

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*L. Wilmot c/o Crocodile Camp, Maun, Botswana.

Waterbuck occur as single individuals, groups or herds of up to 10 individuals in the study area, but more often single individuals or groups of up to four individuals were recorded. Waterbuck are predominantly grazers but some browsing is reported by Pienaar (1963) including wild fruits. Child and Von Richter (1969) mention heavy utilisation of *Cynodon dactylon, Brachiaria latifolia* and *Vossia cuspidata* by Chobe River waterbuck. Limited feeding observations from the study area show utilisation of *Bracharia humidicola* in place of *B. latifolia* plus the other two above-mentioned species.

No breeding data are available but two juvenile waterbuck observed in August were estimated on size to have been born in June or July. Child (1968b) states that waterbuck calve throughout the year with a peak in the cold, dry months.

The M'borogha floodplains were found to contain the highest waterbuck population estimate during the driest period (May 1973), but these largely appear to have moved out after the floods of that year had arrived and a resident population of no more than 25 to 30 individuals appears to exist. Only 10 waterbuck were located on the southern extremity of the Boro floodplains in the study area during October 1973 but these are known to move out of the conserved area. Two waterbuck later located higher up on the Boro floodplain during April 1974 were thought to be part of this same group of 10. Waterbuck require strict protection in the Delta if the populations are to increase as old hunters confirmed a much higher population density on the M'borogha floodplains during the 1960's.

Kobus leche leche Gray, 1850
Lechwe; leTswee (pl maTswee)

Lechwe are widely distributed throughout both floodplain systems in the study area. Well distributed throughout parts of the Delta especially the Khwai, Mokhogelo and Gomoti floodplains, but more limited in the western Delta and absent from the other lower Delta areas.

Lechwe distribution has altered drastically from what it was during the 1850's when lechwe were first recorded from the Boteti River in 1849 (Livingstone, 1857). Ellerman *et. al.* (1953) give the type specimen as collected from Toteng in 1850. Andersson (1856) records "hundreds of lechwe near the Theoge mouth where it spilled into Lake Ngami". Baines (1864) reports nakong (sitatunga) and another new species (probably Lechwe) in the vicinity of the Thamalakane/Boteti junction. Leyland (1866) records several lechwe at different parts along the Zouga (Boteti) River. Baldwin (1894) saw and collected lechwe about 13 days by wagon from Lechulatebes town on the Beauclekky (Boteti) River. Today no lechwe can be found in any of the above-mentioned areas except where reintroduced into the Maun game sanctuary.

Elsewhere they occur down the Savuti channel almost to the Marsh, and on the Kwando/ Linyanti/Chobe floodplain, mainly on the Caprivi side. It is probable that the Okavango Delta population was in the past linked with the Linyanti Swamp population via the Selinda Spillway and the Mababe Marsh, but this is no longer the case, nor will it be unless drastic alterations occur in the present flood regimes to favour the relinking of these two drainage systems.

Changes in lechwe distribution are mainly due to the vast changes in water distribution and thus flooding pattern over the Delta. Tsetse fly control hunting operations between 1942 and 1963 has tended to contribute to a reduction in its former range (Child, Smith and Von Richter, 1970). Heavy local hunting, viz. the influx of refugees to the Estha area, places an increased pressure on hunting within this area. The highest populations are still found in protected areas or in areas where little local hunting takes place.

Today no lechwe occur on the Boteti River or in the vicinity of Lake Ngami. The Delta population exists from the vicinity of Seronga 18°45'S to 19°45'S and from 22°30'E to 24°E along the Khwai River drainage. A separate population recognised also by Child (1968b) exists along Botswana's northern boundary on the Kwando/Linyanti/Chobe/Savuti system, connecting with the Zambesi system.

Lechwe are grazers associated with the floodplain vegetation types, the riverine verges and the immediately adjacent riverine and marginal vegetation types. They utilise all aquatic vegetation types except deep water Madiba and Middle Channel Communities but occur immediately adjacent to them. Lechwe are found to occur in Outlet Channel Communities in low water level conditions. Sumps, Flats and Shallow Backwater Communities are all utilised, but the habitat type being utilised at any moment is dependent on water levels and thus the degree of inundation of a specific habitat type at a specific time. Primary Floodplain and *Sporobolus spicatus* Island Grassland Communities are heavily utilised.

Secondary Floodplain Communities do not form favoured habitat, and are only heavily utilised when water levels are too high in the favoured habitat types and thus force lechwe to utilise the shallower Secondary Floodplain Communities. During excessive flood years old drainage courses and floodplains which have not been inundated for several years and are evolving towards dryland types, usually *Acacia tortilis, A. erioloba* or *Combretum imberbe* Savanna Woodlands, become inundated and will also be utilised by lechwe.

Lechwe movement is thus in accordance with and directly controlled by water levels. Lechwe favour water levels of 0,15 to 0,60 m deep and although they occur in water levels exceeding this at times it is not favoured. In general they occur adjacent to favoured water level habitat types but spend a large proportion of their daily activity grazing or resting up on dryland areas, especially those surrounded by inundated areas, viz. flattened termitaria with a short grass covering, small to medium-sized islands lacking in woody vegetation cover and *Sporobolus spicatus* Island Grassland Communities surrounded by or adjacent to madiba.

Two groups of lechwe were found to be resident all year round in a specific area. These areas were generally adjacent to or enclosed by a lediba and are composed of short, open *Sporobolus spicatus* Island Grassland Community with a high water table, but which did not become excessively inundated and on which there were always dryland short grass areas available for resting up. In the areas which became submerged in excess of 0,60 m, the lechwe moved away from the adjacent Middle or Outlet Channel Communities towards the shallower margins of the flooded areas, or downstream on an Outlet Channel Community but remaining within the floodplain system, viz. the Khwai River extremity.

In the late 1950's lechwe still moved down the Kwai River as far as the start of the Mababe Depression (*Dandridge pers.comm.) when floodwaters reached that far. However even in the high floods of 1975 this was not the case, as no lechwe moved beyond the extremity of the floodplain system of the Khwai River (below Khwai River Lodge). Below this point only a single outlet channel occurs with suitable immediate margins but no floodplain. The same situation was found on the Mokhokelo/Zankuio River system where no lechwe moved beyond the limit of a clearly defined floodplain terminus. Lent (1969) states that lechwe in the Okavango exist only where the floodplain is over 100 m in width in the low water season. Lechwe today still move down the Savuti Channel which is comparable to the terminal sections of the Khwai and Mokhokelo Rivers.

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*D. Dandrige, Kerr, Downey and Selby, Box 27, Maun

The study of movement patterns from marked lechwe unfortunately only covered a high flood year which excluded large-scale movement. Males were found to be fairly localised and no male moved further than 11 km (No. 13) from their initial marking point. Three marked males remained in areas impenetrable due to excessive flooding and could therefore not be regularly observed for social organisation studies. Male No. 1 tended to stick fairly rigidly to his original area of marking, but due to the problems in getting this animal to recover from the immobilisation it may well be that he suffered brain damage as this lechwe showed marked atypical behaviour when subsequently sighted. Other marked males (No. 3 and No. 11) were sighted in different areas although they ranged no more than 5 km from the original marking site.

Females tended to move slightly greater distances and showed different group composition on several sightings. The greatest movement, shown by No. 4 was 13 km from the point of marking in January 1975 where she was found in a group of 63 females and juveniles. During late February 1975 No. 4 was sighted twice near the first locality but each time with a group of 40 females and sub-adults. No. 4 was again sighted on 4 September 1975, 5 km further east in a group of three adult females, two sub-adult females and one juvenile.

Female No. 6 was first located on the Khwai airstrip on 23 February 1975 in a mixed group of 50 lechwe. On the 27th March 1975 she was in a mixed group of 204 individuals in the same locality (with No. 2 female also present), and at this stage a juvenile was accompanying No. 6. On 7 May 1975, No. 6 was still present on the Khwai airstrip but after September she disappeared and was never relocated. Female No. 2 was not seen again on the airstrip but was relocated on 6 September 1975 opposite the north gate camp in a group of nine lechwe with one adult male present, having moved 7 km westwards.

On the Boro floodplains, during high water levels, the majority of lechwe move westwards out of the conserved area as more favourable habitat occurs in Khurunaragha area. On the M'borogha floodplains during high water conditions the majority of movement occurs down the Mokhokelo and Gomoti floodplain systems largely into the conserved areas of Moremi Wildlife Reserve.

Lechwe are grazers, feeding in the water on emergent aquatic to semi-aquatic herbaceous plants and on dryland and dry floodplain grasses and sedges. More time is spent on feeding on non-flooded aquatic vegetation types, non-flooded *Sporobolus spicatus* Island Grassland Communities or marginal dried out areas, than is spent on actually feeding in the water.

Observed feeding records include *Cynodon dactylon, Sporobolus spicatus, S. acinifolius, S. salsus, Vossia cuspidata, Echinochloa stagnina, E. colona, E. holubii, Panicum aphanoneurum, P. repens, Brachiaria humidicola, Imperata cylindrica, Oryza longisteminata, Miscanthidium junceum, Ischaemum afrum, Sacciolepus typhura, Sorgum almum, S. verticilliflorum, Andropogon eucomis, Setaria sphacelata, Eulalia geniculata, Eragrostis rigidior, Acroceras macrum, Phragmites* spp. (young shoots), *Cyperus articulatus, C. fulgens C. haspan, C. compressus, C. sphacelatus, C. dives, C. longus, Scirpus inclinatus, S. muricinux, Kyllinga erecta, Fimbrystylis furruginea, F. dichotoma, F. hispidula, Fuirena ciliaris, Juncellus laevigatus, Eleocharis fistulosa, E. dulcis* and *Mariscus squarrosus.*

Lechwe are diurnal and nocturnal, occurring singly, in small groups or large concentrations. Concentrations may be found at any time of the year but are more prevalent in either extremes of low or high water conditions. In the former case they are forced to concentrate near channels still containing water or near madiba, whilst in the latter case they are forced into less typical shallowly flooded habitat as a result of extreme flooding in their more favoured habitat types. Concentrations in the Delta were never found to exceed 400 individuals per group but more usually between 100 and 200 lechwe which is low when compared with other lechwe concentrations. Child (1968b) estimates concentrations on the Chobe River to be of the order of 2 000 to 2 500 individuals. Sayer and Van Lavieren (1975) estimate some concentrations of Kafue lechwe to be in the order of 2 000 to 6 000 individuals and Grimsdell and Bell (1975) report concentrations of up to 3 000 black lechwe *(Kobus leche smithemani)* at certain seasons in the Bangweulu Basin of Zambia.

Although preferring open, short grass or sedge areas lechwe are never far removed from tall grass aquatic areas of *Miscanthidium junceum* or the sedge *Cyperus papyrus* where this latter occurs. They have clearly defined paths traversing such areas and connecting with open areas of either *Sporobolus spicatus* Island Grassland Communities flattened termitaria or the. more open Shallow Backwater and Sumps Communities.

The hotter parts of the day are spent lying up on open, flattened termitaria or *Sporobolus spicatus* Island Grassland Communities in the floodplains but always adjacent to tall aquatic vegetation into which they can make effective escape. Lent (1969) reports early morning and late evening bimodal daily activity for most individuals with less than 40 per cent active during the hotter afternoons. Lechwe make use of conical, partially flattened termitaria as a vantage point when alarmed in an effort to locate the adversary; and in doing so continually erode such to form the typical flattened island discs (old termitaria) scattered within the taller flooded grassed areas so typically seen from the air in parts of the Delta. When alarmed, lechwe amble off with head and nose held low to the ground, which probably results from the attitude adopted when moving along their paths through tall *Miscanthidium junceum.* When seriously disturbed, lechwe move off at a lumbering gallop, the males with their horns held low and laid back over their shoulders. If in water, they bounce in a series of plunges, with the well-developed hindquarter muscles lifting the animal out of the water and making efficient progress across medium flooded areas. Lechwe are strong swimmers and can move through deep water in this fashion, but they show strong reluctance to enter deep water (Child and Von Richter 1969), probably as a result of susceptability to crocodile predation under these circumstances (Robinette and Child, 1964). A nasal snort is issued as an alarm signal, or a long series of short, low grunts are issued by males normally after chasing females, or after males' challenge ritual encounters. Lechwe often defecate in the water, and this serves to fertilise waters (Tinley, 1966) for lower animals in the food chain.

Several authors have published on the general biology and behaviour of different subspecies of lechwe (Allen, 1963; Robinette and Child, 1964; De Vos and Dowsett, 1966; Child and Von Richter, 1969; Lent, 1969; Grimsdell and Bell, 1972b; Joubert, 1972; Bell and Grimsdell, 1973; Sayer and Van Lavieren, 1975 and Grimsdell and Bell, 1975) mainly covering populations in Zambia. De Vos and Dowsett *(op. cit.)* first reported territorial behaviour in lechwe from Zambia, whilst Lent *(op. cit.)* reported some territorial behaviour in Okavango lechwe, substantiated by Joubert *(op. cit).*

During the course of this study, territoriality in lechwe was observed in some instances, whilst the major social behaviour pattern appeared to be one of a dominance hierarchy amongst males in a mixed herd. Lent *(op. cit.)* describes Okavango lechwe from adjacent areas, (five kilometres from one another) showing two distinct forms of social organisation at the same time of the year.

Group or herd structure appears to be very loose amongst lechwe with frequent changes in her composition. Grimsdell and Bell *(op. cit.)* report the same for black lechwe in Zambia. Herd size in the Delta (Fig. 23) nowhere approaches that reported for Caprivi or Zambian lechwe concentrations, with groups in excess of 100 individuals being seldom encountered, except during either extremes of flood conditions.

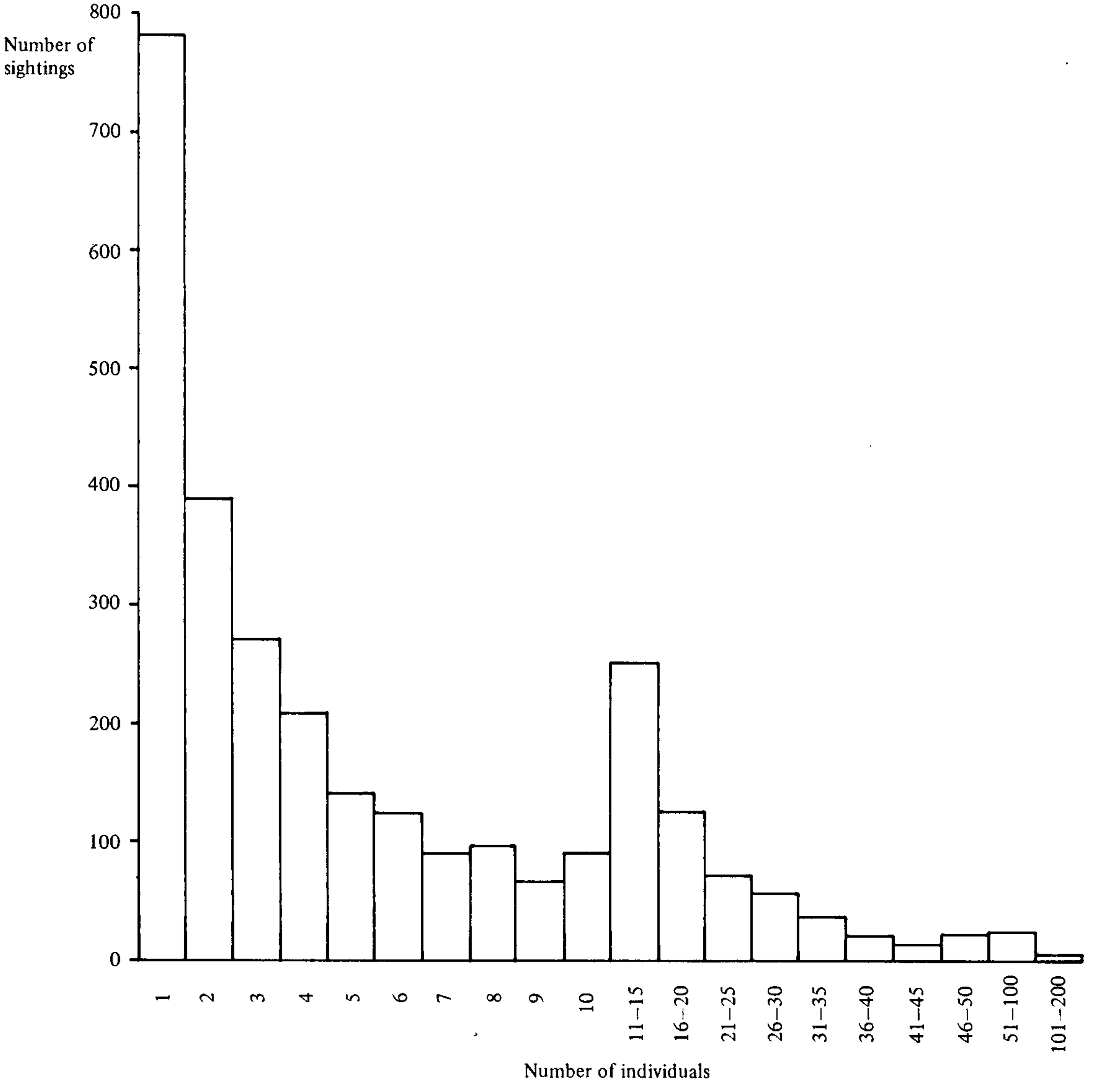

FIGURE 23 – Herd size of red lechwe in the conserved and adjacent areas Okavango Delta, Botswana, March 1973 to November 1975.

All mixed groups of lechwe containing more than one adult male (not obviously spatially arranged as in a territorial network) were classified within the dominance hierarchy social organisation. However, manifestation of this form of social organisation is far more evident in mixed herds containing several males of different ages. This is not always evident and large mixed groups at certain times show very little dominance behaviour. Males of similar age and conformation show light intensity challenge ritual, although isolated encounters are regarded as fairly heavy intensity challenge ritual. On several occassions when two lesser males were encountering each other, a more dominant male would come trotting up with nose held high in a threat display and disperse the challenging pair. As the most dominant male moves through the group, lesser males will often move towards him and indulge in peri-anal sniffing. The dominant male does not reciprocate but stands with nose held high and often displays an erection in a threat display, at which the lesser males appears submissive and accepts the alpha dominant males' position. In general these dominance challenge encounters are of short duration and position is established with the minimum of aggression or injury.

On several occassions the dominance hierarchy herds displayed mating behaviour. One female obviously in heat was checked by five different males in fairly close proximity and several attempts were made to mount her, but no serious aggression occurred amongst the males. Adult males often occur adjacent to each other or collectively in small groups under these circumstances and thus no territorial network seems to exist in these cases. The above observations took place during March 1975. On exactly the same area during October 1975 a definite territorial network was observed. An adult male made several attempts to herd a group of females and keep them in his territory. Whilst showing initial stages of challenge ritual to an adjacent male along their common territorial boundary, the females all left to a third adult male's territory on the other side. The first male unsuccessfully tried to prevent this, and the third male now herded the females which were moving towards the second male's area. These two males then met along the common territorial boundary and went into a high intensity challenge ritual in about 0,60 m of water. Heads went under water and clashed but were lifted quickly as they cannot spar underwater. The challenge ritual continued and whilst the males were thus occupied all the females moved to the second male's territory. On dryland territorial areas the same has been witnessed but the challenges are fairly vicious as male lechwe have extremely well-developed necks and severe injuries sometimes result. During such challenge rituals the various described procedures (Lynch, 1971) of reverse parallel and mutual anal sniffing, horning, common boundary patrolling and displacement grazing were observed. It is noteworthy that 55 per cent of territorial behaviour was observed during October which is not the main rutting season. These territories where observed and did not exceed an average of 150 to 200 m. Joubert (1972) found similar sizes for territories in Moremi Wildlife Reserve, but De Vos and Dowsett (1966) found that lechwe territories in Zambia never exceeded 50 to 100 m. A few heterosexual encounters as described by Lent (1969) were observed, but these always involved sub-adult lechwe.

Group size (Fig. 5) showed a preponderance of single individuals. Within the smaller herds any sex and age structure could be encountered, some herds comprising only females and sub-adults, some only females, some a mixture of males, females and sub-adults and mainly during the rutting season a single adult male accompanying a group of females. Batchelor herds also comprise this group, the largest number encountered being 22 individuals. This number is low when compared with Kafue lechwe male herds (Robinette and Child, 1964) where groups of over 100 individuals are recorded. Larger herds comprised mixed groups or female and sub-adult individuals, but within the mixed groups there invariably was a predominance of females.

Lechwe in general have a shaggy, lean appearance. Tinley (1966) reports that during his field observation period in July 1964 many lechwe appeared to be in a poor condition and quotes P.R. Hill saying that lechwe have a scruffy appearance at any time. In spite of this apparently lean external condition, their internal kidney fat reserves show them to be in better condition than what their external appearance suggests (Table 37). Lechwe did not show the marked peak in condition which impala showed prior to the rut, nor did they reach that height of condition. They did however maintain a slightly higher average kidney fat index throughout the year when compared with impala. (Tables 32 and 37).

The peak in adult male lechwe condition occurred after the floods were receeding, and plenty of fresh prime habitat became available. Adult females were separated into two classes since it appears that their condition is directly related to their state of pregnancy or stage of rearing a juvenile. Pregnant females have a high kidney fat index (average 40 per cent) building up to a peak in condition two to three months prior to giving birth. Thus during the latter stages of pregnancy (as with the impala females) the condition index declines, but still maintains a fairly high level. After parturition condition drops rapidly until weaning and conception takes place again when a sharp build up in condition occurs (Table 38).

Table 37 – Average seasonal kidney fat indices (percentages) of lechwe from conserved and adjacent areas, Okavango Delta, Botswana, April 1973 – October 1975.

MONTH	YEAR	MALES	FEMALES		REMARKS
			Non-pregnant or lactating	Pregnant	
April	1973	17,04	–	–	
May	1973	6,55*	11,08	30,10	
June	1973	11,46	–	–	
July	1973	–	–	–	Flood levels peak
August	1973	11,58	–	49,35	
September	1973	12,49	–	38,35	
October	1973	29,06	12,70	35,20	
November	1973	–	12,30	24,80	
December	1973	–	–	32,61	
January	1974	–	–	–	Excessive rain and local flood
February	1974	–	–	–	Excessive rain and local flood
March	1974	–	–	41,80	Flood levels high
April	1974	–	21,50	–	Flood levels high
May	1974	–	–	–	Flood levels high
June	1974	29,08	–	–	Flood levels high
July	1974	–	–	–	Flood levels high
August	1974	24,72	–	–	Flood levels high
September	1974	13,69	6,06*	–	Flood levels dropping
October	1974	–	–	–	
November	1974	–	–	–	
December	1974	–	–	–	
January	1975	–	–	–	
February	1975	51,34	–	62,08	
March	1975	20,47	–	51,20	
April	1975	–	44,67	–	Floods arrive
May	1975	–	–	–	
June	1975	22,23	–	42,75	
July	1975	15,86	–	–	
August	1975	14,20	–	14,58	Second flood peak
September	1975	16,28	–	23,51	
October	1975	11,30	9,45	25,38	

*Young

Table 38 – Foetal lechwe data, conception and parturition dates after Huggett and Widdas (1951) for conserved and adjacent areas, Okavango Delta, Botswana, May 1973 – October 1975.

DATE OF COLLECTION	MASS (GRAM)	SEX	CROWN-RUMP LENGTH (MILLIMETRES)	POST-CONCEPTION AGE (DAYS)	APPROXIMATE CONCEPTION DATE	APPROXIMATE PARTURITION DATE
16 May 1973	3,4	?	32,5	58	19 Mar. 1973	25 Oct. 1973
16 Aug. 1973	4 750,0	F	440,0	197	1 Feb. 1973	8 Sept. 1973
17 Aug. 1973	465,3	M	215,0	114	25 Apr. 1973	1 Dec. 1973
6 Sept. 1973	3 800,0	F	405,0	186	4 Mar. 1973	11 Oct. 1973
15 Sept. 1973	5 000,0	F	445,0	199	1 Mar. 1973	6 Oct. 1973
16 Oct. 1973	3 000,0	F	382,0	175	24 Apr. 1973	30 Nov. 1973
2 Nov. 1973	316,1	M	203,0	106	19 July 1973	24 Feb. 1974
28 Dec. 1973	7 700,0	M	540,0	218	25 May 1973	31 Dec. 1973
3 Mar. 1974	99,7	M	141,0	85	8 Dec. 1973	16 July 1973
2 Feb. 1975	5 500,0	F	544,0	204	26 July 1974	18 Feb. 1975
12 Mar. 1975	145,3	M	166,0	92	10 Dec. 1974	18 July 1975
15 June 1975	4,1	?	39,0	59	17 Apr. 1975	23 Nov. 1975
15 June 1975	1 296,0	F	337,0	143	23 Jan. 1975	31 Aug. 1975
12 Aug. 1975	637,7	M	–	122	12 Apr. 1975	17 Nov. 1975
9 Sept. 1975	1 449,9	M	335,0	147	15 Apr. 1975	21 Nov. 1975
9 Sept. 1975	5 000,0	M	536,0	199	22 Feb. 1975	29 Sept. 1975
11 Sept. 1975	8 000,0	M	–	220	4 Feb. 1975	12 Sept. 1975
11 Sept. 1975	576,5	F	–	120	14 May 1975	19 Dec. 1975
14 Sept. 1975	3 000,0	M	483,0	175	23 Mar. 1975	29 Oct. 1975
14 Sept. 1975	5 000,0	M	569,0	199	28 Feb. 1975	6 Oct. 1975
20 Oct. 1975	6,1	?	47,0	61	20 Aug. 1975	28 Mar. 1976

Due to the difficulties experienced in collecting lechwe during the high floods of 1974, a paucity of recordings exists for that year. However, peak condition in females occurred approximately 66 per cent of the way through pregnancy and lowest conditions occurred in all lechwe when flooding conditions are at a maximum. Robbel and Child (1976) also found that the lowest condition prevailed in lechwe during the peak of flooding and further reported that at the best time of the year most animals were thin. This appears erroneous since individual lechwe with kidney fat indices of 52,6 and 46,1 (August 1973); 60,5 (September 1973); 41,6 (October 1973); 41,8 (March 1974); 80,70 and 62,1 (February 1975); 51,2 (March 1975); 44,7 (April 1975); and 63,3 (June 1975) are in good to excellent condition for African game animals when compared to Childs (1968) Kariba kidney fat indices.

The drop in condition at the peak of floods is expected and is a natural phenomenon in this wetland ecosystem in providing rest for some otherwise very overutilised floodplain and aquatic vegetation types, which would deteriorate if large mammals were not forced off them (See section on vegetation status and trends). Robbel and Child (1976) further suggest that lechwe on islands in the flooded areas maintain a better physical condition than lechwe on the floodplains. This was not found to be the case from specimens collected deep within the flooded areas, as habitat range was also limited by flood levels there and those lechwe consequently showed a similar drop in physical condition.

Lechwe breed throughout the year but show a definite peak during the late spring – early summer months from October to December. This occurs prior to the onset of the summer rains or during their early stages. Tinley (1966) states young lechwe are born in March and April. Child (1968b) records young lambs from the Chobe between July and January and states that peaks of births occurred in early September during 1965 and 1966. Lent (1969) states that it is likely that some births occur in all or nearly all months of the year with a peak of births during the rainy season. In Zambia the peak breeding season for Kafue lechwe is from mid-July to mid-October (Sayer and Van Lavieren, 1975). It thus appears that all lechwe populations are capable of giving birth in any month, but that definite peaks occur in Zambia (usually in August), in Chobe (usually in September) and in the Delta (usually in October/November).

Births during the early summer months are advantageous as floodwaters have normally receded then and a maximum of good quality favoured habitat is then available. The major rutting major rutting months are February, March and April (Table 38) and mating takes place on dryland or in shallow water.

Males show the typical vulva smelling, "laufsclhag" (Walter 1966) and the raising of the head in "flehmen"; but the well-pronounced curling of the upper lip was not witnessed to the degree that it is displayed by other ungulates, viz. impala or tsessebe. Females usually move their tails to one side and urinate and Lent (1969) describes the full behavioural patterns during mating.

Shortly prior to giving birth, pregnant females leave the herd and retire alone to the taller swamp vegetation of *Miscanthidium junceum* or *Cyperus papyrus.* In well-concealed dry areas of this tall vegetation they give birth and the lambs remain hidden for protection. They then spend the time grazing in open areas in the vicinity apparently only returning to nurse the lamb. Sometimes small groups of nursing females are found together, but it is unknown if the lambs are collectively hidden in one spot. Lent *(op. cit.)* records one lamb being born in a Closed Riverine Woodland Community, but this could have been caused by the presence of lions which killed another lechwe in the proximity. The lamb spends an estimated five to ten days hidden before accompanying the female. Shortly after accompanying the female, the pair will join up with a group or herd.

Male lechwe display puberty between one and two years of age, but only appear to be sexually mature when between two and three years old. Female lechwe appear to produce their first offspring at about 2 years of age and thus first conceive at about 17 to 21 months of age, but this is dependent on individual growth and the available nutrition.

Lechwe population density varies greatly in the study area being dependent on the flooding conditions of the study area and the adjacent areas to which the lechwe move. The highest population in the total study area is between 4 000 and 5 000 lechwe when Delta conditions are at their driest. The M'borogha floodplains carry 4,5 lechwe/km^2 and the Boro floodplains 2,8 lechwe/km^2. Chief's Island only carries insignificant numbers of lechwe and then only marginally in inundated floodplains which abutt into it during high floods. The lechwe population density dropped from both floodplain systems as more water became available. On the M'borogha floodplains the density dropped to 1,6 lechwe/km^2 during April 1974 and about 1,0 lechwe/km^2 during July 1974. On the Boro floodplains the density dropped to 0,7 lechwe/km^2 during April 1974 and 0,5 lechwe/km^2 during July 1974. By December 1974 as conditions were drying out the population density for both areas had doubled from what they were during July. (See Appendices 1-17).

Four surveys were carried out during 1975 in the conserved and adjacent areas of the Moremi Wildlife Reserve. The lowest water levels during February 1975 produced the lowest overall population density of 4,1 lechwe/km^2. During the higher water levels an average of 4,7 (April 1975) or 4,8 (July 1975) lechwe/km^2 was recorded. The mid-Delta stratum (Moanashira-M'borogha) showed the lowest average density of 3,4 lechwe/km^2 for the year. The population density in this area decreased as the water levels increased, except for October 1975 when water levels dropped as did lechwe density. The lower-Delta areas showed the highest average population densities of 5,4 lechwe/km^2 (Mokokhelo-Gomoti) and 4,4 lechwe/km^2 (Khwai). However in the year 1975 the Delta was heavily flooded in all these areas during the course of the aerial survey work and the population remained almost static between 6 500 and 7 500 lechwe. A marked reduction in lechwe population density would have been evident from the two lower-Delta areas in a dry year like 1973. (See Appendix 18). Total Delta population is estimated at 18 000 to 20 000 lechwe at a maximum.

Mass and measurements of lechwe are given in Tables 39 and 40.

External parasites:
(Acarina)

Rhipicephalus evertsi evertsi Neumann, 1897
R. appendiculatus Neumann, 1901
Boophilus decoloratus (Koch, 1844)
(Subcutaneous Diptera)
Strobiloestrus vanzyli Zumpt, 1961

Internal parasites:

Setaria bicornata (Linstow, 1901) Raillieit & Henry, 1911
S. boulengeri Thwaite, 1927
Avitellina centripunctata (Rivolta, 1874) Gough, 1911
Haemonchus contortus (Rudolphi, 1803) Cobb 1898
Fasciola gigantica Cobbold, 1855
Dictyocaulus sp.
Carmyerius mancupatus (Fischoeder, 1901) Goedelst, 1911
Paramphistomum calicophorum Fischoeder, 1901

Table 39 – Male lechwe mass (Kg) and measurements (mm) from conserved and adjacent areas, Okavango Delta, Botswana, April 1973 – October 1975.

DATE	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL Zygomatic width	SKULL Total length
Adults								
1973:								
6 Apr.	78	1 789	348	455	952	146	129	279
11 Apr.	102	2 018	421	489	940	148	133	286
27 Apr.	115	2 101	437	484	1 015	154	134	303
21 Jun.	101	1 899	390	460	990	157	–	–
26 Jun.	101	2 004	412	480	1 073	144	134	287
17 Aug.	80	1 856	425	483	968	156	123	286
14 Sept.	102	1 951	453	489	994	155	130	286
8 Oct.	97	1 900	389	466	968	149	–	–
17 Oct.	103	2 039	420	477	976	154	130	–
1974:								
10 Jun.	90	1 843	370	466	980	143	132	281
21 Aug.	109	1 943	394	481	852	149	130	295
8 Sept.	87	1 918	446	481	946	149	133	289
19 Sept.	84	1 956	428	485	1 018	158	125	286
1975:								
14 Feb.	109	1 895	407	471	1 015	148	132	293
14 Feb.	127	2 113	434	470	1 007	156	134	310
11 Mar.	111	2 048	444	478	945	154	129	298
12 Mar.	96	1 944	444	471	950	144	128	291
12 Mar.	95	1 900	393	474	955	143	125	288
3 Apr.	108	2 004	404	470	921	159	136	310
11 Jun.	97	1 981	403	482	925	149	126	289
11 Jun.	108	2 002	444	506	1 070	160	134	300
28 Jul.	83	1 879	371	460	918	148	126	285
29 Jul.	91	2 076	441	486	1 020	154	135	306
11 Aug.	102	1 986	437	485	1 000	156	127	297
10 Sept.	111	1 965	423	462	1 000	151	130	297
10 Sept.	110	2 134	455	474	970	162	133	301
11 Sept.	96	1 960	401	482	935	153	127	300
13 Sept.	101	1 942	394	475	1 000	148	133	293
13 Sept.	87	1 956	436	476	955	150	124	287
12 Oct.	86	1 906	422	485	985	158	–	–
26 Oct.	83	1 961	406	480	997	149	–	–
Sub-adults								
1973:								
25 May	72	1 820	354	460	980	142	120	266
17 Aug.	62	1 691	374	466	915	146	121	272
29 Sept.	73	1 736	382	481	881	141	–	–
15 Oct.	72	1 810	383	483	916	150	–	–
1975:								
6 March	75	1 858	398	476	865	151	119	273

– = damaged skulls.

Table 40 – Female lechwe mass (Kg) and measurements (mm) from conserved and adjacent areas, Okavango Delta, Botswana, May 1973 – October 1975.

DATE	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL	
							Zygomatic width	Total length
Adults								
1973:								
7 May	64	–	–	–	856	146	110	265
7 May	72	1 729	340	443	920	151	116	282
16 May	54	1 573	330	441	844	137	108	246
16 May	84	2 035	439	500	995	151	119	284
16 Aug.	81	1 819	365	463	935	140	113	274
17 Aug.	75	1 819	345	462	960	146	120	275
6 Sept.	78	1 858	357	459	899	149	115	–
17 Aug.	54	1 656	342	439	930	144	109	255
15 Sept.	76	1 755	373	452	948	144	–	–
16 Oct.	78	1 785	304	437	830	144	–	–
2 Nov.	70	1 943	425	473	863	145	117	280
28 Nov.	81	1 910	412	467	945	149	–	–
28 Nov.	62	1 754	384	460	921	147	113	269
28 Dec.	86	1 844	362	466	954	150	121	283
1974:								
3 March	78	1 821	369	467	896	149	124	270
12 Apr.	78	1 835	375	472	891	144	120	267
19 Sept.	71	1 833	395	454	965	147	115	287
1975:								
2 Feb.	89	1 889	367	469	931	154	120	288
12 March	67	1 853	358	451	845	150	115	270
4 Apr.	73	1 745	307	452	885	150	114	274
15 Jun.	74	1 956	380	479	915	143	121	280
15 Jun.	75	1 788	366	437	895	146	120	262
12 Aug.	63	1 920	372	452	884	145	114	273
9 Sept.	70	1 798	382	453	887	143	117	274
9 Sept.	79	1 825	367	453	919	151	116	–
11 Sept.	79	1 846	394	459	885	142	123	294
11 Sept.	84	1 952	438	480	943	151	116	273
14 Sept.	80	1 881	390	465	890	148	116	280
14 Sept.	83	1 872	378	444	885	149	116	273
12 Oct.	82	1 973	399	474	923	149	–	–
20 Oct.	70	1 923	340	450	850	147	–	–
Sub-adults								
1973:								
6 Oct.	46	1 678	367	447	846	140	109	266
1975:								
6 Aug.	38	1 511	302	437	850	140	95	230

– = damaged skulls

Stephanopharynx coilos Dollfus, 1963
Stephanopharynx compactus Fischoeder, 1910
Schistosoma leiperi Le Roux, 1955
Schistosoma margrebowiei Le Roux, 1933
Trypanosoma congolense Broden, 1904
Trypanosoma spp.

External examination of lechwe for ticks showed low number of from zero to six ticks per lechwe out of a sample of 99, which is considered a light tick burden. Subcutaneous fly-larvae appear far more numerous in juvenile and sub-adult lechwe as very few were ever found in adult lechwe. Of the internal parasites only *Paramphistomoldea* was recorded in large numbers occurring in one or more of the stomach compartments.

Schistosoma leiperi and *S. margrebowiei* belong to the Trematoda and some congenerics (viz. *S. haematobium* and *S. mansoni*) are blood flukes of man causing bilharzia (Lapage, 1963). It is currently theorised that where lechwe occur in high population density either or both of the lechwe schistosomes may prevent the development of the human parasites (Pitchford, 1976).

Lechwe were in general found to carry a heavy load of *Trypanosoma* spp. in their blood. These were either *Trypanosoma rhodesiensis, T. congolense* or *T. brucei.* They are thought to be the latter and thus non-responsible for Trypanosomiasis (sleeping sickness) in man (*Drager pers.comm.), but tests will have to be carried out before this can be substantiated.

Hippotragus equinus cottoni Dollman and Burlace, 1928
Roan; Kwalata etshetlha

Roan are rare in the study area with only one adult male actually recorded. A group of five were also recorded in Khuranxaragha adjacent to the southwestern tip of the study area. Elsewhere in the Delta they occur around most of the drier fringes but not in the north, (Smithers, 1971). Tinley (1966) and Robbel and Child (1976) report roan present but uncommon in the Moremi Wildlife Reserve. They are more typical of the northern drier habitat types.

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Roan appear to favour scrub vegetation (*Colophospermum mopane, Terminalia sericea* and *Combretum* spp.) and sometimes occur in *Colophospermum mopane* or *Acacia* spp. Savanna Woodlands or Woodlands. Joubert (1976) states typical roan habitats to be lightly wooded or open grassland savannas from the Kruger National Park, National Parks in Angola and in Rhodesia, although relatively thickly wooded savanna is also utilised. Thus there is some limited habitat types available to roan in the study areas, especially on Chief's Island. Roan and sable habitat overlap and sable occur in greater numbers in Botswana although none were located in the study area. The extreme flooding conditions surrounding Chief's Island would possibly prevent these species from establishing themselves permanently in the area.

Roan are mainly gregarious, occurring in small herds of two to nine individuals, but also singly. They are largely grazers but do some limited browsing. Young are born chiefly in November but also from August to February (Tinley 1966).

Syncerus caffer caffer (Sparman, 1779)
Buffalo; nare (pl. diNare)

Buffaloes are widely distributed throughout the study area and occur on both the eastern and the western floodplains and on Chief's Island, but more seasonally on the latter. Buffaloes occur in virtually all the vegetation types but show a strong preference to utilise dry or lightly inundated Primary and Secondary Floodplain Communities, Closed Riverine Woodland and marginal vegetation types, *Acacia tortilis* Savanna Woodland, *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna, *Sporobolus spicatus* Island Grassland Community and Shallow Backwater and Outlet Channel Communities in drier periods.

Buffaloes move in and out of the study area but some herds appear to remain resident in the study area all the year round. Definite movement occurs between Moremi Wildlife Reserve and the M'borogha floodplain system and Chief's Island. The same can be said for Chief's Island and the Boro Floodplains and the Khuranxaragha/Jao areas. During the rains when pan water is available on Chief's Island, buffaloes seem to utilise the *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna for fresh annual and perennial grass growth to the greatest degree. During the winter (May to July) and spring periods (August to October) they are more associated with the floodplains and adjacent islands. Towards the end of this period they are especially concentrated on the floodplain vegetation types. Tinley (1966) and Smithers (1971) report lack of floodplain utilisation by buffaloes during the day. This was not the case in the study area when they were encountered on this habitat type fairly often during daylight hours. This may be due to the more extensive floodplain systems in the study area and less persecution, as my own observations in the lower Delta areas confirmed crepuscular and night use of the floodplains.

Buffaloes are largely grazers on a wide variety of grasses but also do a limited amount of browsing (Sinclair and Gwynne, 1972). Recorded plant species eaten from observation include *Sporobolus spicatus, Cynodon dactylon, Chloris gayana, Vossia cuspidata, Echinochloa colona, Cenchrus ciliaris, Brachiaria humidicola, Panicum repens, Imperata cylindrica* and *Setaria verticillata.*

Buffaloes are gregarious and occur in herds of from 30 to 600 individuals in the study area. Solitary males or bull groups of up to 12 individuals occur. Bull groups varied from solitary individuals up to seven most commonly or less frequently up to 12. One group of 14 individuals comprised 12 adult bulls, one adult female and one sub-adult female, but this was only recorded once. The large herds are made up of all sex and age classes, with a fairly high percentage of adult bulls. During the heat of the day they actively seek shade and lie up under trees, in tall *Miscanthidium junceum* or in reedbeds *(Phragmites* spp.). Buffaloes are diurnal and nocturnal.

The physical condition of buffaloes was fair to poor for adult males, and fair to good for adult females (from limited specimens collected for a buffalo study in Botswana) depending on the stage of pregnancy. Buffaloes are largely seasonal breeders, the peak of calving falling from December to March, but scattered births take place outside these dates. The gestation period is 335 days (Brand, 1963).

The buffalo population in the study area varied between 1 500 and 7 000 individuals. All three habitat zones always harboured some buffalo but usually there were few on the floodplain systems during December and onwards when the main utilisation centred on Chief's Island whilst fresh grazing and pan water existed. Average population densities on the M'borogha floodplains were 1,4 buffalo/km^2, on Chief's Island and on the Boro floodplains 2 buffalo/km^2.

SIZES AND MASS

Males

No	TL	T	Hfc/u	E	Mass (Kg)
22	3 325	785	615	264	616
79	3 265	809	590	254	616

Female

No	TL	T	Hfc/u	E	Mass (Kg)
23	3 091	689	580	260	500

External parasites:
(Acarina)

Hyalomma marginatum Koch, 1844
H. truncatum Koch, 1844
Rhipicephalus evertsi evertsi Neumann, 1897
R. simus simus Koch, 1844

Internal parasites:

Moniezia benedeni (Moniez, 1879) R. Blanchard, 1891
Fasciolia gigantica Cobbold, 1855
Carmyerius mancupatus (Fischoeder, 1901) Goedelst, 1911
Paramphistomum microbothrium Fischoeder, 1901

Connochaetes taurinus taurinus (Burchell, 1832)
Blue wildebeest; Kgokong

Wildebeest are widely distributed and 300 to 1 000 occur within the study area. Greater numbers occur on the lower and less flooded peripheral Delta areas and in the Moremi Wildlife Reserve (Robbel and Child 1976), but movement from here is towards the Mababe Depression. The Boro floodplains had the highest average population size (298 individuals), and some local movement occurred between here and Chief's Island during the 1973 rainy season.

Wildebeest show a strong preference for open grassland either on the floodplains or on islands with 83 per cent of all sightings derived from such areas. Secondary Floodplain

Communities showed 44 per cent of occurrences, Primary Floodplain Communities 25 per cent of occurrences and *Sporobolus spicatus* Island Grassland Communities 14 per cent of occurrences. *Acacia tortilis* Savanna Woodlands showed an 11 per cent occurrence and *Acacia erioloba* Woodland and Savanna Woodland together with *Colophospermum mopane* Woodland and Pyrophytic Scrub Savanna made up the remaining 6 per cent.

Wildebeest are almost exclusively grazers (Owaga, 1975) and observed feeding records include *Cynodon dactylon, Digitaria eriantha, Ischaemum afrum, Setaria sphacelata, S. Woodii, Sprobolus spicatus, S. acinifolius, Panicum repens, P. coloratum, Dactylotenium aegypticum, Erasgrostis* spp., *Brachiara humidicola* and *B. brizantha.* Although wildebeest and zebra show an overlap in habitat utilization, wildebeest selectively take far more leaf material and zebra more coarse material viz. sheath and stem (Bell 1969, Owaga *op. cit.).*

Wildebeest occur either solitary or are gregarious, occurring in the study area in herds of from two to 30 individuals being encountered, but herds of 31 to 65 (the latter the largest recorded herd size) were fairly common (Fig. 24). There was no evidence of the mass concentrations of wildebeest in the study area which are so apparent during migrations in other parts of Botswana. Wildebeest are more strictly diurnal, but also nocturnal to a degree. The hottest parts of the day are spent resting up in shade, and they show no fear of crossing shallow to medium-inundated floodplains. Wildebeest show a strong tendency to associate with tsessebe. From a limited number of wildebeest collected, preliminary condition indices seem to show a similar tendency to other seasonal breeders viz. impala.

Wildebeest are strictly seasonal breeders and calving occurs in November to February with isolated births outside this period. Tinley (1966) gives the calving season as September to October. Mating takes place between March and June and the gestation period is 245 days (Watson, 1969).

The population in the study area varied between 300 and 1 000 wildebeest. The Boro floodplains showed the highest average population density of 0,8 wildebeest/km^2 as against an average of 0,2 wildebeest/km^2 for the M'borogha floodplains and Chief's Island. The highest population density was recorded from the driest periods and although movement takes place between the floodplain systems and Chief's Island, the greatest movement during high floods takes place out of the study area to the south. The tendency to move onto Chief's Island occurs during the early part of the summer months, substantiating the tendency to utilise a high percentage of leaf material.

Mass and measurements of blue wildebeest appear in Table 41.

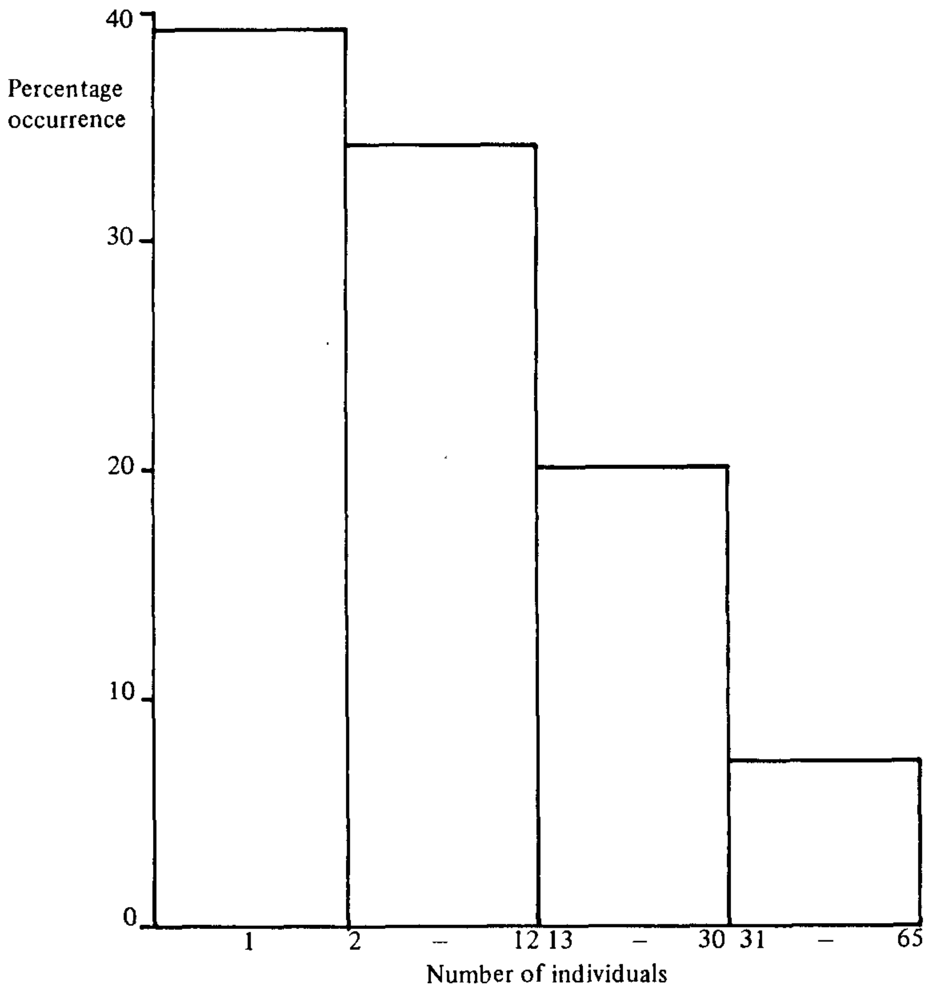

FIGURE 24 – Herd size distribution based on single individuals small, medium or large herds of blue wildebeest in the study area, Okavango Delta, Botswana, March 1973 to November 1974.

Table 41 – Mass (Kg) and measurements (mm) of wildebeest from the study area, Okavango Delta, Botswana, May 1973 – September 1974.

DATE	SEX	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL		REMARKS
								Zygomatic width	Total length	
15 May 1973	M	226	2 569	606	521	1 350	194	185	459	
22 Sept. 1973	M	198	2 446	625	530	1 342	202	170	451	
16 Nov. 1973	M	143	2 170	514	494	1 141	177	159	395	Subadult
12 Dec. 1973	M	181	2 320	532	496	1 268	187	167	428	
17 May 1974	M	188	2 390	650	519	1 277	210	171	445	
18 Jul. 1973	F	202	2 375	513	510	1 205	185	180	455	Pregnant
16 Sept. 1974	F	154	2 254	560	502	1 202	179	163	425	Subadult

External parasites:

(Acarina)

Rhipicephalus evertsi evertsi Neumann, 1897

(Cranial cavity Diptera)

Oestrus variolosus (Loew, 1863)

Internal parasites:

Fasciola gigantea Cobbold, 1855
Cysticercus (regis) Baer, 1923
Oesophagostomun sp.
Carmyerius mancupatus (Fischoeder, 1901) Goedelst, 1911
Stephanopharynx coilos Dollfus, 1963

Damaliscus lunatus lunatus (Burchell, 1823)
Tsessebe; Kabole

Tsessebes are widely distributed throughout the study area and are fairly common.

They are well represented on the M'borogha and Boro floodplain systems but not so, except on the verges, on Chief's Island.

Tsessebes show the highest preference for the open dry floodplain vegetation types and together with most other species viz. zebra, blue wildebeest and warthog; show a strong preference for freshly burnt areas. Thirty-six per cent of all tsessebe observations (531) were made on Secondary Floodplain Communities, 18 per cent on Primary Floodplain Communities, 18 per cent on alterns or ecotones between the floodplain vegetation types and Closed Riverine Woodland or marginal vegetation types, 13 per cent on *Sporobolus spicatus* Island Grassland Communities, 7 per cent on *Acacia tortilis* Savanna Woodland and 4 per cent each on termitaria or *Colophospermum mopane* and *Acacia erioloba* Woodland and Savanna Woodland. Tsessebes show no fear of crossing water 1 m in depth, and some appear to be more or less resident within the study area, whilst others show appreciable movement in and out of it. Elsewhere in Botswana, Child, Robbel and Hepburn (1972) report tsessebes as resident with restricted movement in the Chobe area.

Tsessebes are almost exclusively grazers although they have been observed to browse lightly (Child *et. al. op. cit.;* Grobler, 1973). They show a preference for short grass areas and burns, but if these are unavailable they will make use of taller dry grass areas. Observed feeding records include *Sporobolus spicatus, Setaria sphacelata, Eragrostis* spp., *Panicum aphanoneurum, P. repens, Brachiaria humidicola, Cynodon dactylon, Chloris gayana* and *Imperata cylindrica.*

Tsessebes occur either solitary, in male bachelor herds of up to 11 individuals or in small to medium-sized breeding herds. Solitary males are common providing 20 per cent of all observations, groups of two to three individuals (either bachelor groups or all females or mixed) provided 23 per cent, groups of four to ten individuals provided 48 per cent of the observations and groups of 11 to 14 individuals provided 9 per cent of all observations. The largest bachelor group recorded was 11 individuals and the largest overall group of 14 individuals comprised seven adult females and seven juveniles. Smithers (1971) also recorded a maximum group of 14 tsessebes for Botswana and Grobler (1973) recorded 12 individuals in a breeding herd and a herd of 22 bachelors for Rhodesia, while Child, Robbel and Hepburn (1972) report bachelor herds of up to 31 individuals from other parts of Botswana. Tsessebes appear to adhere strictly to localised areas under favourable grazing conditions, the same herd often being encountered in the same area for three to four months.

Tsessebe males are probably territorial from limited observations of challenge rituals. However they do not occur in the same population densities as its congenerics, viz. Bontebok, *Damaliscus dorcas dorcas* (David, 1970), and Blesbok, *Damaliscus dorcas phillipsi* (Lynch, 1971). In the study area, tsessebe were found to be strict seasonal breeders, with calves born from mid-October to mid-January depending on the season in question. Generally the calving period is of short duration lasting about six weeks during which time 80 per cent of the calves are born with isolated births outside this period. Child *et al.* (1972) and Huntley (1972) report similar conditions for tsessebe populations in other parts of Botswana and the Transvaal respectively, whilst Fairall (1968) reports that 90 per cent of the claves are born in a 40-day period in the Kruger National Park.

The rut occurs during March and April or in a poor flood season as late as May. The gestation period is about 8 months (Huntley *op. cit.).* Females display puberty during their second year but sexual maturity during their third year of life. All adult females examined (33 months and older) were found to calve annually except one adult female which showed no signs of ever having ovulated or reproduced (Neotony), with masculine features and originally mistaken for a male. Only two pregnant females were collected and both showed right horn implantation and right ovary ovulation. Child *et al.*, *(op.cit.)* records ipsilateral implantation from 42 specimens collected in Botswana. All recorded births were single. Males apparently reach sexual maturity in time for the rut during their fourth year (Child *et.al.* 1972).

From the seven tsessebes collected, the condition pattern seems to follow that of impala closely (seasonal breeders). Adult males reach their maximum of condition (49,2 per cent Kidney Fat Index (K.F.I.) just prior to the rut, during which time condition drops off drastically, then maintenance of a fairly steady condition, with a build up in condition towards the end of the year. Adult females show a high average K.F.I. of 79,4 per cent approximately 4,5 months into pregnancy which occurs in August/September.

From aerial surveys results the population in the study area varies between 100 and 700 individuals. Tsessebe movement does not appear to be governed by floodlevels as with so many of the other mammalian species, since there was no correllation of numbers with water conditions. Thus peak dry periods showed populations of about 450 (May 1973) and 100 (December 1973) as against that of peak wet periods of 112 (April 1974) and 350 (July 1974). Average population densities throughout the study period were 0,25 tsessebes/km^2 for the M'borogha floodplains; 0,05 tsessebes/km^2 for Chief's Island and 0,35 tsessebes/km^2 for the Boro floodplains.

Mass and measurements for tsessebes appear in Table 42.

External parasites:
(Acarina)
Rhipicephalus evertsi evertsi Neumann, 1897
(Cranial Diptera)
Oestrus sp. (prob. *O. aureoargentatus* or *O. variolosus*)
Gedoelstia sp.

Order Lagomorpha

Lepus saxitilis F. Cuvier, 1823
Scrub Hare; Mmutla

Scrub hares are scarce in the study area, none having been recorded by myself. Two recordings from a reliable witness resident in the study area warrent its inclusion.

Scrub hares are nocturnal and seem to prefer the drier areas being more common from the lower-Delta and surroundings as observed whilst travelling in these sectors.

Table 42 – Mass (Kg) and measurements (mm) of tsessebe from the study and adjacent areas, Okavango Delta, Botswana, March 1974 – August 1975.

DATE	SEX	MASS	TOTAL LENGTH	TAIL	HIND FOOT CUM UNGUIS	SHOULDER HEIGHT	EAR	SKULL		REMARKS
								Zygomatic width	Total length	
1 Mar. 1974	M	143	2 175	469	512	1 271	193	168	394	
17 Jun. 1974	M	136	2 340	518	556	1 220	194	159	389	
17 Sept. 1974	M	139	2 214	545	517	1 319	187	162	390	
13 Feb. 1975	M	134	2 274	530	546	1 323	196	165	419	
19 Feb. 1975	M	104	2 030	478	518	1 156	190	144	367	Subadult
9 May 1975	M	140	2 246	535	536	1 260	190	148	398	
12 Aug. 1975	M	141	2 301	586	545	1 345	185	156	385	
3 Sept. 1975	M	128	2 255	535	535	1 270	191	148	393	Subadult
3 Sept. 1975	M	119	2 250	548	537	1 255	189	149	399	Subadult
6 Sept. 1974	F	147	2 257	482	537	1 202	192	159	389	Pregnant *
2 Aug. 1975	F	117	2 113	482	530	1 200	194	151	376	
2 Aug. 1975	F	155	2 212	491	545	1 260	191	153	416	Pregnant

Order Rodentia

Family Bathyergidae
Cryptomys damarensis (Ogilby, 1838)
Damara Mole-rat

Damara Mole-rats are common and widespread throughout the floodplain systems and on the islands. From their burrow mound evidence they are only present on the verges of Chief's Island and interdigitating floodplains. Damara mole-rats occur typically on the open areas devoid of woody vegetation, viz. Primary and Secondary Floodplain Communities and *Sporobolus spicatus* Island Grassland Communities.

Habitat utilisation at any particular time is directly dependent on floodwater levels. During the driest seasons their typical conical mounds in winding rows are present in the Primary Floodplain Communities. As water levels rise they move onto Secondary Floodplain Communities and as these become flooded, onto *Sporobolus spicatus* Island Grassland Communities. In exceptionally high flood conditions they are forced into adjacent Closed Riverine Woodland, marginal vegetation types or some dryland vegetation types. They move prior to surface flooding and their movements are strong indications of flooding conditions shortly to prevail.

Damara mole-rats predominantly feed on underground tubers, bulbs, rhizomes and roots of sedges and grasses. They are communal, living in an underground burrow system and throw up mounds at intervals along this winding system. These mounds have typical sausage-shaped rolls when fresh, proceeding to the form of a conical mound and finally flattened when old and abandoned. Smithers (1971) states that they are more active during the wetter months of the year, and within the study area their activity was found to be correllated with rising and falling flood levels affecting their prime habitat.

Freshest mounds were always found to be terminal in the line of the burrow, and mole-rats were easily captured by disrupting and placing the special "Macabee" trap in this terminal mound. Eighty three per cent of males were caught indicating that these tend to show a stronger tendency to investigate and remedy disruptence to their burrow mounds than the females. Smithers *(op. cit.)* indicates that births may take place throughout the year, and that females carry three to five foetuses.

SIZES AND MASS

Males

TL	$\bar{X}$	=	160;	n	=	25;	range	122	–	200
T	$\bar{X}$	=	14;	n	=	25;	range	8	–	22
Hfc/u	$\bar{X}$	=	25;	n	=	25;	range	21	–	30
Mass	$\bar{X}$	=	103;	n	=	7;	range	61	–	150 g

Females

TL	$\bar{X}$	=	177;	n	=	5;	range	142	–	199
T	$\bar{X}$	=	15;	n	=	5;	range	13	–	18
Hfc/u	$\bar{X}$	=	27;	n	=	5;	range	21	–	31
Mass	$\bar{X}$	=	123;	n	=	3;	range	84	–	148 g

External parasites
(Acarina)
Androlaelaps capensis (Hirst, 1916)

Family Hystricidae
Hystrix africaeaustralis Peters, 1852
Porcupine; Noko

From quill evidence and a few sightings porcupines appear to be widely distributed on the M'borogha and Boro floodplain systems. Some evidence of porcupines exists on Chief's Island and due to their wide tolerance of habitat types (Smithers, 1971) they may occur there in high population numbers.

Porcupines were encountered in Closed Riverine Woodland, marginal vegetation types, *Acacia tortilis* and *A. erioloba* Savanna Woodland and dry Primary and Secondary Flood-plain Communities. Nothing is known of their movement patterns in the study area.

All live individuals were located at night occurring either singly or in pairs. During daylight hours they rest up in disused antbear holes. Breeding data for Botswana do not exist, but Ansell (1960) records juveniles from Zambia in August, December and March.

Family Pedetidae

Pedetes capensis damarensis Roberts, 1926

Springhare; Ntole

Springhares are widespread and common in the sandier portions of southern Chief's Island and the lower half of the Boro floodplains. Isolated sightings or droppings were found from sandy parts of northern Chief's Island and the adjacent Secondary Floodplain Communities. No evidence of springhare presence was found from the M'borogha floodplain system but they may be present in the northern sandy portions where dessication is advancing.

Springhares occur especially on the downgraded Secondary Floodplain Communities and nearly all specimens were recorded from this habitat. There is a strong tendency to remain in such areas except when flooding forces them to move to adjacent higher lying habitats.

Springhares are strictly nocturnal and occur singly, in pairs or groups but the latter may be interpreted as collections of singles and pairs in a confined floodplain (12 recorded as a group). They feed on bulbs, roots and young shoots of plants (Dorst and Dandelot, 1970).

Breeding occurs throughout the year and a single young at a time is born in Botswana (Smithers, 1971). No evidence ixists amongst the local population of the heavy utilisation of this species which is reported as a food source for the central and southern areas of Botswana (Silberbauer, 1965; Butynski, 1974).

Family Muscardinidae

Graphiurus murinus (Desmarest, 1822)

Dormouse

Only one specimen of dormouse was captured on the northwestern sector of Chief's Island in *Acacia tortilis* Savanna Woodland, close to the verge of Closed Riverine Woodland. Dormice are granivorous and insectivorous, nocturnal and arboreal (Smithers, *op. cit.*).

Family Sciuridae

Paraxerus cepapi maunensis Roberts, 1932

Bush Squirrel; seThora

Widespread and common throughout the islands of both floodplain systems and on Chief's Island. Bush squirrels are localised mainly in all the woodland communities, but are most common in Closed Riverine Woodland, *Colophospermum mopane* Woodland, *Acacia nigrescens* – *Croton megalobotrys* Woodland, *A. tortilis* Savanna Woodland and *A. erioloba* Woodland. They occur less commonly in *Combretum imberbe* – *Croton megalobotrys* Woodland and *Terminalia sericea* – *Combretum collinum* Savanna Woodland.

They are vegetarians, eating a wide variety of wild fruits, berries and seeds; and are avid thieves from bush camps, being especially fond of mealie meal. Smithers (1971) reports them eating fresh green shoots of *Acacia* spp., forbs and green *Cynodon dactylon.*

Bush squirrels are mainly arboreal but terrestrial to a lesser degree. They are strictly diurnal and occur singly, in pairs or in family units. The subspecies appears capable of breeding throughout the year, but there is a marked increase in breeding throughout the summer months, and lowest breeding peak during the winter months. Births are singles, twins or triplets (Smithers, *op. cit.*)

Family Octodontidae

Thryonomys swinderianus (Temminck, 1827)

Greater Cane Rat; QaQadi

No cane rats were observed in the study area, but local guides claimed that the species exists in the northern well-watered margins of Upper and Middle Channel Communities (*Phragmites* spp. and *Miscanthidium junceum).* Observed by myself outside of the study area at Matlapaneng and Smithers *(op. cit.)* also records them from here, from the northern Moremi Wildlife Reserve and from the "sleeve" of the Delta.

Cane rats are vegetarian, largely nocturnal and gregarious, but may occassionally be encountered during daylight hours.

Families Cricetidae and Muridae

Rats and Mice referred to collectively in seTswana as Peba

Otomys angoniensis maximus Roberts, 1924

Angoni Vlei Rat

Angoni vlei rats were captured along the Boro River verges of the western floodplains. Attempts to establish their presence in the same habitat type on the eastern floodplains were unsuccessful. However suitable habitat types do exist and they should be present in it as Smithers (1971) records them from lower down on this same system.

Angoni vlei rats appear to be confined to the margins of permanently inundated areas of tall grass and/or sedge vegetation i.e. the margins of Middle or Outlet Channel Communities, some Madiba, Sumps and Shallow Backwater Communities. They are largely vegetarian and granivorous, predominantly nocturnal and all specimens were collected during the hours of darkness. They occur singly, in pairs or in small family parties (Smithers, *op. cit.*)

Smithers *(op. cit.)* gives the breeding season for these rats as probably confined to between the months of August and March but states that births outside this period are possible. Three females captured in June were all non-gravid.

SIZES AND MASS

Males (n = 2)

TL	$\bar{X}$	=	255;	range	224	–	285
T	$\bar{X}$	=	90;	range	88	–	91
Hfc/u	$\bar{X}$	=	34;	range	32	–	36
E	$\bar{X}$	=	22;	range	20	–	24
Mass	$\bar{X}$	=	168,3g	range	161,2	–	175,4 g

Females (n = 3)

TL	$\bar{X}$	=	258;	range	198	–	300
T	$\bar{X}$	=	89;	range	65	–	111
Hfc/u	$\bar{X}$	=	32;	range	30	–	34
E	$\bar{X}$	=	21;	range	20	–	22
Mass	$\bar{X}$	=	199,7 g	range	182,8	–	223,4g

External parasites:

(Acarina)

Androlaelaps zulu (Berlese, 1918)
Listrophoroides womersleyi (Lawrence, 1951)
Ornithonyssus bacoti (Hirst, 1913)
Haemaphysalis sp.
(Anoplura)

Polyplax otomydis cummings, 1912

Pellomys fallax rhodesiae Roberts, 1929
Creek Rat

Only one specimen of creek rat (a sub-adult male) was trapped on the verges of the central Boro River. Smithers (1971) mentions the difficulties in trapping this subspecies and their absence in his records from apparently suitable habitat in the central Delta areas. They seem to overlap in occurrence with *Otomys angoniensis* and doubtless there must be more present from the verges of Middle or Outlet Channel Communities in the study area.

Creek rats are vegetarians, feeding on green plants, semi-aquatic and almost wholly diurnal (Smithers, *op. cit.*) states that the only available breeding records are from juveniles recorded between August and April.

Dasymys incomtus nudipes (Peters, 1870)
Water Rat

Five water rats were collected in the central area of the Boro floodplains. All were collected on the margin of an Outlet Channel Community in tall aquatic and semi-aquatic grasses and sedges. Although suitable similar habitat exists on the M'borogha floodplains, no specimens of water rat were collected there. All specimens were collected at night.

Water rats are largely nocturnal, but Smithers *(op. cit.)* reports some diurnal activity for the Kasane population. They are more strictly confined to the wet areas than *Otomys angoniensis*. Smithers *(op. cit.)* again postulates an August to March breeding season.

SIZES:

Male (n = 1)

TL = 310; T = 143; Hfc/u = 40; E = 20.

Females (n = 4)

TL	$\overline{X}$	=	297;	range	237	–	332
T	$\overline{X}$	=	149;	range	140	–	158
Hfc/u	$\overline{X}$	=	37;	range	36	–	37
E	$\overline{X}$	=	20;	range	18	–	22

External parasites:
(Acarina)

Laelaps roubaudi Taufflieb, 1954
Listrophoroides dasymus Radford, 1942

Leggada minutoides induta (Thomas, 1910)
Pygmy mouse

Only one specimen of pygmy mouse was collected on the verge of Closed Riverine Woodland adjacent to the Boro River. Smithers (1971) reports the pygmy mouse to occur from a wide variety of vegetation types and his distribution map confirms this. It is difficult to understand why so few occur in this wetter environment.

Pigmy mice are graminivorous, nocturnal and terrestrial. Smithers *(op. cit.)* reports them as breeding throughout the year, but with a peak in the summer months.

Praomys natalensis microdon (Peters, 1852)
Multimammate Mouse

Widely distributed and common throughout the study area and they show a wide tolerance of vegetation types, occurring in all but aquatic vegetation types. They were found to be especially common around camps and villages as the multimammate mouse is a commensal with man. Smithers *(op. cit.)* reports them as widely distributed throughout Ngamiland.

They commonly occurred on islands in Closed Riverine Woodland, all marginal vegetation types and the ecotone of adjacent floodplain or aquatic vegetation types. On Chief's Island they were recorded from all dryland vegetation types present.

Multimammate mice feed on grass seeds, *Acacia* spp. pods and seeds and other wild fruits. Where habitation is available they are omnivorous and feed on virtually all household edibles and gnaw on all plastics. They are nocturnal and terrestrial, and soon establish runs under groundsheets or any fixed camp equipment resting on the ground and are pests in any semi-permanent camp.

Smithers (1971) reports multimammate mice to breed in all months except that no record exists for June, but with a peak of activity in March. Of a sample of seven females caught in September 1973, six were gravid, carrying from seven to 17 foetuses.

SIZES AND MASS

Males

TL	$\bar{X}$	=	217;	n	=	22;	range	172 – 273
T	$\bar{X}$	=	105;	n	=	22;	range	80 – 132
Hfc/u	$\bar{X}$	=	23;	n	=	22;	range	20 – 32
E	$\bar{X}$	=	19;	n	=	22;	range	15 – 23
Mass	$\bar{X}$	=	49,8 g;	n	=	6;	range	33 – 81,8 g

Females

TL	$\bar{X}$	=	209;	n	=	19;	range	174 – 248
T	$\bar{X}$	=	99;	n	=	19;	range	75 – 117
Hfc/u	$\bar{X}$	=	22;	n	=	19;	range	20 – 24
E	$\bar{X}$	=	18;	n	=	19;	range	16 – 20
Mass	$\bar{X}$	=	57,8 g;	n	=	10;	range	24,3 – 88,9 g

External parasites:
(Acarina)

Androlaelaps marshalli Berlese, 1911
Cheyletus sp.
Laelaps roubaudi Taufflieb, 1954

Subfamily Gerbillinae

Tatera leucogaster (Peters, 1852)

Bushveld Gerbil

Widely distributed and plentiful especially on the sandy areas of Chief's Island and the larger islands. Some small islands with suitable sandy substrate also hold lesser populations.

Bushveld gerbils occur in *Acacia tortilis* Savanna Woodland, *A. erioloba* Woodland and Savanna Woodland, *Grewia* spp. – *Croton megalobotrys* Scrub Savanna, *Terminalia sericea* – *Combretum collinum* Savanna Woodland and Scrub Savanna and *Colophospermum mopane* Woodland and pyrophytic Scrub Savanna. Lesser numbers were found to occur on Secondary Floodplain Communities, marginal vegetation types and Closed Riverine Woodland.

They feed on fruit of grasses, fruit and seeds of shrubs and trees, grass rhizomes and bulbs (Smithers, 1971). They are terrestrial, nocturnal and live in warrens displaying well worn runs between the burrow openings. Young are born throughout the year with two to nine being the observed range of foetuses (Smithers, *op. cit.*).

SIZES

Males (n = 4)

TL	$\bar{X}$	=	235;	range	191	–	276
T	$\bar{X}$	=	119;	range	95	–	143
Hfc/u	$\bar{X}$	=	33;	range	30	–	36
E	$\bar{X}$	=	20;	range	19	–	21

Females (n = 14)

TL	$\bar{X}$	=	261;	range	221	–	308
T	$\bar{X}$	=	137;	range	115	–	164
Hfc/u	$\bar{X}$	=	34;	range	30	–	38
E	$\bar{X}$	=	20;	range	19	–	22

Tatera brantsi griquae Wroughton, 1906

Brants' Gerbil

Only one specimen of Brants' Gerbil was collected from the southern end of Chief's Island in a *Colophospermum mopane* Woodland ecotone with *Acacia erioloba* Woodland. The habits and food are much the same as for *T. leucogaster*, but *T. brantsi griquae* seems to tolerate drier conditions. The range of foetuses carried was lower (one to five) and the breeding season seems more restricted (Smithers, *op. cit.*) than in *T. leucogaster*.

PAST AND PRESENT WATER REGIME OF THE OKAVANGO DELTA

In the relatively short period for which verbal evidence and written account of the pattern of water distribution of the Okavango Delta is available, fairly radical changes have taken place. The major causes of these changes are seismic activity, consolidation of vegetation blockages via sedimentation and large aquatic animal movement. The result of seismic activity altering base levels in an area of extremely low gradient (1: 5 000) must be the most radical factor and will of necessity result in aquatic vegetation changes. All three factors mentioned above can act independently on one another but they more likely all interact in bringing about permanent changes of water distribution. The living blocks of *Cyperus papyrus* used in downstream navigation and the subsequent abandonment of such rafts together with seismicity has probably been the prime factors in the evolution of the Thaoge River blockages and the Nqogha blockage.

Minor alteration of water distribution is caused by large scale termitarium establishment and the evolution of aquatic vegetation and its friction to the passage of water. Clear-cut evidence of major and minor channel alteration exists from recent vegetation patterns depicted on aerial photographs (1969) in areas where no channels are even evident. Present ancient landforms provide some evidence of the past pattern of major water flow (Grove, 1969) outside the Delta. From all this evidence one can attempt to construct a hypothetical ancient to more recent water regime.

POSTULATED ANCIENT WATER REGIME : BEFORE 1849

The full extent of the rift system southwards from East Africa is poorly documented (Fairhead and Girdler, 1969). Using joint epicentral determination (J.E.D.) Fairhead and Girdler (op cit) show a western rift extension from Lake Mweru continuing southwards through Zambia, Rhodesia, Botswana and into the Republic of South Africa possibly as low as 24°S with incipient rifting presently extending this far. It should be noted that the man-made Kariba Dam once filled and lying on this western branch of the rift valley has been the cause of earthquakes (Fairhead and Girdler, *op. cit.)*; when supposedly no earth tremors were recorded from that area before. The mass of water overlying the Delta may also be contributing to the prevalence of seismic activity in this area. Scholtz, *et al.* (1975) believe the Okavango Delta to be the southwestern end of a belt of seismicity, apparently marking an incipiently rifting arm of the East African rift system; and that the tectonic activity associated with the Delta may be the earliest stage of rifting.

Schwarz (1920) had many erroneous ideas about climate and especially rainfall, but recognises ancient drainage lines tending to the southwestern corner of Botswana linking the Okavango and Orange drainage patterns. This is borne out by Gaigher and Pott (1973) in explaining affinities and similarities in fish fauna dating back to the mid-Pliocene of the Tertiary Era. This is probably the origin of the "great pan systems" of southwestern Botswana and the Northern Cape Province (*Tinley pers.comm.).

Some factor, possibly wind-blown deposits laying down the Kalahari Sands, has altered the drainage from a southwestern tending pattern to a southeastern tending one. Seismicity is not ruled out, but most major faulting in the Ngamiland and surrounding area tends on a northeastern to southwestern axis. Scholtz *et. al.* (1975) show the origin of the Delta's sleeve as parallel northwest to southeast tending faultlines, and Gaigher and Pott (*op. cit.*) date the late Pliocene of the Tertiary Era as a period when the Okavango, Upper Zambesi and Upper Limpopo drainage patterns were linked.

In Pleistocene times a vast inland drainage basin, the Makgadikgadi-Okavango Basin, is postulated (De Heinzelin, 1964). This basin was fed from the north by the Okavango, Kwando/ Linyanti, Zambesi and possibly the Luangwa River systems, terminating in an inland lake, the Makgadikgadi Lake. This lake initially had an outlet or overflow to the Limpopo River. The large channel which the Limpopo River has cut certainly bears out that this drainage system carried a greater quantity of water in earlier times. Due to the general absence of gradient in Botswana, the country geomorphologically is open to the formation of large inland lakes and deltas. After this period geological activity has caused uplift along Botswana's eastern frontier forming a divide in drainage pattern and largely cutting down on added discharge water to the Limpopo River. Fossil diatoms collected recently on either side of this divide show probable previous linkages of these water systems, and prospecting for diamonds initially yielded the first discoveries from alluvial soils to the east of the divide, whereas the Kimberlite bearing diamond pipes occur on the west of this divide (Civil Engineering Equipment Digest, 1972).

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PAST WATER REGIME : 1849 – 1968

Significantly, on Green's second visit to Lake Ngami in 1855, he agreed with the opinion expressed by one of its discoverers, "Those who had a desire to visit the Lake had better be quick about it, otherwise they would arrive to see a dry one" (Green, 1857). Most early visitors to Lake Ngami gave varying reports as to its previous size and differing reports as to the direction of water flow in the Nghabe or Lake River. It does seem probable that when Lake Ngami reached its greatest size that the Nghabe River did serve as an outlet or during periods when maximum floodwater discharge from the Thaoge River was flowing into the Lake. Under present conditions this is impossible and the Lake River drains towards the now virtually fossil Lake Ngami.

Of the early visitors, only Andersson (1856) and Green (*op. cit.*) penetrated the western Delta travelling up the Thaoge River in the hopes of establishing a navigable trade link to the west coast. Both explorers travelled up by mekoro and boat respectively as far as the baYei capital in the vicinity of Tubu Island. Green who had a custom boat specially constructed for this trip had to proceed beyond Tubu Island by foot up the western bank to Andara, and gave up all hope of an extensive navigable water course for trade. Schultz and Hammer (1897) investigated the possibilities of a trade link from the Zambesi/Chobe/Linyanti/Kwando System to the Okavango but also abandoned their ideas.

Until the time of Moremi II the baTawana apparently paid annual tribute to the haMambukushu to assure the continued season flow of water down to the Lake from Andara; as the haMambukushu were acknowledged as rainmakers and those responsible for all water coming down the system (Stigand 1923). Apparently burning (probably of the *Cyperus papyrus* obstructions) was carried out to increase the water flow down the Thaoge River. Physical efforts were made lower down the Thaoge system by the local inhabitants apparently to cut water flow to "Lake Ngami" supposedly to discourage Boer and other settlement around this area (Botswana National Archives, 1932).

The Lake appears to have truly dried up for the first time in 1895/96 (Stigand, *op. cit.).* At this stage movement of the old baTawana capital occurred several times. The capital town sites were chosen, established and changed, either due to excessive water flooding the sites or insufficient supply forcing upstream migration. These sites varied between Toteng and Tsau. Tsau was eventually chosen as the permanent capital (Stigand, 1913), but due to further dessication the capital town was moved to Maun in 1915, where it still exists today.

Captain A.G. Stigand, the then resident magistrate for Ngamiland, travelled the Delta extensively during 1909 to 1920, and provided the first reliable map of the Delta and documented the existing conditions at that time. During this period the Gomoti River delivered the greatest water discharge out of the Delta and into the Thamalakane River. Prior to these dates it is possible that the Mogohelo or Khwai River systems delivered their greatest discharge out of the Delta towards the "Mababe Marsh". When Livingstone visited the "Mababe Marsh" in 1851 it certainly still contained a small quantity of water (Schapera, 1960); and the existing extensions of the Khwai and Mogohelo drainage towards the Mababe Depression (the Mochaba and Zankuio Rivers respectively), certainly still bear evidence of channels which carried a good water discharge in the past. These same channels' distant extensions receive little or no water discharge even in exessive present flood years, viz. 1973/74 and 1974/75; and no floodwater reaches the Mababe River or the Depression at present.

Further faulting along the Linyanti/Chobe River systems have lead to this system's capture by the Zambesi River, and has deprived firstly the Mababe Depression and then the Savuti Marsh of discharge waters. The lower Savuti River channel and the Savuti Marsh dried up completely in about 1888 (Stigand: *In* Du Toit, 1925) and was only reflooded in about the mid 1950's probably as a result of excessive floodwaters in conjunction with surface blockages forming in the Linyanti/Chobe River system below the Savuti River mouth offtake. The presence of numerous hippopotami in the Kwando/Linyanti system and in the Savuti channel have probably played a significant role in the re-establishment of this Savuti System.

During the 1930's Colonel Naus (a self-styled hydrological engineer) commenced "channel improvement" at the M'borogha River split forming the Santantadibe and Gomoti Rivers headwaters. Naus' ideas of some methods for increasing channel discharge were erroneous, but he recognised the necessity of initially clearing the channel of vegetation and the **continual maintenance** of such clearing. Naus also conducted "channel improvement" via dams with narrow outlets on the Thamalakane River. During this period (as well as during Stigand's residence in Ngamiland) the Boro River was an annual river, whose discharge was only reliable for a few months of the year (less than 3 months) depending on the seasonal flood regime (Naus, 1936 b).

Naus (1934) had some good but conflicting ideas of the value of hippopotami in the Delta. "The principal causes of the water losses are hippo roads and melapos. Hippo are too numerous at places, their numbers should be reduced by expert killing, bearing in mind that they are exterminated nearer to civilisation where a number of these animals would be useful. The natives should not be allowed to kill them south of the N'Borogha and Santantadibe junction.

Melapos and hippo roads should be closed up." Naus does not take into account that hippopotami can move over large distances and that it is impossible to close hippopotamus paths with any lasting effect in such level areas where they are not confined to a single channel.

Naus' "improvement" work was questionable and although he convinced the administrators and the residents, the engineers Jeffares and Brind succeeded in getting his work terminated (Clarke, 1938). The hydrological engineers focused attention at this stage on the main Thaoge and Nqogha River blockages (Botswana National Archives, 1939). Martinus Drotsky was employed with large gangs of African labour to clear *Cyperus papyrus* vegetation and to straighten the channel in the main Thaoge River blockage (Fig. 25) as well as to conduct clearing work on the Nqogha blockage. All this work was in vain, since it was never properly completed or monitored, and in the absence of re-creating a channel without sufficient depth, velocity and discharge the aquatic vegetation will just recolonise the channel as happened here. Brind and McIlraith (± 1950) even developed a papyrus cutting machine but due to operating difficulties and lack of finance these clearing operations ceased.

During the 1940's the Santantadibe River was providing the major water discharge from the Delta into the Thamalakane River. Naus' work may have played some role here, but seismicity was probably the major factor. During the 1960's the Boro River evolved to provide the maximum discharge from the Delta into the Thamalakane River probably as a result of seismicity in conjunction with the total consolidation of the Nqogha blockage.

PRESENT WATER REGIME : 1969 – 1975

Only since 1969, when the Surveys and Training for the Development of Water Resources and Agricultural Production (BOT I Survey) was commenced by the Food and Agriculture Organisation (FAO) of the United Nations, was gauging and discharge of the overall Delta commenced. Inflow discharges are available for a longer period from the Okavango River where it transverses South West Africa. Some gauging stations in the Delta were closed after a short period (due to reasonably stable flow or difficulties in continuity monitoring such) and new gauging stations opened during the excessive floods of 1973/74 and 1974/75. However the overall position is a lack of data in general and an insufficient duration of recordings to provide accurate statistics and to predict future conditions. Nevertheless a base has been established and this is produced below.

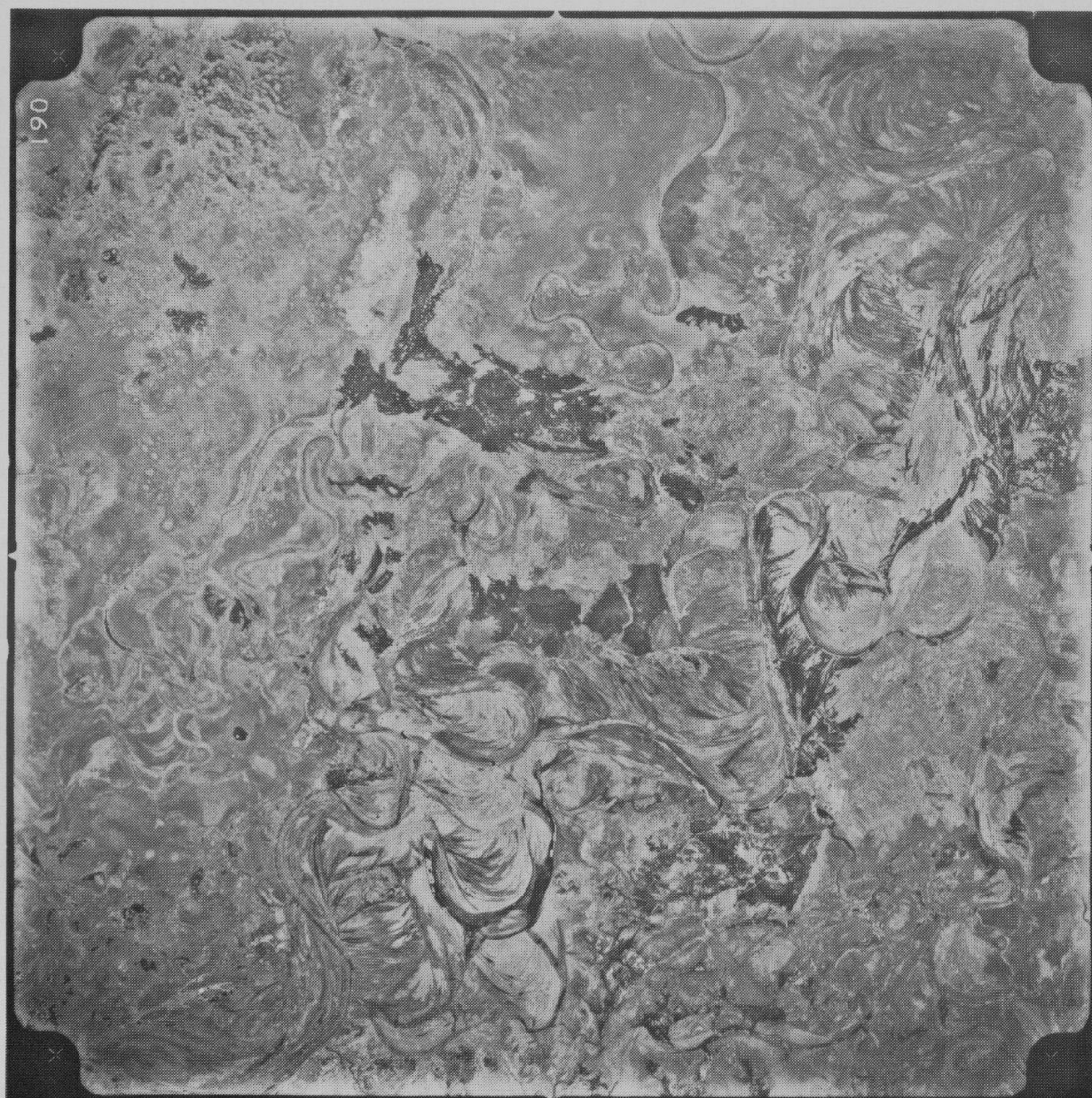

FIGURE 25 – The vast meanders of the ancient Thaoge River and its now virtually dead floodplain system, Okavango Delta, Botswana.

A hydrological year or season embraces average monthly flow rates in m^3/sec from October of one year to September of the following year. In many instances at certain gauging stations only one flow rate recording per month is available; whilst at less accessible gauging stations the frequency of flow rate recordings is even less. Some flow rate data prior to 1972 for certain stations are obviously incorrect and have to be adjusted. Such adjustments are naturally open to criticism and variation by different interpreters.

The Okavango River arises in southeastern Angola where the major tributory, the Cubango River has a catchment area of 115 000 km^2 and an average annual rainfall of 983 mm (Range 605 to 1 127 mm). This catchment area embraces the margin of the Bieplanalto (Benquela Plateau) whose surface is formed of crystalline rocks of the Fundamental Complex with a high, all-year-run-off, near the western end of the South Equatorial Divide (Wellington, 1955). The second major tributary is the Cuito River whose catchment area of 65 400 km^2 lies to the east in porous sandveld with a mean annual rainfall of 876 mm (Range 476 to 1 100 mm). The Cubango River thus forms the major and more reliable source feeding the Okavango River. In spite of this the average discharge of the Cubango River at Rundu is approximately 5 8000 x 10^6 m^3 per annum; and at Andara after the Cuito River as joined the mainstream approximately 11 000 x 10^6 m^3 per annum. This provides a discharge difference of the order of 600 x 10^6 m^3 in the two major tributries.

After the junction of the two major tributaries near Dirico the single channel of the Okavango River is formed. Further downstream at the gauging point of Mukwe (5 km northwest of the junction of latitude 18°S and longitude 21°E) good flow rate gaugings exist from the 1949/50 season. This Mukwe station gives an average annual inflow of 10 561, 20 x 10^6 m^3, or an average flow rate of 338 m^3/s. Figure 25 shows a histogram of peak discharge month.

The Okavango River continues flowing eastwards until Andara where it swings to a southerly direction and flows over the Popa Falls and then enters northwestern Botswana as a single channel at Mohembo. Shortly after Mohembo the Okavango River forms the "sleeve" of the Delta at the base of which the main continuation is the Nqogha River and a now minor distributary the Thaoge River takes off to form the western bank of the Delta. During the 1700's and the first part of the 1800's this Thaoge River was the main continuation of the Okavango River feeding "Lake Ngami". After this bifurcation water spreads out to form a large permanently inundated swamp area.

Figure 27 shows the present various channels and their average annual discharge rates for the available flow data. The present main continuation of the Okavango River; the Nqogha River at Duba (K3) gauging station shows an average discharge of about 94 m^3/s (1969/70 Average

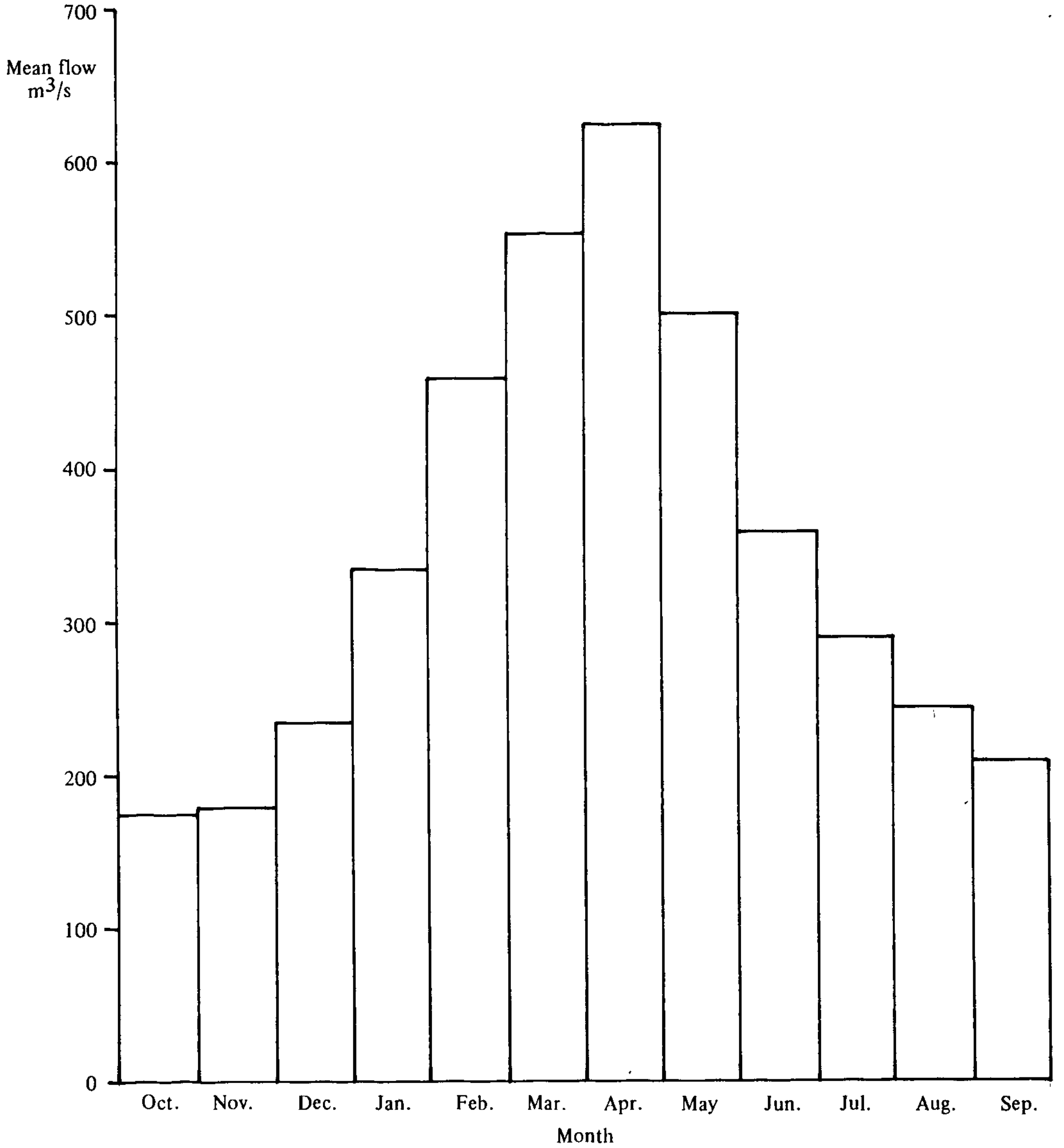

FIGURE 26 – Mean monthly flow rates (m^3/s) of the Okavango River at Mukwe in South West Africa for the period 1949/50 to 1973/74.

for 10 months). Since November and December are the months omitted the average may be considered slightly less. About 40 km downstream of Duba the Gaenga (K4) gauging station provides an average discharge of about 49 m^3/s (3 seasons' average discharge for 9 months). Both these stations are located on an upper channel and maximum monthly flow variation for Duba is 16 m^3/s and for Gaenga is 8 m^3/s between months of lowest flow rate versus months of highest flow rate. Below Gaenga the man-made "Smith's Channel" established in late 1973 is delivering an average of 10,38 m^3/s (9 recordings since established) of flow, but at an ever-increasing discharge in accordance with the flooding season. This channel in my opinion will deliver an ever-increasing quantity of water down the upper eastern system and may evolve to become the major Nqogha continuation.

From here downstream it is necessary to deal with the middle and outlet channel series of systems independently, starting from the east and proceeding to the west.

The Moanashira/Khwai/Mochaba/Kudumane drainage

At the gauging station KQ1 on the Moanashira River the average discharge is 10,38 m^3/s (1969/70, Average for 10 months). This discharge could be increased slightly since April and May recordings do not exist but the floodwaters had probably not yet arrived then. The maximum variation recorded for 1969/70 is 5,5 m^3/s. At the gauging station KQ2 near the base of the perennial swamps the average discharge is 3,10 m^3/s (3 seasons' average discharge for 8 months). At the gauging station KQ3 on the Khwai River (North Gate bridge) flow has been too unreliable for gauging, and the river often dried up completely for a few months during 1971, 1972 and 1973. Only during 1974 and 1975 was the water supply good at this gauge. The Mochaba River received a small flow of water during the 1973/74 and 1974/75 seasons, but the Kudumane and Mababe Rivers were dry throughout.

The M'borogha/Nambope System

These two middle channels are dealt with independently of the outlet channels arising from their system. These two middle channels fall almost totally within the study area and there can be no doubt that both were carrying a significantly greater discharge before events (seismic blockages and *Cyperus papyrus* rafts) altered conditions to the east of the northern tip of Chief's Island.

A major channel flowing north of Chief's Island and passing the bulk of water down its eastern margin and probably feeding the Nambope River which was its downstream continuation has

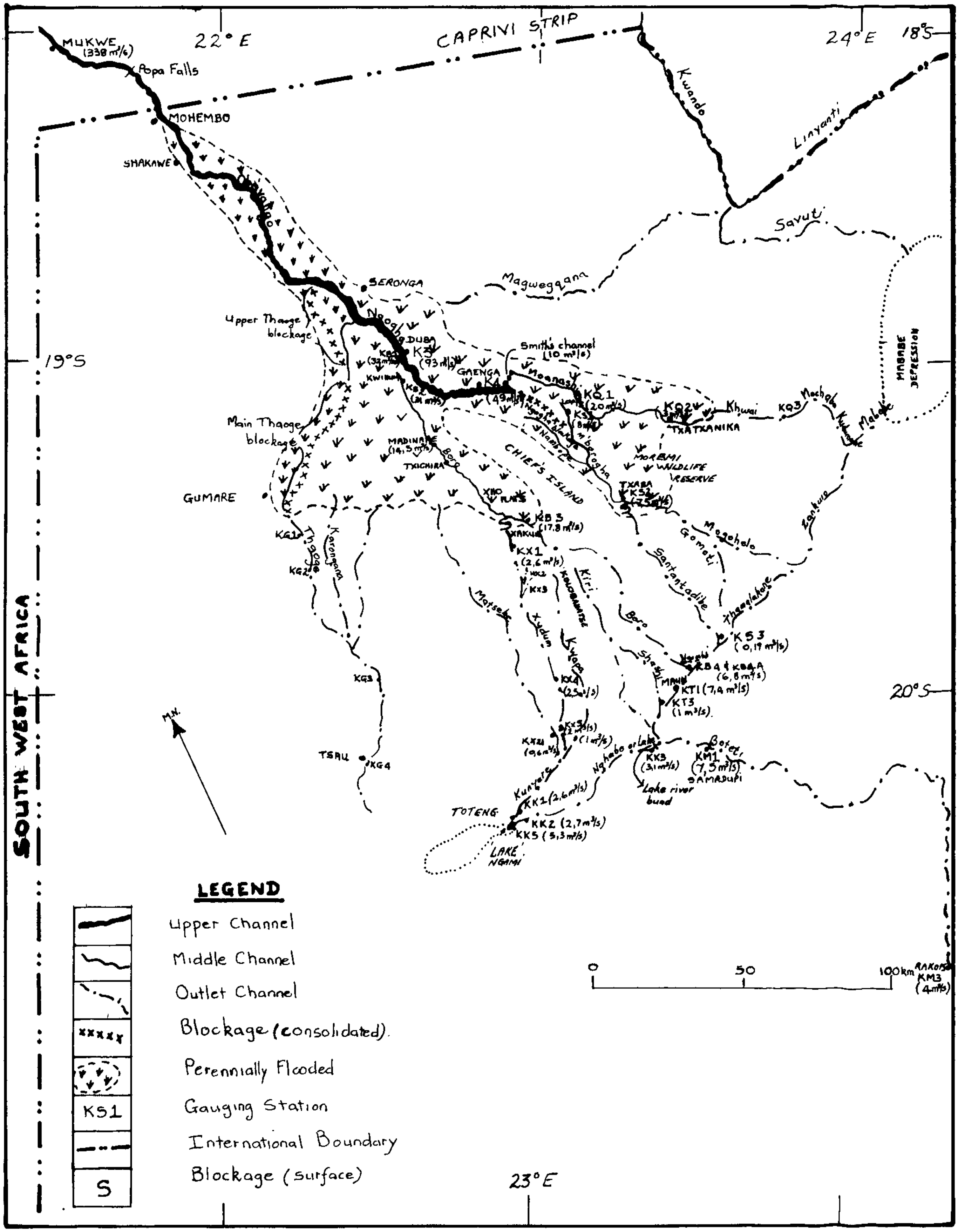

FIGURE 27 – Okavango Delta, Botswana, channel system and mean annual flow rate at main gauging stations (KGI, KQI, KBI, KTI, KKI, KMI etc).

become blocked and fouled with aquatic vegetation thus strangling this system. The consolidation of the old Nqogha blockage has likewise cut off major discharge down the M'borogha River and hence the dual reasons for the diminishing discharge from outlet channels arising to the immediate east of lower Chief's Island. Under the present regime these conditions can only perpetually worsen. At the KS1 (Lopis or Qusai) gauging station there is an average discharge of 8,32 m^3/s (3 seasons' average discharge for 6 months) and at KS2 (Xaba) an average discharge of 7,59 m^3/s (6 seasons' average discharge for 9 months). The high average at Xaba gauging station is maintained by the inflow of the Nambope River to the M'borogha River above Xaba Island. No flow measurements were available for the Nambope River.

The Mogohelo/Zankuio drainage

No gauging sites exist and neither are any flow measurements taken in this drainage system due to the fact of its progressive evolution towards a decreased discharge probably from the early 1900's. During the extreme high flood years of 1973/74 and 1974/ 75 floodwaters pushed well down into the Zankuio River, but reached nowhere near to its link with the Mababe River. With the decreased discharge of floodwaters down the M'borogha/Nambope Rivers drainage, this system can probably be considered as drying up.

The Gomoti River drainage

The Gomoti River is also no longer gauged. Naus (1937) reported that this River was drying out, and conditions have progressively worsened so much that the Gomoti River only delivers a small discharge into the Thamalakane River in extreme high flood years viz. 1973/74 and 1974/75.

The Santantadibe River drainage

Ellenberger's (1931) boat trip and report show the Santantadibe River to be in fairly poor order (September/October).

Roberts (1955) reported the Santantadibe River as the only channel permitting a fairly free passage by boat at this time (July) of the year, and to offer the most favourable route for conducting water from the swamps. Naus (1936 b) reported practically the whole discharge from the M'borogha as feeding the Santantadibe River, whilst the Gomoti River was only being fed through swamp leakages. Discharge conditions have obviously improved initially down the Santantadibe River at the expense of water flowing down the Gomoti River. These conditions have persisted until the 1960's when the Santantadibe discharge has become negligible when compared with that of the Boro River. At the Malalakaka (KS3) gauging station the average discharge is 0,19 m^3/s (4 seasons' average of 7 months). The Santantadibe River system under present conditions can also be considered as slowly drying up.

All three above drainage systems have been radically effected by loss of upstream discharge, caused by blockages and seismicity. From earlier reports of Ellenberger (1931) and Naus (1936 a) it is clearly evident that hippopotami were far more numerous in these systems, and that other channels existed then (Naus, 1935).

The Jao/Ncwarelanwana/Boro System

Collectively this whole system is known as the Boro River today. Stigand (1925) states "The Boro River has been dry for the past 4 or 5 years except at the height of the Flood season, when an inconsiderable amount of water comes down it." During 1931 (August-September) Ellenberger travelled up this system and reports travelling over last season's mealie lands in the lower Boro River. Jeffares (1938) states the Boro River discharged flood water for 5 months of the 1937/38 season providing about 9 m^3/s at peak flow on July 27th, 1937 but down to about 2 m^3/s by the 5th of October.

The Boro River cross channel inflow (KB1) gauging station shows an average discharge of 32,67 m^3/s (1 season average for 9 months).

The Kwihum (KB2) gauging station shows an average discharge of 31,68 m^3/s (2 seasons' average for 9 months), whilst lower at Madinare Island the Boro River shows an average discharge of 14,50 m^3/s (3 seasons' average for 8 months). At the mid-Boro River gauging station of Xakwe (KB3) the average discharge is 17,84 m^3/s (6 seasons' average for 9 months). This downstream increase is attributed to added water provided from the west into the Xho Flats area. At the Boro River junction with the Thamalakane River gauging station (KB4 and KB4A) the average discharge is 6,86 m^3/s (7 seasons' average for 11 months). This station was dry for 2 months in the 1969/70 and for 3 months in the 1972/73 floodseasons. This Boro River drainage is undoubtedly the system which will be concentrated on for improving the Delta's outflow since it is the system evolving to greatest discharge in recent years. The Ngombi or Xasinare primary floodplain (melopo) is significantly important in the lower Boro River drainage and was discharging up to 3,48 m^3/s during peak conditions in poor flood years prior to being bunded off by the Anglo American Corporation and on average took 28,91 per cent of Boro flow during 1972. The Boranyane delivers a small discharge in high flood seasons.

The Kiri/Shashi/Xotega drainage system

This system varies from being dry throughout the season (1972/73) to flowing throughout the season (1974/75) after a previous good flood season. Under average conditions it can be expected to be dry for 6 months of the hydrological year. Average discharge at the Shashi junction bridge (KT3) is 1,02 m^3/s (7 seasons' average for 12 months).

The Kwapa/Xudum/Matsebe/Kunyere drainage system

This system has not been as carefully monitored as some of the other more reliable systems, as it is dry or contributes very little discharge in all except good flood seasons. The lower reaches of the Xudum and Matsebe Rivers delivered greater average sustained discharge from heavy local rainfall viz. 1973/74 than from the good floodwaters of the 1974/75 season, although peak discharge was highest in the 1974/75 season. This serves to illustrate the importance of "the previous degree of saturation factor" and the importance of heavy local rainfall.

The lower reaches of the Kwapa River show an average discharge of 1,03 m^3/s (2 seasons' average for 12 months) in good flood seasons, but at this point it is still dry for about 7 months of such seasons.

The Xudum River is the most important one of this drainage system, delivering the greatest and most sustained discharge. The upper Xudum River at KX1 discharges 2,67 m^3/s (3 seasons' average for 8 months). This discharge includes the 1972/73 poor flood season and the Xudum River at this point is dry for 6 months in poor flood seasons, and for an average of 2 months in good flood seasons. The central Xudum River at KX4 discharges on average 2,59 m^3/s (2 seasons' average for 11 months), but has received inflow from two melapos (KX2 and KX3) providing about 0,25 to 0,50 m^3/s respectively in good flood or rain seasons. KX4 is dry on average for 4 months of good flood seasons. The lower Xudum River at KX5 discharges on average 2,05 m^3/s (2 seasons' average for 12 months); and is dry for an average of 6 months in good flood seasons. In poor flood seasons KX5 receives little water or may even be dry throughout the season.

The Matsebe River's lower reaches show an average discharge of 0,67 m^3/s (2 seasons' average for 12 months); but only flows in this region in good flood years and even then is dry for an average period of 6 months per season.

The Kunyere River is of importance, as it and the Nghabe or Lake River are the only two rivers now feeding "Lake Ngami". In recent years the discharge of the Kunyere River has visually decreased, (*M. Clements pers.comm.) apparently due to blockages of the upper reaches of the rivers draining into the Kunyere River (mainly the Upper Xudum River). Flow rate recordings for the Kunyere River apparently show some obvious errors (**Wollander, pers.comm.) and these have been revised on the advice of the above government official. Since gauging commenced it is clearly apparent that Clements' observations are correct and the discharge in this river system has dropped drastically, probably due to changes in the upper reaches of the systems feeding it (Table 43).

The average flow is 3,19 m^3/s (5 seasons' average for 12 months omitting 1972/73) or 2,66 m^3/s (6 seasons' average for 12 months) if the totally dry 1972/73 season is included. On average, the Kunyere River is dry for four to five months during good seasons and for 10 to 12 months during poor seasons. The importance of this drop in discharge to the continued existence of Lake Ngami cannot be over-emphasised.

The Thaoge/Karongana drainage system

There is no doubt from past evidence (Andersson, 1856; Green 1857; Stigand 1923) and the large ancient floodplain systems that the Thaoge River was the former main continuation of the Okavango River ending its discharge into "Lake Ngami". Blockages in the upper reaches of the Thoage River from *Cyperus papyrus* rafts and possibly seismic activity have resulted in this great river's death. Unless massive changes take place in the Upper Delta it is unlikely that the Thaoge River will ever be re-instated to its former discharge.

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* M. Clements (now deceased).

** B. Wollander, Department of Water Affairs, Private Bag 0029, Gaborone, Botswana.

Table 43. Average seasonal discharge rates (m^3/s) of the Kunyere River, Okavango Delta, Botswana, 1968/69 to 1973/74.

SEASON	AVERAGE FLOW OVER 12 MONTHS	MONTHS DRY OR NO FLOW
1968/69	9,71	5
1969/70	4,30	4
1970/71	0,67	9
1971/72	0,06	10
1972/73	0,00	12
1973/74	1,22	7

Due to the prevailing situation little monitoring of this system takes place, and as such only isolated significant measurements can be quoted. At Nokaneng gauging station KG1 the 1968/69 average discharge was 0,55 m^3/s (3 months recordings). During March and April 1974 the average discharge rose to 6,24 m^3/s. At gauging station KG2 no water had reached the gauge since installed, (19 April 1969) by 1 February 1974. On 9 March 1974 the guage could not be found as water was probably flowing right over it. At Masamo gauging station KG3, 3,70 m^3/s was flowing on 21 June 1974. Note here that a large amount of this water (approximately 1,5 m^3/s) is derived from the Karongano and its associated river systems. At the Tsau bridge gauging station KG4 a peak of 6,69 m^3/s was flowing on the 19 April 1974. A large amount of this water must have been derived from local catchment above the gauging station.

The Thamalakane/Boteti/Nghabe drainage system

This system embraces all drainage collected from the central and lower eastern sectors of the Delta, providing a minor percentage of discharge to "Lake Ngami" and the major discharge eastwards towards the Makgadikgadi pan system. The average discharges presented here are over a longer period due to their importance for human and industrial utilisation and the easier accessibility to gauging stations.

The Maun bridge (KTI) gauging station on the Thamalakane River provides an average discharge of 7,40 m^3/s (7 seasons' average of 11 months). The discharge recordings vary from zero flow (March to June 1973) to 37,03 m^3/s in July 1975. Due to several questionable discharge recordings the average of 7,40 m^3/s may be regarded as slightly low, or the KMI gauge average discharge slightly high.

Between gauging station KTI and KMI the Shashi and Xotega Rivers add discharge to the Thamalakane River. This is of the order of 2,0 to 2,5 m^3/s annual average at high flow and between 0 and 1,5 m^3/s annual average in poor seasons accounting for the increase at KMI.

The Samadupi (KMI) gauging station on the Boteti River provides an average discharge of 7,58 m^3/s (5 seasons' average for 12 months). The discharge recordings vary from zero flow (April to July 1973) to 38,0 m^3/s in August 1975. A rise in water level of just below 2 m occurs between low and peak flood conditions. The average dry period is one month, varying from 4 dry months in poor flood seasons to continually discharging water in good flood seasons. The Makalamabedi gauging station at Ramothupi Drift (KM2) is not assessed since data are incorrect. The Rakops gauging station (KM3) provides an average discharge of 4,13 m^3/s (6 seasons' average for 11 months). On average KM3 shows no flow for almost 6 months of the year and discharge varies from zero flow to 26,2 m^3/s recorded on 20 August 1975.

Further down the Boteti River no reliable discharge rates could be obtained but Bauer (1975), who produced a "mathematical swamp model", has estimated the discharge at Mopipi from hydrographs to show a time lag of between one and two weeks between Rakops and Mopipi and the discharge peak to reach about 85 per cent of the Rakops flow. A more accurate average discharge figure is probably in the region of 80 per cent of the Rakops flow.

For the period 1952/53 to 1968/69 the Ngabe River received 40 per cent of the Thamalakane discharge and the Boteti River 60 per cent. The bund established just after the Ngabe River take-off resulted in only 28 per cent and 9 per cent of the Thamalakane River's discharge flowing down the Ngabe River in the 1969/70 and 1970/71 seasons respectively. This effectively robbed Lake Ngami of 46,99 and 24,76 x 10^6 m^3 of water during these seasons respectively, and together with the decrease in Junyere River flow is assisting to kill the Lake. On average the Ngabe River should discharge about 3,1 m^3/s annually at KK3 and about 2,7 m^3/s at gauging station KK2. Table 44 illustrates the actual flow in the Thamalakane River and the expected and actual flows in the Ngabe River at KK2 for the period 1968/69 to 1974/75 and shows the loss due to the bund. This loss would normally lead to a combined average inflow in Lake Ngami of 5,36 m^3/s at KK5 from the Kunyere and Ngabe Rivers. The main inflow rate at Lake Ngami given by the UNDP BOT I Survey of 9,57 m^3/s is considered an overestimate as their average discharge at Maun Bridge KTI is considered excessively high.

Average discharge for KK5 varies from no flow to a peak of 16,74 m^3/s for August 1975 but this gauge is dry on average for eight to nine months of the year.

Table 44 **Actual flow rates (m^3/s) in the Thamalakane and Shashi Rivers and actual and expected flow rates in the Ngabe River affected by bunding at the base of the Okavango Delta,Botswana,during the period 1968/69 to 1974/75.**

SEASON	MEAN ANNUAL FLOW RATES				
	Thamalakane KT1	Shashi KT3	Thamalakane KT2	Ngabe KK3 Expected range	Ngabe KK3 Actual flow
1968/69	9,54	2,23	11,77	3,06 – 4,12	3,07
1969/70	6,72	1,05	7,77	2,02 – 2,72	0,88
1970/71	3,17	0,29	3,46	0,90 – 1,21	0,27
1971/72	2,49	0,01	2,50	0,65 – 0,86	0,00
1972/73	1,37	0,00	1,37	0,36 – 0,48	0,00
1973/74	10,59	1,27	11,86	3,08 – 4,15	1,60
1974/75	17,89	2,30	20,19	5,25 – 7,06	4,44

WATER MANIPULATIONS AND ITS EFFECTS ON THE ECOLOGY OF THE STUDY AREA

The limited manipulation work of channel improvement and "melapo" bunding (Fig. 28) carried out to date by Anglo American Corporation can only have localised effects on the lower Boro River and its floodplain system. These manipulations in no way effect the study area. The bund however established by Anglo American at the headwaters of the Ngabhe Eiver has seriously diminished flow rate and quantity of water reaching Lake Ngami, and successfully provided greater discharge down the Boteti River.

Natural Alterations

Flooding patterns of the system fluctuate from excessive inundation depths and floodwater duration in good flood seasons to zero inundation more often in poor flood seasons. The prevailing situation is that from the vegetation point of view some parts of the mid and upper-eastern floodplain tracts are showing a drying out tendency and are slowly evolving towards marginal and dryland vegetation types. Chief's Island itself has evolved as an increasingly larger sized land mass by absence of floodwater penetrating both ancient Primary and Secondary Floodplain Communities. By being deprived of surface water, woody vegetation encroachment

FIGURE 28 – Bunding of Primary Floodplain Communities by Anglo American Corporation offstream of the lower Boro River floodplain system during 1973, Okavango Delta, Botswana.

and development has served to unite adjacent islands and to expand this dryland mass. This is clearly more evident and recent in the northern Chief's Island area where old residents pointed out areas which they claimed used to be open grasslands, (Secondary Floodplain Communities) but which were now covered by one or other of the marginal or dryland woody plant communities. Piajio area on the northwest side of northern Chief's Island has been encroached by woody plants, and today supports a denser stand of woody species than that which is depicted by the 1937 oblique aerial photographs. The Piajio area Primary and Secondary Floodplain Communities in earlier years cut right across Chief's Islands. No water even penetrates some of these more ancient flooded areas today even in excessive flood years viz. 1973/74 or 1974/75. Several old "channels" or ancient Primary Floodplain Communities with clear-cut channels in both the extreme northern Chief's Island area and the central and upper eastern floodplain areas receive no water in poor seasons and small quantities in high flood seasons.

On the western floodplains the margin of Chief's Island is expanding. This process will have temporarily been curbed by the excessive 1973/74 and 1974/75 floodseasons; but it is predicted that this tendency will continue unless the Boro River carries an increased average water discharge. The present tendency of Delta distributary discharge seems to be evolving to a greater volume of water being carried by the Boro River.

The continual establishment (during dry conditions) and erosion (during wet conditions) of termitaria leads to the latters' significance in altering base levels (Fig. 29).

Man-made Alterations

The overall tendency of Delta evolution appears to be an expansion of the permanently flooded area at the expense of the seasonally flooded area (Clements **pers.comm.**.) with which I agree.

If floodwater conditions remained as for the 1973/74 and 1974/75 flood seasons, no manipulations or improvements to outflow would be required whatsoever. Since these conditions can never be maintained, manipulations will sometime be brought into effect with the prime object in mind being to provide sufficient sustained outflow. Several logical methods are available and each and its possible effects will be dealt with independently.

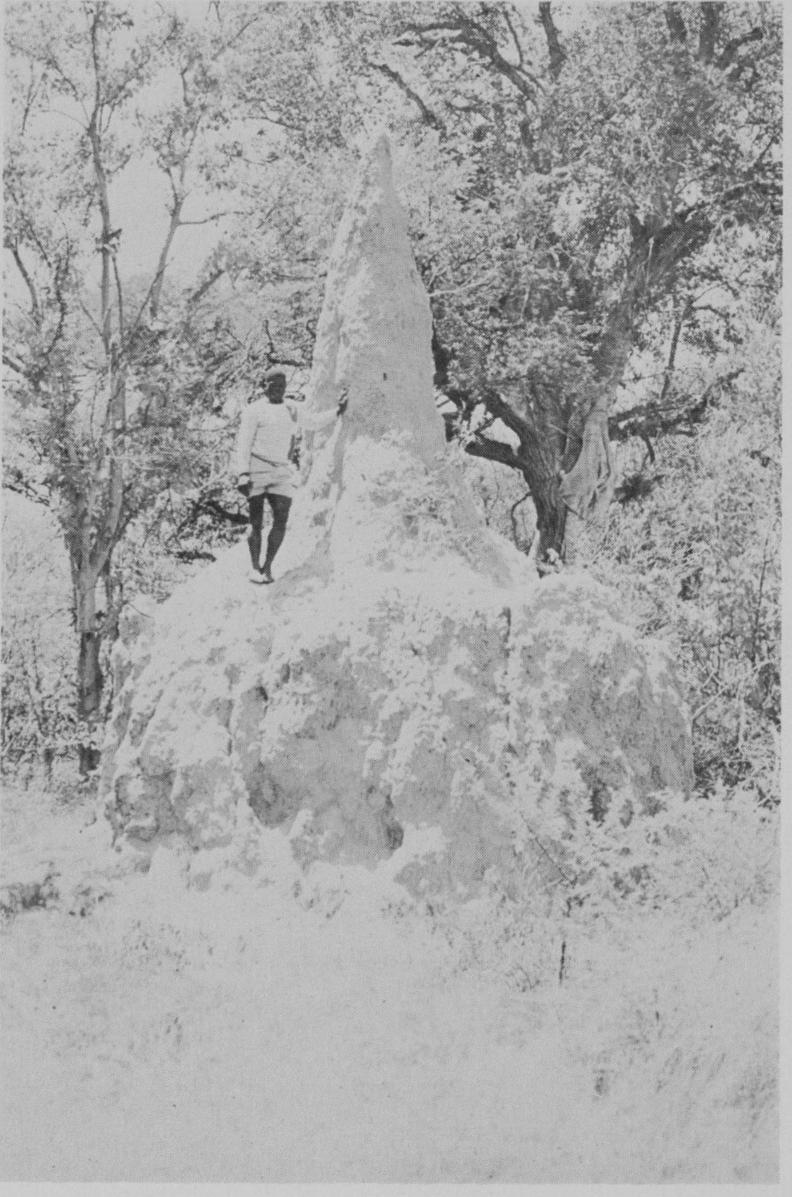

FIGURE 29 – The enormous size of termitaria in the Okavango Delta, Botswana and their subsequent evolution to form raised ground levels for woody vegetation establishment and local altered base levels can easily be gauged from this figure.

Peripheral Pipeline

The establishment of a pipeline has been investigated by previous workers (Lund, 1965, Sweco, 1973) but discounted due to the high economic cost involved. From an ecological, sociological and overall reliability point of view due to the seismic activity prevailing, the pipeline offers the only method without possibly causing irreversable internal Delta manipulations. All other schemes are dependent on the stability of the present reigning water regime and the increase in output down the Boro River system. The cost of such a pipeline due to the distances involved and the locality and gradient is, however, prohibitive.

This scheme would involve water being withdrawn from a suitable point at the base of the Delta's sleeve in the vicinity of Sepopa (Fig. 30). Water would then have to be piped via Gomare, Nokaneng, Tsau, Sehitwa and Toteng to Maun and Shorobe. Steel pipes should be used to keep friction losses at a minimum and thus ensure that the hydraulic grade line remains above the pipe and that positive flow is maintained. Pipe diameter affects friction loss and thus pipes must be sized to keep the hydraulic grade line between the straight line joining Sepopa and Maun and ground level. Pipes must follow the ground contours at a constant depth where possible.

Pumping on the main line is disregarded because of the isolated conditions affecting maintenance, and because of the large distances involved, the pumping head required to significantly alter the hydraulic gradient would involve numerous pumps and their maintenance. The water would have to be chlorinated at Sepopa to eliminate bacteria which corrode the pipe or grow in the pipe and restrict its free-flow cross-section. A further small dose of chlorine would be required at each distribution point. This would involve a 'chlorine gas' plant at Sepopa and Maun and smaller 'hypochlorite' plants at each of the other distribution points.

At each distribution point water from the pipeline would first go to a reservoir with two days storage capacity. It would then pass through the chlorination plant from where it would be pumped into a water tower, which would give it sufficient head for distribution. This would provide for human and live-stock requirements on the basis of 100 ℓ/head/day for humans, 50 ℓ/head/day and 5 ℓ/head/day for large and small stock respectively. The approximate cost of such a scheme is in the vicinity of R42 million, but may be in error by as much as R10 million (*P. Hahn, *pers. comm.*).

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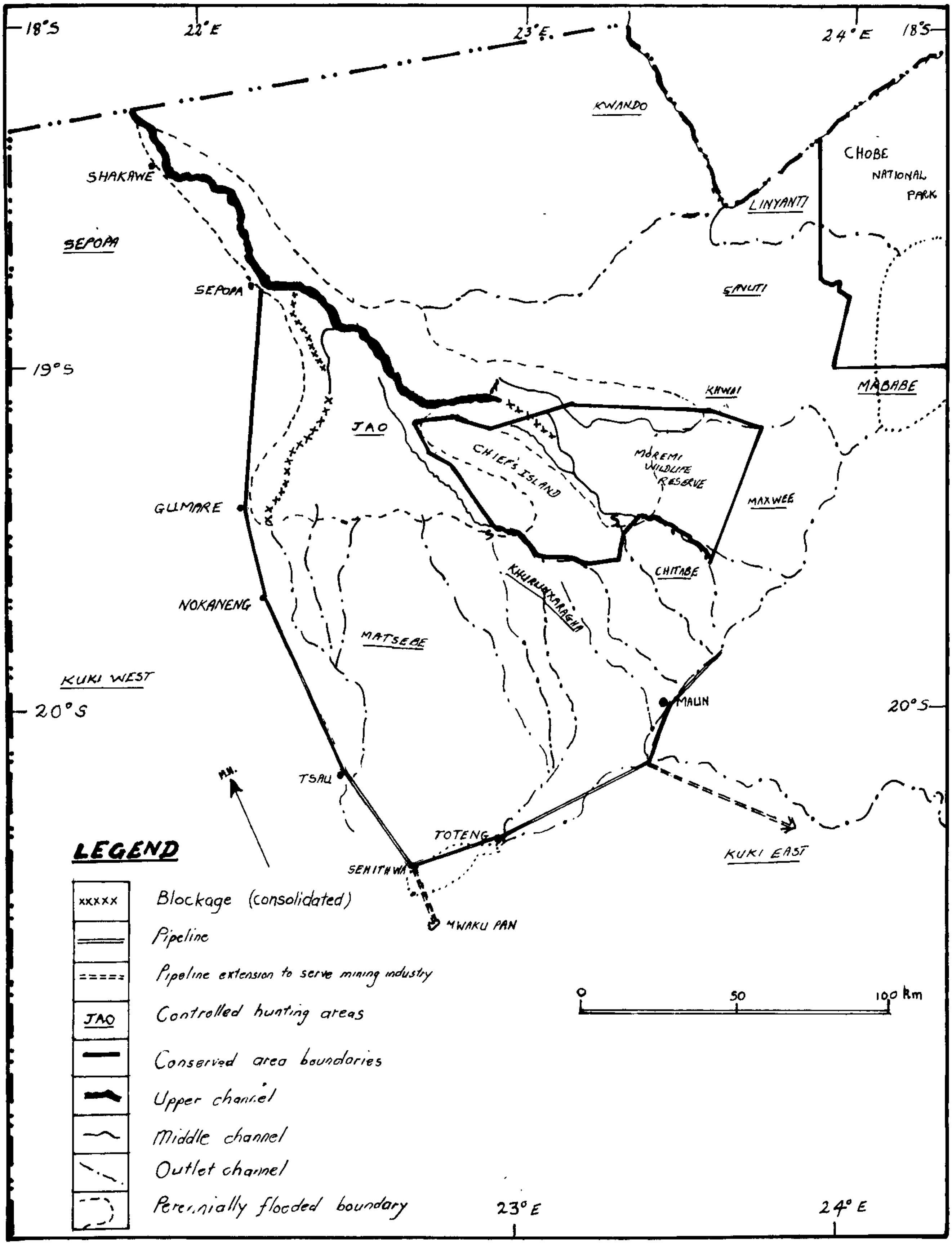

FIGURE 30 – Okavango Delta, Botswana, proposed pipeline and controlled hunting areas.

It is possible to supply all the water needs of Orapa and Letlakane diamond mines as an extension to the proposed scheme. In such a case all the pipes from Sepopa will have to be of larger diameter, implying higher pipe, transport, laying and accessory costs; and in addition the Maun-Mopipi pipeline. The estimated cost of the whole scheme would be R110 million.

Further modifications could also supply the Copper deposits of Ncauko Pan and later the coal deposits to be exploited at Matsitamma. The water demands made for irrigation projects are unrealistic, since the soils are generally poor and Ngamiland having a low agricultural potential does not warrant such water to be sensibly piped.

Improved outflow and control in the lower Boro and upper Boteti/Nghabe River system

This scheme firstly involves the removal of the Lake River bund to ensure the old water distribution down the Nghabe and Boteti Rivers, and thus a fair supply to Lake Ngami. The present bund should be transformed into a shallow control section, and then a flow control structure established at Samedupi on the Boteti River. This latter control structure should form an integral part of the wall for a reservoir dam at Samedupi (if the following proposed scheme is adopted). The following stage would be to complete the dredging up to the Kunyere fault line which the Anglo American Corporation was prevented in completing. Bunding of this lower Boro River section should be allowed to prevent water loss and enhance flow out of this lower section where floodplains are hardly required.

Low overfall weirs to form shallow storage facilities at sites from which water could be pumped to off-stream cattle ranches may be required.

This scheme would slightly effect the lower Boro River ecology but involves no manipulations higher up in the Delta and thus due to its much lower costs is probably the best scheme for improved output. Should flow down the Boro River be altered significantly the scheme may prove to be inadequate.

Storage on the Thamalakane/Boteti/Nghabe River System

This scheme is a direct extension of the previous scheme. It involves the extension of the Samedupi control structure to the dimensions required for a reservoir dam, and the construction of a control reservoir dam at Toteng.

These two dams would effectively form a river valley storage reservoir with a maximum capacity of 168 x 10^6 m^3 (Ernest, 1976). Ernest (*op. cit.*) claims that this scheme will not affect natural flooding pattern downstream which has to be maintained for the riverine populations, but would guarantee a minimum continuous outflow. This could be directly pumped from a small reservoir at the Mopipi terminus into the existing high lift system thus saving on low lift pumping costs and improving the quality of water to Orapa.

This scheme is dependent on increased Boro River outflow to fill the river valley reservoir, and thus would involve further manipulations on the Boro River affecting its middle reaches ecology. Also, should water distribution in the Delta change significantly, the scheme will prove inadequate in supplying water demands.

Redistribution of flow in the central branches of the seasonal swamps via bunding, culverts and control weirs.

This scheme involves restriction and prevention of floodwaters entering certain Delta areas, and thus recovering potential infiltration and evapotranspiration losses in the central Delta axis. The bunding would be irreversible but the control gates would remain open to allow flooding under "normal" conditions, but will remain closed throughout when insufficient flows are forecasted.

The bund line will follow the Khurunaragha/Txichira line of islands ridge, starting near Kolobahtse and extending northwards as water supply demand increases. This will effectively retain Kiri River water from reaching the Khwapa River in all but good flood years. As the control line extends northwards so it will also cut Boro River losses to the Xudum and Matsebe River systems. Since this will drastically affect the Kunyere River, being the natural intercepter channel for the above three affected systems, Kraatz (1975) preposes creating a diversion weir on the Xotega River to recompensate flow down the Kunyere River for local inhabitants and to feed towards Lake Ngami. Ernest (*op. cit.*) mentions the upstream limit of bunding as dictated by need to maintain flow in the Matsebe channel for wildlife and cattle. Further work will require channel cutting for improvement of flow between the Xotega/Kiri and Shashe River systems and finally additional 'upstream measures' to further increase outflow if required. These presumably infer Boro River channel improvement and bunding from Xakwe southwards on that river to the Kunyere fault line. Kraatz (*op. cit.*) has also proposed drainage trenches in the Boro River's *Cyperus papyrus* filter community intake to increase the Boro inflow.

This scheme, if carried out, will definitely affect the ecology of the lower Khwapa, Xudum and Matsebe River's and their floodplains. If the entire ridge is controlled the prime wildlife floodplain systems of upper Khurunxaragha and Ngabegha will effectively die. The further bunding on the Boro River from Xakwe southwards cannot be condoned as this will kill the middle and lower Boro floodplain systems. Any manipulations in the Boro River intake can have far reaching effects in blockage formation from sudd. Boro River channel improvement to increase outflow without the use of bunding should rather be resorted to.

Improvement of the Thaoge River channel

Large water demands have been made by Sweco (1973) for irrigation schemes on the old Thaoge floodplain system. Although these soils offer a better agricultural potential then others of the Delta or Ngamiland they cannot be considered as prime arable land and this scheme may well never reach its proposed production.

However, any water required for agricultural production in this area will have to be obtained from rehabilitation of the Thaoge River as proposed by Ernest (1976). Basically this involves the recleaning of the middle Thaoge between Gomare and the Karongana confluence, with some bends requiring shortcutting over this 130 km strip. Next, the middle Thaoge would have to be connected to the base of the permanent swamp in the northwest via a bypass channel of some 22 km in length, which partially exists but would require improvement in width and depth over crucial parts. Further channel cleaning and shortcutting upstream of Gomare and a 4 km channel excavation to bypass consolidated blockages should in all restore a perennial flow as far as Tsau. However none of this work is worthwhile unless large-scale crop irrigation can be successfully conducted on the Nokaneng Flats.

The scheme which will provide for minimal alteration to the ecosystem and maximum sustained water take-off without any loss via evapotranspiration is the piping of water from the upper-Delta. Each distributary system will lose a small amount of water proportional to the present flow. Any further natural internal Delta changes affecting water distribution cannot affect the pipeline unless seismic activity affects the pipeline itself. Although excessively expensive to establish, the upkeep costs will be minimal once it is in operation. No irreversible damage can be caused to the Delta and the predictability of the scheme is sound.

In conjunction with the peripheral pipeline the establishment of the Thamalakane reservoir with control weirs at Samadupi and Toteng could be considered. This will provide for a further backup supply for human, stock agriculture, mining and other industrial use, as well as creating a potential for fisheries and tourism. Part of "Lake Ngami" could also be kept alive from this scheme. This scheme could initially be put into operation with the peripheral pipeline to follow.

The only internal Delta manipulations should possibly be slight channel improvement to the Boro River channel itself from Xakwe southwards. The only bunding on this channel should be below the Kunyere fault line. The channel improvement on the Boro River should only be resorted to if the discharge into the Thamalakane River is below the average expected in accordance with the input at Mohembo andlocal Delta rainfall.

Some hydrological engineers have proposed supplementing the water output of the Delta from Kwando/Linyanti waters. The scheme would involve opening up of the Savuti River mouth intake off the Linyanti, improving its existing channel and continuing the channel to the old Mababe Marsh. Water would then be lifted from this point and piped to the Thamalakane River and discharged into it on the Maun side of the critical high level in it. This critical high level lies between the Gomoti and Mogohelo River discharge points into the Thamalakane River. This would involve a piping distance of less than 150 km.

Such a scheme would lessen discharge down the Chobe River system into the Zambesi River. If the scheme could be well-controlled in supplying a reasonable discharge of water down the Chobe River to maintain its floodplain system to Caprivi and northeastern Botswana and hence the Zambesi River; and also create an increased floodplain system in the Savuti/Mababe Marsh areas it would be well worthwhile. International permission would be required before any steps could be taken.

If the Chobe system could be reasonably maintained and provided the engineers allow sufficient water to extend the present Savuti Marsh floodplain system the scheme could benefit certain wildlife species in the area and provide extra water past Maun. However *Salvinia molesta* is present in the Zambezi/Chobe system and thus its possibility of reaching the Thamalakane and spreading up into the Delta would preclude such a scheme. To create an increased floodplain in the Savuti Marsh would, however, be most desirable.

MANAGEMENT TECHNIQUES AND RECOMMENDATIONS

The study area now included as an extension of the Moremi Wildlife Reserve should not be developed in any way whatsoever, but retained as a pure wilderness area with the following management techniques applied.

TOURISM

Initially tourism of the area should be handled by licenced tourist operators working under a representative of the Department of Wildlife and National Parks. The latter will serve as an armed guide and representative to ensure that regulations are adhered to. Self-equipped parties of tourists may also enter the area in the presence of a similar representative from the Department.

No motorised vehicle transport (excluding motor boats) should be allowed into the area except for members of the Department of Wildlife and National Parks conducting routine work. Other exceptions provided with a Departmental permit would include bona fide Government or Tribal officials and research workers conducting duties which require their presence in the above area.

Tourists, either on their own or under a licenced operator would enter the area either by aircraft, motor boat or mekoro. All tourist operators' base camps are to be established outside the gazetted area or are to work from their annual existing base camps in the Moremi Wildlife Reserve. None of these camps should be established as permanent structures. Tours may then be conducted by motor boat, mekoro and foot anywhere throughout the new gazetted area allowing the tourists to camp anywhere within it. The government representative would be the only armed member of the party and would ensure that no littering, uncontrolled fires, provocation, defacing or removal of any fauna or flora occurs. An exception here would be the rights of fishing under licence to provide parties with fresh meat should they so desire. Both Departmental officials and tourist operators should be conversant with the basic ecology of the area, to enable them to conduct such a tour safely and to make it educational and interesting to the participants.

Whether the party be private or under a tourist operator, either the former or the latter is responsible for all food and medical supplies; and an indemnity must be signed absolving the Department of any death, injury, loss or illness which may be the result of such a tour.

Numerous such tours could be conducted through the area making use of the local baYei population as guides, boat drivers, mekoro ponters or those more responsible even appointed as the Departmental representative, since these people are conversant with the waterways, the area and its ecology. Sufficient villages of baYei exist in peripheral reserve areas to provide the male population with a good income by utilising their skills and knowledge of the area. They would only have to be made more conversant with the wildlife ordinances to become successful Departmental officials and Wardens of a reserve which hereditarily has been theirs for over a century. As the scheme progresses, more refinements can be made to ultimately allow for complete Departmental control.

CONTROL OF EXOTIC VEGETATION AND BURNING PROGRAMMES

The possibility of certain exotic aquatic vegetation plants establishing themselves within the study area or any part of the Delta is a real and significant threat to the whole water ecology of the Delta. Thompson (1975) has elaborated on the threat of *Pistia, Salvinia* or *Eichornia crassipes* entering and establishing themselves on the system. Already foreign boats entering these waterways are required to be sprayed by law. This and a continual watch for any of these plants entering the system will have to be maintained.

Burning of some Primary and Secondary Floodplain Communities will have to be carried out, to open up certain heavily vegetated floodplains and enhance water flow (Fig. 31). In the case of Secondary Floodplain Communities this will bring about mammalian utilisation on some otherwise poorly-utilised floodplains. Downgrading open Secondary Floodplain Community should on no account be burnt until such time as marked recovery has taken place in these communities. The decision of burning will have to be taken by inspection and conducted shortly prior to flooding inundation and on the basis of good floodwater quantity arriving and ensuring subsequent flooding.

No Closed Riverine Woodland Communities should be subjected to fire. Marginal and dryland vegetation types should also not be subjected to fire, but some isolated overgrown communities should be burnt in November or December shortly after commencement of first local seasonal rainfall. Isolated aquatic vegetation types may also have to be burnt to enhance water flow. All burning should only take place after inspection of the areas concerned.

FIGURE 31 – Burnt Primary Floodplain Community to enhance increased water velocity can be advantageously conducted just prior to floodwater arrival. However no floodwaters reached this injudiciously burnt Primary Floodplain Community, Okavango Delta, Botswana during 1973.

WATER DEMAND AND POSSIBLE MANIPULATIONS

Present average waterflow down any of the distributaries has been calculated, and on the basis of any year's input at Mohembo a reasonable supply to be delivered down any part of the system can be calculated with some degree of accuracy. In the event of any man-made manipulations in any part of the Delta, the reserve's distributaries are entitled to their present mean water discharge to ensure maintenance of the aquatic and floodplain vegetation types and their fauna densities. In the absence of this water demand the marginal and dryland vegetation types will encroach and expand in the reserves at the expense of the wetland fauna and flora component.

The Boro River, where enhanced flow is likely to be the result of manipulation, presents little problem unless flooding becomes excessive. However, no bunding should be resorted to on the mid-Boro System's primary floodplain off-takes. Likewise, no dam development should be allowed in the vicinity of Xakue. The demand for the upper M'borogha River system should be in the vicinity of mean annual flow of 8,0 m^3/s dropping to 7,5 m^3/s in its lower reaches. Monitoring of this system below KS2 will have to be carried out to ensure water distribution down each of the Mogohelo, Gomoti and Santantadibe River systems, rather than any river system here losing water. This is necessary to ensure retention of prime lechwe habitat in the middle sections of the Gomoti and Mogohelo floodplains of southern Moremi Wildlife Reserve.

Likewise the demand at KQ1 and KQ2 should be in the vicinity of mean annual flow rates of 20 m^3/s and 3 m^3/s respectively to maintain the Moanashira and Khwai floodplain systems.

In the event of 'natural' flow changes no demand can be made on anybody, and the only solution is expansion of Delta areas allocated under wildlife management areas, where control from displacement of water distribution and thus floodplain communities can still fall under the jurisdiction of the Department of Wildlife and National Parks.

CROPPING

Certain wildlife populations under strict protection will increase beyond the carrying capacity of the reserve area, without expanding naturally due to physical water barriers. Other species may remain in the area due to the protection offered. In either case overutilisation will result, causing far worse effects on the vegetation status and consequently mammalian condition than the controlled removal of mammals within a reserve.

Impala will have to be controlled eventually as in the absence of drastic water level drops they will be unable to expand out of certain areas. Baboon populations appear excessive in parts and are likely to become human dependent and small numbers should be shot to maintain the populations wild and natural via a fear of human dependence.

Limited elephant and buffalo cropping may in the future also have to be resorted to if monitoring of the populations reveals estimated numbers to exceed the determined carrying capacity. Most other of the common species are not yet near their peak densities for available carrying capacity but will have to be monitored to assess the position in the future.

Mammals such as bushbuck, waterbuck, roan antelope, steenbok and duiker should receive strict protection to attempt to enhance increases in their populations. At present only limited impala cropping should be conducted and this done to feed Departmental staff working in the area and the baYei employed there in tourism. At a later date sale of meat can be initiated to tourist operators to feed clients. The cropping, however, should be strictly controlled by responsible officials of the Department, after scientific study warrants it.

TSETSE FLY CONTROL

Under present circumstances the area involved (as does most of the Delta) enjoys natural pristine conditions supporting healthy wildlife populations due basically to the presence of tsetse fly (*Glossina morsitans*), and thus the lack of large-scale human habitation and domestic stock. Pressure for increased grazing areas for cattle and other domestic stock are in operation with the necessary precondition of tsetse fly eradication from the area. In the event of attempts at total tsetse fly eradication (which cannot be condoned in the interests of wildlife reserves or management via hunting, both safari, recreational or subsistence) and in the absence of strict control only the wildlife can suffer.

In an area as vast as the Delta with its problems of effective wildlife control being carried out by a relatively new and small Department, tsetse fly eradication can only spell out large-scale wildlife eradication. If the Deltas reserves and hunting at all levels are to be maintained, tsetse-fly eradication must not take place. Surely it is better to look into more sophisticated methods of stock production on the existing land, than to expand into and eradicate wildlife from a unique moTswana heritage area, as once this area is raped the problem of sufficient land for stock leading to necessity of refined stock production methods will re-occur. When this happens it will be too late to restore this valuable heritage.

The uncertainty of the effect of the chemical endosulphan (or Thiodan), an organochlorine compound to be used in attempted eradication on the fish fauna and aquatic invertebrates (Russell-Smith, 1976) and its effect on surface waters, (Greve, 1971) which in turn will disrupt another segment of the ecosystem must leave the advisability of tsetse fly eradication in doubt.

WILDLIFE MANAGEMENT AREAS

At present 21 per cent of the Delta is conserved as a Wildlife Reserve with large tracts of surrounding areas forming controlled hunting blocks. It is ideally necessary to maintain the areas surrounding the reserve as buffer zones between conserved wildlife and other forms of land utilisation. In the absence of such buffer zones, conflict between predators and crop raiders takes place with domestic stock and agriculture, causing problems. Hunting in an intermediate buffer zone tends to eliminate some of those problems and is thus desirable.

It is therefore proposed to maintain part or all of the peripheral controlled hunting blocks under wildlife management areas where the Department of Wildlife and National Parks can exercise direct jurisdiction according to prevailing conditions. Should game ranching become feasible in the future such areas would already naturally be stocked to form the basis for meat production potential and continued trophy hunting. The blocks involved would be Jao, lower Kwando, Khwai, Maxwee, Chitabe Khuranxaragha and Matsebe, with the possibility of distal parts of some of these areas falling away to another form of land use. Trophy and recreational hunting brings significant income, both foreign and local to Government and Tribal authorities, as well as supplying local employment and should thus not be phased out.

CONCLUSIONS

The addition of the Chief's Island complex onto the Moremi Wildlife Reserve is a significant move in providing a larger and more representative part of the middle-Delta as conserved area. Every effort must be made to legislate this complex under national park status and thus more safely secure a portion of the Okavango Delta for prosterity. To enable time to provide for success in managing and maintaining this complex it is necessary that the tsetse fly is not eradicated from it or the peripheral hunting areas in the immediate future. Likewise the controlled hunting blocks surrounding the area must be maintained to prevent conflicting land-use interests, provide employment and capital and serve as the nucleus of an area to possibly be used for game-ranching and trophy hunting. This will possibly provide the best economic return from the area as well as to preserve its pristine conditions and maintain the only attraction for foreign visitors to visit Ngamiland. To ensure the viability of the major portion of the Delta, it is necessary that surrounding blocks be declared wildlife management areas so that the Department of Wildlife and National Parks can effectively prevent other doubtfully viable land use forms from irreversibly altering the present status quo. This in turn will ensure potential for continued tourism and hunting providing foreign exchange. It also provides for possible extension onto the conserved complex of small areas which beneficially should be included viz. Xho Flats, part of the Old Sandenberg Concession and part of Maxwee.

Any man-made manipulations must be constructed in such a way that the reserve areas receive their mean annual water discharge and that none of this water is bunded from the floodplains it is destined to maintain.

Tourism and trophy hunting must be encouraged to bring a return for maintaining this unique Delta and advertising the world interest in further retaining it in its pristine condition. Only sections of the western and lower Delta must be opened if necessary for other forms of land utilisation.

Uncontrolled veld fires which are virtually a daily occurrence in the Delta will have to be advertised as an offence in an attempt to curb this malpractice and especially so within the reserve areas.

Monitoring of flooding patterns and the expansion and depression of the plant communities will have to be conducted as well as large mammal population densities to effectively manage the area.

Unfortunately the general attitude prevailing is rather one of eliminating the tsetse fly and providing more new areas to be opened up to provide more grazing for cattle. This every cattle owner sees as potential income to himself, whereas wildlife is looked more upon as cheap meat to provide his sustenance. Until the average man can see financial benefit from retaining the wildlife he can hardly be expected to vote for its retention when he can rather start cattle farming and derive direct income from it. Most Government Departments with the exception of the Department of Wildlife and National Parks favour the tsetse fly removal as they are likewise able to further their aims and ambitions. Either the wildlife must pay beneficially to the average man or there remains little hope of retaining anything but a small proportion of Delta land in its pristine condition.

SUMMARY

The locality of the study area in the central Okavango Delta, Ngamiland, Botswana, is described. The area comprises 1 812 km^2 of the 16 200 km^2 Delta. Detailed historical settlement in the area is described, Lake Ngami's discovery, followed by twentieth century schemes, attempted blockage removal and present human utilisation of this area.

Both the solid and surface geology of the area are described. Isolated outcrops mark portions of the rim of a once vast, shallow, internal drainage basin, the Mkgadikgadi-Okavango Basin covering most of northern Botswana. The oldest rocks are granitoid gneisses of the Archean Basement Complex overlain by quartz schists, quart-zites and dolomitic marbles of late Pre-Cambrian age. Almost completely overlying the solid geology are Kalahari sands of various thickness having been deposited by both wind and water.

Some existing geomorphological formations attest to ancient prevailing conditions, viz. numerous seif dunes of wind-born origin and ancient strandlines of the fossil lakes established by wind action from waves. Sands of the Delta illustrate the more recent importance of waterborne deposition.

In recent years Ngamiland has been found to be tectonically active. Older seismicity and faulting have directly given rise to the formation of the Delta along the Thamalakane fault

line. More recent seismic activity has probably been the major initiating factor in causing redistributed flooding patterns over the Delta. The outlet channel providing main Delta water discharge has changed three or four times over the last century.

Soils of the area fall within the Okavango Complex and comprise five series, the Molapo series, the Boteti series, the Shrobe series, the Motopi series and the Mababe series. Most have a high sand content and only the Molapo and Motopi series have some limited cultivation value.

Two fairly long-term weather recording stations, Maun and Shakawe lying to the south and north of the study area respectively were chosen to represent mean climatic conditions. Comparative tables of rainfall, temperature, relative humidity and evaporation are presented for the two stations. Evapotranspiration from the area is high. The occurrence of mist, dew, frost, wind and cloud cover are briefly discussed.

Five main vegetation types, based on water availability, are recognised. These are further subdivided into 20 plant communities.

Each plant community's compositon is described in detail, as well as its distribution, and present status and possible future trend in accordance with altered flood regimes. The importance of each plant community for maintaining the diversified fauna is discussed. Those plant plant communities most subject to alteration via excess of/or insufficient water availability, excessive fire damage and over-utilisation are dealt with in greater detail.

Surface and consolidated blockage formation, termitaria establishment and evolution and seismicity are the prime factors leading to alteration of flooding patterns and thus plant community distribution.

A total of 63 large and small mammals were recorded from observation and trapping. Each species is dealt with independently giving distribution, movement patterns, habitat requirements, feeding records, social organisation and status. More detailed data are presented for more common species with respect to breeding biology, condition, mass and measurements and parasites. For the larger mammals reasonable seasonal population estimates are provided from four-monthly random aerial strip surveys over fixed grids.

From the aerial surveys results population estimates of larger mammals are provided for the various seasons and in accordance with floodwater level. Emigration and immigration as well as local movement are discussed and the ability of each species to cope with altered water levels. Those species in low population numbers and in need of strict protection are given.

The ancient postulated flood regime of a vast inundated shallow depression is presented from old landform occurrence and vegetation distribution. A large portion of northern Botswana and Ngamiland was shallowly flooded and several large water bodies terminated the drainage of the norther Kalahari, after drainage to the Limpopo River was disrupted. Past water regime since 1850 has showed further dessication and large scale alteration of water distribution pattern with variation in major outlet channel, delivering bulk discharge at the base of the Delta.

Present water regime shows a marked increase in the Boro River output at the expense of the other systems. The situation is by no means stable and any alteration could take place in water distribution and flooding pattern in the future. The initiating agents in order of importance as deemed by this author are:

1. Seismicity causing faulting and rifting and alteration in local base levels.

2. Vegetation blockages and their consolidation under sedimentation when water velocity is decreased.

3. The low density by reduction of large aquatic mobile animals viz. hippopotamus and large crocodiles.

4. Surface blockages of outlet channels mainly initiated by *Rotala myriophylloides* are a direct result of insufficient large aquatic animal movement.

5. Termitarium establishment and their evolution to raised dryland bases and link up for future island formation. In conjunction with formation of levees or sand banks, sand bars and deltaic fans.

6. Water nutrient change or sustained decreases in water velocity favouring proliferation of certain aquatic or semi-aquatic vegetation species.

Local heavy Delta rainfall is most important in causing a "previous degree of saturation factor" which depending on the particular amount of seasonal precipitation will either manifest itself in an excessive flood during that or the following season.

All the above factors have and will always retain a dynamic Delta showing no two similar flood patterns.

The long-term stability of the system cannot be accurately predicted. Major channel improvement and internal Delta dams are discarded, as is bunding in any central or lower conserved area due to floodplain degradation. The only scheme which could be ecologically condoned is the slight improvement of the Boro channel with only bunding in the far lower reaches provided significant water loss does not take place to other prime wildlife areas in the Delta.

The establishment of ex-Delta Dams can be condoned provided a small Lake Ngami is kept alive and human populations living downstream of the Boteti still receive water in any expected flow year for that river. The removal of the present Lake or Nghabe River bund is imperative to restore past flow down the Lake River and discharge into Lake Ngami from this source.

A pipeline from the base of the Delta's sleeve. although prohibitively expensive initially is still deemed to be the long-term solution since internal Delta changes cannot affect its output.

Management techniques for the conserved area involve tourism on foot, boat and mekoro, with no permanent camps established within it. Possible encroachment of exotic aquatic vegetation is stressed, and some early winter burning programmes are advocated for floodplain vegetation types with limited early summer burning of some dryland vegetation types.

A reasonable water demand is made in an effort to maintain the floodplain systems of the conserved areas, as well as other present prime hunting wildlife habitats, all of which it is advocated should fall under Wildlife management areas to preserve the Delta should radically altered water distribution take place. The initiation of a limited cropping scheme is suggested with the wildlife management areas eventually forming the nucleus for continued trophy hunting and meat production from game ranching. The early attempts at tsetse fly eradication is not condoned and nor is it until such time as proper and sensible land utilisation apportionment has been made and can be controlled.

OPSOMMING

Die lokaliteit van die studiegebied in die sentrale Okavango-delta, Ngamiland, Botswana word beskryf. Die studiegebied sluit 1 812 km^2 van die 16 200 km^2 van die Delta in. 'n Gedetailleerde historiese oorsig van die gebied word gegee met verwysing na die ontdekking van die Ngami-meer, gevolg deur skemas van die twintigste eeu, pogings wat aangewend is om blokkerings te verwyder en die hedendaagse menslike gebruik van die gebied.

'n Kort geologiese en grond beskrywing word gegee. Geïsoleerde dagsome verteenwoordig die rand van die eens uitgestrekte, vlak binnelandse dreineringskom, bekend as die Mkgadikgadi-Okavangokom, wat die grootste gedeelte van noordelike Botswana beslaan. Die oudste gesteentes is die granitiese ngeisse van die Argaïese Vloerkompleks oordek deur kwartsokiste, kwartsiete en dolomitiese marmer van die voor Kambriese tydperk. Die geologiese formasies word feitlik geheel en al deur verskillende diktes Kalaharisand wat deur water en wind afgesit is, bedek.

Sommige van die bestaande geomorfologiese formasies is 'n produk van vroeëre omgewingstoestande byvoorbeeld verskeie eoliese lengte duine en ou standlyne van die fossiele mere wat 'n produk van die windaksie van die branders is. Die deltasand is daarteenoor 'n produk van meer resente waterafsettings.

In resente jare is gevind dat Ngamiland tektonies aktief is. Ouer seismisiteit en foutvorming het aanleiding gegee tot die ontstaan van die Delta langs die Thamalakane-fout. Meer resente seismiese aktiwiteit was moontlik verantwoordelik vir die veranderde vloedpatrone van die Delta. Die uitlaatkanaal wat die hoof uitvoerkanaal van water uit die Delta is, het drie of vier keer gedurende die afgelope eeu van posisie verander.

Die gronde van die gebied resorteer onder die Okavangokompleks en sluit vyf series in naamlik: die Molopo-, Boteti-, Shrobe-, Motopi- en Mababeseries. Die meeste van die series het 'n hoë sandinhoud en slegs die Molopo- en Motopiseries het 'n beperkte akkerbou potensiaal.

Die gemiddelde redelike langtermyn weergegewens is afkomstig van die weerstasies by Maun en Shakawe onderskeidelik suid en noord van die studiegebied. Vergelykende tabelle vir reënval, temperatuur, relatiewe vogtigheid en verdamping word vir die twee weerstasies gegee. Evapotranspirasie in die gebied is hoog. Die voorkoms van mis, dou, ryp, wind en wolkbedekking word kortliks bespreek.

Vyf hoofplantegroeitipes, gebaseer op beskikbaarheid van water is onderskei en word in 20 plantgemeenskappe onderverdeel. Die verspreiding van elkeen van die plantgemeenskappe word gegee en floristies in detail bespreek. Die huidige status sowel as die moontlike toekomstige verandering in die plantgemeenskappe as gevolg van veranderde vloedpatrone word bespreek. Die belang van elke gemeenskap vir die handhawing van die diversiteit in die fauna word bespreek. Daardie gemeenskappe wat die meeste aan veranderings blootgestel word deur te veel en/of te min beskikbare water, vuurbeskadiging en oorbenutting word in meer besonderhede beskryf.

Die vorming van oppervlak en gekonsolideerde versperrings, termitariumvestiging en evolusie en seismisiteit is die primêre faktore wat aanleiding tot veranderinge in die vloedpatrone gee en gevolglik veranderinge in die verspreiding van plantgemeenskappe.

Deur middel van waarneming en vangste is daar 63 groot en klein soogdiersoorte vir die gebied aangeteken. Elke spesie word afsonderlik behandel en daar word aandag aan verspreiding, bewegingspatrone, habitatvereistes, voedingsrekords, sosiale organisasie en getalle status gegee. Vir die meer algemene soorte word meer gedetailleerde data ten opsigte van voortplantingsbiologie, kondisie, massa en afmetings en parasiete gegee. Seisoenale bevolkingskattings van die groter soogdiersoorte en soos verkry vanaf viermaandelikse lugsensusse langs 'n vaste ruitsisteem word verskaf.

Met behulp van die resultate wat met die lugsensusse verkry was, is die bevolkingsdigtheid van die groter soogdiere in die verskillende seisoene geskat en in verband met die heersende vloedwatervlak gebring. Die emmigrasie en immigrasie asook lokale rondbeweging van die verskillende diere asook hulle vermoë om aan te pas by die verskillende watervlakke word bespreek. Daardie spesies wat in klein getalle voorkom en wat streng beskerm moet word, word gelys.

Die vervloë voorgestelde vloedregime van 'n uitgestrekte oorstroomde laagliggende gebied word aan die hand van ou landvorme en die verspreiding en voorkoms van plantegroei bespreek. 'n Groot gedeelte van noordelike Botswana en Ngamiland was in die verlede baie vlak gevloed en verskeie groot watermassas het die dreinering van noordelike Botswana, na die ontwrigting van die dreinasie na die Limpoporivier, beëindig.

Die waterregime vanaf 1850 dui op uitdorring en grootskaalse veranderinge in die waterverspreidingspatroon met 'n verandering in die hoof uitlaatkanaal wat die meeste water by die eindpunt van die Delta uitlaat.

Die huidige waterregime dui op 'n aansienlike toename in die lewering van water deur die Bororivier, ten koste van die ander sisteme. Die toestand is egter nie stabiel nie en enige verandering in die verspreiding van water en die vloedpatroon kan in die toekoms voorkom. Die oorsaaklike fatore in dié verband, in orde van belangrikheid soos deur die outeur gesien is:

1. Seismisiteit wat fout- en rifvorming asook afwisseling in lokale grondvlakke tot gevolg het.

2. Plantegroeiversperrings en die konsolidering daarvan as gevolg van sedimentasie, met die afname in die spoed van watervloei.

3. Die lae digtheid as gevolg van die vermindering van diere soos seekoeie en krokodille.

4. Oppervlakversperrings van uitlaatkanale deur *Rotala myriophylloides* wat 'n direkte gevolg is van onvoldoende beweging van groot akwatiese diere.

5. Die vestiging van termitariums en ontwikkeling van droëlandplatforms wat later sydelings aanmekaar sluit om eilande te vorm. Gepaard hiermee gaan die vorming van opgeboude rivieroewers of sandbanke, sandwalle en deltawaaiers.

6. Verandering in die inkrement van voedingstowwe in die water of 'n afname in die vloei van water wat die vermeerdering van bepaalde akwatiese of semi-akwatiese plantsoorte bevoordeel.

Lokale swaar reënval in die Deltagebied kan 'n vooraf versadigde toestand tot gevolg hê wat uiteindelik gemanifesteer word in 'n abnormale hoë vloed gedurende daardie of daaropvolgende seisoen.

Al bogenoemde faktore het en sal altyd 'n dinamiese Delta wat nooit twee eenderse vloedpatrone het nie, tot gevolg hê.

Die stabiliteit van die sisteem oor 'n lang tydperk kan nie akkuraat voorspel word nie.

Hoofkanaal verbeteringe en interne Deltadamme word verwerp so ook "bunding" in enige sentrale of laer beskermde gebied as gevolg van die agteruitgang van die vloedvlaktes. Die enigste skema wat ekologies verantwoord kan word is 'n mate van verbetering aan die Borokanaal en "bundings' slegs in die benede gedeeltes, met die voorbehoud dat dit nie betekenisvolle waterverlies in ander goeie wildlewe gebiede in die Delta tot gevolg het nie.

Die aanbring van damme buite die Deltagebied kan toegelaat word mits die klein Ngami-meer lewenskragtig gebou word en dat die inwoners stroomaf van Boteti water sal ontvang in enige jaar wat daardie rivier onder normale omstandighede sou gevloei het. Die verwydering van die "bund" in die Lake- en Nghaberiviere is noodsaaklik ten einde die vloei van die Lakerivier en die watertoevoer in die Ngami-meer weer te normaliseer.

Alhoewel interne veranderinge in die Delta waarskynlik nie die beskikbaarheid van water in die benede Deltagebied sal verander nie is 'n waterpyplyn uit die gebied, alhoewel aanvanklik baie duur, waarskynlik die enigste oplossing.

Voorgestelde bestuurspraktyke vir die beskermde gebied sluit toerisme per voet, boot en "mekoro" in, terwyl geen permanente kampe binne die gebied toegelaat moet word nie. Die moontlike indringing en vermeerdering van uitheemse waterplante word beklemtoon en vroeë winterbrandprogramme vir vloedvlakte plantegroei tipes en vroeë somerbrandprogramme vir droëlandplantegroei tipes kan voorgestel word.

'n Redelike hoeveelheid water word benodig ten einde die vloedvlakte sisteme binne die beskermde gebied, sowel as ander bestaande primêre wildlewe habitats vir jagdoeleindes te verseker.

Hierdie gebiede moet onder Natuurbestuursgebiede resorteer vir beskerming, vir ingeval radikale veranderinge in die waterverspreiding voorkom. Die daarstelling van 'n beperkte jagskema word voorgestel met dien verstande dat die natuurbestuursgebiede uiteindelik die kern vir voorgestelde trofeejag en vleisproduksie deur middel van wildboerdery sal vorm. Die vroeëre pogings om tsetsevlieë te bekamp moet voortgesit word tot tyd en wyl voldoende en korrekte landverdeling vir benutting gemaak is en gekontroleer kan word.

SYSTEMATIC LIST OF PLANT SPECIES

Plant species are listed from herbaria identification; either from the Botanical Research Institute of Pretoria or the National Herbarium, Salisbury, Rhodesia, but in most instances check identification from both. The systematic order of the families follows that of R.A. Dyer (1975) "The Genera of Southern African Flowering Plants" Volume 1 and 2 for the Angiospermae, and E.A. C.L.E. Schelpe (1970) "Flora Zambesiaca: Pteridophyta" for ferns.

A. PTERIDOPHYTA (Ferns)

Marsileaceae
Marsilea coromandeliana Willd.

Azollaceae
Azolla pinnata R.Br. var. *africana* (Desc.) Bak.

Adiantaceae
Ceratopteris thalictroides (L.) Brongn.

Thelypteridaceae
Thelypteris dentata (Forsk.) E. St. John.
T. quadrangularis (Fée) Schelpe
T. totta (Thunb.) Schelpe

B. ANGIOSPERMAE

(1) Dicotyledonae
Myricaceae
Myrica serrata Lam.

Moraceae
Ficus burkei (Miq.) Miq.
F. pygmaea Welw. ex Hiern.
F. sycamorus L.
F. verruculosa Warb.

Loranthaceae
Plicosepalus kalachariensis (Schinz) Danser
P. undulatus (E. Mey. ex Harv.) Van Tieghem

Olacaceae

Ximenia americana L.

Hydnoraceae

Hydnora africana Thunb.

Polygonaceae

Oxygonum delagoense Kuntze

O. dregeanum Meisn. var. *canescens* (Sond.) R. Grah.

Polygonum limbatum Meisn.

P. salicifolium Brouss.

Rumex woodii N.E. Br.

Chenopodiaceae

Chenopodium album L.

Amaranthaceae

Achyranthus sicula (L.) All.

Aerva lanata Juss.

A. leucura Moq.

Alternanthera sessilis (L.) DC.

Amaranthus

Amaranthus schinzianus Thell.

A. cf. *thunbergii* Moq.

Celosia scabra (Schinz) Schinz

C. trigyna L.

Centemopsis biflora (Schinz) Schinz

Kyphocarpa angustifolia (Moq.) Lopr.

Pupalia atropurpurea Moq.

P. lappacea (L.) Juss.

Nyctaginaceae

Commicarpus africanus (Lour.) Dandy

Aizoaceae

Gisekia africana (Lour.) Kuntze var. *africana*

G. africana (Lour.) Kuntze var. *cymosa* Adamson

Limeum fenestratum (Fenzl) Heimerl

L. sulcatum (Klotzsch) Hutch.

Mollugo nudicaulis Lam.

Portulacaeae

Portulaca oleracea L.

Talinum caffrum (Thunb.) Eckl. & Zeyh.

T. tenuissimum Dinter

Illecebraceae

Pollichia campestris Ait.

Cabombaceae

Brasenia schreiberi J.F. Gmel.

Nymphaeaceae

Nymphaea caerulea Sav.

N. lotus L.

Ceratophyllaceae

Ceratophyllum demersum L.

Menispermaceae

Cissampelos mucronata A. Rich.

Cocculus hirsutus (L.) Diels

Cruciferae

Heliophila sp.

Capparaceae

Boscia mossambicensis Klotzsch

Capparis tomentosa Lam.

Cleome elegantissima Briq.

C. gynandra L.

C. hirta (Klotzsch) Oliv.

C. rubella Burch.

Maerua gilgii Schinz

Droseraceae

Drosera sp.

Crassulaceae

Kalanchoe lanceolata Pers.

Vahliaceae

Vahlia capensis Thunb.

Rosaceae

Rubus rigidus Sm.

Leguminosae

Mimosoideae (Mimosaceae)

Acacia erioloba E. Mey.

A. fleckii Schinz

A. galpinii Burtt Davy

A. hereroensis Engl.

A. hebeclada DC. subsp. *chobiensis* (O.B. Mill.) Schreiber

A. luederitzii Engl. var. *luederitzii*

A. luederitzii Engl. var. *retinens* (Sim) J. Ross & Brenan

A. nigrescens Oliv.

A. sieberana DC. var. *vermoeseni* (De Wild.) Keay & Brenan

A. tortilis (Forsk.) Hayne subsp. *heteracantha* (Burch.) Brenan

Albizia brevifolia Schinz

A. harveyi Fourn.

Dichrostachys cinerea (L.) Wight & Arn.

Neptunia oleracea Lour.

Caesalpinioideae (Caesalpiniaceae)

Bauhinia macrantha Oliv.

Cassia absus L.

C. capensis Thunb.

C. falcinella Oliv. var. *parviflora* Steyaert

C. mimosoides L.

Colophospermum mopane (Kirk ex Benth.) Kirk ex J. Léonard

Papilionoideae (Fabacae)

Aeschynomene fluitans Peter

Calpurnia sp.

Crotalaria sphaerocarpa Perr. ex DC.

C. steudneri Schweinf.

Indigofera astragalina DC.

I. charlieriana Schinz var. *charlieriana*

I. flavicans Bak.

Lessertia benguellensis Bak.

Lonchocarpus capassa (Klotzsch) Rolfe

L. nelsii (Schinz) Heer & Hutch.

Rhynchosia caribaea DC.

R. minima (L.) var. minima

R. totta (Thunb.) DC.

Sesbania bispinosa (Jacq.) W.F. Wight

S. rostrata Brem. & Oberm.

Tephrosia lupinifolia (Burch.) DC.

Tephrosia purpurea (L.) Pers. subsp. *leptostachya* (DC.) Brummitt

Vigna luteola (Jacq.) Benth.

Zornia glochidiata Reichb. ex DC.

Geraniaceae

Monsonia angustifolia E. Mey. ex A. Rich.

Zygophyllaceae

Tribulus terrestris L.

Burseraceae

Commiphora africana (A. Rich.) Engl.

Polygalaceae

Polygala albida Schinz

Euphorbiaceae

Acalypha indica L.

A. petiolaris Hochst.

Antidesma venosum E. Mey. ex Tul.

Croton megalobotrys Muell. Arg.

Phyllanthus reticulatus Poir.

Pterococcus africanus (Sond.) Pax & K. Hoffm.

Anacardiaceae

Rhus pyroides Burch.

R. quartiniana A. Rich.

R. tenuinervis Engl. & Gilg

Sclerocarya caffra Sond.

Celastraceae

Cassine transvaalensis (Burtt Davy) N. Robson

Maytenus heterophylla (Eckl. & Zeyh.) N. Robson

M. senegalensis (Lam.) Exell

Sapindaceae

Cardiospermum halicacabum L.

Rhamnaceae

Berchemia discolor (Klotzsch) Hemsl.

Ziziphus mucronata Willd.

Tiliaceae

Corchorus tridens L.

C. trilocularis L.

Grewia flavescens Juss. var. *flavescens*

G. flavescens Juss. var. *olukondae* (Schinz) Willd.

G. retinervis Burret

G. schinzii K. Schum.

G. subspathulata N.E. Br.

G. villosa Willd.

Triumfetta sp.

Malvaceae

Abutilon angulatum (Guill. & Perr.) Mast.

A. austro-africanum Hochr.

A. engleranum Ulbr.

A. ramosum (Cav.) Guill. & Perr.

Hibiscus calyphyllus Cav.

H. diversifolius Jacq. subsp. *rivularis* (Brem. & Oberm.) Exell

H. engleri K. Schum.

H. micranthus L. f.

H. sidiformis Baill.

Pavonia senegalensis (Cav.) Leistner

Sida alba L.

S. cordifolia L.

S. hoepfneri Guerke

Wissadula rostrata (K. Schum.) Hook f.

Bombacaceae

Adansonia digitata L.

Sterculiaceae

Hermannia glanduligera K. Schum.

H. modesta (Ehrenb.) Mast.

Melhania forbesii Planch. ex Mast.
Waltheria indica L.

Guttiferae
Garcinia livingstonei T. Anders.

Elatinaceae
Bergia pentherana Keissl.

Lythraceae
Ammannia auriculata Willd.
Nesaea crassicaulis (Guill. & Perr.) Köehne
Rotala myriophylloides Welw. ex Hiern

Combretaceae
Combretum collinum Fresen.
C. hereroense Schinz var. *hereroense*
C. hereroense Schinz var. *villosissimum* Engl. & Diels
C. imberbe Wawra
C. molle R. Br. ex G. Don
Terminalia sericea Burch. ex DC.

Myrtaceae
Syzygium cordatum Hochst.
S. guineense (Willd.) DC.

Onagraceae
Ludwigia octovalvis (Jacq.) Raven subsp. *octovalvis*
L. stolonifera (Guill. & Perr.) Raven

Trapaceae
Trapa natans L. var. *bispinosa* (Roxb.) Makino

Umbelliferae
Hydrocotyle bonariensis Lam.
H. verticillata Thunb.

Plumbaginaceae
Plumbago zeylanica L.

Ebenaceae
Diospyros lycioides Desf. subsp. *lycioides*
D. mespiliformis Hochst. ex A. DC.

Euclea crispa (Thunb.) Guerke var. *crispa*

E. divinorum Hiern

Oleaceae

Jasminum fluminense Vell.

Genitaceae

Nymphoides indica (L.) Kuntze

Apocynaceae

Carissa edulis Vahl

Periplocaceae

Tacazzea apiculata Oliv.

Asclepiadaceae

Asclepias burchellii Schltr.

A. cf. *decipiens* N.E. Br.

Orthanthera jasminiflora (Decne.) N. E. Br. ex Schinz

Pergularia daemia (Forsk.) Chiov. var. *daemia*

Convolvulaceae

Evolvulus alsinoides (L.) L. var. *linifolius* (L.) Bak.

Ipomaea hackeliana (Schinz) Hall. f.

I. magnusiana Schinz var. *magnusiana*

Merremia tridentata (L.) Hall. f. subsp. *angustifolia* (Jacq.) Ooststr.

Boraginaceae

Heliotropoium ciliatum Kaplan

H. ovalifolium Forsk.

H. strigosum Willd.

H. subulatum (Hochst. ex A. DC.) Vatke

Verbenaceae

Clerodendrum ternatum Schinz

C. unicinatum Schinz

Lantana rugosa Thunb.

Labiatae

Acrotome inflata Benth.

Hoslundia opposita Vahl

Leonotis nepetifolia (L.) Ait. f.

Leucas martinicensis (Jacq.) R. Br.
Ocimum canum Sims
Plectranthus cf. *cylindraceus* Hochst. ex Benth.

Solanaceae
Lycium albiflorum Damm.
Physalis sp.
Solanum catombelense Peyr.
S. delagoense Dun.
S. nigrum L.
S. nodiflorum Jacq.

Scrophulariaceae
Diclis petiolaris Benth.
Limnophila ceratophylloides (Hiern) Skan
L. indica (L.) Druce
Mimulus gracilis R. Br.
Rhamphicarpa tubulosa (L.f.) Benth.
Sopubia simplex Hochst.
Striga asiatica (L.) Kuntze
Sutera cf. *adpressa* Dinter

Bignoniaceae
Kigelia africana (Lam.) Benth.
Markhamia acuminata (Klotzsch) K. Schum.
Rhigozum brevispinosum Kuntze

Pedaliaceae
Dicerocaryum zanguebarium (Lour.) Merr.
Harpagophytum sp.
Sesamum alatum Thonn.

Lentibularaceae
Utricularia foliosa L.
U. inflexa Forsk.
U. stellaris L.f.

Acanthaceae
Barleria lancifolia T. Anders.
B. mackenii Hook. f.
B. senensis Klotzsch

Blepharis diversispina (Nees) C.B. Cl.
Dicliptera micranthes Nees
Hemigraphis prunelloides S. Moore
Justicia dinteri S. Moore
J. heterocarpa T. Anders.
J. matammensis (Schweinf.) Oliv.
Monechma debile (Forsk.) Nees
M. divaricatum (Nees) C.B. Cl.
Nelsonia canescens (Lam.) Spreng.
Peristrophe bicalyculata (Retz.) Nees
Ruellia otaviensis P.G. Mey.
R. patula Jacq.
Ruspolia hypocrateriformis (Vahl) M.–Redh. var. *australis* M.–Redh.

Rubiaceae
Borreria paludosa Hepper ex Deser.
Gardenia spathulifolia Stapf & Hutch.
Kohautia aspersa (Heyne ex Roth) Bremek.
K. caespitosa Schinz
Oldenlandia caespitosa Hiern
Pentodon pentander (Schumach.) Vatke
Vangueria esculenta S. Moore

Cucurbitaceae
Acanthosicyos naudiniana (Sond.) Jeffrey
Corallocarpus bainesii (Hook. f.) A. Meeuse
Kedrostis hirtella (Naud.) Cogn.
Zehneria marlothii (Cogn.) R. & A. Fernandes

Campanulaceae
Lightfootia denticulata (Burch.) Sond. var. *transvaalensis* Adamson

Compositae
Adenostemma caffrum DC.
Aspilia mossambicensis (Oliv.) Wild
Bidens pilosa L.
B. schimperi Sch. Bip. ex Walp.
Blumea caffra (DC.) O. Hoffm.
B. lacera (Burm.f.) DC.

Crassocephalum picridifolium (DC.) S. Moore

Dicoma schinzii O. Hoffm.

Dicoma tomentosa Cass.

Eclipta prostrata (L.) L.

Erigeron floribundus (H.B.K.) Sch. Bip.

Ethulia conyzoides L.

Gnaphalium luteo-album L.

G. undulatum L.

Hirpicium gorterioides (Oliv. & Hiern) Roessl. subsp. *gorterioides*

Melanthera scandens (Schumach. & Thonn). Roberty subsp. *madagascariensis* (BAK.) Willd.

Mikania cordata (Burm. f.) B.L. Robson

M. sagittifera B.L. Robson

Nidorella resedifolia DC. subsp. *resedifolia*

Nolletia ciliaris (DC.) Steetz

Philyrophyllum schinzii O. Hoffm.

Pechuel-Loeschea leubnitziae (Kuntze) O. Hoffm. *(= Pluchea leubnitziae)*

Senecio strictifolius Hiern

Sphaeranthus humilis O. Hoffm.

Vernonia amygdalina Del.

V. colorata (Willd.) Drake

V. glabra (Steetz) Vatke

Monocotyledonae

Thyphaceae

Typha latifolia L. subsp. *capensis* Rohrb.

Potamogetonaceae

Potamogeton octandrus Poir.

P. pectinatus L.

P. thunbergii Cham. & Schlechtd.

Najadaceae

Najas pectinata (Parl.) Magnus

Alismataceae

Limnophyton obtusifolium (L.) Miq.

Hydrocharitaceae

Lagarosiphon ilicifolius Oberm.

L. major (Ridl.) Moss. ex Wager

Ottelia exserta (Ridl.) Dandy

O. kunenensis (Guerke) Dandy

O. muricata (Wright) Dandy

O. ulvifolia (Planch.) Walp.

Poaceae – Gramineae

Oryzeae

Oryza longistaminata Chev. & Roehr.

Leersia hexandra Swartz

Arundineae

Phragmites australis (Cav.) Trin. ex Steud. *(= P. communis)*

Phragmites mauritianus Kunth

Aristideae

Aristida sp. cf. *adscensionis* L. subsp. *guineenis* (Trin. & Rupr.) Henr.

A. argentea Schweick.

A. canescens Henr.

A. meridionalis Henr.

A. pilgeri Henr.

A. stipitata Hack. var. *robusta* (Stent & Rattray) De Wint.

Stipagrostis hirtigluma (Steud.) De Wint.

S. uniplumis (Licht.) De Wint. var. *uniplumis*

Pappophoreae

Schmidtia kalihariensis Stent

S. pappophoroides Steud. ex J.A. Schmidt

Eragrostideae

Leptocarydion vulpiastrum (De Not.) Stapf

Dactyloctenium aegypticum (L.) Beauv.

D. giganteum Fischer & Schweick.

Diandrochloa namaquensis (Nees) De Wint.

Eragrostis atrovirens (Desf.) Trin. ex Steud.

E. biflora Hack. ex Schinz

E. cilianensis (All.) Lutati

E. curvula (Schrad.) Nees

E. echinochloidea Stapf

E. gummiflua Nees

E. inamoena K. Schum.

E. lappula Nees var. *divaricata* Stapf

E. lappula Nees var. *lappula*

E. Lehmanniana Nees

E. pallens Hack.

E. patentissima Hack.

E. rigidior Pilg.

E. rotifer Rendle

E. superba Peyr.

E. tricophora Coss. & Dur.

E. viscosa (Retz.) Trin.

Pogonarthria fleckii (Hack.) Stafp

P. squarrosa (Licht. ex Roem. & Schult.) Pilg.

Sporoboleae

Sporobolus acinifolius Stapf

S. fimbriatus Nees var. *fimbriatus*

S. fimbriatus Nees var. *latifolius* Stent

S. fourcadii Stent

S. natalensis (Steud.) Dur. & Schinz

S. pyramidalis P. Beauv.

S. salsus Mez

S. spicatus Kunth

Chlorideae

Enteropogon macrostachys (Hochst. ex A. Rich.) Munro ex Benth.

Chloris gayana Kunth

C. radiata (L.) Swartz

C. virgata Swartz

Cynodon dactylon (L.) Pers.

Zoysieae

Tragus berteronianus Schult.

T. racemosus (L.) All.

Paniceae

Panicum aphanoneurum Stapf

P. coloratum L.

P. kalaharense Mez

P. maximum Jacq.

P. repens L.

Setaria anceps Stapf ex Massey

S. chevalieri Stapf ex Stapf & C.E. Hubb.

S. sphacelata (Schumach.) var. *sphacelata*

S. tenuiseta De Wit

S. verticillata (L.) Beauv.

S. woodii Hack.

Cymbosetaria sagittifolia (A. Rich.) Schweick.

Sacciolepsis typhura (Stapf) Stapf

Echinochloa colona (L.) Link

E. holubii (Stapf) Stapf

E. stagnina (Retz.) Beauv.

Oplismenus hirtellus (L.) Beauv.

Paspalidium platyrrachis C.E. Hubb.

Brachiaria brizantha (Hochst.) Stapf

B. humidicola (Rendle) Schweick.

Pseudobrachiaria deflexa (Schumach.) Launert

Urochloa brachyura (Hack.) Stapf

U. trichopus (Hochst.) Stapf

Acroceras macrum Stapf

Paspalidium orbiculare Forsk.

Digitaria debilis (Desf.) Willd.

D. eriantha Steud.

D. milanjiana (Licht.) De Wint.

D. polevansii Stent

D. smutsii Stent

D. zeyheri (Nees) Henr.

Rhynchelytrum repens (Willd.) C.E. Hubb.

Tricholaena monachne (Trin.) Stapf & C.E. Hubb

Cenchrus ciliaris L.

Andropogoneae

Sorghum almum Parodi

S. verticilliflorum (Steud.) Stapf

Sorghastrum friesii (Pilg.) Pilg.

Vetiveria nigritana (Benth.) Stapf

Vossia cuspidata (Roxb.) Griff.

Imperata cylindrica (L.) Beauv.

Miscanthidium teretifolium (Stapf) Stapf (=*M. junceum*)

Eulalia geniculata Stapf

Ischaemum afrum (J.F. Gmel.) Dandy

Trachypogon spicatus Kuntze

Andropogon eucomus Nees

A. huillensis Rendle

Schizachyrium sanguineum (Retz.) Alst.

Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy

C. plurinodis (Stapf) Stapf ex Burtt Davy

Hyparrhenia dichroa (Steud.) Stapf

H. rufa (Nees) Stapf var. *rufa*

Hyperthelia dissoluta Nees) Clayton

Cyperaceae

Ascolepsis capensis Ridl.

Bulbostylis burchellii (Fical. & Hiern) C.B.Cl.

B. kirkii C.B.Cl.

Cladium mariscus R. Br.

Cyperus amabilis Vahl

C. articulatus L.

C. compressus L.

C. denudatus L.f. var. *sphaerospermus* (Schrad.) Kuckenth.

C. difformis L.

C. dives Del.

Cyperus fastigiatus Rottb.

C. fulgens L.

C. haspan L.

C. immensus C.B.Cl.

C. longus L. var. *tenuiflorus* (Rottb.) Kuekenth.

C. margaritaceus Vahl

C. nervoso-striatus Turrill

C. papyrus L.

C. sphacelatus Rottb.

C. sphaerospermus Schrad.

C. sp. cf. *tenuiculmis* Boeck.

C. usitatus Burch.

C. zollingeri Steud.

Eleocharis acutangula (Roxb.) Schult.

E. dulcis (Burm.f.) Hensch.

E. fistulosa Link

Fimbristylis complanata (Retz.) Link

F. dichotoma (L.) Vahl.

F. hispidula (Vahl) Kunth

Fuirena sp. cf. *cillaris* Ridl.

Juncellus laevigatus C.B.Cl.

Kyllinga alba Nees

K. erecta (Schum.) var. *intricata* C.B.Cl.

K. melanosperma Nees

Mariscus cyperoides (Nees) Dietr.

M. laxifolius Turrill

M. sieberanus Nees ex C.B.Cl.

M. squarrosus (L.) C.B.Cl.

Pycreus albomarginatus Nees

P. lanceus (Thunb.) Turrill

P. nitidus (Lam.) Raynal

P. pelophilus (Ridl.) C.B.Cl.

Rhynchospora holoschoenoides (L.C. Rich.) Herter (=*R, mauritti*)

Scirpus articulatus L.

S. corymbosus Roth.

S. inclinatus (Del.) Aschers & Schweinf. ex Boiss.

S. muricinux C.B.Cl.

S. paludicola Kunth

S. sororius (Kunth) C.B.Cl.

Websteria coniferoides (Poir.) Hooper

Palmae (Arecaceae)

Phoenix reclinata Jacq.

Hyphaene ventricosa Kirk (=*H. benguellensis* Welw. var. *ventricosa*) Kirk

Lemnaceae

Lemna perpusilla Torrey

Pseudowolffia repanda (Hegelm.) Den Hartog & v.d. Plas

Eriocaulaceae

Eriocaulon bifistulosa van Heurck & Muell.

Commelinaceae

Commelina benghalensis L.

C. erecta L. subsp. *livingstonei* (C.B.Cl.) Morton

C. scandens Welw. ex C.B.Cl.

C. subulata Roth

Floscopia glomerata Hassk.

Pontederiaceae

Eichhornia natans (Beauv.) Solms-Laub.

Liliaceae

Aloe zebrina Bak.

Asparagus africanus Lam.

A. nelsii Schinz

Gloriosa superba L.

Ornithogalum polyphyllum Jacq.

Sansevieria aethiopica Thunb.

S. hyancinthoides (L.) Druce

Amaryllidaceae

Crinum caroli-schmidtii Dinter

Haemanthus multiflorus Mart.

Orchidaceae

Ansellia sp.

Habenaria cf. *chlorotica* Reichb. f.

SYSTEMATIC LIST OF BIRD SPECIES

The outline of classification follows Roberts Birds of South Africa (McLachlan and Liversidge, 1965). Identifications are from limited collected material sent to the South African Institute for Medical Research (J. Ledger) or the National Museum and Art Gallery, Gaberones, Botswana (Formerly K. Ullberg). Visual identifications are from Messrs J.M.J. van Rensburg (Natal Parks Game and Fish Preservation Board), R. Gababolae (Department of Wildlife and National Parks, Botswana) and R.C. Biggs. Common names and numbers in brackets at end follows Roberts Birds of South Africa.

Struthionidae
Struthio camelus Linnaeus, 1758. Ostrich (1)

Podicipidae
Podiceps ruficollis (Pallas, 1764). Cape Dabchick (6)

Pelecanidae
Pelecanus onocrotalus Linnaeus, 1758. White Pelican (42)

Phalacrocoracidae
Phalacrocorax carbo (Linnaeus, 1758). White-breasted Cormorant (47)
Phalacrocorax africanus (Gmelin, 1789). Reed Cormorant (50)

Anhingidae
Anhinga rufa (Lacépède et Daudin, 1802). Darter (52)

Ardeidae
Ardea cinerea Linnaeus, 1758. Grey Heron (54)
Ardea melanocephala Vigors and Children, 1826. Black-headed Heron (55)
Ardea goliath Cretzschmar, 1826. Goliath Heron (56)
Ardea purpurea Linnaeus, 1766. Purple Heron (57)
Casmerodius albus (Linnaeus, 1758). Great White Heron (58)
Egretta garzetta (Linnaeus, 1766). Little Egret (59)
Mesophonyx intermedius (Wagler, 1829). Yellow-billed Egret (60)
Bubulcus ibis (Linnaeus, 1758). Cattle Egret (61)
Ardeola ralloides (Scopoli, 1769). Squacco Heron (62)
Sooty Egret
Butorides striatus (Linnaeus, 1758). Green-backed Heron (63)
Melanophoyx ardesiaca (Wagler, 1827). Black Heron (64)

Erythrocnus rufiventris (Sundevall, 1850). Rufous Heron (65)

Ardeirallus sturmii (Wagler, 1827). Dwarf Bittern (66)

Nycticorax nycticorax (Linnaeus, 1758). Night Heron (69)

Scopidae

Scopus umbralla Gmelin, 1789. Hamerkop (72)

Ciconiidae

Leptoptilos crumeniferus (Lesson, 1831). Marabou Stork (73)

Anastomus lamelligerus Temminck, 1823. Openbill (74)

Ephippiorhynchus senegalensis (Shaw, 1800). Saddlebill (75)

Ibis ibis (Linnaeus, 1766). Wood Ibis (76)

Sphenorhynchus abdimii (Lichtenstein, 1823). White-bellied Stork (78)

Threskiornithidae

Threskiornis aethiopicus (Latham, 1790). Sacred Ibis (81)

Hagedashia hagedash (Latham, 1790). Hadeda (84)

Plataleidae

Platalea alba Scopoli, 1786. Spoonbill (85)

Anatadae

Plectropterus gambensis (Linnaeus, 1766). Spurwing Goose (88)

Alopochen aegyptiacus (Linnaeus, 1766). Egyptian Goose (89)

Sarkidiornis melanotos (Pennant, 1769). Knop-billed Duck (91)

Nettapus auritus (Boddaert, 1783). Dwarf Goose (92)

Anas undulata Dubois, 1837. Yellowbill (96)

Anas erythrorhyncha Gmelin, 1789. Red-bill Teal (97)

Dendrocygna viduata (Linnaeus, 1766). White-faced Duck (100)

Dendrocygna bicolor (Viellot, 1816). Whistling Duck (101)

Netta erythrophthalma (Wred, 1833). South African Pochard (102)

Thalassornis leuconotus Eyton, 1838. White-backed Duck (104)

Sagittariidae

Sagittarius serpentarius (Miller, 1779). Secretary Bird (105)

Aegypiidae

Gyps coprotheres (Forster, 1798). Cape Vulture (106)

Gyps africanus (Salvadori, 1865). White-backed Vulture (107)

Trogos tracheliotus (Forster, 1791). Black Vulture (108)

Trigonoceps occipitalis (Burchell, 1824). White-headed Vulture (109)

Necrosyrtes monachus (Temminck, 1823). Hooded Vulture (110)

Falconidae

Falco dickinsoni P.L. Sclater, 1864. Dickinson's Kestrel (121)

Aquilidae

Milvus migrans (Boddaert, 1783). Black Kite (128)

Milvus aegyptius (Gmelin, 1788). Yellow-billed Kite (129)

Polemaëtus bellicosus (Daudin, 1800). Martial Eagle (142)

Circaëtus cinereus Vieillot, 1818. Brown Snake-eagle (145)

Circaëtus pectoralis A. Smith, 1829. Black-breasted Snake-eagle (146)

Haliaëtus vocifer (Daudin, 1800). Fish Eagle (149)

Terathopius ecaudatus (Daudin, 1800). Bateleur (151)

Micronisus gabar (Daudin, 1800). Gabar Goshawk (162) Black variety.

Meliërax metabates Heuglin, 1861. Dark Chanting Goshawk (163)

Circus ranivorus (Daudin, 1800). African Marsh Harrier (167)

Polyboroides typus A. Smith, 1829. Banded Harrier Hawk (171)

Pandion haliaëtus (Linnaeus, 1758). Osprey (172)

Phasianidae

Francolinus sephaena (A. Smith, 1836). Crested Francolin (174)

Francolinus adspersus Waterhouse, 1838. Red-villed Francolin (182)

Pternistis swainsoni (A. Smith, 1836). Swainson's Francolin (185)

Numididae

Numida meleagris (Linnaeus, 1758). Crowned Guinea-fowl (192)

Turnicidae

Turnix sylvatica (Desfontaine, 1787). Kurrichane button-quail (196)

Rallidae

Porzana pusilla (Pallas, 1776). Baillon's Crake (202)

Limnocorax flavirostra (Swainson, 1837). Black Crake (203)

Porphyrio porphyrio (Linnaeus, 1766). Purple Gallinule (208)

Gruidae

Burgeranus carunculatus (Gmelin, 1789). Wattled Crane (215)

Otidae

Ardeotis kori (Burchell, 1822). Kori Bustard (217)

Afrotis afra (Linnaeus, 1766). Black Korhaan (225)

Lissotis melanogaster (Rüppel, 1835). Black-bellied Korhaan (227)

Jacanidae

Actophilornis africanus (Gmelin, 1789). African Jacana (228)

Microparra capensis (A. Smith, 1839). Lesser Jacana (229)

Choradriidae

Charadrius marginatus Vieillot, 1818. White-fronted Sandplover (235)

Charadrius pecuarius Temminck, 1823. Kittlitz's Sandplover (237)

Charadrius tricollaris Vieillot, 1818. Three-banded Sandplover (238)

Stephanibys coronatus (Boddaert, 1783). Crowned Plover (242)

Hoplopterus armatus (Burchell, 1882). Blacksmith Plover (245)

Afribyx senegalensis (Linnaeus, 1766). Wattled Plover (247)

Hemiparra crassirostis (Hartlaub, 1855). White-winged Plover (248)

Scolopacidae

Capella nigripennis (Bonaparte, 1839). Ethiopian Snipe (250)

Actitis hypoleucos (Linnaeus, 1758). Common Sandpiper (258)

Tringa stagnatilis (Bechstein, 1803). Marsh Sandpiper (262)

Tringa nebularia (Gunnerus, 1767). Greenshank (263)

Tringa glareola (Linnaeus, 1758). Wood Sandpiper (264)

Rcurvirostridae

Recurvirostra avosetta Linnaeus, 1758. Avocet (269)

Himantopus himantopus (Linnaeus, 1758). Black-winged Stilt (270)

Burhinidae

Burhinus vermiculatus (Cabanis, 1868). Water Dikkop

Burhinus capensis (Lichtenstein, 1823). Cape Dikkop

Sternidae

Chlidonias leucoptera (Temminck, 1815). White-winged Lake Tern (304)

Pteroclidae

Pterocles bicinctus Temminck, 1815. Double-banded Sandgrouse (810)

Columbidae

Streptopelia semitorquata (Rüppel, 1837). Red-eyed Turtle Dove (314)

Streptopelia decipens (Finsch and Hartlaub, 1870). Angola Mourning Dove (315)

Streptopelia capicola (Sundevall, 1857). Cape Turtle Dove (316)

Stigmatopelia senegalensis (Linnaeus, 1766). Laughing Dove (317)

Oena capensis (Linnaeus, 1766). Namaqua Dove (318)

Turtur chalcospilos (Wagler, 1827). Emerald-spotted Wood Dove (321)

Treronidae

Tetron calva (Temminck and Knip, 1909). Green pigeon (323)

Psittacidae

Poicephalus meyeri (Cretzchmar, 1826). Meyer's Parrot (327)

Musophagidae

Corythaixoides concolor (A. Smith, 1833). Grey Loerie (339)

Cuculidae

Centropus cupreicaudus Reichenow, 1896. Coppery-tailed Coucal (354)

Centropus superciliosus Hemprich and Ehrenberg, 1833. Burchell's Coucal (356)

Bubonidae

Otus scops (Linnaeus, 1758). Scops Owl (363)

Glaucidium perlatum (Vieillot, 1817). Pearl-spotted Owlet (365)

Glaucidium capense (A. Smith, 1834). Barred Owlet (366)

Bubo africanus (Temminck, 1823). Spotted Eagle Owl (368)

Bubo lacteus (Temminck, 1824). Giant Eagle Owl (369)

Scotopelia peli Bonaparte, 1859. Fishing Owl (370)

Caprimulgidae

Caprimulgus tristigma Rüppel, 1849. Freckled Nightjar (374)

Micropodidae

Cypsiurus parvus (Lichtenstein, 1823). Palm Swift (287)

Coliidae

Urocolius indicus (Latham, 1790). Red-faced Mousebird (392)

Alcedinidae

Ceryle rudis (Linnaeus, 1758). Pied Kingfisher (394)

Megaryle maxima (Pallas, 1769). Giant Kingfisher (395)

Corythornis cristata (Pallas, 1764). Malachite Kingfisher (397)

Halcyon senegalensis (Linnaeus, 1766). Angola Kingfisher (399)

Halcyon albiventris (Scopoli, 1786). Brown-hooded Kingfisher (402)

Halcyon chelicuti (Stanley, 1814). Striped Kingfisher (403)

Meropidae

Merops nubicoides Des Murs and Pucheran, 1846. Carmine Bee-eater (407)

Mellittophagus pusillus (Müller, 1776). Little Bee-eater (410)

Dicrocerus hirundineus (Lichtenstein, 1793). Swallow-tailed bee-eater (411)

Coraciidae

Coracias caudata Linnaeus, 1766. Lilac-breasted Roller (413)

Coracias naevia Daudin, 1800. Mozambique Roller (415)

Upupidae

Upupa africana Bechstein, 1811. African Hoopoe (418)

Phoeniculus purpureus (Miller, 1794). Red-billed Hoopoe (419)

Rhinopomastus cyanomelas (Vieillot, 1819). Scimitar-billed Hoopoe (421)

Bucerotidae

Lophoceras nasutus (Linnaeus, 1766). Grey Hornbill (424)

Lophoceros erythrorhynchus (Temminck, 1823). Red-billed Hornbill (425)

Lophoceros flavirostris (Rüppell, 1835). Yellow-billed Hornbill (426)

Lophoceros bradfieldi (Roberts, 1930). Bradfield's Hornbill (428)

Bucorvis leadbeateri (Vigors, 1825). Ground Hornbill (430)

Capitonidae

Lybius torquatus (Dumont, 1806. Black-collared Barbet (431)

Pogoniulus chrysoconus (Temminck, 1832). Yellow-fronted Tinker Barbet (437)

Trachyphonus vaillantii Ranzani, 1821. Crested Barbet (439)

Indicatoridae

Indicator indicator (Sparrman, 1777). Greater Honey-guide (440)

Indicator minor Stephens, 1815. Lesser Honey-guide (442)

Prodotiscidae

Prodotiscus regulus Sundevall, 1850. Sharp-billed Honey-guide (443)

Picidae

Campethera abingoni (A. Smith, 1836). Golden-tailed Woodpecker (447)

Dendropicos fuscescens (Vieillot, 1818). Cardinal Woodpecker (450)

Thripias namaquus (Lichtenstein, 1793). Bearded Woodpecker (451)

Alaudidae

Eremopterix verticalis (A. Smith, 1836). Grey-backed Finch-lark (485)

Hirundinidae

Pseudhirundo griseopyga (Sundevall, 1859). Grey-rumped Swallow (499)

Cecropis abyssinica (Guérin, 1843). Lesser-Striped Swallow (503)

Riparia cincta (Boddaert, 1783). Banded Sand-Martin (510)

Dicruridae

Dicrurus adsimilis (Bechstein, 1794). Fork-tailed Drongo (517)

Oriolidae

Oriolus larvatus Lichtenstein, 1823. Black-headed Oriole (521)

Corvidae

Corvus albus Müller, 1776. Pied Crow (522)

Paridae

Parus after Gmelin, 1789. Grey Tit (525)

Parus niger Vieillot, 1818. Black Tit (527)

Remizidae

Anthoscopus minutus (Shaw and Nodder, 1812). Penduline Tit (531)

Timaliidae

Turdoides jardineii (A. Smith, 1836). Arrow-marked Babbler (533)

Turdoides leucopygia (Rüppell, 1840). White rumped Babbler (585)

Pycnonotidae

Pycnonotus nigricans (Vieillot, 1818). Red-eyed Bulbul (544)

Pycnonotus barbatus (Desfontaines, 1787). Black-eyed Bulbul (545)

Phyllastrephus terrestris Swainson, 1837. Terrestrial Bulbul (546)

Turdidae

Turdus libonyanus (A. Smith, 1836). Kurrichane Thrush (552)

Turdus litsitsirupa (A. Smith, 1836). Groundscraper Thrush (557)

Oenanthe pileata (Gmelin, 1789). Capped Wheatear (568)

Myrmecocichla arnotti (Tristram, 1869). Arnott's Chat (574)

Saxicola torquata (Linnaeus, 1766). Stone Chat (576)

Cossypha heuglini Hartlaub, 1886. White-browed Robin (580)

Erythropygia paena A. Smith, 1836. Kalahari Scrub Robin (586)

Erythropygia leucophrys (Vieillot, 1817). White-browed Scrub Robin (588)

Sylviidae

Calamocichla gracilirostris (Hartlaub, 1864). Cape Reed Warbler (604)

Sylvietta rufescens (Vieillot, 1817). Crombek (621)

Apalis flavida (Strickland, 1852). Yellow-breasted Apalis (625)

Camaraoptera brevicaudata (Cretzschmar, 1831). Grey-backed Bush Warbler (628)

Cisticola chiniana (A. Smith, 1843). Rattling Cisticola (642)

Cisticola galactotes (Temminck, 1823). Black-backed Cisticola (645)

Cisticola tinniens (Lichtenstein, 1842). Le Vaillant's Cisticola (646)

Priniidae

Prinia subflava (Gmelin, 1789). Tawny-flanked Prinia (649)

Muscicapidae

Muscicapa cinerca (Cassin, 1856). Blue-grey flycatcher (656)

Parisoma plumbeam (Hartlaub, 1858). Grey Tit-babbler (657)

Parisoma subcaeruleum (Vieillot, 1817). Tit-babbler (658)

Melaenormis pammelania (Stanley, 1814). Black Flycatcher (664)

Batis molitor (Huhn and Küster, 1850). White-flanked Flycatcher (673)

Motacillidae

Motacilla capensis Linnaeus, 1766. Cape Wagtail (686)

Anthus richardi Vieillot, 1918. Richard's Pipit (692)

Anthus similis Jerdon, 1840. Nicholson's Pipit (693)

Laniidae

Lanius collurio Linnaeus, 1758. Red-backed Shrike (708)

Laniarius ferrugineus (Gmelin, 1788). Boubou Shrike (709)

Laniarius atro-coccineus Burchell, 1822. Crimson-breasted Shrike (711)

Dryoscopus cubla (Shaw, 1809). Puffback Shrike (712)

Tchagra australis (A. Smith, 1836). Three-streaked Tchagra (714)

Tchagra senegala (Linnaeus, 1766). Black-crowned Tchagra (715)

Chlorophoneus sulphureopectus (Lesson, 1831). Orange-breasted Bush Shrike (719)

Urolestes melanoleucus (Jardine, 1831). Longtailed Shrike (724)

Prionops plumata (Shaw, 1809). White Helmet Shrike (727)

Sigmoctus retzii (Wahlberg, 1856). Red-billed Helmet Shrike (728)

Eurocephalus anguitimens A. Smith, 1836. White-crowned Shrike (730)

Nilaus afer (Latham, 1801). Brubru Shrike (731)

Sturnidae

Creatophora cinerea (Menschen, 1787). Wattled Starling (735)

Lamproeolius chalybaeus (Hemprich and Ehrenburg, 1828). Blue-eared Glossy Starling (738)

Lamprotornis mevesii (Wahlberg, 1857). Long-tailed Starling (742)

Lamprotornis australis (A. Smith, 1836). Burchell's Glossy Starling (743)

Byphagidae

Buphagus africanus Linnaeus, 1766. Yellow-billed Oxpecker (747)

Buphagus erythrorhynchus (Stanley, 1814). Red-billed Oxpecker (748)

Nectariniidae

Cinnyris mariquensis A. Smith, 1836. Marico Sunbird (755)

Cinnyris talatala A. Smith, 1836. White-breasted Sunbird (763)

Zosteropidae

Zosterops senegalensis Bonaparte, 1850. Yellow White-eye (777)

Bubalornithinae

Bubalornis albirostris (Vieillot, 1817). Buffalo Weaver (779)

Plocepasserinae

Plocepasser mahali A. Smith, 1836. White-browed Sparrow-weaver (780)

Passerinae

Passer diffusus (A. Smith, 1836). Grey-headed Sparrow (787)

Petronia superciliaris (Blyth, 1845). Yellow-throated Sparrow (788)

Ploceinae

Ploceus intermedius Rüppell, 1845. Lesser Masked Weaver (792)

Anaplectes rubriceps (Sundevall, 1851). Red-headed Weaver (793)

Ploceus cucullatus (Müller, 1776). Spotted-backed Weaver (797)

Ploceus xanthops (Hartlaub, 1862). Larger Golden Weaver (801)

Quelea quelea (Linnaeus, 1758). Red-billed Quelea (805)

Coliuspasser axillaris (A. Smith, 1838). Red-shouldered Widow-bird (816)

Estrildinae

Pytelia melba (Linnaeus, 1758). Melba Finch (830)

Lagonosticta senegala (Linnaeus, 1766). Red-billed Firefinch (837)

Uraeginthus angolensis (Linnaeus, 1758). Blue Waxbill (839)

Estrilda erythronotos (Vieillot, 1817). Black-cheeked Waxbill (841)

Estrilda astrild (Linnaeus, 1758). Common Waxbill (843)

Ortygospiza atricollis (Vieillot, 1817). Quail Finch (844)

SYSTEMATIC LIST OF MAMMAL SPECIES

Scientific nomenclature and systematic order follows that of R.H.N. Smithers (1971), "The Mammals of Botswana", with exceptions as cited under **MAMMAL FAUNA** – Results p. Species are noted from sight records, specimens identified by the National Museums of Rhodesia and in two instances from reliable persons operating in the study area.

Insectivora
Crocidura flavescens (I. Geoffroy, 1827). Giant Musk Shrew
Crocidura bicolor woosnami Dollman, 1915. Tiny Musk Shrew
Crocidura mariquensis shortridgei St. Ledger, 1932. Black Musk Shrew

Chiroptera
Epomophorus crypturus Peters, 1852. Peters' Epauletted Fruit Bat

Primates
Galago senegalensis bradfieldi Roberts, 1931. Lesser Galago, Night Ape
Cercopithecus aethiops ngamiensis Roberts, 1932. Vervet Monkey
Papio ursinus (Kerr, 1792). Chachma Baboon

Pholidota
Manis temmincki Smuts, 1832. Pangolin

Carnivora
Proteles cristatus (Sparrman, 1783). Aardwolf
Crocuta crocuta (Erxleben, 1777). Spotted Hyaena
Acinonyx jubatus jubatus (Schreber, 1775). Cheetah
Panthera pardus pardus Linnaeus, 1758. Leopard
Panthera leo (Linnaeus, 1758). Lion
Felis libyca griselda Thomas, 1926. Wild Cat
Felis serval serval Schreber, 1776. Serval
Otocyon megalotis megalotis (Desmarest, 1822). Bateared Fox
Lycaon pictus pictus (Temminck, 1820). Wild Dog
Canis adustus adustus Sundevall, 1846. Sidestriped Jackal
Canis mesomelas arenarum (Thomas, 1926). Blackbacked Jackal
Aonyx capensis capensis (Schinz, 1821). Clawless Otter
Lutra maculicollis chobiensis Roberts, 1932. Spotted-necked Otter
Mellivora capensis (Schreber, 1776). Honey Badger, Ratel

Ictonyx striatus (Perry, 1810). Striped Polecat

Viverra civetta civetta Schreber, 1776. Civet

Genetta genetta pulchra Matschie, 1902. Smallspotted Genet

Genetta tigrina rubiginosa Pucheran, 1855. Rustyspotted Genet

Cynictus penicillata (G. Cuvier, 1829). Yellow Mongoose

Herpestes sanguineus Rüppell, 1836. Slender Mongoose

Atilax paludinosis (G. Cuvier, 1829). Water Mongoose

Mungos mungo grisonax Thomas, 1926. Banded Mongoose

Tubulidentata

Orycteropus afer afer (Pallas, 1766). Antbear, Aardvark

Proboscidae

Loxodonta africana africana (Blumenbach, 1797). Elephant

Perissodactyla

Equus burchelli antiquorum (H. Smith, 1841). Burchell's Zebra

Artiodactyla

Phacochoerus aethiopicus sundevalli Lonnberg, 1908. Warthog

Hippopotamus amphibius capensis Desmoulins, 1825. Hippopotamus

Giraffa camelopardalis angolensis Lydekker, 1903. Giraffe

Sylvicapra grimmia splendidula (Gray, 1871). Common or Grey Duiker

Raphicerus campestris steinhardti (Zukowsku, 1924). Steenbok

Tragelaphus strepsiceros strepsiceros (Pallas, 1766). Kudu

Tragelaphus spekei selousi Rothschild, 1898. Sitatunga

Tragelaphus scriptus ornatus Pocock, 1900. Chobe Bushbuck

Aepyceros melampus melampus (Lichtenstein, 1812). Impala

Redunca arundinum arundinum (Boddaert, 1785). Reedbuck

Kobus ellipsiprymnus ellipsiprymnus (Ogilby, 1833). Waterbuck

Kobus leche leche Gray, 1850. Lechwe

Hippotragus equinus cottoni Dollman and Burlace, 1928. Roan

Syncerus caffer caffer (Sparrman, 1779). Buffalo

Connochaetes taurinus taurinus (Burchell, 1832). Blue Wildebeest

Damaliscus lunatus lunatus (Burchell, 1823). Tsessebe

Lagomorpha

Lepus saxitilis F. Cuvier, 1823. Scrub Hare

Rodentia

Cryptomys damarensis (Ogilby, 1838). Damara Mole-rat

Hystrix africaeaustralis Peters, 1852. Porcupine

Pedetes capensis damarensis Roberts, 1926. Spring Hare

Graphiurus murinus (Desmarest, 1822). Dormouse

Paraxerus cepapi maunensis Roberts, 1932. Bush Squirrel

Thryonomys swinderianus (Temminck, 1827). Greater Cane Rat

Otomys angoniensis maximus Roberts, 1924. Angoni Vlei Rat

Pellomys fallax rhodesiae Roberts, 1929. Creek Rat

Dasymys incomtus nudipes (Peters, 1870). Water Rat

Leggada minutoides induta (Thomas, 1910). Pygmy Mouse

Praomys natalensis microdon (Peters, 1852). Multimammate Mouse

Tatera leucogaster (Peters, 1852). Bushveld Gerbil

Tatera brantsi griquae Wroughton, 1906. Brant's Gerbil

MAMMALS NOT RECORDED BY THIS STUDY, BUT LISTED ADJACENTLY BY OTHER AUTHORS

Crocidura hirta deserti Schwann, 1906

Lesser Red' Musk Shrew. Smithers (1971) records from Riverine woodland fringes at Maun.

Tadarida midas midas (Sundevall, 1843)

Sundevall's Freetailed Bat.

This is probably the species of Tadarida as listed which could not be identified due to decomposition.

Tadarida pumila (Cretzschmar, 1830 vee 1831)

Little Freetailed Bat

Recorded from Maun by Smithers (*op. cit.*).

Eptesicus capensis capensis (A. Smith, 1829)

Cape Serotine Bat

Recorded as common and collected from rich Riverine woodland of the Okavango Delta. (Smithers, *op. cit.*)

Scotophilus leucogaster viridis (Peters, 1852)

Lesser Yellow House Bat

Recorded by Smithers (*op. cit.*) as occurring throughout the Okavango Delta.

Nycteris thebaica capensis A. Smith, 1829
Egyptian Slitfaced Bat

Recorded from the lower Khwai and Nokaneng (Smithers, 1971).

Felis caracal limpopoensis (Roberts, 1926)
Caracal Thwane

Caracal were recorded by Smithers (*op. cit.*) and visual records by myself from near Maun and Moremi Wildlife Reserve. Suitable habitat exists on Chief's Island but none were recorded.

Paracynictus selousi ngamiensis Roberts, 1932
Selous' Mongoose

Recorded from the lower Delta areas and being mainly nocturnal may have been missed (Smithers, *op. cit.*).

Herpestes ichneumon mababiensis Roberts, 1932
Large Grey Mongoose

Recorded from the Okavango River and northern parts of the Delta (Smithers, *op. cit.*). Being predominantly diurnal it is unlikely they were overlooked.

Ichneumia albicauda grandis (Thomas, 1890)
White-tailed Mongoose

Recorded on the Khwai and Gomoti Rivers and in the western extremity of Moremi Wildlife Reserve (Smithers, *op. cit.*). Being nocturnal and from close adjacent areas white-tailed mongoose may well occur.

Helogale parvula parvula (Sundevall, 1846)
Dwarf Mongoose leSwekete

Recorded from Moremi Wildlife Reserve (Smithers, *op. cit.*) and myself but appear to prefer drier areas near water. Being gregarious and diurnal, they are thought not to occur in the study area.

Ceratotherium simum simum (Burchell, 1817)
Squarelipped Rhinoceros

Extinct from Botswana but expansion or movement from recent introductions (1974) into the Moremi Wildlife Reserve may see this species present in the future in the study area.

Diceros bicornis bicornis (Linnaeus, 1758)
Black Rhinoceros Tshukudu

Recorded in Smithers *(op. cit.)* by Wilmot over Chief's Island. Although searched for after old residents also claimed black rhinoceros present in the past, no evidence of such could be found. They seem now restricted to the Kwando/Linyanti/Savuti areas and in Eastern Botswana opposite Wankie National Park.

Potamochoerus porcus (Linnaeus, 1758)

Bushpig Kolobe dombo

Recorded by Smithers (1971) and local residents from the extreme northern parts of the Delta. It is possible that bushpig occur in the extreme north of the study area but no evidence was found.

Hippotragus niger niger (Harris, 1838)

Sable Kwalata entsho

Although *J. Ramsden (verb.comm.) claimed to have seen Sable on Chief's Island, no evidence was found, and their distribution shows them to be marginal Delta inhabitants.

Saccostomus campestris (Peters, 1846)

Pouched Mouse

Recorded by Smithers (*op. cit.*) from the fringes of the Okavango Delta.

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SYSTEMATIC LIST OF REPTILES RECORDED

Species listed are from collected specimens identified by the Transvaal Museum, Pretoria; and in seven cases from sight records and own identification. The systematic order of the families follows that of FitzSimons (1943), Roiux-Estéve (1974) and Broadley, Gans and Visser (1976), (for Lizards); FitzSimons (1962) and Broadley (1971), (for Snakes); and Broadley (*op. cit.*), (for Tortoises and Crocodile).

SAURIA (LACERTILIA)

Gekkonidae

Lygodactylus capensis capensis (A. Smith, 1849).Common Dwarf Gecko

Chamaelontidae

Chamaelo dilepis dilepis Leach, 1819. Common East African or Flap-necked Chamaeleon.

Scincidae

Mabuya varia (Peters, 1867). Common Variegated Skink

Mabuya Striata Wahlbergii (A. Smith, 1869). Wahlberg's Striped skink

Riopa sundevallii sundevallii (A. Smith, 1849). Sundevall's Skink

Afroablepharus wahlbergii (A. Smith, 1849). Wahlberg's Dwarf Skink

Varanidae

Varanus exanthematicus albigulars (Daudin, 1802). White-throated Monitor, Rock or Tree Leguaan

Varanus niloticus (Linnaeus, 1762). Nile Monitor, Water or River Leguaan

Suborder Amphisbaenia

Amphisbaenidae

Dalophia pistillum (Boettger, 1895). Worm Lizard

SERPENTES (OPHIDIA)

Typhlopidae

Rhinotyphlops schlegelii dinga (Peters, 1854). Northern Zambesi or Variegated Blind Snake

Pythonidae

Python sebae (Gmelin, 1789). Common African Python

Colubridae

Philothamnus irregularis irregularis (Leach, 1819). Green Swamp Snake

Dasypeltis scabra scabra (Linnaeus, 1758). Common Egg-eater

Thelotornis capensis oatesii (Günther, 1881). Oates' Vine Snake

Xenocalamus mechowii inornatus Witte and Laurent, 1947. Western Quill-snouted Snake

Elapidae

Dendroaspis polylepis polylepis Günther, 1864. Black Mamba

Naja sp. cf. *haje anchaetae* Bocage, 1879. Egyptian Cobra

Viperidae

Causus rhombeatus (Lichtenstein, 1823). Common or Rhombic Night Adder

Crocodylia

Crocodylus niloticus Laurentus (part), 1768. Nile Crocodile

TESTUDINES (CHELONIA)

Testudinidae

Geochelone pardalis babcocki (Loveridge, 1935). Leopard Tortoise

Kinixys beliana belliana Gray, 1931. Bell's Hinged Tortoise

Pelomedusidae

Pelusios bechuanicus FitzSimon, 1932. Okavango Hinged Terrapin

Pelusios castaneus Hewitt, 1927. Hinged Terrapin

Pelusios subniger Lacépède, 1789. Pan Terrapin

SYSTEMATIC LIST OF AMPHIBIANS RECORDED

Species listed are from collected specimens identified by the Transvaal Museum Pretoria. Systematic order of the Families follows that of Poynton (1964).

Pipidae

Xenopus muelleri (Peters, 1844). Northem Platanna

Bufonidae

Bufo regularis Reuss, 1834. Common Toad

Ranidae

Hemisinae

Hermisus marmoratum (Peters, 1854). Mottled Burrowing Frog

Hyperolinae

Hyperolius angolensis Steindachner, 1867. Angolan Painted Reedfrog

Hyperolius nasutus Günther, 1864. Long Reed Frog

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APPENDIX 1

STATISTICAL RESULTS SAMPLE CENSUS I EASTERN FLOODPLAINS 30.5.73
MORNING COUNT. FLYING TIME 3 HRS. 13 MINS. PERCENTAGE OF STRATUM SAMPLED 18,5 OBSERVERS 2. n = 13

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR $(\hat{Y})$	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT OF $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
LECHWE	4 110	1 170 724	6,14	1 082	± 2 121	52
IMPALA	1 434	337 561	2,14	581	± 1 139	79
BUFFALO	1 045	481 636	1,56	694	± 1 360	130
WARTHOG	662	22 500	0,99	150	± 294	44
WILDEBEEST	390	36 481	0,58	191	± 374	96
ZEBRA	322	47 961	0,48	219	± 429	133
HIPPOPOTAMUS	331	16 384	0,49	128	± 251	76
TSESSEBE	370	9 216	0,55	96	± 188	51
WATERBUCK	248	20 164	0,37	142	± 278	112
WILD DOG	126	4 489	0,19	67	± 131	104
KUDU	110	3 600	0,16	60	± 118	107
REEDBUCK	66	576	0,098	24	± 47	71
SITATUNGA	62	361	0,092	19	± 37	60
BABOON TROOPS	26	169	0,039	13	± 25	98
GIRAFFE	5	25	0,008	5	± 10	196
STEENBOK	5	25	0,008	5	± 10	196

APPENDIX 2

STATISTICAL RESULTS SAMPLE CENSUS II CHIEF'S ISLAND 7.7.73
AFTERNOON COUNT. FLYING TIME 3 HRS. 30 MINS. PERCENTAGE OF STRATUM SAMPLED 7,80. OBSERVERS 1. n = 16.

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	1 920	289 444	2,44	538	± 1 054	55
BUFFALO	1 100	1 207 801	1,39	1 099	± 2 154	196
GIRAFFE	428	19 881	0,54	141	± 276	64
ZEBRA	422	63 504	0,54	252	± 494	117
WARTHOG	320	11 449	0,41	107	± 210	66
WILDEBEEST	134	6 241	0,17	79	± 155	116
TSESSEBE	74	2 704	0,09	52	± 102	138
KUDU	78	1 600	0,10	40	± 78	100
OSTRICH	94	3 136	0,12	56	± 110	117
BABOON TROOPS	29	400	0,04	20	± 39	135
ELEPHANT	14	196	0,02	14	± 27	196
LECHWE	14	196	0,02	14	± 27	196
MONKEY GROUPS	14	196	0,02	14	± 27	196

APPENDIX 3

STATISTICAL RESULTS SAMPLE CENSUS III WESTERN FLOODPLAINS 30.8.73
MORNING COUNT. FLYING TIME 3 HRS. 59 MINS. PERCENTAGE OF STRATUM SAMPLED 17,4. OBSERVERS 1. n = 27

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
BUFFALO	1 105	1 134 225	3,14	1 065	± 2 087	189
LECHWE	1 325	695 556	3,77	834	± 1 635	123
IMPALA	1 509	248 004	4,28	498	± 976	65
WILDEBEEST	664	98 596	1,89	314	± 615	93
WARTHOG	390	7 569	1,11	87	± 171	44
TSESSEBE	203	15 376	0,58	124	± 243	120
ZEBRA	63	2 500	0,18	50	± 98	156
KUDU	90	4 356	0,26	66	± 129	144
BABOON TROOPS	43	256	0,12	16	± 31	73
GIRAFFE	45	1 369	0,13	37	± 72	161
REEDBUCK	34	625	0,10	25	± 49	144
HIPPOPOTAMUS	5	25	0,01	5	± 10	196

APPENDIX 4

STATISTICAL RESULTS SAMPLE CENSUS IV EASTERN FLOODPLAINS 31.8.73
AFTERNOON COUNT. FLYING TIME 4 HRS. PERCENTAGE OF STRATUM SAMPLED 10,26. OBSERVERS 1. n = 14

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
LECHWE	2 500	632 035	3,73	795	± 1 558	62
TSESSEBE	412	36 864	0,62	192	± 376	91
WARTHOG	310	22 500	0,46	150	± 294	95
BUFFALO	221	48 400	0,33	220	± 431	195
WILDEBEEST	144	8 836	0,21	94	± 184	128
HIPPOPOTAMUS	77	2 025	0,12	45	± 88	115
BABOON TROOPS	95	625	0,14	25	± 49	52
KUDU	119	14 400	0,18	120	± 235	198
ELEPHANT	77	3 481	0,12	59	± 116	150
IMPALA	68	1 849	0,10	43	± 84	124
REEDBUCK	48	1 156	0,07	34	± 67	139
SITATUNGA	30	256	0,04	16	± 31	105

APPENDIX 5

STATISTICAL RESULTS SAMPLE CENSUS V – CHIEF'S ISLAND 24.11.73
MORNING COUNT. FLYING TIME 3 HRS. 50 MINS. PERCENTAGE OF STRATUM SAMPLED 15,6. OBSERVERS 2. n = 18

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	1 813	231 961	2,29	531	± 1 041	57
ZEBRA	383	26 896	0,49	164	± 321	83
WILDEBEEST	321	41 209	0,41	103	± 398	124
GIRAFFE	290	7 056	0,37	84	± 165	57
WARTHOG	136	1 225	0,17	35	± 69	50
KUDU	78	2 704	0,10	52	± 102	131
TSESSEBE	12	64	0,02	8	± 16	131
OSTRICH	12	64	0,02	8	± 16	131
ELEPHANT	6	36	0,01	6	± 12	196
BUFFALO	7	49	0,01	7	± 14	196

APPENDIX 6

STATISTICAL RESULTS SAMPLE CENSUS VI WESTERN FLOODPLAINS 1.12.73
AFTERNOON COUNT. FLYING TIME 4 HRS. 20 MINS. PERCENTAGE OF STRATUM SAMPLED 34,82. OBSERVERS 2. n = 26

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
BUFFALO	539	274 576	1,53	524	± 1 027	191
LECHWE	706	61 009	2,01	247	± 484	69
ZEBRA	309	31 684	0,88	178	± 349	113
IMPALA	291	12 100	0,83	110	± 216	74
WILDEBEEST	187	7 396	0,53	86	± 169	90
WARTHOG	82	484	0,23	22	± 43	53
GIRAFFE	96	2 209	0,27	47	± 92	96
TSESSEBE	59	1 089	0,17	33	± 65	110
BABOON TROOPS	44	121	0,13	11	± 22	49
KUDU	14	196	0,04	14	± 27	196
REEDBUCK	10	25	0,03	5	± 10	98
OSTRICH	7	49	0,02	7	± 14	196
HIPPOPOTAMUS	5	16	0,01	4	± 8	157
SITATUNGA	5	16	0,01	4	± 8	157

APPENDIX 7

STATISTICAL RESULTS SAMPLE CENSUS VII EASTERN FLOODPLAINS 13.12.73
MORNING COUNT. FLYING TIME 3 HRS. 50 MINS. PERCENTAGE OF STRATUM SAMPLED 20,54. OBSERVERS 2. n = 14

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	1 994	208 849	2,98	457	± 896	45
LECHWE	1 158	36 864	1,73	192	± 376	32
REEDBUCK	95	841	0,14	29	± 57	60
BUFFALO	56	3 136	0,08	56	± 110	196
WARTHOG	52	256	0,08	16	± 31	60
HIPPOPOTAMUS	23	529	0,03	23	± 45	196
GIRAFFE	15	225	0,02	15	± 29	196
BABOON TROOPS	23	169	0,03	13	± 25	111
TSESSEBE	18	100	0,03	10	± 20	109
KUDU	4	16	0,01	4	± 8	196
SITATUNGA	4	16	0,01	4	± 8	196

APPENDIX 8

STATISTICAL RESULTS SAMPLE CENSUS VIII CHIEF'S ISLAND 13.12.73
AFTERNOON COUNT. FLYING TIME 3 HRS. 40 MINS. PERCENTAGE OF STRATUM SAMPLED 15,6. OBSERVERS 2. n = 18

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR $(\hat{Y})$	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT OF $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	4 320	829 921	5,47	911	± 1 786	41
BUFFALO	781	240 100	1,00	490	± 960	123
GIRAFFE	312	7 396	0,40	86	± 169	54
WILDEBEEST	316	40 401	0,40	201	± 394	125
KUDU	208	7 569	0,26	87	± 171	82
ZEBRA	172	7 396	0,22	86	± 169	98
OSTRICH	55	1 764	0,07	42	± 82	150
WARTHOG	32	361	0,04	19	± 37	116
TSESSEBE	25	400	0,32	20	± 39	157
LION	16	256	0,02	16	± 31	196
REEDBUCK	27	729	0,03	27	± 53	196
LECHWE	13	169	0,02	13	± 25	196
BUSHBUCK	7	49	0,01	7	± 14	196
STEENBOK	6	36	0,01	6	± 12	196
BABOON TROOPS	7	49	0,01	7	± 14	196

APPENDIX 9

STATISTICAL RESULTS SAMPLE CENSUS IX WESTERN FLOODPLAINS 18.4.74
MORNING COUNT. FLYING TIME 3 HRS. 15 MINS. PERCENTAGE OF STRATUM SAMPLED 34,82. OBSERVERS 2. n = 27

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	355	18 310	1,01	135	± 265	75
LECHWE	237	4 314	0,67	66	± 129	54
WILDEBEEST	185	8 936	0,53	95	± 186	101
BUFFALO	489	232 953	1,39	483	± 947	194
WARTHOG	143	1 444	0,41	38	± 74	52
TSESSEBE	62	1 119	0,18	33	± 65	105
GIRAFFE	72	789	0,21	28	± 55	76
REEDBUCK	56	485	0,16	22	± 43	77
ZEBRA	27	708	0,08	27	± 53	196
KUDU	28	191	0,08	14	± 27	96
BABOON TROOPS	19	78	0,05	9	± 18	95
STEENBOK	5	20	0,01	5	± 10	200

APPENDIX 10

STATISTICAL RESULTS SAMPLE CENSUS X CHIEF'S ISLAND 18.4.74
AFTERNOON COUNT. FLYING TIME 3 HRS. 15 MINS. PERCENTAGE OF STRATUM SAMPLES 15,60. OBSERVERS 2. n = 18

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	2 135	290 307	2,70	539	± 1 056	49
BUFFALO	2 109	1 048 481	2,67	1 024	± 2 007	95
ELEPHANT	451	179 009	0,57	423	± 829	184
GIRAFFE	330	6 261	0,39	79	± 155	47
ZEBRA	94	2 182	0,12	47	± 92	98
WARTHOG	104	1 427	0,12	38	± 74	72
KUDU	54	1 611	0,07	40	± 78	145
OSTRICH	43	1 888	0,06	43	± 84	196
LECHWE	49	918	0,06	30	± 59	120
WILDEBEEST	34	469	0,04	17	± 33	98
TSESSEBE	20	404	0,03	20	± 39	196
BABOON TROOPS	22	122	0,03	11	± 22	98
STEENBOK	17	126	0,02	12	± 24	138
HIPPOPOTAMUS	5	19	0,01	4	± 8	157

APPENDIX 11

STATISTICAL RESULTS SAMPLE CENSUS XI EASTERN FLOODPLAINS 19.4.74
MORNING COUNT. FLYING TIME 3 HRS. PERCENTAGE OF STRATUM SAMPLED 20,54. OBSERVERS 2. n = 14

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR $(\hat{Y})$	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT OF $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
LECHWE	1 044	141 353	1,56	376	± 737	71
IMPALA	689	70 787	1,03	266	± 521	76
BUFFALO	486	165 648	0,73	407	± 798	164
GIRAFFE	99	1 628	0,15	40	± 78	79
WARTHOG	60	617	0,09	25	± 49	82
REEDBUCK	45	789	0,07	28	± 55	122
WILDEBEEST	34	789	0,05	28	± 55	161
TSESSEBE	30	893	0,05	30	± 59	196
BABOON TROOPS	12	64	0,02	8	± 16	131
DUIKER	10	42	0,01	6	± 12	118
LION	5	23	0,01	5	± 10	196

APPENDIX 12

STATISTICAL RESULTS SAMPLE CENSUS XII WESTERN FLOODPLAINS 28.7.74
MORNING COUNT. FLYING TIME 3 HRS 10 MINS. PERCENTAGE OF STRATUM SAMPLED 34,82. OBSERVERS 2. n = 27

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
BUFFALO	1 176	1 036 196	3,34	1 018	± 1 995	170
IMPALA	534	35 797	1,52	189	± 370	69
WILDEBEEST	249	13 027	0,71	114	± 223	90
LECHWE	184	2 983	0,52	55	± 108	59
TSESSEBE	179	8 052	0,51	90	± 176	99
WARTHOG	98	1 001	0,28	32	± 63	64
GIRAFFE	76	2 196	0,22	47	± 92	121
REEDBUCK	94	1 158	0,27	34	± 67	71
ZEBRA	31	311	0,09	18	± 35	114
KUDU	42	475	0,12	22	± 43	103
LION	38	837	0,11	29	± 57	150
BABOON TROOPS	13	53	0,04	7	± 14	106

APPENDIX 13

STATISTICAL RESULTS SAMPLE CENSUS XIII CHIEF'S ISLAND 28.7.74
AFTERNOON COUNT. FLYING TIME 3 HRS 20 MINS. PERCENTAGE OF STRATUM SAMPLED 15,60. OBSERVERS 2. n = 18

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	4 773	1 584 026	6,04	1 259	± 2 468	52
BUFFALO	2 103	3 816 694	2,66	1 954	± 3 829	182
GIRAFFE	169	2 245	0,21	47	± 92	55
ZEBRA	121	3 609	0,15	60	± 118	97
WILDEBEEST	128	6 106	0,16	78	± 153	119
ELEPHANT	81	2 014	0,10	45	± 88	109
WARTHOG	50	336	0,06	18	± 35	71
KUDU	40	860	0,05	29	± 57	142
TSESSEBE	49	1 175	0,06	35	± 69	140
LECHWE	25	357	0,03	19	± 37	149
BABOON TROOPS	19	105	0,02	10	± 20	103
REEDBUCK	14	197	0,02	14	± 27	196
HIPPOPOTAMUS	9	79	0,01	9	± 18	196
OSTRICH	6	40	0,01	6	± 12	196

APPENDIX 14

STATISTICAL RESULTS SAMPLE CENSUS XIV EASTERN FLOODPLAINS 29.7.74
MORNING COUNT. FLYING TIME 3 HRS. 25 MINS. PERCENTAGE OF STRATUM SAMPLED 20,54. OBSERVERS 2. n = 14

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR $(\hat{Y})$	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT OF $(\hat{Y})$	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
BUFFALO	3 735	1 567 325	5,58	1 252	± 2 454	65
LECHWE	654	32 014	0,98	179	± 351	54
IMPALA	577	56 161	0,86	237	± 465	81
ELEPHANT	383	41 560	0,57	204	± 400	104
WARTHOG	154	3 428	0,23	59	± 116	75
TSESSEBE	124	9 496	0,19	97	± 190	153
KUDU	96	2 540	0,14	50	± 98	102
GIRAFFE	46	1 752	0,07	42	± 82	179
WILDEBEEST	57	1 036	0,09	32	± 63	110
WATERBUCK	25	641	0,04	25	± 49	196
REEDBUCK	37	148	0,06	12	± 24	64
BABOON TROOPS	26	148	0,04	12	± 24	90
OSTRICH	10	42	0,01	6	± 12	118

APPENDIX 15

STATISTICAL RESULTS SAMPLE CENSUS XV WESTERN FLOODPLAINS 4.12.74
MORNING COUNT. FLYING TIME 3 HRS. 30 MINS. PERCENTAGE OF STRATUM SAMPLED 34,82. OBSERVERS 2. n = 27

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
IMPALA	1 434	257 115	4,07	507	± 994	69
LECHWE	413	36 709	1,17	192	± 376	91
WILDEBEEST	205	15 923	0,58	126	± 247	120
BUFFALO	147	15 740	0,42	125	± 245	167
GIRAFFE	139	3 855	0,39	62	± 122	87
TSESSEBE	105	1 881	0,30	43	± 84	80
WARTHOG	84	551	0,24	23	± 45	54
ZEBRA	125	9 269	0,36	96	± 188	151
KUDU	58	1 846	0,17	43	± 84	145
REEDBUCK	26	118	0,07	11	± 22	83
BABOON TROOPS	33	130	0,09	11	± 22	65

APPENDIX 16

STATISTICAL RESULTS OF SAMPLE CENSUS XVI CHIEF'S ISLAND 4.12.74
AFTERNOON COUNT. FLYING TIME 3 HRS. 35 MINS. PERCENTAGE OF STRATUM SAMPLED 15,60. OBSERVERS 2. n = 18

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
BUFFALO	3 569	3 846 868	4,52	1 961	± 3 844	108
IMPALA	3 212	719 043	4,07	848	± 1 662	52
GIRAFFE	329	5 078	0,42	71	± 139	42
ZEBRA	233	24 194	0,30	156	± 306	131
WARTHOG	183	4 553	0,23	67	± 131	72
KUDU	72	1 469	0,09	38	± 74	103
ELEPHANT	37	713	0,05	27	± 53	143
WILDEBEEST	52	671	0,07	26	± 51	98
TSESSEBE	34	650	0,04	26	± 51	150
BABOON TROOPS	38	230	0,05	15	± 29	77
LECHWE	14	208	0,02	14	± 27	196
REEDBUCK	9	80	0,01	9	± 18	196

APPENDIX 17

STATISTICAL RESULTS SAMPLE CENSUS XVII EASTERN FLOODPLAINS 5.12.74
MORNING COUNT. FLYING TIME 3 HRS. 20 MINS. PERCENTAGE STRATUM SAMPLED 20,54. OBSERVERS 2. n = 14

MAMMAL	POPULATION ESTIMATE $\hat{Y}$	POPULATION VARIANCE VAR ($\hat{Y}$)	AVERAGE DENSITY PER SQUARE KILOMETRE di	STANDARD ERROR S.E. ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT OF ($\hat{Y}$)	95 PER CENT CONFIDENCE LIMIT AS A PERCENTAGE OF $\hat{Y}$
LECHWE	1 239	65 953	1,85	257	± 504	41
IMPALA	242	19 880	0,36	141	± 276	114
REEDBUCK	180	1 727	0,27	42	± 82	46
WARTHOG	209	5 155	0,31	72	± 141	68
GIRAFFE	81	1 036	0,12	32	± 63	77
BABOON TROOPS	65	715	0,10	27	± 53	81
WILDEBEEST	49	1 357	0,07	37	± 73	148
TSESSEBE	42	1 751	0,06	42	± 82	196
LION	45	2 096	0,07	45	± 88	196
WATERBUCK	23	518	0,03	23	± 45	196
BUFFALO	9	69	0,01	8	± 16	174
HIPPOPOTAMUS	5	23	0,01	5	± 10	196

APPENDIX 18

SUMMARY OF RESULTS OF FOUR RED LECHWE AERIAL CENSUSES ON A 2 KM^2 GRID IN THE MOREMI WILDLIFE RESERVE AND ADJACENT FLOODPLAINS 1975

DATE	TOTAL COUNTED IN 2 x 300 METRE TRANSECTS			POPULATION ESTIMATE CORRECTED Ŷ			TOTAL
	MOANACHIRA-M'BOROGHA	MOGHELO-GOMOTI	KHWAI	MOANACHIRA-M'BOROGHA	MOGOHELO GOMOTI	KHWAI	
5 – 6 February 1975							
Area	461 km^2	709 km^2	302 km^2	461 km^2	709 km^2	302 km^2	1472 km^2
	583	777	598	1943	2590	1993	6526 *
Standard Error				± 243	± 497	± 325	
Density Per km^2				(4,21)	(3,65)	(6,60)	
26 – 27 April 1975	521	1358	348	1736	4526	1160	7422
Standard Error				± 340	± 642	± 198	
Density Per km^2				(3,77)	(6,38)	(3,84)	
22 – 24 July 1975	473	1234	501	1577	4123	1670	7370
Standard Error				± 318	± 586	± 349	
Density Per km^2				(3,42)	(5,82)	(5,53)	
17 – 18 October 1975	347	1474	455	1156	4913	1517	7586
Standard Error				± 224	± 823	± 287	
Density Per km^2				(2,51)	(6,93)	(5,02)	

* Total estimate considered low due to missing some prime lechwe habitat because of navigational problems.

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