SOUTHERN SUDAN
Co-ordinator

SOUDAN DU SUD
Coordonnateur

Mary J. BURGIS

5.1. THE SUDD

by R.G. BAILEY

1. Geography and Morphology

Location: The Sudd wetland is here considered to include the Bahr el Jebel - White Nile system with its associated lakes, swamps and floodplains lying between Mongalla and Malakal (Figs. 5.1 and 5.3). Lat. 6°-9°30'N and Long. 30°-32°E; Altitude: 380-448 m.

Morphology: The Nile provides perennial inflow into the Sudd (Bahr el Jebel). It descends northwards onto the Sudan plains bringing water from the East African lakes and Equatorial Highlands. From Mongalla it initially flows in parallel channels within a well-delineated, steeply-banked trough. Further out onto the flat, gently northwards-sloping terrain, the lateral restrictions are lost, its pace slackens and spillage results in a broadening belt of wetland. This consists of a complex of braided flowing-river channels and shallow lakes which northwards, becomes increasingly diffuse and ill-defined, in vast tracts of shaded-swamp vegetation. The main channel remains intact however with depths of 5-7, maximally 10 m. At lake No (see 5.2) it receives a minor input from the Bahr el Ghazal (draining a very different catchment to the west) and then regains some water from the central and eastern swamps via the Bahr el Zeraf. The river is now called the White Nile or Bahr el Abiat. It flows eastwards in a clearly defined trough with a narrow floodplain before resuming its northward passage below the Sobat confluence.

2. Geology

The major wetlands and shallow water-bodies of the Southern Sudan are located in plains which occupy a broad tectonic depression infilled by fluviatile and lacustrine sediments. These gravels, sands and heavy black clays, belong to the Umm Ruwaba formation of uncertain age (? Tertiary and Pleistocene) and depth (more than 200 m) (Berry in Rzoska 1976). The plains are encircled to the south by the Equatorial Highlands and the Ethiopian plateau.

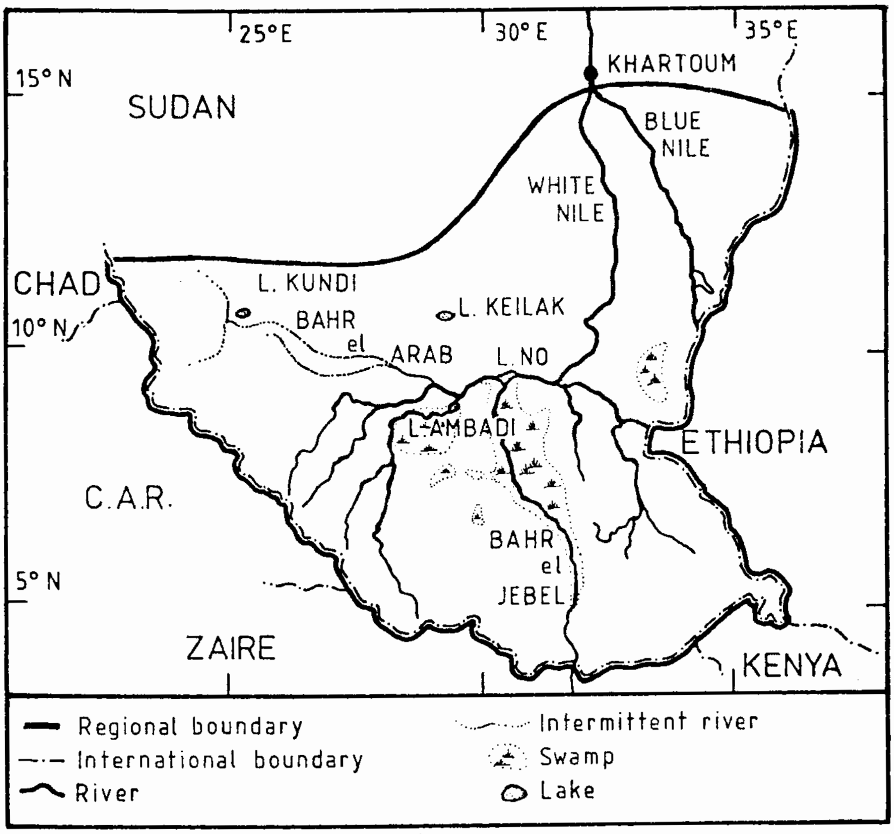


Fig. 5.1 General map of the area included in Region 5.

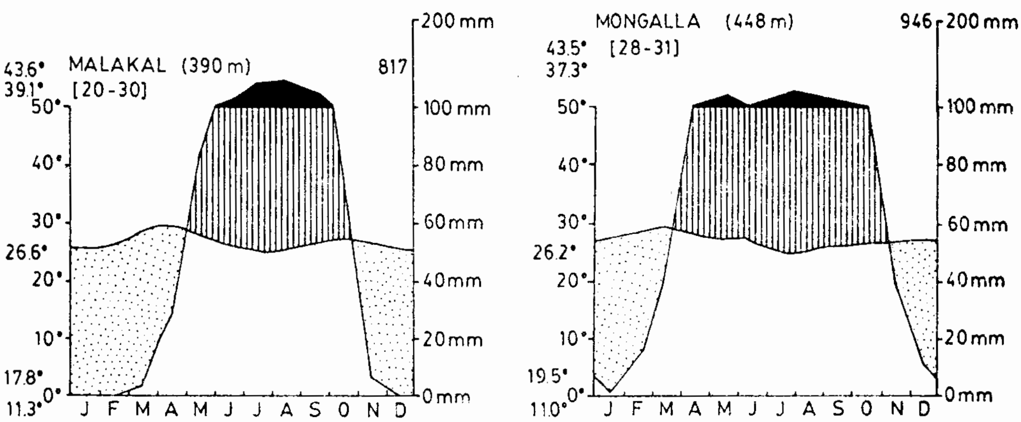


Fig. 5.2 Climatic diagram for Mongala, at the southern extremity, and Malakal, at the northern extremity of the Sudd.

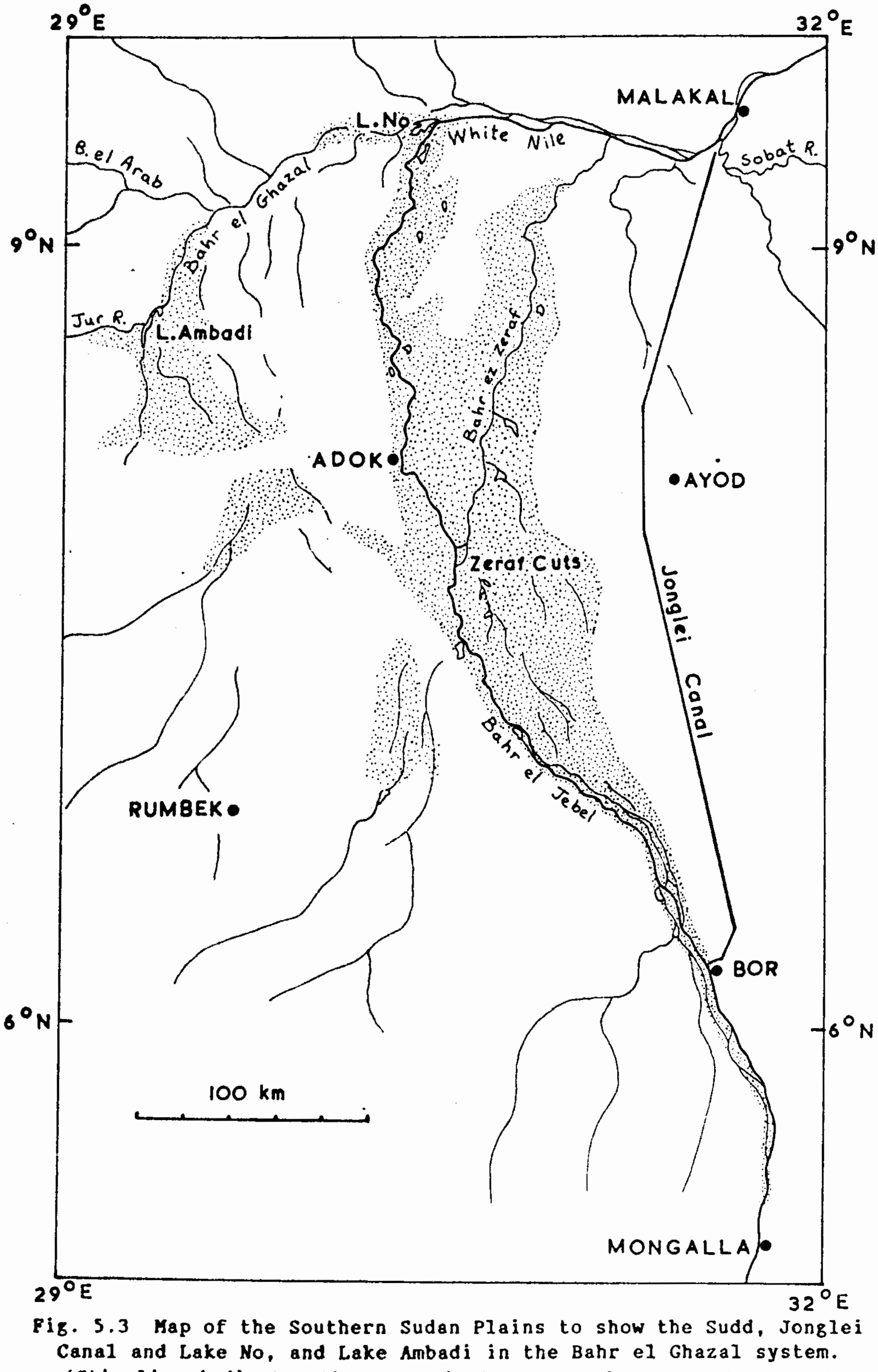


Fig. 5.3 Map of the Southern Sudan Plains to show the Sudd, Jonglei Canal and Lake No, and Lake Ambadi in the Bahr el Ghazal system. (Stippling indicates the approximate areas of permanent swamp.)

3. Climate

Unless otherwise indicated, the data given are derived from the Sudan Meteorological Department for 1941-70 at Malakal (9°31'N, 31°40'E) and Bor (6°18'N, 31°34'E). Summarising climatic diagrams from Walter & Lieth's Climatic World Atlas (1960-67) are given for Mongalla and Malakal in Fig. 5.2.

Köppen code: Aw_6

Insolation (hr): mean per year at Malakal 2,847; month of maximum: December (328); month of minimum: July (142).

Solar radiation ($Jm^{-2}d^{-1}$): mean at Malakal 67.5; month of maximum: April (74.5); month of minimum: July (59.5).

Wind ($m.sec^{-1}$):	Malakal		Bor (1977-81)	
mean monthly		2.77		1.18
month of maximum	Feb/Dec	3.98	Dec	1.97
Month of minimum	Sept	1.74	July	0.75

Highest average windspeeds occur between December and April in the dry season. Winds are mainly from the north-east and often dust-laden. Lowest average wind speeds occur between July and September in the wet season. Winds are variable but predominantly southerly (Mefit-Babtie 1983).

Rainfall (mm):	Malakal		Bor	
mean annual total		787		905
month of maximum	Aug	167	July	142
month of minimum	Dec-Feb	0	Dec	4

Recorded annual totals over the area as a whole range between 730-920 mm. Maximum annual totals more than 1,000 mm; and minimum annual totals less than 600 mm have been recorded. Rainfall periodicity: wet season - May to October; dry season - November to April.

Evaporation (mm):	Malakal		Bor	
mean annual total		2008		2150
month of maximum	March	205	Dec/Jan	217
month of minimum	Aug	133	July/Aug	140

Evaporation rates in the Sudd swamps approximate to those for open water with a value similar to that recorded above for Bor (Sutcliffe & Parks 1982).

Air temperature (°C)	Malakal		Bor	
mean monthly		27.8		27.4
month of maximum	April	31.1	March	29.7
month of minimum	July/Aug	26.1	Sept	25.3

Data for Nyany (6°52'N, 31°25'E): 1981-82 (Waring for Mefit-Babtie 1983)

	mean daily maximum & range	mean daily minimum & range
warmest month: March	38.5 (35-44)	23 (18.5-26)
coolest month: Aug	31 (27-34)	21 (19.5-22.5)

4. Hydrology

The hydrology of the Sudd is characterised by the effects of both long-term and seasonal variations in the inflow of the Nile. Long-term variations in discharges from the East African lakes are well-documented if not satisfactorily explained. During this century they increased sharply, if briefly, in 1916-18, and then again in 1961, for a protracted period which has continued up to the present time. The recorded mean annual inflows and outflows of the Sudd, before and after 1961 are (Mefit-Babtie 1983):

	Inflow at Mongalla ($m^3.10^6$)	Outflow at Malakal (excluding Sobat discharge)
1905-1960	26,831	14,158
1961-1980	50,324	21,387

The marked diminution in volume at the end of the swamps relative to the inflow is indicative of the high evaporative losses which occur in the Sudd. Note that whereas the mean inflow since 1961 has increased by a factor of 1.88, the outflow has only risen by 1.51, which may be attributed to evaporation from the enlarged areas of open water and swamp. Sutcliffe & Parks (1982) provide the only available hydrological model of the system and show how the area of perennial swamp has a positive correlation with discharge into the Sudd. For example during low discharges in 1950-52 the permanently inundated area of the Sudd downstream of Mongalla was estimated at c. 3,000 km^2 compared with 16,500 km^2 in 1980 during the current period of high river flow.

Seasonal variations in the inflow result from annual fluctuations in the discharges from the great lakes and affluents of the Bahr el Jebel between them and Mongalla. High inflows commence in April or May and, with some variations, persist until November. The outflow has a damped seasonal cycle and therefore remains relatively constant. An important consequence of seasonally high flows is an annual overspill from the permanent aquatic system which floods large areas of grassland, especially to the east and on Zeraf Island. It is also probable that some water leaks westwards into the Bahr el Ghazal catchment at this time. Flooding normally coincides with the wet season, but rainfall may seal the black "cracking" clays on the alluvial plains in advance of the flood. Moreover flooding in the eastern grasslands may be enhanced by the "creeping-flow" of rainfall run-off from the south along almost imperceptible north-westerly gradients. The total area of seasonally river-flooded grasslands downstream of Mongalla was estimated at c. 15,500 km^2 in 1980 compared with ca. 11,000 km^2 in 1950-52 (Mefit-Babtie 1983). Very little water returns to the permanent aquatic system from the eastern floodplain which rapidly dries out except for some pools of standing water which may persist well into the dry season.

3. Physico-chemical characteristics of the water

Considerable spatial and seasonal variations in physico-chemical characteristics are apparent in the recorded data from the Sudd.

a) Main channels: a number of longitudinal surveys have demonstrated the influence of riverain swamps during the Sudd passage (Talling 1957; Bishai 1962; Kurdin 1968; Prosser for Mefit-Babtie 1983).
Temperature: 22-30°C.
Secchi disc transparency: 0.17-1.90 m. Transparency is greatest during the dry season but at all times it generally increases through the system as turbidity is reduced.
Conductivity: $150\text{-}360.10^{-6}$ $S.cm^{-1}$ (20°C).
Total alkalinity: 1.14-2.90 $meq.l^{-1}$
Higher values occur in the dry season. Evaporation losses in the Sudd may be expected to increase conductivity and alkalinity during the river passage and this is so in data for the wet season and one of two dry season studies. Sobat flood water has a marked dilutant effect and conductivities downstream of the confluence may fall to less than 100.10^{-6} $S.cm^{-1}$.

pH: 6.7-8.4
O_2 % saturation: 10-87
CO_2: 0.5-25.0 $mg.l^{-1}$

Processes of decomposition in the swamp result in lowered dissolved oxygen and pH, and raised carbon dioxide levels in the first half of the river passage, but further downstream an improvement occurs. Talling found that deoxygenation of river water was more strongly developed in the period of high flows and rain, possibly as a consequence of swamp flushing.

Ca: 4- 9 $mg.l^{-1}$	Si: 1-14 $mg.l^{-1}$	PO_4P: $5\text{-}140.10^{-6}$ $g.l^{-1}$
Mg: 3-10 $mg.l^{-1}$	SO_4: 0.5-10.0 $mg.l^{-1}$	NO_3N: $6\text{-}60.10^{-6}$ $g.l^{-1}$
Cl: 3-12 $mg.l^{-1}$	Fe: $50\text{-}1300.10^{-6}$ $g.l^{-1}$	NH_3N: $6\text{-}110.10^{-6}$ $g.l^{-1}$

Silicon, total iron and ammonia show an increase during the river passage through the Sudd, whereas nitrate, phosphate and sulphate especially, generally decrease in concentration.

b) Lakes and swamps: Open-water bodies have increased considerably since the 1960s so that a range of "lake" conditions now occur in the Sudd. These vary from short-retention widenings of river channels to extensive basins with river connections but long retention times; and from sheets of apparently isolated standing water to swamp pools. All are shallow, less than 3 m deep, with recorded values for other parameters generally falling within the ranges given above for main channels.

A southern river-lake investigated by Prosser (for Mefit-Babtie 1983) exhibited a short, turbid and dilute flood-phase, followed by a longer lake-phase with higher transparency, pH and total dissolved solids but some reduction in plant nutrients, notably phosphorus. Swamp enclosed lakes, and swamp-influenced water in river-associated lakes, have extreme clarity for much of the year, with raised conductivity, alkalinity, phosphate, ammonia and CO_2, combined with depressed pH, silicon, sulphate and dissolved oxygen (where submerged plants are absent).

Lake waters may become supersaturated with O_2 over prolific beds of submerged vegetation and fall to 10-20% saturation beneath mats of floating plants.

c) Interstitial swamp water presents another reducing environment with impoverished O_2, and high CO_2 and ammonia concentrations. It is possible that as a result of the increased quantities of water passing through the system since 1961, less extreme levels of deoxygenation overall are currently experienced in the Sudd (Mefit-Babtie 1983).
Transient oxygen depletion accompanies seasonal flooding of grasslands before algal associations develop. Pools left by the receding floods become increasingly turbid and concentrated with conductivities reaching between 500-1000.10^{-6} $S.cm^{-1}$.

4. Macrophytes

Shaded swamp gives the Sudd its distinctive physiognomy. Cyperus papyrus forms a central riparian belt the breadth of which diminishes from south to north. Outside this in the middle and north lie tracts of Typha domingensis which have spread enormously since the early 1960s. Vossia cuspidata and Phragmites karka are also found in waterside fringes. (Lock for Mefit-Babtie 1983; Denny 1984). Eichhornia crassipes, first recorded in the Nile in the 1950s (Gay 1968) has extensively invaded the Sudd. It fringes main channels anbd lakes taking over the niche formerly occupied by Pistia stratiotes. It also blocks minor channels, forms rafts on rivers and large circular islands on lakes.

Submerged and floating-leaved macrophytes in lakes include Ceratophyllum demersum, Najas pectinata, Vallisneria sp., Ottelia ulvifolia, O. scabra, Nymphaea lotus, Trapa natans and Potamogeton sp.

In the seasonally river-flooded grasslands, Vossia and Echinochloa occupy areas inundated for the longest period, but overall Oryza longistaminata predominates (Mefit-Babtie 1983).

The productivity of papyrus in the Sudd is high and probably matches the value of 10,000-12,000 $g.m^{-2}yr^{-1}$ determined for Uganda swamps (Thompson 1977). By contrast the few data available suggest that Typha production is much lower than has been recorded elsewhere. Oryza production has been estimated at around 550 $g.m^{-2}yr^{-1}$ (Lock & Goldsworthy for Mefit-Babtie 1983).

5. Algae

A sparse phytoplankton in flowing waters comprises long-term river elements dominated by Melosira granulata and Lyngbya limnetica (Prowse & Talling 1958) and generally short-term lake or swamp-generated elements, for example pennate diatoms, desmids and dinoflagellates, flushed out in the flood-phase (Prosser for Mefit-Babtie 1983). Lakes contain a richer plankton than river channels in general, although recorded standing crops vary widely (less than 1 to 144.10^{-6} g chlorophyll a l^{-1}) depending upon lake type and season. Rich periphytic assemblages of diatoms and cyanophytes are associated with submerged macrophytes, notably Najas.

Algal production in Sudd lakes appears to be nutrient, rather than light, limited.

A succession of mobile and epiphytic algal communities develop in the pools on seasonally flooded grassland, amongst which euglenoids, desmids and filamentous green algae are important (Mefit-Babtie 1983).

6. Invertebrates

Zooplankton collections in river channels and lakes comprise up to six cladocerans, including Diaphanosoma excisum, Daphnia barbata and Moina dubia; 2-6 copepods, including Thermocyclops neglectus, Thermodiaptomus galebi and Tropodiaptomus spp.; and about 24 rotiferans of which Brachionus, Lecane, Keratella and Filinia appear to be the most species-rich genera (Rzoska 1974; Monakov 1969; Mefit-Babtie 1983). Recorded standing crops are highly variable ranging from 600-600,000 individuals m^{-3}; 0.001-0.246 $g.m^{-3}$; with the lowest values coming from flowing water. Copepods usually predominate in net samples; cladocerans are more frequently found in plankton from lakes and backwaters.

Fringing vegetation may support diverse communities of small crustaceans, including cladocerans (34 spp., Rzçska 1952), copepods, ostracods and the conchostracan Cyclestheria hislopi.

Pools in flooded grasslands develop large populations of microscopic life, ciliates and testate amoebae, while recorded mean densities for rotifers and small crustaceans combined, ranged between 1,100-2,350 l^{-1} (Litterick for Mefit-Babtie 1983).

Zoobenthos: samples from river and lake beds indicate an impoverished zoobenthos of oligochaetes, chironomid larvae and, in lakes only, molluscs. Monakov (1969) gives some biomass data; 0-0.2 $g.m^{-2}$ in the main channels; 1.0-4.7 $g.m^{-2}$ in lakes. By contrast bottom-feeding fish may have guts filled with chironomids, chaoborids and bivalve molluscs (Mefit-Babtie 1983). In addition Odonata, Ephemeroptera, Trichoptera, Hemiptera, Diptera, water-mites, gastropods, leeches and the larger crustaceans, Caridina nilotica and Macrobrachium niloticus, contribute to recorded fresh-weight biomasses ranging from 5 - 12 $g.m^{-2}$.

Interstitial swamp water contains air-breathing or oxygen-thrifty species of Coleoptera, Hemiptera, Diptera and pulmonate gastropods. Beetles again predominate in a diverse insect fauna, which includes culicids, on the floodplains. Sixty-three mosquito species occur in the Sudd of which 47 are true swamp-breeders (Lewis in Rzçska 1974). Molluscs, some of which overcome the dry period by aestivation e.g. Pila spp, are also important in seasonal habitats.

7. Fish

About 100 species of fish have been recorded from the Sudd region (Sandon 1950) including 31 siluroids, 16 characoids, 14 cyprinoids, 11 mormyrids, 8 cichlids and 7 cyprinodontids.

Sixty-six species were identified in catches from a recent survey (Hickley & Bailey for Mefit-Babtie 1983) of which 61 occurred in rivers, lakes and fringing vegetation. Most numerous were Alestes dentex, Hydrocynus forskahlii, Synodontis frontosus, Eutropius niloticus, Auchenoglanis biscutatus, Oreochromis niloticus, Citharinus latus, Distichodus rostratus, Labeo niloticus, Mormyrus cashive, Heterotis niloticus, Lates niloticus and the smaller species, Micralestes acutidens and Chelaethiops bibie. Except for zooplanktivores, representatives from all strata in the trophic spectrum were found with a predominance of omnivores and carnivores. Submerged plants provide food for herbivores and the extensive root mats of water hyacinth afford cover and browsing for smaller fishes, including the juveniles of several larger species.

Of sixteen species associated with papyrus and Typha, Polypterus spp., Heterotis spp., Gymnarchus niloticus and Clarias spp (known or believed to be air-breathers) may penetrate the swamps, and the tiny cyprinodontids, Aplocheilichthys spp and Epiplatys spp., inhabit "interstitial" pools.

Twenty-two species were recorded in the eastern, seasonally river flooded grasslands, including Protopterus aethiopicus, Polypterus spp., Heterotis spp., Clarias spp., Channa obscura and a variety of smaller fishes, notably Barbus spp., anabantids, cyprinodontids and cichlids (including juvenile tilapias). Of these most are insectivorous but larger fishes are in part piscivores.

The majority of Sudd fishes spawn in the permanent system but Protopterus, Polypterus, Heterotis and Gymnarchus nest in the permanent and seasonal swamps, and amongst the grassland invaders, clariid catfishes and many of the accompanying small species, are intent on spawning.

8. Other vertebrates

i) Amphibia and Reptiles: At least 9 species of frogs and toads are known in the Sudd. Crocodiles have reportedly declined, but the monitor lizard Varanus niloticus, and two terrapins, Pelusios subniger and Trionyx tringuis, are common in the swamp and floodplain.

ii) Birds: Birds are amongst the most prominent inhabitants of the Sudd region, the majority being associated with the floodplains which are regarded as having the richest avifauna of any African wetland. About 20 species, mainly ducks and geese, feed on submerged vegetation in shallow water; 100, inluding storks, ibises, waders, lily-trotters, rails and wagtails on the ground, and swifts, swallows and pratincoles in the air, feed on aquatic or emergent invertebrates of one sort or another; and 40, including grebes, cormorants, pelicans, herons, storks, fish eagles, terns and kingfishers, are known to catch and eat fishes and amphibians. A particularly noteworthy inhabitant of the permanent swamps is the shoebill stork, Balaeniceps rex (Mefit-Babtie 1983).

Mammals: Year-round inhabitants of the Sudd are hippopotamus, buffalo, sitatunga antelope and Nile lechwe. During the dry season a variety of herbivores, some in vast numbers, migrate to feed in the re-exposed grasslands and to drink in remnant pools and at the edges of the permanent system. The main migrants in order of numerical importance are: tiang (topi), Mongalla gazelle, reedbuck, white-eared cob, waterbuck, giraffe, oribi, elephant and zebra. Herbivores are followed by predators, for example lion and hyena (Mefit-Babtie 1983).

9. Human activities

i) Population and development: The people of the Sudan Plains in the vicinity of the Sudd are, the Dinka in the south, west and north-east; the Nuer in the centre including Zeraf island; and the Shilluk along the White Nile at the tail of the swamps. All three groups are essentially pastoralists who have adopted cultivation and some exploitation of wildlife resources as integral parts of their activities. Compared with the more sedentary Shilluk, the Dinka and Nuer are migratory following the seasonal pattern of hydrobiological events. Their permanent homesteads are located in the "highlands" distinguished as areas less liable to flooding rather than by altitude. Here, in the wet season, cattle, sheep and goats are kept and sorghum (dura) is grown. In the dry season the unmarried people and cattle move towards the Sudd for the grazing and watering places afforded by the uncovered floodplains. They follow established, traditional routes, living in temporary cattle-camps, and hunting and fishing in the grasslands and swamp margins. With the onset of the rains, a return migration ensues (J.I.T. 1954, J.E.O. 1982). The total population in the area of and around the Sudd is probably about 400,000. There are few towns or large villages (Fig. 5.3) and communications and services are seriously disrupted during the wet season.
The Sudd has been traversed in the exploration for oil in the Southern Sudan Plains and it is probable that an abstraction industry will commence in the near future. A major development project in the area is the construction of the Jonglei Canal, see below.

ii) Wetland exploitation:

Navigation: At present the navigable channel of the Nile offers the only year-round surface transportation through the area. Two enterprises operate passenger and cargo services.

Fisheries: Unlike other African cattlemen, the Nilotics appreciate the value of fish and they have traditionally obtained a major seasonal food supplement, chiefly by spear-fishing in the floodplains and at their interface with the riverain swamps. Clarias is prominent in the catch which also includes Protopterus, Polypterus, Heterotis, and Gymnarchus. Seasonal activities range from opportunistic fishing from the cattle-camps to organised fishing "holidays" and "festivals" involving groups of men or entrie families.

While grazing has been lost by swamp encroachment since the floods in 1961, the new wetland areas and their lakes have enlarged the potential for perennial fisheries. Some Dinka and Nuer and many riparian Shilluk have increasingly turned to fishing as a means of obtaining both subsistence and income. Year-round fishing camps in the Sudd have increased, using staked gill-nets as the major gear, supplemented in places by drift, seine and cast-nets. The fishes caught in order of overall importance are Distichodus, Citharinus, Heterotis, tilapias, Lates, Gymnarchus, large mormyrids, large catfishes, large characids and Labeo. Catches for market are mostly sun-dried but there is a fluctuating salt-fish industry operated by Arab merchants, Fellat (West African origin), a Shilluk Cooperative and the Government Fisheries Department.

Some estimates of the potential yield of the Sudd fisheries, to the order of 100,000-200,000 t are unduly high, being based upon inflated evaluation of the area of the Sudd and assumptions about its floodplains extrapolated from elsewhere. However much larger harvests could be sustained than at present, if reliable transportation and markets can be established. An FAO/UNDP Sudd Fisheries Development Programme has been set up and it is based in Bor (Fig. 5.3). (Bailey, Trottier & McWeeny for Mefit-Babtie 1983.)

Hunting: This is an important seasonal activity on the floodplain and around the permanent settlements. In the south-east of the area it has been estimated that wild animals contribute 25% of the annual meat intake. Hunting centres on the more numerous herbivores, notably the Tiang and Mongalla gazelle (Mefit-Babtie 1983)

Abstraction: When it becomes operational, the Jonglei Canal will subject the Sudd to a major, man-induced manipulation. Its path is shown in Fig. 5.3. Excavation began in 1978 and was scheduled for completion in 1985. The canal, 360 km long, c. 50 m wide and 4 m deep, will divert 20-25 million cubic metres of the daily flow of the Bahr el Jebel around the swamp and return it to the Nile at the Sobat confluence. Primarily intended to conserve water for irrigation, the navigable canal and its accompanying all-weather road, will also greatly improve communications in the area. At the same time the operational canal must bring about a shift in the distribution and areas of the wetland zones. The available predictions suggest that the swamps will shrink in area by 21-25% and the floodplains by 15-17%. However, only if the Nile discharge into the Sudan Plains reverts to its pre-1961 levels or abstraction is doubled by the construction of a second canal, will the wetland suffer drastic reduction.

The Jonglei Canal project has generated considerable activity aimed at introducing simple proposals for ameliorating any adverse effects of the canal and to take advantage of the general impetus to development its construction affords.

Vegetation control: The management of the main navigable channels requires periodic clearing of "sudd-blocks", natural dams created initially by rafts of Vossia and papyrus. This is achieved by cutting and more recently in the course of oil exploration, by explosives. Regular river traffic reduces the frequency of blocks.

Eichhornia crassipes obstructs minor channels and may cover over lakes and backwaters. Fishermen force and maintain narrow passages through the hyacinth and the weevil, Neochetina spp. have been introduced as a biological control method. Harvesting and utilisation of hyacinth have been advocated (Freidel 1979; Mefit-Babtie 1983).

Protective legislation: The Sudd is one of the most important wetlands in the world. It contains a diversity of habitats and wildlife including the majority of the world's population of the shoebill stork and the Nile lechwe. In addition it is a vital refuge for migratory birds from Europe, the Middle East and Asia.

Three areas have accordingly been gazetted as wildlife reserves, near Shambe, Zeraf Island in entirety, and Fanyikang, an island at the tail of the swamps.

5.2. LAKES NO AND AMBADI

by J. GREEN

5.2.a LAKE NO

1. Geography and Morphology

Location: Junction of the Bahr el Ghazal and Bahr el Jebel, South Sudan. Lat. 9°30'N, long. 30°37'E, Altitude 385 m (Fig. 5.3)

Morphometry: The lake is surrounded by extensive papyrus swamps. It is about 10 km long and 2.5 km wide. The maximum depth is about 9 m.

2. Climate: similar to that at Malakal (see fig. 5.2).

3. Hydrology

The normal discharge of the Bahr el Ghazal is between one and two million m^3 per day, but rises to about 4 million m^3 per day in October, and in exceptional years may rise to 8 million m^3 per day. These rates of flow include some spillage from the Bahr el Jebel, and are only about 4% of the flow in the jebel. The hydrology of Lake No is complicated by the flood regime of the Sobat. When the Sobat is in flood the waters back up in Lake No and partway down the Bahr el Jebel.

4. Physico-chemical characteristcs of the water

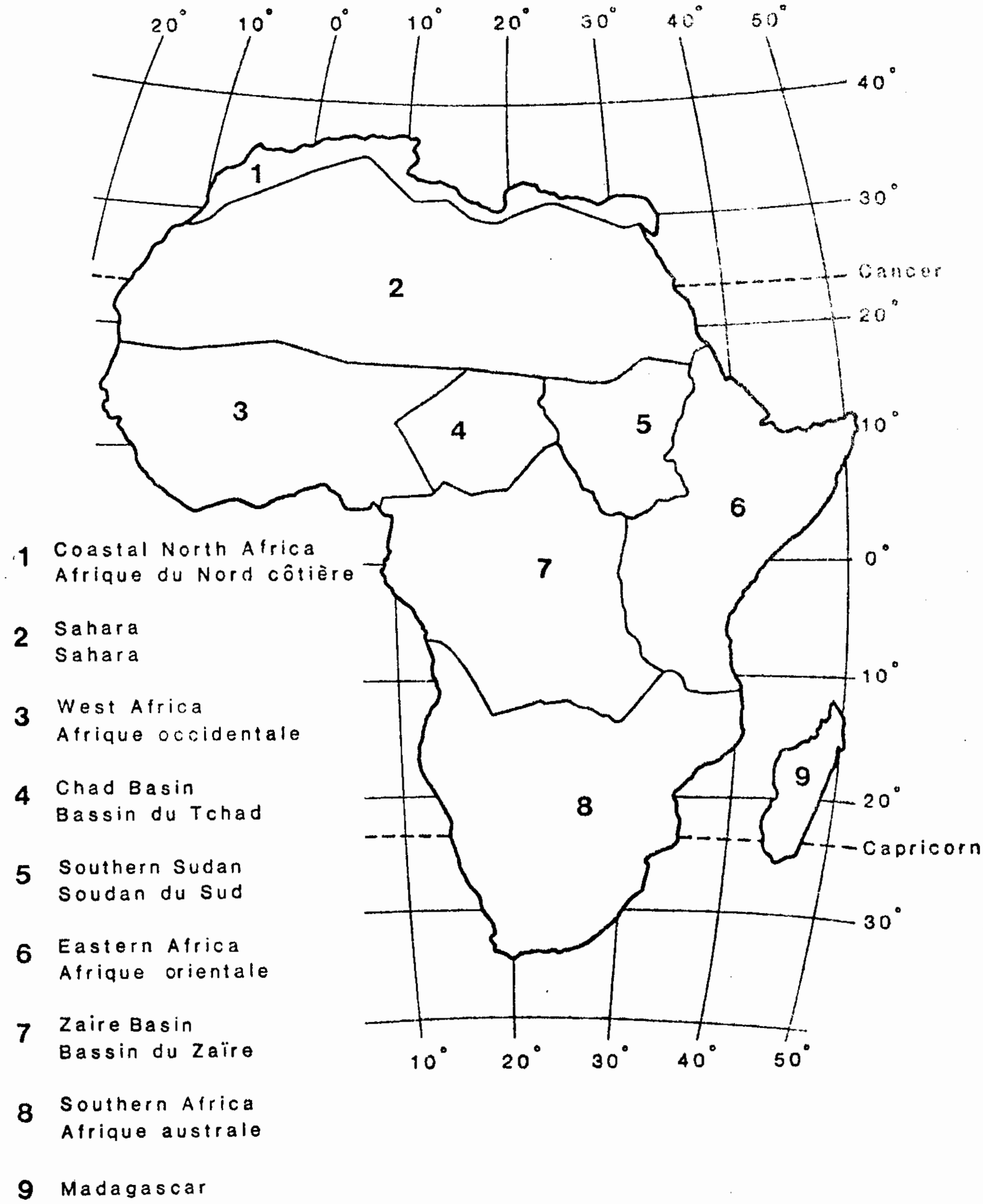
Conductivity: $200\text{-}250.10^{-6}$ $S.cm^{-1}$ (20°C).
pH: 7.1 - 7.8
Secchi disc: 30 - 60 cm
Oxygen (Dec. 1976): 90% saturated at 27.5°C (10 cm depth); 72% saturated at 27.5°C (70 cm depth); 56-65% saturated in Jan. and Dec. 1954 (Talling 1957)

5. Macrophytes

The edge of the lake is surrounded by Cyperus papyrus, and at the base of this marginal vegetation there is a fringe of Eichhornia crassipes. The open water has large patches of Najas pectinata and Nymphaea lotus.

6. Phytoplankton

Major components of the phytoplankton include Lyngbya limnetica, Melosira granulata, and Anabaena flos-aquae. In December - January 1953-54 algal cell numbers were found to range from 1720 to 2880 per ml (Rzoska 1974)



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African wetlands and shallow water bodies

Zones humides et lacs peu profonds d'Afrique

M. J. BURGIS
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