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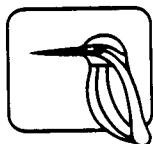
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Wattled Crane



Photo by L. Walkinshaw.

STATUS AND ECOLOGY OF WATTLED CRANE IN AFRICA

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Abstract: Wattled cranes (*Bucyranus carunculatus*) are distributed throughout the southern 3rd of Africa with a small separate population in the highlands of southwestern Ethiopia, inhabiting small wetlands throughout their range. Six large wetlands, the Kafue Flats, Bangweulu, Busanga, and Liuwa in Zambia, and the Okavango and Magadigadi in Botswana provide extensive floodplains which are preferred habitat for feeding and nesting. Individual wetlands support 250 to 3,000 cranes during peak seasons. These large, stately cranes, named for their 2 pendant chin wattles, feed mainly by digging nutritious sedge tubers and rhizomes with their large beak. They usually nest during the rainy season, in small wetland habitats, when ample water is available and sedge growth rejuvenates. In the large wetlands nesting takes place in expanses of open, shallow water as floodwaters recede and the floodplain margin provides large areas of sedge foods. The numbers of wattled crane pairs nesting and the amount of available food are directly related to the amount of flooding or receding water (the area of the floodplain) in the large wetlands. The wattled crane has the lowest reproductive rate of the crane family and its ecology closely resembles its closest relative, the endangered Siberian white crane (*Bucyranus leucogeranus*). Wattled cranes are presently declining in numbers throughout their historic range. Small wetland habitats have been lost through habitat alteration and destruction by intensive agricultural practices, afforestation, and wetland drainage or damming. These developments and low reproductive rates have resulted in the extirpation of the wattled crane in Swaziland and Cape Province, South Africa. South Africa lists the wattled crane as an endangered species in the provinces of Natal and Transvaal. The wattled crane is declining or present only in small numbers in Zimbabwe, Malawi, Ethiopia, Namibia, Angola, Zaire, and Mozambique. The large wetlands of Zambia and Botswana are targets for large development projects including wetland reclamation (Okavango), hydroelectric schemes and damming (Kafue Flats; Bangweulu), while human pressures are suppressing the reproduction of a theoretically protected population of wattled cranes (Liuwa). The most alarming project includes the damming of the Kafue River above Kafue Flats to regulate annual flooding, thereby directly reducing the area available to feeding and nesting wattled cranes and threatening the future of their largest population. Conservation recommendations and future research needs are outlined for these cranes and the wetlands they inhabit.

The wattled crane (Fig. 1) is a truly unique member of Gruidae which inhabits some of the world's largest and biologically diverse wetland ecosystems, existing in remote regions of southcentral Africa. Due to worldwide destruction and alteration of wetlands by human activities, valuable wetland resources and their dependent wildlife communities are fast disappearing. Cranes, due to their habitat and territorial requirements, are often the 1st species affected by wetland development. The wattled crane is Africa's largest crane and requires a specialized habitat, depending on shallow wetlands and predominantly sedge-based vegetarian diet. The species is easily observed and counted due to its large size and long conspicuous white neck; thus, it is an excellent indicator species of wetland stability and human wildlife values.

The endangered status of 6 crane species (Vincent 1966), and the concern of West (1976, 1977) and Douthwaite (1974) for the wattled crane, prompted the initiation of this study. From October 1978 to March 1979, this International Crane Foundation researcher, with the financial support of the New York Zoological Society, investigated the status of wattled cranes and their wetlands in Zambia, Botswana, and South Africa, in order to document information on the biology of the species, to define conservation problems, and to propose solutions through appropriate channels in each country. This paper is a comprehensive account of the information collected during the study.

Walkinshaw (1973) and Snow (1978) have analyzed the distribution of the wattled crane in Africa (Fig. 2). The nucleus population is found in the southern 3rd of the continent (desert regions) and a separate population exists in Ethiopia.

LARGE WETLANDS

The large wetlands in the interior of southcentral Africa are international treasures of water and plant

and animal life. Formed along major river drainages, these wetlands are linked to a relatively level plateau with low gradients, widely spaced drainage networks, and high rainfall during the wet season, especially in the northern basins. In this region, 6 large wetlands were found to be of major importance to the wattled crane as resident and nesting areas. These include Kafue Flats, Bangweulu, Busanga, and Liuwa in Zambia and the Okavango in Botswana. The Magadigadi of Botswana is also included in this group because of its importance as a wet season concentration area (Fig. 3).

These large wetlands are located along the major river systems: the Zambezi, Congo, and Okavango. Kafue Flats and Busanga are formed along the Kafue River, a major tributary of the Zambezi. The Luambimba and Luanginga Rivers, which are also tributaries of the Zambezi, flood Liuwa. Bangweulu is located along the Chambezi-Luapula Rivers drainage, the headwaters of the Congo River basin. The Okavango is at the terminus of the Okavango River. The Botlote River drains southeast from the Okavango to provide limited water to the Magadigadi.

Tropical freshwater wetlands have the highest productivity of all natural communities. Tropical wetlands are complex and either have high densities of individuals or high diversities of species, or both, and have very tight nutrient cycles (Thompson 1976). Wetlands formed on river systems have a marked influence on the hydrology because they flood rapidly during the rainy season, but release water slowly as the dry season advances. The wetlands form sponges, increasing the water storage capacity of the rivers in their upper basins, thereby regulating flow and limiting the amplitude of the runoff to prevent floods downriver during the wet season and to continue to release waters to give a more continual flow to the river system during the dry season. Wetlands also store nutrients, provide natural filters, minimize

erosion, and in some circumstances recharge groundwater supplies.

The number of wattled cranes in each large wetland is probably related to the area of floodplain in each wetland. The wattled crane's nesting strategy is associated with the flooding cycles of each large wetland. Pairs begin nesting as floodwaters recede after peak flooding. The timing of flooding depends on hydrological factors unique to each wetland but factors include the amount of inflow from local precipitation, the timing of floodwaters from distant upper basins, and the amount of outflow via natural drainage and evapotranspiration. This nest initiation strategy takes advantage of large areas of shallow floodplain which "boom" with an abundance of sedges after a dormant period during high floods. The strategy ensures ample foods for the family if the nesting attempt is successful.

Migrations of wattled cranes may occur throughout the large wetlands and are necessitated by changes in habitat due to heavy seasonal flooding or dry conditions in small wetlands. The Magadigadi is used by wattled cranes solely as a wet-season concentration area; however, little is known of the movements of these birds.

The large wetlands important to wattled cranes (except Magadigadi) are also inhabited by large herds of lechwe (*Kobus lechwe*), a medium-sized antelope that has adapted to wetland floodplains where water levels are shallow enough for the herds to wade in and graze

on submergent vegetation. The lechwe and wattled cranes share the same floodplain habitat and are often seen feeding together.

The large wetlands host many levels of life, most notably the diverse plant life, trees, invertebrates, fishes, reptiles, birds, and mammals. These wetlands produce huge quantities of fish, supporting important fisheries and providing food for large human populations. They provide extensive habitats for a great variety of birdlife, which uses them for feeding, roosting, migrating, wintering, resting, moulting, or nesting. Large mammals use either the wetland proper or the vegetation of the dried floodplain for feeding, especially during the dry season, when upland grasslands are dry or burned over. Domestic livestock also use the wetland borders as pasturelands.

Large wetlands are often targets for development by agricultural, irrigation, industrial, mining, and hydroelectric interests. These developments must only be considered with great restraint. Africa is still in a development infancy and therefore must consider the consequences suffered by the loss of valuable wetlands in Europe, Asia, North America, and the Nile River system to the north (Curry-Lindahl 1972).

Kafue Flats

Kafue Flats is a large riparian floodplain encompassing over 6,000 km² along the meandering 255-km course of the Kafue River's eastward flow where the gradient falls less than 10 m over the entire

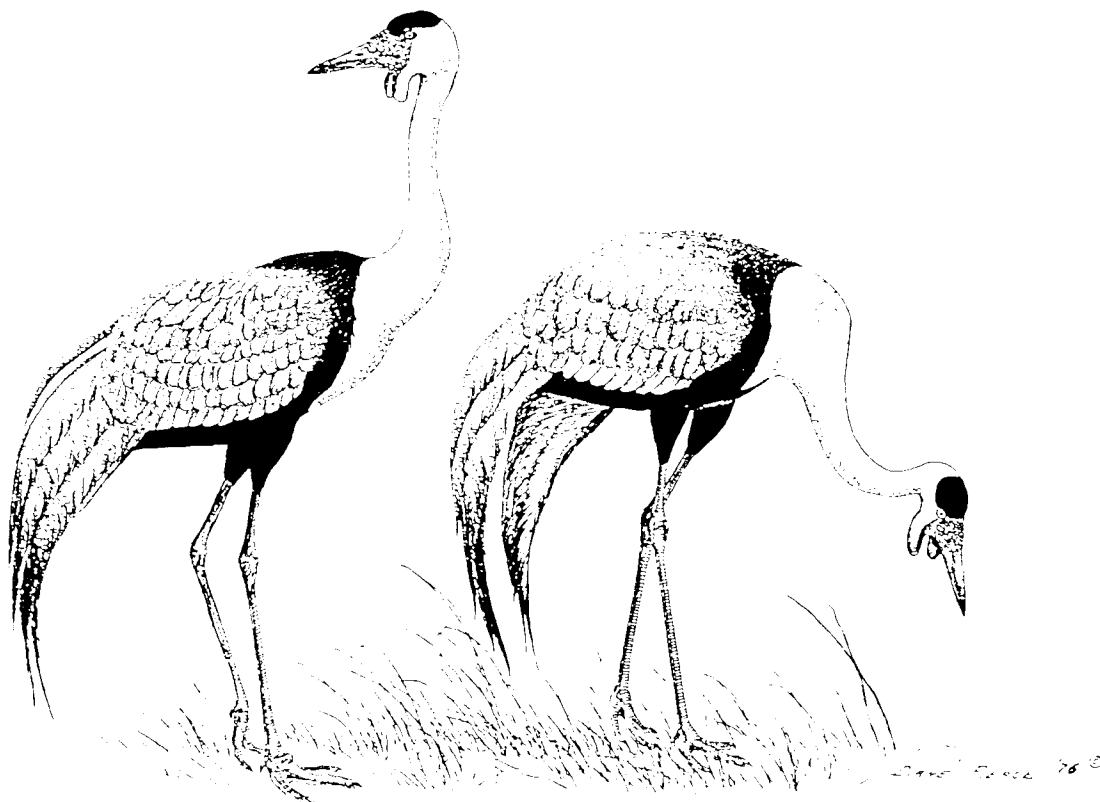


Fig. 1. Wattled crane. Ink study by Diane Pierce, courtesy of Edge of the Wild Studios, Mentor, Ohio.

flats. The flooding cycle begins with the onset of the rains in November. The greatest water volumes originate in upper Kafue Basin where rainfall is higher than on Kafue Flats (Table 1). The floods reach a peak in March on the western side of Kafue Flats, but may take until June to reach the eastern end. The timing and duration of flooding are variable from year to year, as is the extent of flooding. However, the natural flooding of the Kafue Flats is now being altered by a large hydroelectric scheme.

Kafue Flats supports Africa's largest population of wattled cranes, numbering about 300 breeding pairs and up to 3,000 individuals at peak seasons (Douthwaite 1974). These population peaks correspond with receding floodwaters which provide large areas of floodplain along the wetland edges. Vesey-FitzGerald (1965) describes the floodplain as a "water meadow grassland." When flooded this meadow comprises a semifloating sward of grasses and sedges which collapse as the water recedes, forming a thick mat with nodes growing up through the prostrate mat. As floodwaters recede the cranes are attracted to this shallow floodplain to feed on the tubers and rhizomes of submerged sedges, which are procured by digging with their large beaks.

Douthwaite (1974) lists the sedges consumed by wattled cranes on the Kafue Flats as *Cyperus esculentus*, *Cyperus usitatus*, and *Eleocharis dulcis*. Gerard Ellenbroek (pers. comm.) includes *Cyperus rotundus* and indicates that *Cyperus* rhizomes measure 3 to 5 mm in diameter, while *Eleocharis dulcis* rhizomes are at least 8 mm in diameter during the wet season and may be slightly thicker during the dry season. Although variable in area, the floodplain of shallow water and thick vegetation may extend 100 m or more from the wetland border, with water levels generally less than 1.5 m deep.

Pairs nest as floodwaters recede and provide shallow lagoons and large expanses of shallow, open floodplain as nesting habitat. Most nesting takes place from May to September with a peak in June and July. The number of pairs nesting each year is dependent on the amount of flooding. Douthwaite (1974) found that approximately 40% of the pairs observed nested in a normal year of flooding, while in a year of limited flooding only 3% of the pairs nested.

During observations on the Kafue Flats a total of 552 wattled cranes were seen (Table 2). Breeding pairs made up 64% of the total; 11% of the pairs observed were successful in raising a chick to fledging (Tables 3 and 4). Nonbreeding birds made up 32% of the population. Only 20 chicks (3.6% of the population) were observed, a very low productivity rate.

During the rainy season (November through March) wattled cranes begin feeding on sedges in moistened upland soils, but also continue feeding on the floodplain. However, during high floods the uplands become more important as the wattled cranes feed on sedge tubers and rhizomes, grass seeds, and insects (Douthwaite 1974). The high floods also mark a period of partial winter dormancy for floodplain vegetation (Vesey-FitzGerald 1965). The cranes return to the floodplains at the onset of the dry season when the flood-controlled meadows vegetate as floodwaters recede and the rain-controlled grasslands are dry and often burnt (op. cit.).

Many wattled cranes leave Kafue Flats during years of high rainfall (Douthwaite 1974), perhaps due to lower food availability during high floods. Movements

from the Kafue Flats coincide with influxes of wattled cranes into the Magadigadi of northeastern Botswana (south of Kafue Flats) where large flocks, numbering up to 2,000 in some years, moult and feed from January to May in uplands adjacent to wetlands of Magadigadi (Mark Muller, pers. comm.). The Kafue Flats population makeup is not well understood because with seasonal changes (Douthwaite 1974) some of the population of wattled cranes resides outside Kafue Flats, but uses the Flats as a staging area. Additional studies using color-coded numbered bands or radio-tags, or both, are needed to properly understand the movements of these birds in the wetlands of southcentral Africa.

The floodplains of Kafue Flats are dominated by the endemic Kafue lechwe (*Kobus lechwe kafuensis*) which has adapted to feeding in the wet meadow grasslands of the floodplains. Kafue lechwe and wattled cranes share this special habitat along with great numbers and diverse species of wading birds and waterfowl. The grazing and trampling of the submergent vegetation by lechwe opens feeding areas for many water birds. The floodplain also provides insects, snails, fishes, and other nonvegetative foods.

The floodplain of Kafue Flats provides a wildlife spectacle, with herds of thousands of lechwe grazing with many species of plovers, jacana, kingfishers, herons, ibis, storks, cranes, ducks, and geese using the floodplain in their respective foraging niches. It is a scene filled with color, motion, and a unique collage of sounds.

Sheppe and Osborne (1971) describe the pattern of floodplain use by mammals on the Kafue Flats including Kafue lechwe, zebra (*Equus gurchelli*), wildebeest (*Connochaetes taurinus*), buffalo (*Synceus caffer*), roan (*Hippotragus equinus*), reedbuck (*Redunda arundinum*), eland (*Taurotragus oryx*), hippo (*Hippopotamus amphibius*), clawless otter (*Aonyx capensis*), and spotted-necked otter (*Lutra maculicollis*). However, mammalian populations are presently only a fraction of those existing before intensive hunting which began in the 1930's and continues today by poachers. Elephant (*Loxodonta africana*), waterbuck (*Kobus ellipsiprymnus*), puku (*K. vardoni*), sable (*Hippotragus niger*), hartebeest (*Alcelaphus lichtensteini*), and wart hog (*Phacochoerus aethiopicus*), have been exterminated from the area of Kafue Flats and few large predators remain. The avifauna of Kafue Flats has been listed by Dowsett and deVos (1965), Osborne (1973), and Douthwaite (1977, 1978).

Kafue Flats contains Lochinvar and Blue Lagoon National Parks with a combined area of 840 km² (Fig. 4). Lochinvar National Park is located on the south side of Kafue Flats and provides important crane habitat, including the principal range of the grey crowned crane (*Balearica regularum*) (Robert Douthwaite, pers. comm.). However, the national park status of Lochinvar is threatened by misuse by neighboring fishermen and pastoralists. Fishermen openly use wetlands and roads within the national park, being admitted at the main park gate. Also herds of hundreds of domestic cattle are pastured within Lochinvar, directly competing with resident wildlife.

Fishermen and stockmen should be restricted to areas outside national park boundaries because their presence is not conducive to the proper management of the park and apparently hinders wattled and crowned cranes from nesting in upland marshes as they used to when park regulations were strictly administered (Walkinshaw 1973). Blue Lagoon National Park has been closed to the public in recent years, presumably for

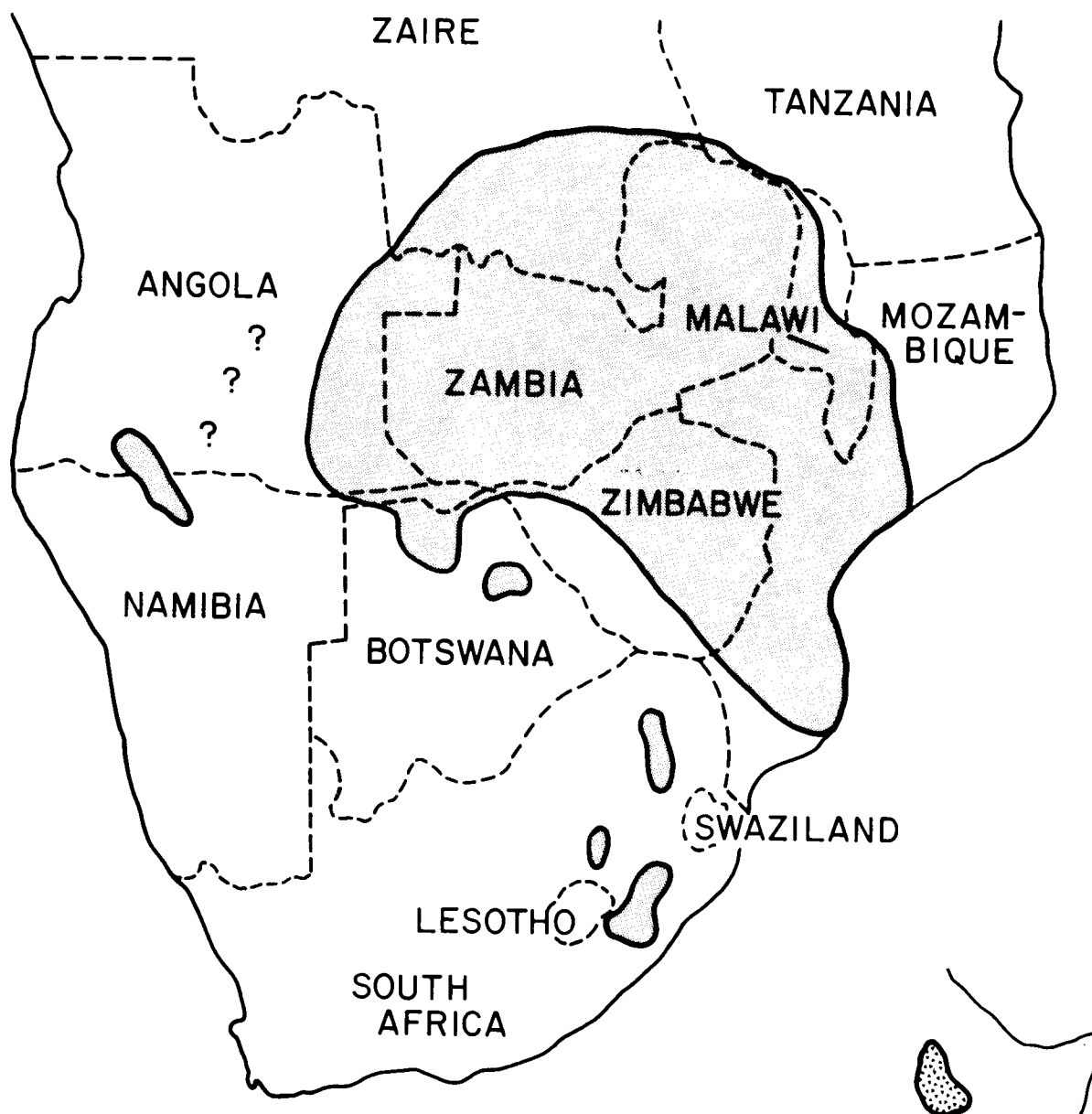
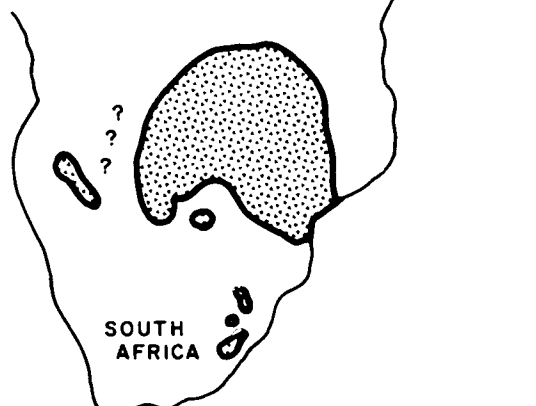


Fig. 2. Distribution of wattled cranes in Africa (lower right), with the more detailed distribution for the southern third of the continent shown above.

security reasons. However, this valuable park should be reopened, especially considering its proximity to Lusaka, Zambia's capital city, and the many citizens who could enjoy viewing the environs and wildlife. These recommendations are reasonable because the national park system on Kafue Flats is a small fraction of the area open to extensive human use.

Kafue Flats has been described as 1 of Africa's greatest wetlands. The great importance of this region to the Zambians is reflected in fishing, agricultural, pastoral, mining, industrial, hydroelectric, national parks, and wildlife interests. With so many separate interests involved in the use of this wetland, Kafue Flats may be the most studied, most developed, and most controversial.



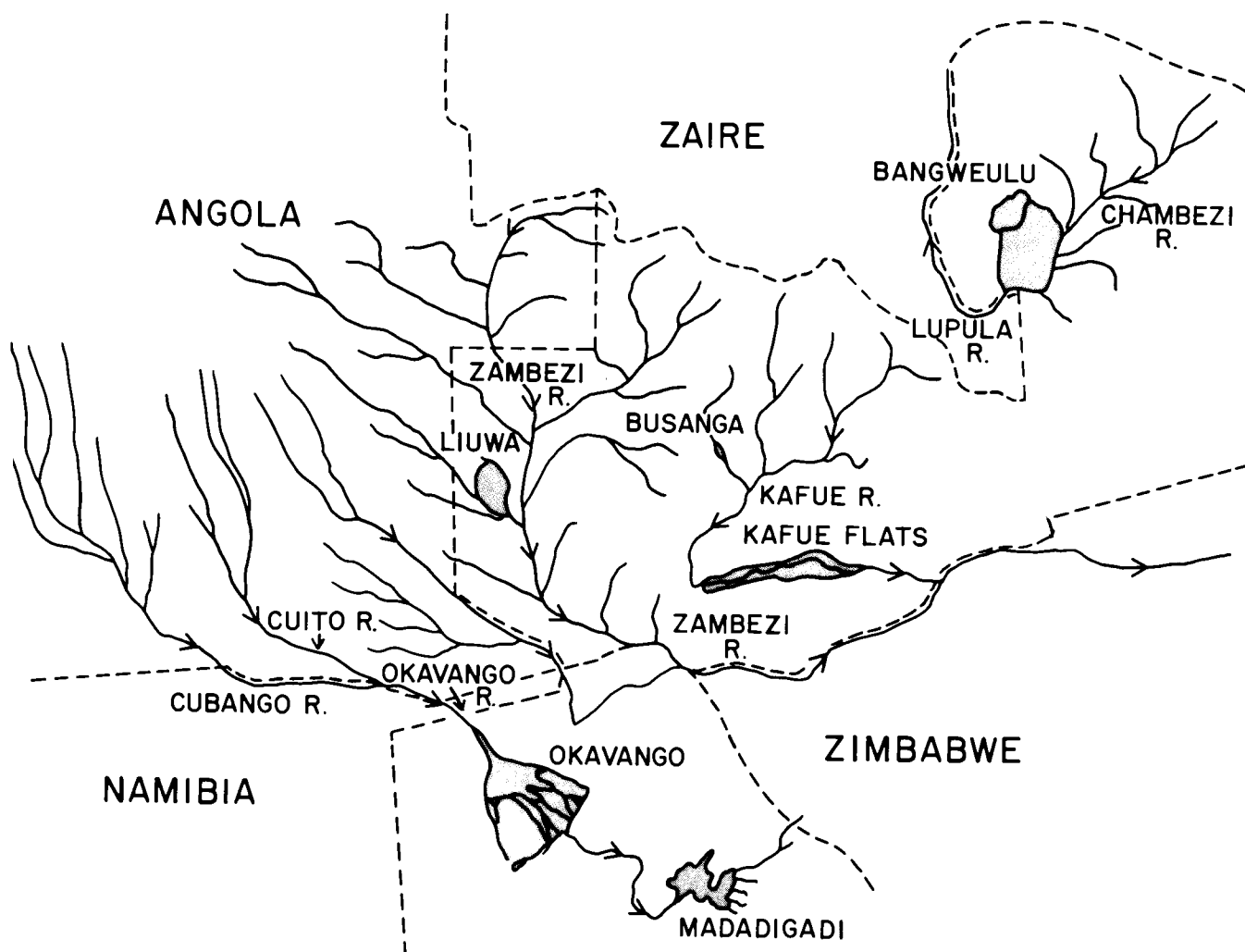


Fig. 3. Major river drainages and the large wetlands.

Table 1. Average rainfall (cm) as recorded at towns near African wetlands important to wattled cranes (see Fig. 6).

Wetland ^a	Monthly rainfall												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	28.8	25.2	18.4	3.9	0.5	0	0	0.1	0.1	1.2	13.0	24.9	116.1
2	21.8	19.6	10.6	2.1	0.4	0	0	0	0	1.5	9.1	18.6	83.7
3	26.2	25.1	25.9	6.9	0.8	0	0	0	0.1	1.7	13.5	23.7	123.9
4	21.7	21.5	15.1	3.8	0.2	0	0	0	0.2	3.5	10.2	22.2	98.4
5	20.3	16.4	23.6	9.0	0.9	0	0	0	1.1	6.7	14.9	19.1	112.0
6	10.4	9.5	8.1	2.5	0.5	0	0	0	0.1	1.7	4.3	8.1	45.2
7	10.2	8.2	6.9	1.7	0.5	0.2	0.1	0.1	0.2	1.9	5.6	9.1	44.7

^aUpper Kafue Basin-Busanga and Kafue Flats (Ndola, Zambia); (2) Kafue Flats (Lusaka, Zambia); (3) Bangweulu (Kasama, Zambia); (4) Liuwa (Mongu, Zambia); (5) Upper Angola Basin-Liuwa and Okavango (Chitembo, Angola); (6) Okavango (Maun, Botswana); and (7) Magadigadi (Francistown, Botswana).

A great controversy began with the initiation of a hydroelectric scheme including construction of a dam at each end of Kafue Flats (Fig. 4). A background history of this hydroelectric development is presented by Williams (1977). Kafue Gorge Dam was completed in 1972, its reservoir flooding the eastern end of the Flats with small effect on the wildlife. However, the recently completed Iteshiteshi Dam located on the upstream (west) end of Kafue Flats may have monumental effects on the wildlife communities, especially those associated with the floodplain on which wattled cranes and Kafue Lechwe are dependent.

Iteshiteshi Dam was built to hold water in its reservoir during the flow of potential floodwaters from the upper Kafue River Basin, and to release waters during the low water period to offset the seasonal discharge variations of the river. Therefore, contrary to the natural flooding regime, streamflow will be reduced during the rainy season and increased during the dry season. This scheme will reduce the area of floodplain by reducing the area of seasonal flooding and by permanently flooding lagoons and low depressions. The vegetation, fish, wildlife, and man have all adapted over centuries to the flooding regime of Kafue Flats; therefore, it is anticipated that the populations of organisms that rely on the floodplain will be reduced in relation to reduction of floodplain area.

The present hydroelectric scheme on Kafue Flats will greatly effect the population size of the wattled crane by restricting the area of the floodplain and consequently constricting the feeding areas, the total wetland habitat, and the nesting territories located within the floodplain. As stated earlier, fewer wattled crane pairs nest with low flooding (Douthwaite 1974). This habitat change presents a serious situation for the future of Africa's largest population of wattled cranes. Perhaps the population size will remain static over several years while reproduction lags, but in a decade the population size will have dropped due to lower recruitment caused by the impact of present Iteshiteshi Dam hydrology policy. This trend is already a factor because only 3.6% of the total population observed on Kafue Flats in 1978-1979 were young of the year.

The fishing industry will be affected by the permanent flooding caused by waters released from Iteshiteshi Reservoir because flooding reduces the available prime fishing areas and affects the spawning of native fishes which is also closely related to the annual flooding cycle. This fishery decline is of great importance to Zambia because Kafue Flats accounts for up to one-quarter of the total annual fish production for a nation dependent on this resource to feed its human population.

Pastoralists will also be affected by Iteshiteshi because their domestic cattle herds are dependent on the vegetation of the dry floodplains. The smaller floodplain area flooded and dried each season will limit the number of cattle below present numbers.

Likewise the upland mammals relying on the dry floodplain vegetation will be affected, namely zebra, wildebeast, roan, buffalo, eland, and reedbuck. The Kafue lechwe are more closely dependent on the floodplains used by the wattled cranes and their population size will also be affected due to the constriction of their floodplain habitat.

The water discharge at Iteshiteshi Dam should not only be dictated by the needs of the hydroelectric

Table 2. Wattled crane census results in selected wetlands of southern Africa, 1978-1979.

Wetland	Number observed	Pairs	Chicks	Nonbreeders
Kafue Flats	552	180	20	172
Bangweulu	20	5	0	10
Busanga	31	14	2	1
Liuwa	145	42	8	53
Okavango	21	9	2	1
Magadigadi	15	4	1	6
Total	784	254	33	249

scheme but also by the needs of the resident people, wildlife, and natural ecology of Kafue Flats ecosystem. Proper regulation and timing of water discharge at Iteshiteshi Dam is most important and can be used to the advantage of all interests. Regulation of this water could enhance the total production of the Kafue Flats--ecologically and industrially. To date no effort has been made to involve all interests in determining the regulation of waters discharged at Iteshiteshi by the Zambian government. Although the Kafue Gorge Power Station can provide all of Zambia's electrical energy, any deficit in electrical output caused by water regulation can easily be made up through Kariba Dam's Power Corporation, which includes Zambia.

I hope that the special interests within Zambia's Ministry of Power, Transport, and Communication; Ministry of Lands and Natural Resources; Ministry of Agriculture and Water Development; Ministry of Tourism; the Zambia Electricity Supply Corporation; Central Africa Power Corporation; and the Kafue Basin Research Committee, along with international representatives, will join together in a reevaluation of the annual regulation of water discharged from Iteshiteshi Dam for the combined good of all interests. The wattled cranes of Kafue Flats can continue to survive at current population levels with the proper management of this large wetland.

Bangweulu

Bangweulu is a 20,000-km² wetland composed of a lake and adjoining permanent wetland with a seasonal

Table 3. Wattled crane population structure at selected wetlands of southern Africa, 1978-1979.

Wetland	% of population		
	Pairs	Fledged young	Nonbreeders
Kafue Flats	64.2	3.6	32.2
Bangweulu	50.0	0.0	50.0
Busanga	90.3	6.5	3.2
Liuwa	57.9	5.5	36.6
Okavango	85.7	9.5	4.8
Magadigadi	53.3	6.7	40.0
Mean %	64.3	4.2	31.5

Table 4. Wattled crane productivity data for selected wetlands of southern Africa, 1978-1979.

Wetland	% successful breeding pairs	% productivity	Chicks/pair	Pairs/chick
Kafue Flats	11.1	3.6	0.11	9.0
Busanga	14.3	6.5	0.14	7.0
Liuwa	19.0	5.5	0.19	5.2
Okavango	22.2	9.5	0.22	4.5
Magadigadi	25.0	6.7	0.25	4.0
Mean	13.0	4.2	0.13	7.7

flooding regime which pervades all aspects of the ecology and economics of the area. The water level over this wetland varies seasonally between 1 and 2 m causing the floodline to advance and recede by as much as 45 km at the periphery (Grimsdell and Bell 1976; Fig. 5). The 190,000-km² catchment basin receives the highest rainfall in Zambia with the mean annual rainfall measuring up to 160 cm. Most precipitation falls between November and March (Table 1; Fig. 6). Bangweulu is fed by 17 principal rivers, the Chambezi is the largest. The Luapula River, a headwater of the Congo, is the only river draining the Bangweulu.

A water meadow formed along the floodplain is marked by an association of *Cyperus latifolius* with *Eleocharis fistulosa* (Vesey-FitzGerald 1965). This habitat provides feeding areas for both the black lechwe (*Kobus lechwe niger*) and wattled cranes. Although the wattled crane is a well-known resident of Bangweulu, little information about this species has been recorded. Bangweulu's wattled cranes have not been censused, but from earlier observations this population probably numbers several hundred (Brelsford 1947, Mwenya 1973, Grimsdell and van Lavieren in Douthwaite 1974). Most wattled cranes were observed along the southeastern floodplain during a preliminary aerial survey of Bangweulu in October 1978. Considering the low numbers observed during the flight (20), it may be theorized that some movement may take place between Bangweulu and other wetlands (i.e., Kafue Flats), especially because unusually high water levels were present even during the driest period (late Octo-

ber) due to extremely heavy rains earlier in 1978. In the future it will be important to census Bangweulu for wattled cranes throughout the year to gain information on the population status and movements of these cranes.

Bangweulu is an important wetland for wildlife, supporting a diverse fauna including the largest known populations of the endemic black lechwe, the sitatunga (*Tragelaphus spekii*), an antelope restricted a deep wetland (*papyrus*) environ, and the shoebill stork (*Balaeniceps rex*). Large numbers of local and migrant water birds are present in Bangweulu including waders, shorebirds, waterfowl, and many mammals.

Except for a small area included in Isangano National Park, the entire area of Bangweulu is included in game management areas which protect resident wildlife, but allow hunting of predetermined numbers of certain species by permits issued by the National Parks and Wildlife Service. Most wildlife exist below the carrying capacity of the region due to previous indiscriminate hunting and poaching. This is notably seen in the black lechwe population which was thought to be greater than 200,000 before 1936 and was reduced to about 16,000 by 1969, though it numbers over 30,000 today (Bell and Grimsdell 1973).

Bangweulu supports 1 of Zambia's largest fishing industries with small fishing villages and camps scattered along the wetlands perimeter and islands. Currently Zambia is building a road which will bisect the

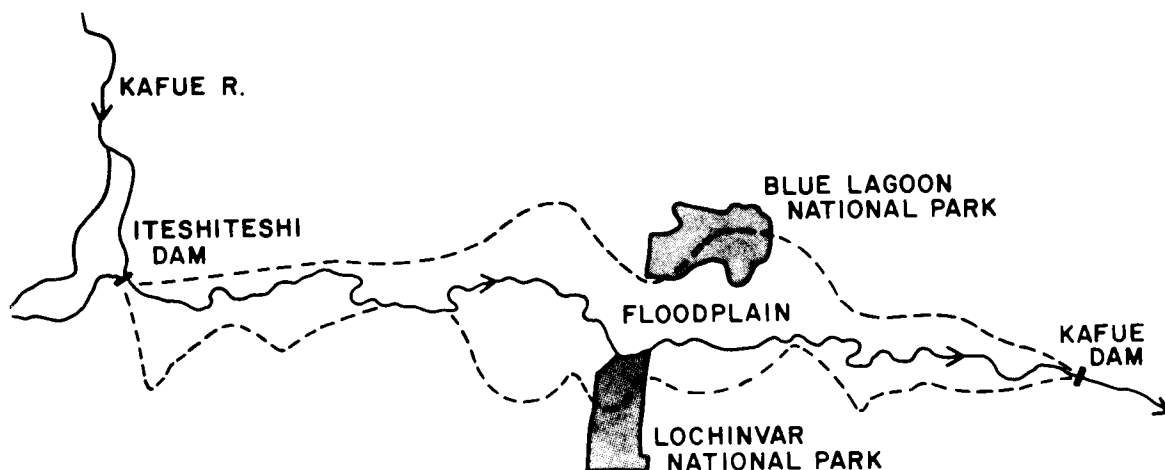


Fig. 4. Bangweulu (20,000 km²) with its associated wetland and floodplain.

southwestern floodplain of Bangweulu. It is unfortunate that this highway could not skirt the side of Bangweulu to avoid disrupting the floodplain of this wetland and dealing with the added problems of supporting a road on the unstable footing of the wetland substrate. The planning and construction of this road must be questioned; however, if proper drainage is provided under the roadway, the ecology of Bangweulu should not be appreciably harmed and the road will provide easier access to this wetland.

Other long-range developments have been proposed including a major hydroelectric scheme involving 2 dams on the Lauapula River with the Bangweulu basically acting as a reservoir (Grimsdell and Bell 1976). This project would have disastrous effects on the ecology of Bangweulu and its wildlife populations. A channelization project has also been proposed which would enable easier water transportation through the wetland (Gilson Kaweche, pers. comm.). The rational use of Bangweulu's resources must be wisely considered when development projects are planned so the development enhances the total area rather than downgrading the whole or parts of it.

Busanga

Busanga is a permanent wetland encompassing about 400 km² in the upper Kafue Basin and is drained to the south by the Lafupa River, a tributary of the Kafue River. A floodplain is formed as a perimeter around Busanga and extends to the south along the Lafupa's drainage (Fig. 7). Floodwaters rise throughout the rainy season (November through March) and continue through May when they begin to recede.

As floodwaters recede, wattled cranes begin nesting in June and July over large open expanses of shallow floodplain. Pairs of wattled cranes also nest in outlying seasonal wetlands (some located 30 km from Busanga), but rely on Busanga during the dry season (John Hazam, pers. comm.). In late October 1978, Busanga's floodplain was very dry with pairs of wattled and crowned cranes on territories centering around small wetlands formed along dry drainage channels and the permanent wetland border. The behavior of wattled cranes during the high flood period has not been documented at Busanga; however, because little habitat remains due to high water levels, these birds are very likely to disperse to surrounding wetlands or concentration areas such as Kafue Flats or Magadigadi. The wattled crane population in Busanga was censused 4 times in 1971-1972 by Logsden and van Lavieren during lechwe surveys and was estimated to number between 145 and 328 birds (Douthwaite 1974).

Large numbers of local and migrant waterfowl use this wetland during the floods and when waters recede the plain becomes host to many birds, including yellow-billed storks (*Mycteria ibis*), saddlebill storks (*Ephippiorhynchus senegalensis*), openbill storks (*Anastomus lamelligerus lamelligerus*), spur-winged geese (*Plectropterus gambensis*), Senegal wattled plovers (*Xiphioides senegallus lateralis*), and African fish eagles (*Haliaeetus vocifer*), along with a variety of other fauna. Hippo, sitatunga, and Nile crocodiles (*Crocodilus niloticus*) inhabit the permanent wetland while zebra, wildebeest, and puku graze the greened floodplain during the dry season.

Busanga presently has a resident red lechwe (*Kobus lechwe lechwe*) population of approximately 3,000, which has increased steadily since a low point in 1946, and supports 1 of Africa's largest buffalo herds, numbering over 2,000. Nearly all of Busanga's wetland area

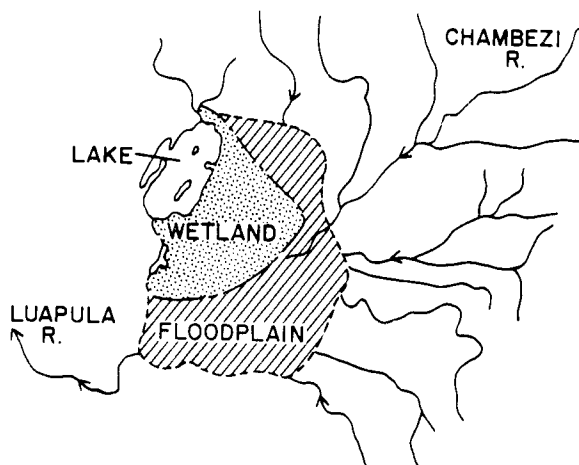


Fig. 5. Bangweulu (20,000 km²) with its associated wetland and floodplain.

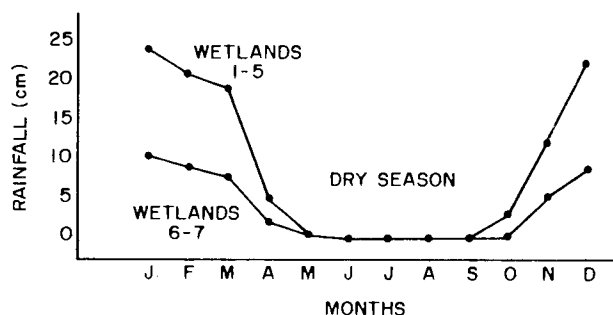


Fig. 6. Average rainfall at towns near African wetlands important to wattled cranes (see footnote of Table 1 for key to wetland numbers).

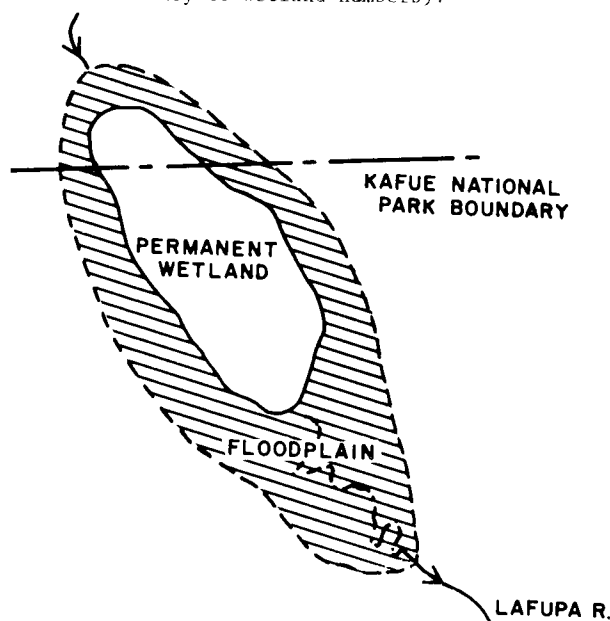


Fig. 7. Busanga (400 km²) and the associated floodplain.

is protected as a natural wildlife preserve within Kafue National Park (Fig. 7); consequently, this wetland and its wattled cranes are well protected for the future.

Liuwa

Liuwa is a 3,500-km² floodplain formed in the upper Zambezi River Basin between the Luanginga and Luambimba Rivers. Mundi Stream, a tributary of the Luambimba River, follows a course through the center of Liuwa, and is instrumental in the flooding and drainage of most of the floodplain (Fig. 8). Floodwaters occur in December as a consequence of rainfall locally and in eastern Angola (Table 1). Rains cover the large floodplain with 1-2 m of water due to the low, flat terrain and a high watertable. Draining by June, Liuwa is a broad, flat plain with scattered small wetlands and limited woodlands along slightly elevated ridges.

Wattled cranes are abundant in Liuwa and may number over 500. Most nesting takes place in June, July, and August in the scattered small wetlands which may be 1 ha after floodwaters recede. Some nesting also occurs along flooded stream borders. During a census of selected areas of Liuwa in November 1978, 145 wattled cranes were observed (58% were paired). Only 8 of the pairs were successful in raising a chick to fledging (Tables 2, 3, and 4). The Liuwa is important to wattled cranes because it represents the largest population and habitat area under total protection within Liuwa Plain National Park. However, this protection is superficial and in fact during the nesting season the wattled crane is under pressure from fishermen who rob the nests of their eggs, disturb the nesting pair enough to cause failure of the nest, or capture unfledged chicks (Pete Conant, pers. comm.). This is a serious problem to the crane population in Liuwa.

Liuwa also provides prime habitat for crowned cranes which were observed to be 6 times more populous than wattled cranes in the areas censused (836 total) and can be observed in large flocks in the dry season, some numbering from 100 to 400 birds. Crowned crane abundance is due to their more upland habits and the extensive, undisturbed breeding areas during the rainy season (high floodwaters prevent disturbance by fishermen). Their reproductive rates are also higher with 2 or 3 chicks often raised.

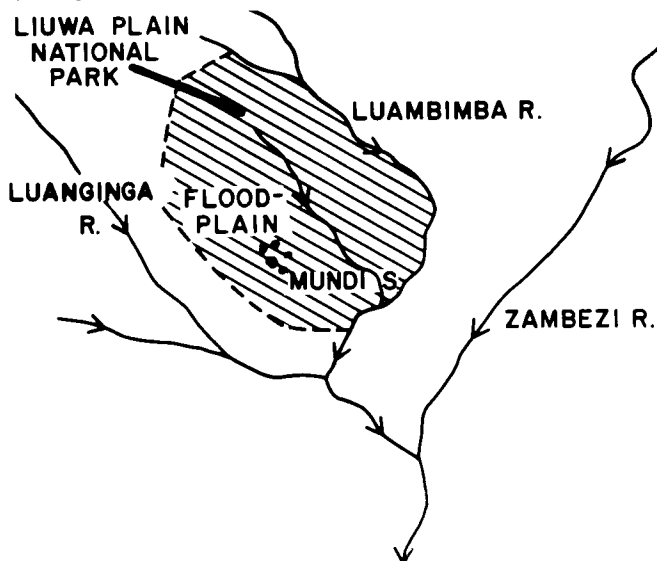


Fig. 8. Liuwa (3,500 m²) wetland.

Today Liuwa remains a wild and remote region supporting a diverse and plentiful wildlife community. Liuwa is totally dominated by the huge wildebeast herds, perhaps numbering 40,000 while zebra, red lechwe, oribi (*Ourebia ourebi*), and tsetsebe (*Damaliscus lunatus*) make up the principal big game populations with lions (*Panthera leo*) the most numerous large predators. The region is also important to local and migrant waterfowl and shorebirds along with bustards and birds of prey. This wetland is aptly included in Liuwa Plain National Park (3,660 km²).

Liuwa has long been controlled by the resident Lozi people of Zambia. Liuwa's significance to the wildlife of the region was realized long ago and the Paramount Chief or Litunga of the Lozi people made the Liuwa a game reserve nearly 300 years ago. This tribal protection continued until 1972 when Liuwa Plain National Park was established by the Zambian Government. However, Liuwa now has a great human problem. Although the Litunga refused to disturb the animals, prohibited hunting, and, at least originally, did not allow settlement in Liuwa, about a century ago a few hunting camps became established. These camps became small villages over the years. Today about 1,000 people live inside Liuwa Plain National Park and exploit the natural resources through fishing, poaching, growing casava, and grazing thousands of domestic cattle (Pete Conant, pers. comm.), all to the detriment of national park interests and against government established laws.

A solution to this problem would include the relocation of the villages located within park boundaries; however, these people prefer living in the park. An alternative solution might include relocation of national park boundaries. Most villages are located inside the south and east borders of Liuwa Plain National Park; consequently, a shift of the boundaries to the north and west would exclude most villages and people and include in the national park open lands toward Angola. Any villages then remaining inside the new park boundaries could be relocated (Pete Conant, pers. comm.). Liuwa Plain National Park must then be administered as a national park in the strictest sense, eliminating all fishing, poaching, livestock herding, and all other illegal forms of trespass. An educational program should be initiated to instruct the neighboring people about the importance of Liuwa to wildlife populations and the legalities of a national park--that wild animals do not constitute food, but their own cattle herds do. This transition will take time, but is of paramount importance to the future of the Liuwa Plain National Park and its wildlife.

Okavango

The Okavango of northwestern Botswana consists of a permanent wetland, seasonally flooded lowlands with dry woodland-grassland islands, and adjoining savannas within a 13,000-km² area. It is a mosaic of habitats and forms the world's largest inland river delta. The major river channels of the Okavango, including the Thaoqe, Matsebe, Xudum, Boro, Santantadibe, Kawi, and Thamalakhan, are relatively narrow and shallow but meander within broad floodplains and with slight increases in water level inundate large areas (Fig. 9). The source of water for the Okavango begins in the Central Highlands of Angola where the Cubango and Cuito Rivers transport water to the Okavango River which follows a southeastern course to the Delta (Fig. 3).

Water levels of the Okavango are dependent upon the rainfall in the headwater basins of the Angola high-

lands where heavy rains occur from November through April (Table 1). High water levels usually reach the upper Okavango in March, but do not reach their maximum throughout Okavango until June or July. Receding floodwaters reach a low in January when local rainfall (November through March) adds to the waters; however, the rains and flooding cycle of the Okavango are subject to annual variations in timing and volume.

Wattled cranes inhabit the shallow southern border of the permanent wetland and the floodplains of the numerous river courses. Feeding on the usual sedges, the wattled cranes nest as floodwaters recede in August and September. The United Nations Development Program ecologists, in cooperation with the Botswana Department of Wildlife, National Parks, and Tourism, conducted aerial surveys of the principal wildlife populations in the Okavango, including 1 census of wattled cranes in February 1977 using a systematic method of transect sampling (Astle and Graham 1976). The results of this survey have not been analyzed for wattled cranes (Douglas Williamson, pers. comm.) although this population may number over 1,000.

Based on information gathered during a February 1979 survey of western Okavango, when 9 pairs (2 with fledged chicks) and 1 single wattled crane was observed, I suggest that October may be a better month to census wattled cranes. By October, floodwaters have drained to provide large open floodplains for feeding wattled cranes, but by January and February many cranes appear to leave due to dry conditions, perhaps moving to the Magadigadi Pans to join migrant concentrations there.

Thousands of large mammals rely on the extensive and varied habitats of the Okavango, including impala (*Aephyceras melampus*), baboons (*Papio ursinus*), red lechwe, buffalo, zebra, tsetsebe, wildebeest, bushbuck (*Tragelaphus scriptus*), kudu (*Tragelaphus strepsiceros*), giraffe (*Giraffe camelopardalis*), sitatunga, wart hog, and elephants, along with over 400 species of birds. The Moremi Wildlife Reserve is located in the northeastern section (Fig. 9) and includes all the major habitats of the Okavango with the exception of papyrus swamp (Astle and Graham 1976).

Today the Okavango remains a wild, natural area inhabited by a colorful biota living in pristine conditions. Man has not penetrated this wetland for any length of time and even today is limited to small villages along the edges of the Delta. However, since most of Botswana consists of the dry sands and low bush of the Kalahari Desert, the waters of the Okavango are of great interest for future development. To date the savior of this wild region has been the seemingly insignificant tsetse fly (*Glossina morsitans*) which passes the dread sleeping sickness by the transfer of parasitic trypanosomes from host species of game animals and has long kept man and his domestic livestock from the Okavango.

In an effort of wetland reclamation the government of Botswana has long been involved in programs for the eradication of the tsetse fly, beginning in early days with game destruction and bush clearing, and even eventually leading to large-scale ground applications of Dieldrin and DDT from 1967 through 1976. The use of diluted solutions applied selectively to specific vegetation sites helped reduce the negative effects of these persistent insects. Since 1973 a program of aerial spraying of Endosulphan has been applied in specific "blocks" in which 6 applications are made over 100 days. Endosulphan has important differences from previously used insecticides; it has a relatively

low persistence but a higher toxicity to fishes than to tsetse flies, which may be harmful to the fishing industry due to the nonspecific applications via aerial spraying (Russell-Smith 1976).

The tsetse fly eradication program is designed to open areas of the Okavango to human use of pastoral, agricultural, and mining interests. When flying over interior Okavango, abundant wildlife is seen in quiet seclusion but along the edge of the Delta, where man now lives in small numbers with his herds of cattle, goats, and donkeys, little wildlife is observed. In disturbed areas waterfowl, egrets, herons, marabou storks (*Leptoptilos crumeniferous*), and openbill storks are observed but the large mammals and shy birds, including the wattled cranes and saddlebill storks, are absent. As the Okavango is opened for human use it can be predicted that the wildlife will be replaced by the herds of domestic livestock and people now limited to the border, and that the forested areas will be cleared and plowed for agricultural purposes to further scar the natural beauty of this unique wetland.

Botswana's government has made apparent its concern for sensible development of the Okavango by sponsoring a "Symposium on the Okavango Delta" in 1976 when people representing a wide variety of interests and concerns gathered to discuss the future of this great wetland. It is hoped the resulting information will provide a basis for intelligent and restrained use of this valuable resource.

Magadigadi

In the northeastern expanse of the Kalahari Desert a flat, ancient lake bed evolved into a unique wetland consisting of 2 large alkaline salt pans with many smaller alkaline wetlands along their bleached white borders, all collectively known as the Magadigadi (or Makgadikgadi, Mahgadihgadi, or Makarikari). The Botleteti River, draining from the Okavango, enters the southwestern corner of Ntwetwe Pan, which is linked to Soa Pan, although the latter is mainly fed by the Nata, Semowane, Mosetse, Lapashe, and Mosupa Rivers draining from the east (Fig. 10). The Magadigadi

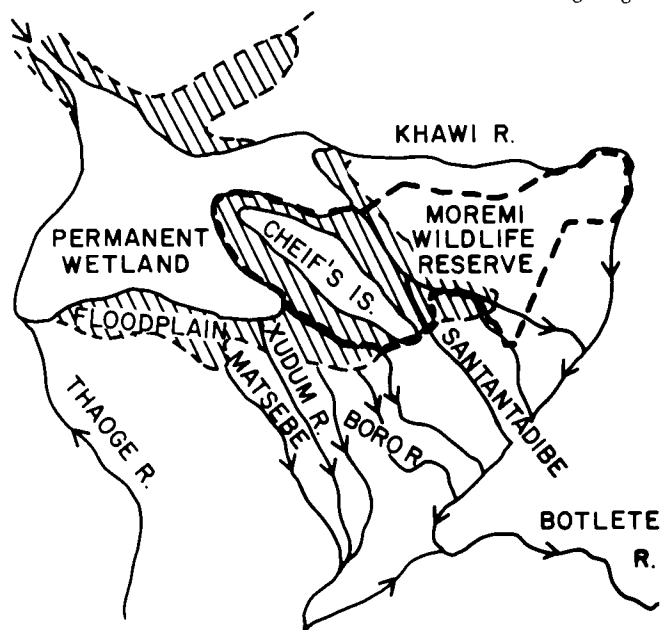


Fig. 9. Okavango (13,000 m²) and Moremi Wildlife Reserve.

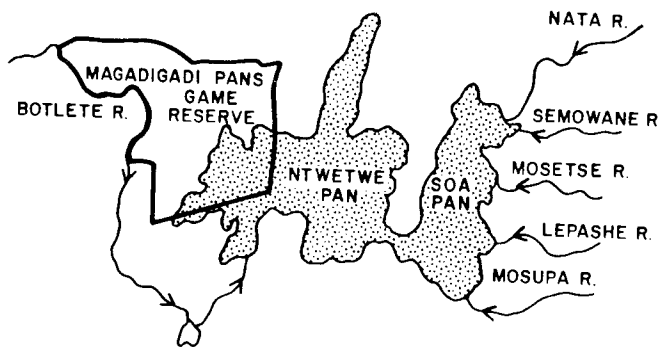


Fig. 10. Magadigadi Pans, including Ntwetwe Pan, Soa Pan, and Magadigadi Pans Game Reserve.

dries totally most years except at the Botletse River inlet, but fills with a shallow sheet of water from local rains which fall from November to March (Table 1). The Magadigadi and its associated plains are a vast, wild, and virtually uninhabited region of Botswana.

Unlike the other large wetlands described in this paper the wattled crane is known only as a migrant to the Magadigadi during the wet season. Migrant wattled cranes are present from January to May and may number from several hundred up to 2,000 in a given year (Mark Muller, pers. comm.). The origin of these flocks is thought to be Kafue Flats in Zambia, which wattled cranes are known to leave during the periods of high flooding (Douthwaite 1974). Although this movement has not been confirmed, it is the most likely theory at this time. There may also be some migrant recruitment from the Okavango. These movements should be documented by marking birds with color-coded, numbered bands or radio-tags. During their stay at Magadigadi the wattled cranes feed on *Cyperus* tubers (Smithers in West 1977) on the rain-moistened uplands and roost in small rain-filled pans. Many of the wattled cranes migrating to the Magadigadi moult during their stay, becoming totally flightless at times (Mark Muller, pers. comm.).

During a 1 February 1979 aerial survey of Ntwetwe Pan only 15 wattled cranes were observed, in the small pans near the northwestern border of Ntwetwe. However, about 400 wattled cranes were observed in the area north of Soa Pan (Robert Douthwaite, pers. comm.).

The biology of the wattled cranes concentrating in the Magadigadi has not been studied and future research should identify wetland and upland habitat use, movements within this wetland, and feeding behavior. Perhaps most important is an annual census of the Magadigadi during peak populations, perhaps the end of March or early April, which coincides with seasonal use of this wetland by other migrant and wet season residents. The Botswana Department of Wildlife, National Parks, and Tourism is best suited to perform this annual survey and would benefit by this information gathered for future management of the Magadigadi.

Each year 6 to 12 wattled cranes are captured from clocks in the Magadigadi for export to zoological parks by Birds and Game Botswana Ltd. under license issued annually by the Botswana Department of Wild-

life, National Parks, and Tourism (unpubl. dep. records). These birds add to captive breeding programs and make it possible for zoo visitors to see these impressive birds. However, this practice should not be expanded or developed elsewhere.

Other migrant wildlife also rely on the Magadigadi when water is present. With game trails etched in the Kalahari sands to show their passing, huge herds of zebra, wildebeest, tsetsebe, gemsbok (*Oryx gazella*), and springbok (*Antidorcus marsupialis*) seek out the water of the Magadigadi, especially in the northwestern regions. Most of these herds are migratory and follow an annual cycle through much of northern Botswana. Also present during the rains are flocks of red-billed teal (*Anas erythrorhynchos*), spur-winged geese, yellow-billed storks, saddlebill storks, white pelicans (*Pelecanus onocrotalus*), pink-backed pelicans (*Pelecanus rufescens*), lesser flamingos (*Phoeniconaias minor*), and greater flamingos (*Phoenicopterus ruber roseus*), with the latter 2 species nesting and raising young in the Magadigadi's brackish waters in some years. Ostrich (*Struthio camelus*), black-bellied korrhaan (*Eupodotis melanogaster*), and secretary birds (*Sagittarius serpentarius*) are resident on the plains areas along with some herd animals, especially gemsbok. The northwestern portion of Ntwetwe Pan, and a larger area of the plain including many scattered small pans near Ntwetwe's edge, are included in the Magadigadi Pans Game Reserve (Fig. 10).

SMALL WETLANDS

Throughout their range wattled cranes feed, roost, and nest in scattered small wetlands. These small wetlands can be classified as ephemeral, seasonal, semipermanent, and permanent, and are contained in basins or areas of low gradient along streams or small rivers. Each wetland forms wet meadow and shallow marsh zones and is typically surrounded by level or slightly sloping grassland. In small wetland habitats, wattled cranes are widely scattered with 1 pair inhabiting a single wetland, although more than 1 pair or small groups of nonbreeders may be found in some wetlands.

The small wetland habitats may be divided into 2 subtypes: those found in (1) relatively level lowlands, and (2) hilly highlands. The highland habitats are limited to the edges of the Drakensburg Mountains in Natal and Transvaal, South Africa, highlands along the Zimbabwe-Mozambique border, the plateaus of Malawi and extreme eastern Zambia, the highlands of southwest Ethiopia, and perhaps areas in the Angola Highlands. Lowland wetlands are found elsewhere throughout the wattled crane's range.

Wattled crane pairs tend to be sedentary on their small wetland nesting territories (Warwick Tarboton, pers. comm.). Their nesting period varies throughout the year and is dependent on seasonal and annual water levels, and the water regime of individual wetlands. Nesting appears to peak in December, coinciding with seasonal precipitation and corresponding high water levels in the small wetlands (Walkinshaw 1965, Warwick Tarboton 1981, Robert Dowsett, pers. comm.). However, the reverse is true for Ethiopia (northern hemisphere), where wattled cranes nest mainly from May through August (Mackworth-Praed and Grant 1952), after the "small" and "big" rains from June and September, and before the dry season which runs from October through December (Urban 1974).

The small wetlands make up an important portion of the total habitat available to wattled cranes. How-

ever, the small wetland habitats are more easily disrupted by draining, filling, damming, afforestation, human habitation, and degrading agricultural practices. These developments have led to a decline in numbers of wattled cranes and a decline in the geographical range of the species.

In its southernmost range the wattled crane is becoming increasingly rare and has been extirpated from former range in Swaziland (Ted Reilly, pers. comm.) and in Cape Province, South Africa, where it was formerly widespread (West 1976, 1977). The wattled crane is listed as an endangered species elsewhere in South Africa (Siegfried et al. 1976).

The Transvaal Nature Conservation Division, South Africa, is concerned about the small remaining wattled crane population found in the Transvaal Highlands. Tarboton (1981) is presently collecting distribution, nesting, and production information and indicates that the total wattled crane population probably does not exceed 25 pairs in Transvaal. He lists close human habitation and increasing activities of trout fishermen as indirect causes of nesting losses, while afforestation by local plantations has been the direct cause of the loss of nesting sites. Tarboton predicts the continuation of present development in this region of Transvaal will cause the disappearance of this population and recommends a halt to development in this region. Ideally the area may be preserved in a mountain grassland reserve.

There is also concern about the steady reduction in numbers of wattled cranes in Natal, South Africa. Jack Vincent and William Barnes (pers. comm.), discussing the steady loss of habitat caused by ever-increasing human development, described several nesting pairs that have abandoned historic territories over the last 20 years. The southern African Ornithological Society's Crane Study Group is gathering information on the current distribution and population status of wattled cranes in South Africa. Initial records indicate the Natal population may be 40 breeding pairs (Deryck Day, pers. comm.). The Natal Parks Board is also interested in conserving wattled cranes, with William Barnes recently starting a 3-year study of the 3 crane species native to Natal. I hope the 2 groups will cooperate in preserving the remaining wattled crane habitat to abate the population decline.

In the Orange Free State, South Africa, 2 wattled crane pairs are known to exist, representing an extremely low remnant population (Deryck Day, pers. comm.).

To the north the present distribution and population size of wattled cranes has not been assessed in their small wetland habitats. Their biology and behavior have received little attention. Therefore, a short statement of current knowledge, within each nation included in the wattled crane's distribution, must suffice at present.

In Zimbabwe (formerly Rhodesia) the northeastern high plateau (Mashonaland) and the eastern edge bordering Mozambique are the principal range of wattled cranes. The Zimbabwe Ornithological Society recently initiated a "selected species survey project", that includes the wattled and grey crowned cranes, which will provide valuable information on the status of these cranes (O. West, pers. comm.). West (1977) indicates afforestation is reducing available habitats.

Malawi's highland plateaus host resident wattled cranes, although this population may also be endan-

gered due to human population densities and the continued afforestation of plateau grasslands (West 1977). A program for providing additional habitat should be initiated to add to wetlands already preserved by Malawi's National Park systems.

Mozambique may host a number of wattled cranes in highland plateaus which continue from Malawi and Zimbabwe and in lowland wetlands, but nesting has not been confirmed and other information is sparse.

In Zambia and northern Botswana individual pairs of wattled cranes reside and nest in scattered small wetlands, perhaps more extensively than presently known. The association and movements of these birds between local small wetlands, and the region's large wetlands, are of considerable interest for the future conservation of this species.

In Namibia (formerly South West Africa) wattled cranes occur in extreme northern wetlands and are believed to be decreasing due to human population pressures (West 1977).

The range of wattled cranes in Angola has not been well documented. However, the wetlands formed along tributaries of the Zambeze River in eastern Angola, along with the wetlands bordering Namibia in the south, and the central highland and basins, may support a significant population.

Zaire represents a borderline range for the wattled crane although the southeastern corner of this nation may contain some, especially in the area of Upemba Basin.

The northern population of wattled cranes is found within the borders of Ethiopia (Fig. 2). Urban and Walkinshaw (1967) summarize all information about this separate population and, although the distribution of these birds is well defined, the population size and breeding biology have not been studied. There may also be a possibility of this population forming a separate subspecies due to its long separation from the southern population. Future studies should include a behavioral study for ethological comparisons. This Ethiopian population should be of special interest to the national government and the Ethiopian Wildlife Conservation and Development Department.

I hope that respective government wildlife departments, conservation groups, and ornithologists throughout the wattled crane's distribution will begin to census them in their respective countries as was done in Transvaal, South Africa, to record wetlands used as nesting, feeding, and roosting sites and describe their ecology qualitatively, and to seek the preservation of these wetlands and their surrounding uplands through the benevolence of landowners or by leasing or total protection of the area as a crane park or wetland refuge. The conservation strategy for the wattled crane should include a satellite network of small wetlands throughout their distribution paralleling the United States' network of Waterfowl Production Areas. This conservation effort will ultimately depend on international concern and cooperation.

FEEDING

The procurement of food takes up the greater part of each day for a wattled crane. The foremost method of feeding is by digging; probing the wet substrate or loosely packed drier soils with its long, gradually tapering bill which is well adapted for this mode of feeding. The nutritious tubers and rhizomes of Cyper-

us and *Eleocharis* sedges and waterlilies (*Nymphaea* spp.) are the most commonly eaten foods obtained by digging (Douthwaite 1974, West 1976).

When a food source is located the crane begins digging, rapidly jerking its head, neck, and bill up and down, loosening the soil and procuring entire tubers or parts. The food is swallowed with a quick forward movement of the head which is barely differentiated from the continuous digging movements. At times the digging becomes so involved that the whole body moves, slightly pivoting vertically on the hock joints of the legs, while the dangling wattles flail wildly about as the crane digs furiously for its food. Most of the foodstuff is found by tactile location. Most digging is done in areas covered with variable depths of shallow water.

Wattled cranes dig on the uplands after local rain has softened soils, in areas of loosely packed soil, or along the water's edge. More often these cranes are found digging in shallow water with only their bills submerged, but also feed in deeper water emerging the head, and may even wade into water to the level of the feathered tarsus, submerging the entire head and neck under the water. When the wattled crane submerges its head it must keep a rhythm of breathing, lifting its head periodically for a breath and to look about quickly before underwater digging is resumed. Only rarely did a bird feeding in this manner uproot a full-sized plant rather than just the tuber or rhizome foodstuffs. Table 5 presents the frequency of use of each feeding method as well as use of 3 feeding habitats.

Pecking is another means of foraging by the wattled crane. The bird pecks deliberately at a food item, such as an *Orthoptera* or *Coleoptera* insect, or seeds scattered on the ground. Sand and gravel particles are also eaten in this manner for use in digestion. Pecking usually occurs in the upland, but is also observed on the water's surface or atop matted aquatic vegetation.

The stripping of grass seed heads is mentioned by Douthwaite (1974) on the Kafue Flats. Although I did not observe wattled cranes feeding in this manner,

Table 5. Behavior and habitat utilized by 748 wattled cranes in 772 feeding activities.

Feeding method	Birds observed	%
Digging	760	98.4
Pecking	8	1.0
Picking up snail	1	0.1
Seedhead stripping	0	tr.
Feeding habitat		
Shallow water ^a	668	86.5
Deep water ^b	22	2.8
Uplands	82	10.6

^aOnly bill submersed.

^bHead and, sometimes, neck submersed.

grey crowned cranes and Stanley cranes (*Anthropoides paradisea*) often used this technique when feeding. The bird grasps the grass stem below the seed head, stripping the seeds with 1 upward movement of the head. I observed flocks of crowned cranes moving through a stand of grasses stripping seed heads--all bobbing their heads up and down with stripping motions while walking along as a group, a most comical scene.

I observed a wattled crane twice pick up a large water snail in its bill without attempting to ingest it. However, Douthwaite (1974) describes mollusk shell fragments found in wattled crane excreta, so it is apparent snails are used as a food source at times.

Observations of 772 feeding bouts of 769 wattled cranes in the large wetlands of Zambia show that over 98% of all foraging involves digging, 1.5% pecking, and a single attempt at snail predation. These observations are somewhat biased due to presumed seasonal changes in feeding behavior, lack of observations during all seasons, and the differences observed in individual wetlands. However, the most important observation is that most food is obtained by digging.

REPRODUCTION

The nesting strategies and habitats of wattled cranes have been described within large and small wetlands. Walkinshaw (1973) and West (1963) describe the life history of this crane; life history information about wattled crane population dynamics will now be described.

Cranes typically mature in their 3rd or 4th year and at that time choose a mate, forming a strong pair bond which normally lasts throughout the lifetime of the pair. Nesting pairs are strongly territorial and may defend a nesting territory over 1 km². In small wetlands a single pair may occupy the total area of the wetland. Large expanses of shallow water away from human disturbances are required by the many nesting pairs resident in the large wetlands.

Cranes generally lay a clutch of 2 eggs; however, the wattled crane is the crane most likely to produce a single egg clutch. Among 95 nests (Walkinshaw [1973] for 90 and pers. comm. from Pete Conant and Imanda Illumbella for the remainder) the mean clutch size was only 1.6 eggs. Forty percent of the nests contained a single egg. The chances of finding an incomplete clutch are very slim, because the 2nd egg is laid within 18 hours of the 1st, making the above clutch sizes virtually unbiased.

Productivity is further reduced by pairs that do not nest annually (Douthwaite 1974, Warwick Tarboton, pers. comm.). This irregularity may be the product of evolving in tropical latitudes where they do not react to the rains and humidity of the wet season, as do the crowned, sarus (*Grus antigone*), and brolga (*G. rubicundus*) cranes, or to the dramatic changes in climate and photoperiod of the temperate latitudes as most crane species. Instead, wattled cranes appear to be opportunists. In the large wetlands nesting occurs as floodwaters recede and is associated with the availability of open floodplain which provides nesting territories and sedge foods (Table 1, Fig. 11). In the small wetlands nesting proceeds when the rains provide adequate water and food sources in the wetland edges and surrounding uplands. Some pairs do not nest when conditions are not optimum.

The production of young is further limited because no wattled crane pair has ever been recorded with 2

chicks. Ila tribesmen on the south Kafue Flats consider the wattled cranes poor parents, well aware that they raise only 1 chick (Robert Dowsett, pers. comm.).

As the wattled crane chick develops the legs and feet grow 1st (which is important so that it can keep up with its parents, and to feed and travel in deeper water). Next the body and body feathers develop, and finally the wings and flight feathers. West (1963) states that fledging occurs at 15 to 18 weeks of age; the chick does not fly until it is 5 months old. This is the longest fledging period required by any crane and places the chick at a disadvantage with local predators (including man), especially since the wetlands are drying out as the chicks near fledging.

The slow productivity of wattled cranes and their need for specialized habitat emphasize the importance of immediate and profound conservation measures. If present populations diminish because of the current and future development of African wetlands, the species will be hard-pressed to make an appreciable recovery.

SOCIAL STRUCTURE AND PRODUCTION

Group size and composition were recorded while observing wattled cranes in the large wetlands. Chicks stay with the adult pair for about their 1st year of life, until the adult pair begins nesting the following year. The immatures band together and feed and roost in selected wetlands away from established territories. At age 3 to 5 years cranes choose a mate and a strong bond, which is usually permanent, is formed between the 2 birds. Three categories are used to describe the social structure: mated pair, nonbreeders, and chicks (Table 2).

An assessment of wattled cranes social structure shows paired birds make up the largest portion of all populations. Any 2 cranes observed together, isolated from other cranes or displaying to each other, were considered to be a mated pair and therefore a potential breeding pair. The percentage of pairs in individual wetland populations varied. In Kafue Flats, Bangweulu, Liuwa, and Magadigadi from 50 to 65% of each population was mated pairs. However, 86 and 90% were pairs in Busanga and Okavango. In the latter 2 wetlands resident pairs presumably remained on their territories throughout the dry season, whereas the nonbreeders probably moved to uncensused areas of food availability, or to concentration areas (i.e., Kafue Flats or Magadigadi).

A successful breeding pair was accompanied by their juvenile chick. Chicks are recognized from the ground and from the air by their totally white head, lighter colored body plumage, and submissive behavior relative to the adult pairs. During this study all large wetlands were visited about 6 months after the main breeding seasons, the chicks having fledged by this time.

Productivity was evaluated by the number of chicks raised to fledging. Between 10 and 25% of all pairs successfully raised a chick beyond fledging, although the average for all large wetlands populations was only 13% (Table 4). Fledged chicks accompanying their parents represented less than 10% of the total population in all the large wetlands, varying from 3.6 to 9.5% (Table 3).

The high percentage of pairs observed on Kafue Flats in relation to the low number of successful breeding pairs is significant and probably reflects

reduced nesting habitat due to the effects of the Iteshiteshi Dam. Production levels of wattled cranes were low during this study. Although productivity was assessed shortly after the fledging of chicks raised during 1978, actual productivity is evaluated by the number of young that survive to become breeding birds; this is an intangible parameter in the absence of individually identifiable birds. The period after leaving the parent birds and before mating is a period of unknown mortality for immature cranes, but recruitment into the breeding population is obviously lower than reflected by the number of chicks fledged.

Nonbreeders were observed as single birds or in groups of from 3 to 34 adult-plumaged birds. Nonbreeding flocks are principally made up of immature (unmated) cranes between 1 and 4 years old. These flocks may also be joined by some breeding pairs that did not find the various conditions acceptable for nesting or were unsuccessful in a recent nesting attempt. One large flock including nonbreeding pairs was observed on Kafue Flats.

The nonbreeding segment of the large wetland populations was also divided into the same 2 groups of wetlands as occurred in mated pairs. The Busanga and Okavango populations contained only 3 to 5% nonbreeders, while the 4 other wetlands contained from 32 to 50% nonbreeders in each population (Table 3). Nonbreeders are probably a more mobile part of each population, not adhering to any specific territory, area, or wetland.

CENSUS

Initially I planned to make aerial surveys of each large wetland to estimate populations of wattled cranes thereby providing a basis for an assessment of the status of the species. However, internal security problems related to military conflicts with Rhodesia precipitated a ban on all civilian flying and aerial surveys could not be made. Therefore observations and censusing were restricted to the ground and do not indicate accurate population sampling of the large wetlands (Table 2).

An aerial census of wattled cranes in the large wetlands is perhaps the most important need for future research. In some wetlands (i.e., Busanga and Magadigadi) a total count may be possible; however, in the larger wetlands a method of sampling (Jolly 1969, Norton-Griffiths 1975, Caughley 1977) will be required, with population estimates extrapolated from the number of birds observed in the samples. The area surveyed

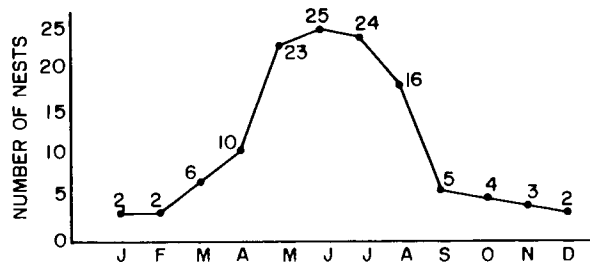


Fig. 11. Wattled crane nesting dates in Zambia based on the following 6 data sources with the number of nests in parentheses: Walkinshaw 1965 (31), Benson et al. 1971 (75), Walkinshaw 1973 (5), Douthwaite 1974 (6), Pete Conant, pers. comm. (3), and Imenda Illumbella, pers. comm. (2).

will be reduced in each wetland because wattled cranes in most instances will be found only in the floodplains. An initial survey should be made of dry season concentrations in each large wetland in an attempt to observe the greatest numbers; however, additional surveys throughout the year will provide interesting information on seasonal use of specific wetlands by wattled cranes as reported by Douthwaite (1974) in Kafue Flats.

Census methods should be selected, carried out, and described in a manner which will allow the uniform duplication of future surveys for true comparisons of data. Kafue Flats, Bangweulu, Busanga, Liuwa, Okavango, and Magadigadi wetlands should be censused initially, with Kafue Flats receiving top priority because population estimates were made before Iteshi-teshi Dam by Douthwaite (1974) and insight can be gained into the initial effects the total hydroelectric scheme have had on this population. Two additional large wetlands, namely the Linyanti-Chobi River floodplain which forms a large wetland along the border of Botswana and Namibia before joining the Zambezi River, and the Upemba along the Congo River headwaters in southeastern Zaire, may hold significant numbers of wattled cranes and should also be surveyed (Fig. 12). Aerial censusing is now possible in Zambia with the recent political settlement in Zimbabwe. A concentrated effort should be made to make an aerial census of wattled cranes in these large wetlands.

There is also a need for censusing wattled cranes inhabiting small wetlands throughout their distribution. Each individual nation should make such a con-

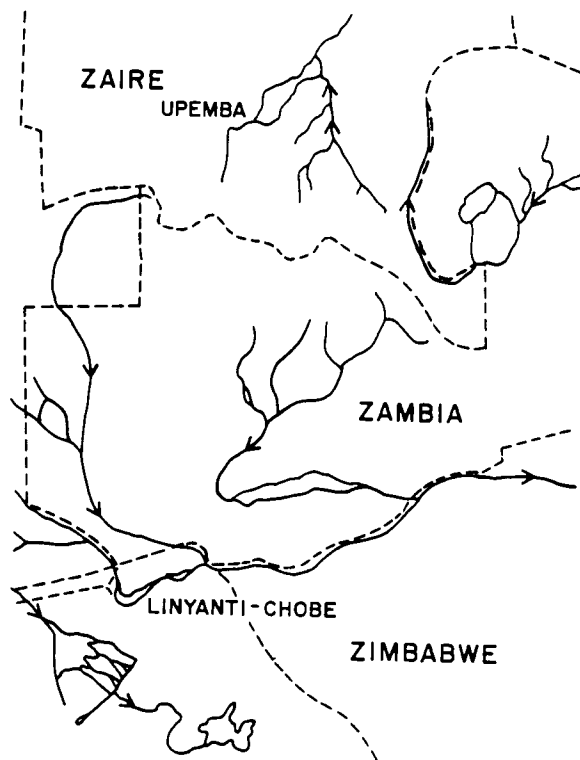


Fig. 12. Upemba wetland in Southeastern Zaire and the Linyanti-Chobe River Floodplain are other wetlands that should be surveyed for wattled cranes.

centrated effort through their respective Wildlife Departments, with the aid of Wildlife Societies, National Park personnel, Ornithological Societies, landowners, and interested individuals. Census of the large wetlands and small wetlands is especially important for the future management of wattled cranes throughout Africa.

MOVEMENTS AND MIGRATION

The movements and migrations of wattled cranes in southcentral Africa are presently a mystery; however, they should be monitored in the future to provide information for management. Marked cranes are necessary to provide insight into the seasonal movements of wattled cranes, requiring the capturing of wild birds and fitting a large plastic, color-coded, numbered band to each. Bands fitting the tibia above the hock joint are considered most appropriate for cranes. The banded wattled cranes would provide information on the movements, territory size, home range, migrations, and life history of individuals of this species; however, the information gained will be limited by the number of observations of banded birds.

An alternative is the use of radio transmitters in combination with the bands. The attached miniature radios transmit signals to portable receivers which aid in the location of radio-tagged birds; however, there are also limitations to the degree of success with these instruments. Present transmitting and receiving equipment have serious distance limitations, short transmitting life, a large size, and would add little to information on migration. I prefer to wait for the more sophisticated solar-powered, ultra-light-weight transmitters which can be tracked by the Nimbus 3 satellite and the location reading relayed to facilities at the National Aeronautics and Space Administration in the United States (Craighead and Dunstan 1976). This equipment should be available soon, allowing the tracking of migrating wattled cranes throughout their total range for a virtually unlimited time throughout the life of these birds. This method will also allow simultaneously monitoring the total radio-tagged population, even with individual cranes in widely separated areas.

It is apparent Kafue Flats and Magadigadi are concentration areas during the dry season and rainy season, respectively. Therefore, these wetlands may be the best areas to begin banding wattled cranes. However, there should be an attempt to band cranes in all large wetlands, especially when the newly designed radio packages are available.

FAUNA ASSOCIATIONS

Studying the ecosystems of the large wetlands presented the opportunity to observe the varied wildlife sharing these areas with the wattled cranes. During these studies a close association was observed between wattled cranes and certain other species, namely, the lechwe, crowned cranes, saddlebill storks, and spur-winged geese.

Lechwe are found in all the large wetlands supporting breeding wattled crane populations (i.e., except Magadigadi). Although there are 3 separate subspecies of lechwe, the red, black, and Kafue, all 3 subspecies utilize the same habitat types and share these with wattled cranes. The lechwe and wattled cranes actually feed on the same plants, the lechwe feeding on the emergent and submerged vegetation and the wattled cranes feeding primarily on the plants' tubers and rhizomes.

Crowned cranes were often observed in association with wattled cranes in Zambian and South African wetlands, although crowned cranes usually prefer a more upland habitat. Their mode of feeding is usually pecking, seed-head stripping, or grazing (as some geese do) rather than the digging typical of wattled cranes.

Saddlebill storks and wattled cranes may share an extensive wetland area or pairs of each species may share a small wetland. Although their similar size enables saddlebills to exploit for food the same wetland habitat as wattled cranes, there is little competition for food between these 2 species, because saddlebill storks have an animal-based rather than vegetarian diet.

Spur-winged geese are often seen inhabiting wetlands with wattled cranes, although they may frequent deeper waters. Douthwaite (1978) describes the seasonal occurrence, distribution, and diet of the spur-winged goose as similar to the wattled crane on Kafue Flats. George Archibald (pers. comm.) observed a similar association between the brolga crane and magpie goose (*Anseranus semipalmata*) in floodplains and domestic sorghum fields in Australia.

ENDANGERED CRANES

Among the 15 species of cranes recognized in the world today, 6 are listed as endangered in the International Union for the Conservation of Nature and Natural Resources Red Data Book (Vincent 1966), including the whooping crane (*G. americana*), red-crowned crane (*G. japonensis*), Siberian white crane (*Bugeranus leucogeranus*), black-necked crane (*G. nigricollis*), white-naped crane (*G. vipio*), and hooded crane (*G. monachas*).

The rare Siberian white crane is closely related to the wattled crane (Archibald 1976, Woods 1979), and its winter habitat use and feeding behavior also closely parallel those of the wattled crane. Siberian cranes are very water-oriented birds, deriving most of their food by digging tubers beneath the water's surface. The food of Siberian cranes on their wintering grounds in India are mainly tubers of *Cyperus* and *Eleocharis* sedges (Ron Sauey, pers. comm.), while tubers from sedges of these 2 genera also constitute most of the wattled cranes' diet. The similarities also extend to the percent of young of the year in populations of Siberian cranes, with 8, 9.5 and 7% observed, respectively, by Walkinshaw (1973), Sauey (1976), and Flint and Kistchinski (this Proceedings), which are actually above the percentages I observed in wattled cranes in the large wetlands (Table 3). Although their nesting habitat in the tundra of the Soviet Union is extensive, the riverine floodplains that once supported wintering Siberian cranes in southern Asia have been destroyed and are inhabited by dense human populations, reducing the total population to less than 400 birds. This example should serve to further emphasize the endangered future of the wattled cranes and the importance of habitat protection of this unique African crane.

FUTURE RESEARCH

The future of the wattled crane depends on research to provide information for the development of a comprehensive conservation plan for the continued existence of this species throughout its historic range.

Future research should begin with aerial census of the large wetlands that support large wattled crane

populations, namely, Kafue Flats, Bangweulu, Busanga, Liuwa, Okavango, and Magadigadi. The Linyanti-Chobe and Upemba wetlands should also be considered for aerial census. This census will be a significant study, providing important base-line data on the status of wattled cranes at each large wetland.

Throughout the wattled crane's range there should be an organization of the nations and their respective wildlife departments and societies to collect information on the distribution, population status, wetland use and ecology, and the life history of resident wattled cranes. This research will require participation of many individuals, and the resulting information will be the product of international interest and cooperation.

During the recommended surveys, data should be collected on the social structure of each population, mated pairs, nonbreeding flocks, and successful pairs with their juvenile chick. This data will provide nesting success and production rates. Observations should also be made on feeding methods and the association of each crane with water.

The movements and migrations of wattled cranes should be monitored by banding for individual field identification and eventually by attaching miniature radio transmitters capable of being tracked by satellite. These methods will provide information on movements, territory size, home range, seasonal migrations, and life history.

Wattled crane research is presently in a developmental stage and these recommendations for future research should provide a sound basis to our future understanding and indicate the importance of individual wetlands to this species.

CONSERVATION RECOMMENDATIONS

Wattled cranes live in wetland ecosystems supporting great numbers of divergent species typical of Africa and species unique to a specific locale. Until recent years wattled crane populations have adapted to a specific habitat, and their numbers have been regulated naturally by limiting factors, including available habitat area and food resources. Today man and his technological developments have become limiting factors through destruction and alteration of habitat. If not controlled, these changes may spell the eventual demise of the wattled crane, as has occurred in closely related crane species. In view of the problems facing the wattled crane several recommendations are presented for the conservation of this species and its wetland ecosystems.

The hydroelectric scheme on Kafue Flats should be altered to include optimum regulation of waters for the combined good of all interests, including existing wattled crane and other wildlife populations, the wetland's large fishing industry and pastoralists, and the total ecology of Kafue Flats. This action is of the greatest importance to the wattled crane.

Blue Lagoon National Park in Kafue Flats should be reopened for public use. In Lochinvar National Park, fishermen and pastoralists with their domestic cattle herds should be restricted to areas outside park boundaries because their presence is not conducive to the proper management of the national park and probably hinders nesting of wattled cranes in upland wetlands. The national park system on Kafue Flats is small in comparison to the entire area.

Plans for dams and hydroelectric schemes for Bangweulu should be abated because the Kafue hydroelectric scheme already provides the total power output needed by Zambia, and the Kariba hydroelectric scheme is available to supply any additional power needs.

All humans in Liuwa Plain National Park should be relocated outside national park boundaries or the boundaries should be shifted to exclude all villages. Thereafter, national park authority must be strictly enforced. An educational program should be initiated to teach wildlife and national park values to persons living near the park.

Wetland reclamation and the eventual multipurpose development of the Okavango should proceed with restraint. The wise use of this wetland's natural resources by humans should benefit native wildlife, including wattled cranes. The small wetlands inhabited by wattled cranes should be surveyed and protected throughout the range of the wattled crane.

Reintroduction of wattled cranes should be considered where populations have been extirpated and suitable protected wetland habitats are available.

Many of the world's wildlife species are becoming rare as a result of man's economic growth and technological development, untempered by adequate concern for natural communities and conservation measures. Modern man has a responsibility to act wisely when considering the future of the wattled crane and wetlands that support bountiful life systems making up each wetland ecosystem. These areas are beautiful examples of Africa and should be preserved as areas of international importance for the future of existing wildlife and for all mankind to treasure.

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