

## **Geese and Red-knobbed Coot on the Kafue Flats in Zambia, 1970–1974**

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### **Summary**

The occurrence, chronology of breeding and wing-moult, and feeding habits of the Pigmy Goose *Nettapus auritus*, Knob-billed Goose *Sarkidiornis melanotos*, Spur-winged Goose *Plectropterus gambensis*, Egyptian Goose *Alopochen aegyptiaca* and Red-knobbed Coot *Fulica cristata* on the Kafue Flats in Zambia are described based on observations made between October 1970 and January 1974 at Lochinvar National Park and, from the air, over the central section of the Flats.

The Pigmy Goose, Knob-billed Goose, Egyptian Goose and Red-knobbed Coot fed largely by grazing. They were most abundant between March and June, occurring in greatest numbers at Lochinvar. Egyptian Geese occasionally nested on the floodplain at Lochinvar between August and January, but there was no proof of the other species nesting there. Many Pigmy Geese and male Knob-billed Geese moulted on the lagoon at Lochinvar between March and June; small numbers of Egyptian Geese and Red-knobbed Coot also moulted in the Park, the former between February and May, the latter in June and July.

The Spur-winged Goose fed mostly by grazing and grubbing. Numbers on the Flats were greatest between June and November when 60,000–90,000 moved down-river as the floods subsided. Many bred between January and March in the fringing zone and moulted on the floodplain between May and July.

A hydroelectric scheme, completed in 1975, may benefit the Pigmy Goose and Red-knobbed Coot but harm the Spur-winged Goose.

### **Introduction**

Some of the most spectacular concentrations of waterbirds in Africa have occurred at times on the Kafue Flats, a river floodplain in southern Zambia (Fig. 1). However, in 1975 the flood regime of the Kafue river was altered by a hydroelectric scheme and management may now be necessary to conserve the wildlife. Parts of the floodplain are within two national parks but the comparative inaccessibility of the area has

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hindered wildlife studies and much of the information on which a wetland wildlife management programme could be based is lacking.

Between October 1970 and January 1974 I studied the cranes, ducks, geese and Red-knobbed Coot *Fulica cristata*, paying particular attention to their occurrence, movements, breeding seasons, wing-moult, feeding behaviour and diet. Observations on the Wattled Crane *Grus carunculatus* and filter-feeding ducks have already been published (Douthwaite, 1974, 1976, 1977); this paper reports on four species of geese—the Pigmy Goose *Nettapus auritus*, Knob-billed Goose *Sarkidiornis melanotos*, Spur-winged Goose *Plectropterus gambensis* and Egyptian Goose *Alopochen aegyptiaca*—and the Red-knobbed Coot, all of which feed by grazing.

### The environment

The Flats, which include the permanently flooded channels and lagoons in the meander belt of the Kafue and the seasonally flooded peripheral plains, cover some 5600 km<sup>2</sup>. Much of the area is vegetated by tall, perennial grasses, but aquatic herbs

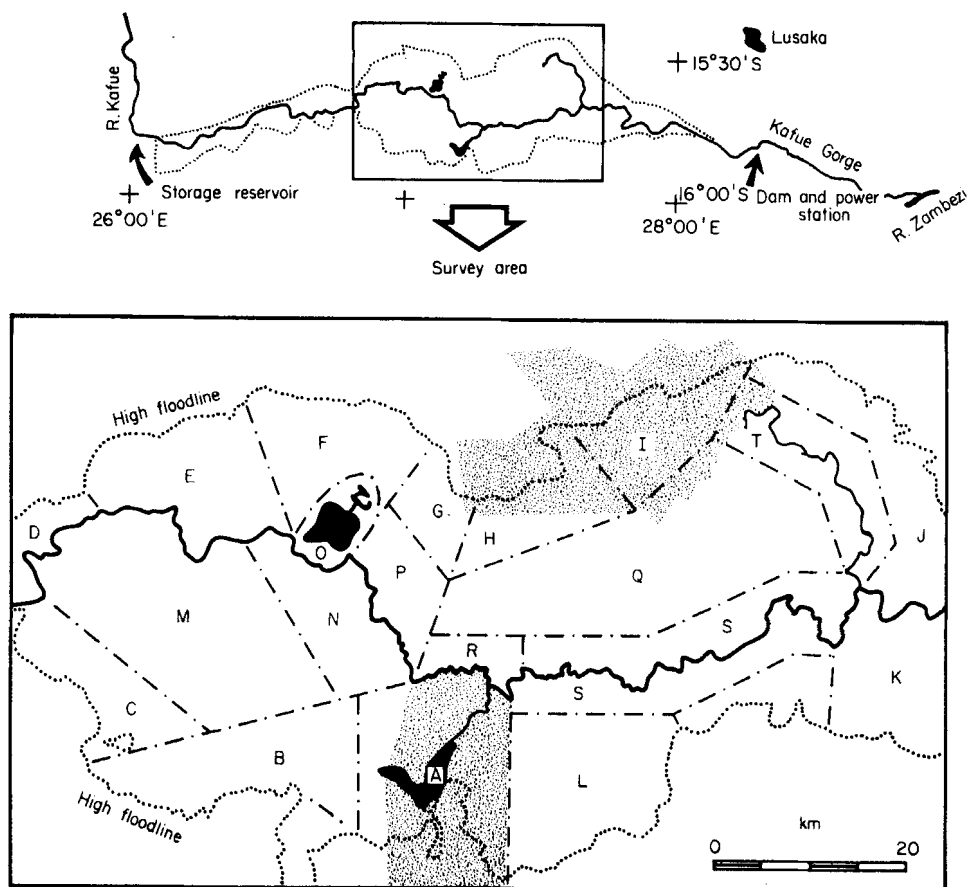


Fig. 1. The Kafue Flats.—Dam sites (top), sectors A–T of the Survey Area (bottom) and national parks (stippled) are indicated. Blue Lagoon National Park lies north of the river, Lochinvar National Park lies to the south.

dominate some lagoons and locally the grassland is modified by lechwe *Kobus leche*, a semi-aquatic antelope. At Lochinvar National Park (Fig. 2) for example, herds suppress the aquatic grass *Echinochloa stagnina* on the southern side of the lagoon by grazing there in the early rains; it is replaced by aquatic herbs, notably the water-lily *Nymphaea capensis*. In other heavily grazed areas of the Park the perennial grassland is suppressed and short annual grasses and terrestrial herbs grow.

The rains last from November to March, but much of the floodwater originates in the upper Kafue basin and its arrival is therefore delayed. Formerly the floods usually

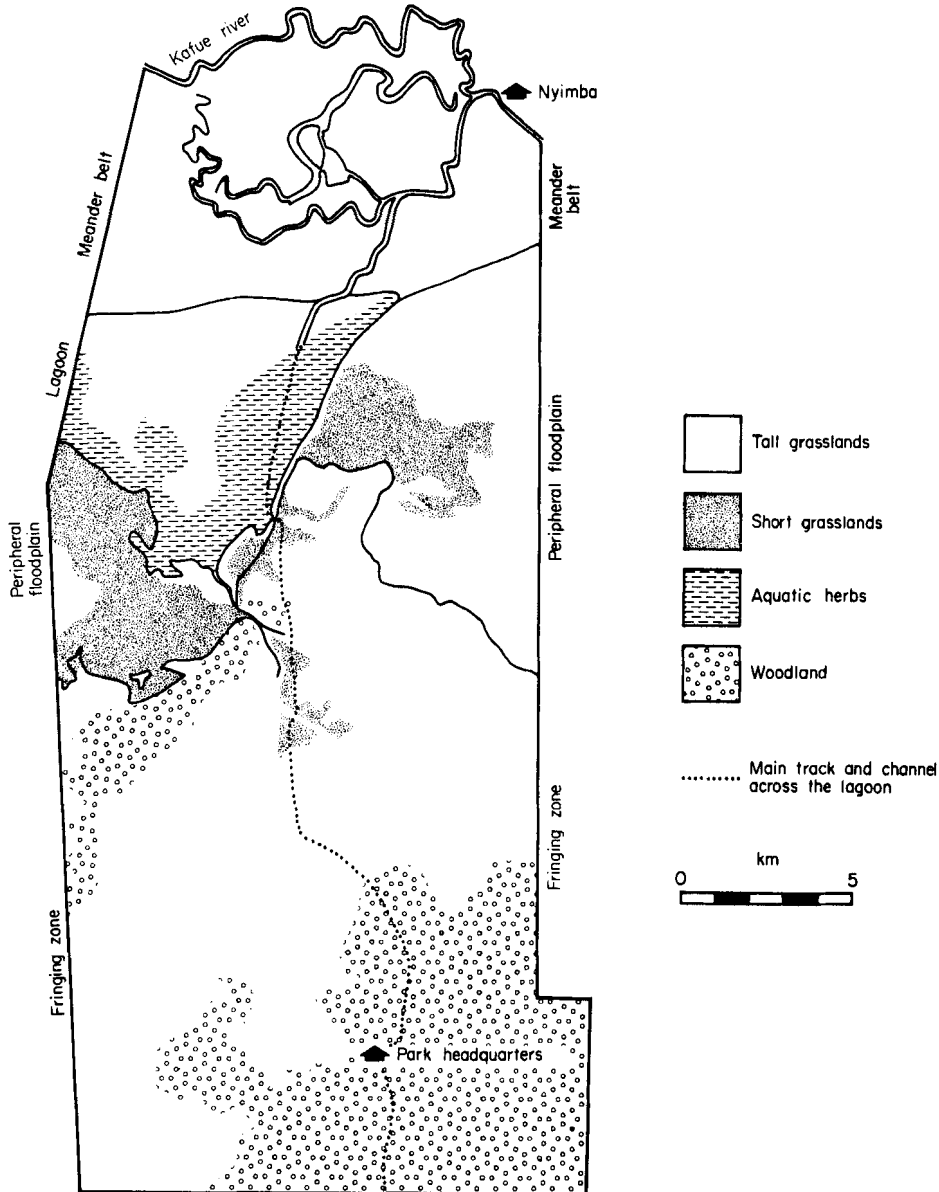


Fig. 2. Physiographic zones and major vegetation types of Lochinvar National Park.

reached their peak in early March at the western end of the Flats, in April or May at Lochinvar, and in late May or June at Kafue Gorge. By October the water had subsided and was normally restricted to drainage channels and lagoons; the floodplain was dry.

The phenology of growth of some plants is related to the rains; of others, to the flood cycle. The terrestrial herbs on the floodplain fruit in December and January, before they are drowned by the rising floods. The grasses fruit between mid-January and April, species dominating higher ground fruiting before those in lower areas. The aquatic herbs begin to fruit heavily in March; some, such as *Nymphoides indica*, continue to do so until stranded by the receding floods while others, such as *Nymphaea capensis*, cease in May or June.

The floods of 1971 and 1972 were normal, but the flood of 1973 was the smallest on record (Fig. 3). The lagoon and parts of the meander belt at Lochinvar were inundated but the peripheral floodplain remained dry. Chawembe Lagoon (sector O) was also flooded briefly, but there was little fresh flooding elsewhere on the Flats. The growth of aquatic herbs in the lagoon at Lochinvar was especially vigorous in 1973 and a submerged herb *Najas pectinata*, previously rare, became co-dominant with floating and emergent species. On the other hand the perennial aquatic grasses failed to fruit.

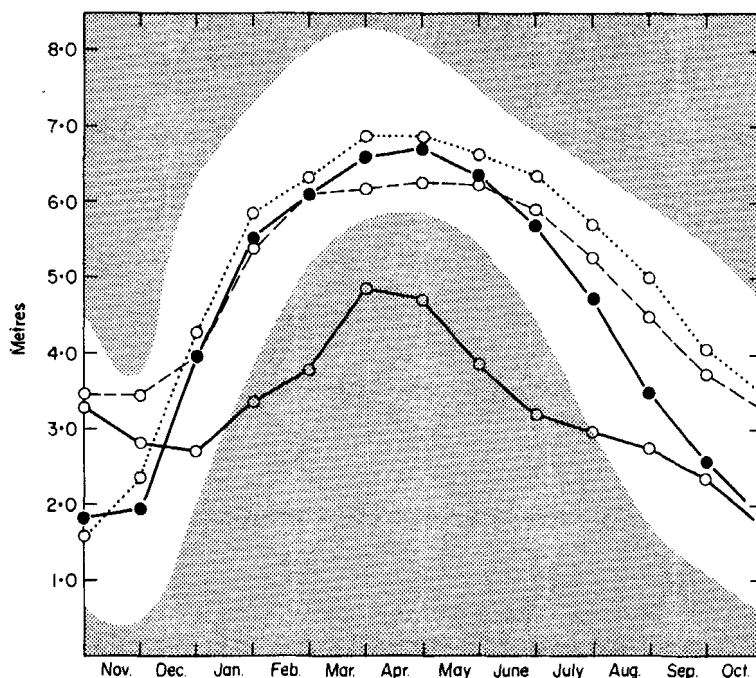


Fig. 3. Water levels at Nyimba, showing the range (unshaded) and average of levels between 1962 and 1970 (●—●), levels in 1970/71 (○ . . . ○), 1971/72 (○ — — — ○) and 1972/73 (○ — — — ○).

At high flood levels (i.e. above 6 m) flooding separates the peripheral shore from the meander belt throughout the Survey Area; at low flood levels (i.e. below 3 m) the floodplain in the Survey Area is dry, apart from a small area in the east flooded by the Kafue Gorge dam.

## Methods

Most observations were made from the ground at Lochinvar National Park, but twenty aerial surveys were also flown over the central section of the Flats, the Survey Area (Fig. 1; Appendix). Most flights were made at a height of 60 m and a ground speed of 160 km h<sup>-1</sup> from high-winged aircraft; they usually followed the floodline, with detours to other potentially important areas, but on four occasions Spur-winged Geese were censused in the manner used by Bell *et al.* (1973) on lechwe. The floodplain was stratified on the basis of probable goose density: adjacent strata were expected to have different densities. The population of each stratum was sampled by flying randomly selected north-south transects and counting the geese within a strip of known width. Strata with high densities were sampled more intensively than those with low densities. Estimated numbers were corrected approximately for bias, determined by photographing selected flocks and counting the birds later. The number of geese in the stratum was the product of the average number of geese per transect and total number of possible transects.

The locations of other species seen during aerial surveys were plotted on maps of the Survey Area and their numbers estimated. A rough correction for estimation bias has been made below, where necessary, by doubling the original estimates.

At Lochinvar, exact counts could seldom be made, except for the Egyptian Goose. Estimates of abundance were therefore derived from local counts and rough calculations of numbers elsewhere. The habitat preferences of each species were noted and observations made to determine their preferred foods. The food of grazing birds could often be identified by field observations. Food was also identified from faeces, particularly of Spur-winged Geese, but most food was identified from gut contents. In examining the gut contents, the gizzard was first separated from the rest of the excised fore-gut and its contents noted. Material in the crop and proventriculus was then sorted, identified by comparison with a reference collection, dried at 40°C and weighed. Only those foods recorded by direct observation, or which comprised at least 20% of the dry weight of food in a crop containing at least 0.02 g, or which were the sole item filling the gizzards of birds with empty crops are tabulated below as principal components of the diet. Few birds were shot once the main foods in a particular habitat had been identified and some important foods are therefore under-represented in the tabulated results below.

No observations were made from July to September 1972 as I went on leave.

## Results

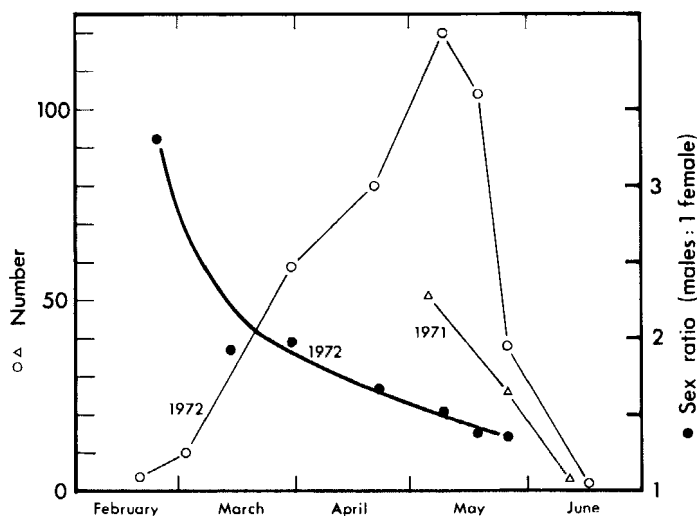
### *Pigmy goose* *Nettapus auritus*

Scattered birds were probably often overlooked during aerial surveys. However, pairs and small groups were noted occasionally on water-lily lagoons between March and September and hundreds were seen on Chawembe Lagoon (sector O), which was dominated by the herb *Najas pectinata*, in October 1971 and between April and November 1972.

Pigmy Geese were recorded at Lochinvar in every month of the year, but large numbers were present only between March and May. The first influx in 1972 was noted on 15 February, and in 1973 on 7 March, but in each year 1971-1973 most birds arrived in March. Thousands used the lagoon but in mid-May numbers fell rapidly and by the end of June emigration was complete. Counts made in 1971 and

**Table 1.** Distribution of grazing ducks and Red-knobbed Coot at Lochinvar in 1971 and 1972. The areas indicated are: fringing zone (F, f), peripheral floodplain (P, p), lagoon (L, l) and meander belt (M, m). The most important area is indicated in upper case; other important ones are shown in lower case; those of minor importance are omitted

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Pigmy Goose	—	P	pl	Lp	L	L	—	—	—	—	—	—
Knob-billed Goose	Fp	F	F	♀P ♂l	♀p ♂l	M	M	M	M	M	M	m
Spur-winged Goose	F	Fp	fp	fpl	fpl	plm	plm	plm	lm	lm	lm	mf
Egyptian Goose	P	P	P	P	P	P	pm	M	M	M	M	M
Red-knobbed Coot	—	P	P	P	pl	pl	L	L	L	L	—	—



**Fig. 4.** Numbers of Pigmy Geese in a transect across the lagoon at Lochinvar in 1971 and 1972, and the sex ratio in sample counts made in 1972.

1972 along a transect 40 m wide and 3.3 km long, from a channel crossing the lagoon, reflected these changes in abundance (Fig. 4). Assuming densities were similar throughout the 12.5 km<sup>2</sup> lagoon the population on 5 May 1971 was about 5000; and in April and early May 1972, 10 000 to 15 000. Comparable counts could not be made in 1973 because of low flood levels, but by roughly estimating numbers in several areas of lagoon the population on 3 May was thought to number 5000.

Most birds seen at Lochinvar between February and June were paired, but small bachelor flocks and lone males were also present; unattached females, however, were rarely seen. In 1972 the excess of males declined as the season progressed (Fig. 4). Most of the males, many of them paired with females, were in immature plumage (see Verheyen, 1953); juveniles were absent. Moulting birds were recorded on the lagoon between 2 March and 19 June, and in each year hundreds were flightless during April and May.

Most breeding records from Zambia fall between January and March (Benson *et al.*, 1971) and a pair seen on several occasions in the woodland at Lochinvar in January 1974 may have been breeding. Although Dowsett & Vos (1965) refer to a brood of goslings less than a week old on the Kafue Flats in late October there was no evidence of nesting on the floodplain during this study.

In conclusion, most of the Pigmy Geese visiting Lochinvar between March and May are immature or non-breeding adult moult migrants. Their origin is unknown, but one bird, an adult male ringed at Lochinvar in May 1973, was recovered in early March 1975 in the Lukanga Swamps, 180 km to the north east.

*Feeding habits.* Pigmy geese fed alone or in small groups. They were entirely aquatic, feeding at the surface by grazing or filtering. The habitats used and foods eaten at Lochinvar are shown in Tables 1 and 2. Apart from a brief period when many birds fed amongst fruiting *Echinochloa stagnina* grassland, the population was almost entirely confined to the lagoon where fruits of the water-lily *Nymphaea capensis* were the most important food. On average 78% of the dry weight of food in twelve crops taken from birds shot on the lagoon consisted of the seeds and other floral parts of water-lilies. Fruits of the grass *Sacciolepis africana* were often grazed at the lagoon margin. Pigmy Geese were often seen amongst the herb *Nymphoides indica*; however, they seldom fed upon its seeds, taking instead the larvae and pupae of the pyralid moth *Nymphula plumbifusalis* from the lower surface of its leaves. On the death of *Nymphaea capensis* in mid-May most Pigmy Geese left. The remaining birds sometimes fed commensally with Knob-billed Geese which, being larger, were still able to reach some of the sinking water-lily fruits. The Pigmy Geese picked up seeds dropped by feeding Knob-billed Geese.

The average contents by dry weight of fourteen crops collected in March, April and May were 86% seeds and fruits, 9% other floral parts and 5% invertebrates (spiders and insects).

**Table 2.** Foods of the Pigmy Goose at Lochinvar. The number in parentheses after each food refers to the number of guts in which it formed a principal component

Feeding zone	Period	Sample size	Principal components of the diet
Peripheral floodplain	February–March 1972	3	Seeds of <i>Digitaria ternata</i> (3), <i>Digitaria ciliaris</i> (3) and <i>Panicum subalbidum</i> (3)
Peripheral floodplain	Late March–early April	2	Fruits of <i>Echinochloa stagnina</i> (2)
Lagoon	March–May	12+	Fruits of <i>Nymphaea</i> , mainly <i>N. capensis</i> but also <i>N. caerulea</i> , (9, and often observed), <i>Sacciolepis africana</i> (1, and occasionally observed), <i>Utricularia inflexa</i> var. <i>stellaris</i> (1973 only: 2, and often observed). Seeds of <i>Polygonum limbatum</i> (1) and <i>Nymphoides indica</i> (2). Larvae and pupae of <i>Nymphula plumbifusalis</i> (Lepidoptera) (1, and often observed)

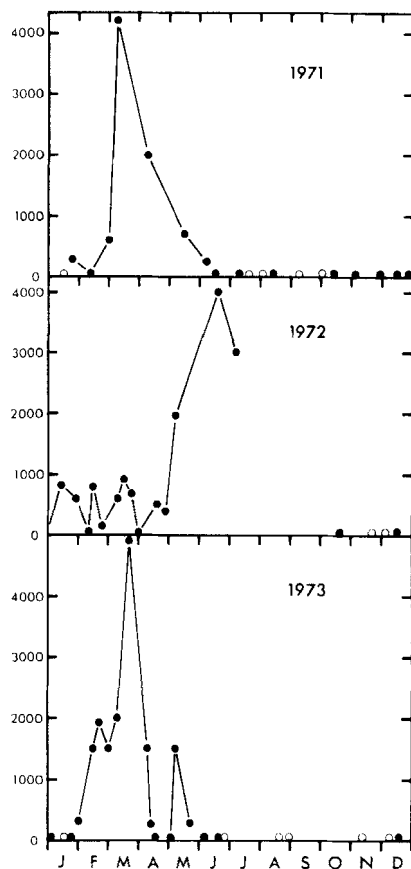


Fig. 5. Population estimates of the Knob-billed Goose at Lochinvar. Estimates in the range 1–10 are shown by open circles.

*Knob-billed Goose Sarkidiornis melanotos*

Each January large flocks arrived at Lochinvar to feed in the short grasslands at the edge of the floodplain (Fig. 5). The birds were sexually inactive, and as the males had small caruncles (see Verheyen, 1953) they were probably immature. In April they were joined at the floodline by females with juveniles. At the same time, flocks of males arrived and used the lagoon. Most were in adult plumage (see Mackworth-Praed & Grant, 1962). During May and June 1972 an average of 43 ( $s=26$ ) males were seen in five counts along a transect 40 m by 3.3 km crossing the lagoon. Some 5.5 km<sup>2</sup> of lagoon was used and the population was therefore about 1800. In 1971 and 1973 most Knob-billed Geese had left Lochinvar by the end of May, but in 1972 large numbers were still present in the meander belt when I went on leave at the beginning of July; however, they had disappeared by my return in September.

Few Knob-billed Geese were seen outside Lochinvar in aerial surveys made during the rains, the largest number being 200 in sector E in February 1972. In April 1971 800 were seen in sectors G, H and I, and in April 1972 200 were again noted in sector E. In July 1971 500 were seen in sector E, but later in the dry season Knob-billed Geese



were generally scarce, apart from small flocks seen regularly at lagoons in the meander belt immediately to the east of Lochinvar (sector S).

Most breeding records for Zambia are in January and February (Benson *et al.*, 1971). Formerly, goslings were regularly seen in the woodland at Lochinvar during February and March (Benson, 1960) and pairs seen there occasionally in the rains during this study may have been breeding. However, none of the twenty-four birds shot on the floodplain between December and July was in breeding condition.

Flightless males were seen on the lagoon at Lochinvar between 14 March and 2 July. Many moulted there in 1971 and 1972, mostly in May, but few did so in 1973. I saw only one female in moult, in flooded grassland in the meander belt at Lochinvar on 8 June 1973, but Grimwood (1957) recorded flightless females on the Flats in April. Moulting birds have been seen at Lake Chilwa in Malawi in October (Schulten and Harrison, unpublished).

Dowsett (1966) considered the Knob-billed Goose to be resident on the Kafue Flats although Grimwood (1957) had noted numbers were much augmented in the rains. Ringing in Rhodesia has shown that some birds are inter-tropical migrants, and one bird, ringed at Mlezu in Rhodesia in November 1967 was killed on the Kafue Flats in April 1969 (Dowsett, 1971). I found that Knob-billed Geese were most abundant in the latter part of the rains and in the early dry season; the population consisted mainly of non-breeding visitors, resident between January and July, and post-breeding passage migrants between April and July. The largest concentrations occurred in sectors heavily used by lechwe, namely A, E, G, H and I.

**Table 3.** Segregation of Knob-billed Goose sexes by habitat. All counts were made at Lochinvar, except for the first which was made at Chobe in northern Botswana

Habitat	Number sexed	Males (%)	Period
Lagoon with aquatic herbs	26	100	January
Lagoon with aquatic herbs	346	96	April–May
Flooded grassland near the shore	44	61	March–April
Shoreline	868	41	February–April
Dry grassland	313	16	December–February
Shoreline	100	0	Late April

*Feeding habits.* Generally, the sexes preferred different habitats for feeding and at Lochinvar males were mainly aquatic, females mainly terrestrial (Table 3). Both fed largely on ripening seeds but when their food plants ceased to fruit they filtered for food in shallow water. For females, this transition took place in April; for males, in June. Birds fed mainly in the early morning and late afternoon. Between January and March the feeding grounds often changed from day to day. In wet spells the flocks grazed in the fringing zone on the fruits of the grass *Brachiaria xantholeuca*, but in dry periods and towards the end of the rains they withdrew to muddy depressions at or near the floodline where they fed principally on the fruits of the grass *Echinochloa colonum* (Table 4). Lechwe herds sometimes grazed the *Brachiaria* grasslands preventing the grass from fruiting and thereby influencing the distribution and perhaps numbers of geese present. By April ripening grass fruits had become scarce in the fringing zone

**Table 4.** Foods of the Knob-billed Goose at Lochinvar. The number in parentheses after each food refers to the number of guts in which it formed a principal component

Feeding zone	Period	Sample size	Principal components of the diet
Fringing zone and peripheral floodplain	January–March	5+	Fruits of <i>Brachiaria xantholeuca</i> (3 and often observed), <i>Echinochloa colonum</i> (1 and observed) and <i>Heliotropium ovalifolium</i> (1). Germinating seeds of unidentified dicotyledons (1 and observed)
Peripheral floodplain	March–May	4+	Fruits of <i>Echinochloa colonum</i> (1 and often observed), <i>Digitaria ciliaris</i> (1) and <i>Sacciolepis africana</i> (1 and observed). Seeds of <i>Ambrosia maritima</i> (1)
Lagoon	April–July	4+	Fruits of <i>Nymphaea capensis</i> (2 and often observed in April and May), <i>Aeschynomene fluitans</i> (1 and observed) and <i>Sacciolepis africana</i> (observed). Seeds of <i>Nymphoides indica</i> (1)
Meander belt	May–July 1972	2	Seeds of <i>Aeschynomene nilotica</i> (1) and <i>Sorghum verticilliflorum</i> var. <i>latiglume</i> (1). Rhizomes of ? <i>Cyperus esculentus</i> (1)
Floodline	November–December	1+	Fruits of <i>Ambrosia maritima</i> (observed), <i>Heliotropium baclei</i> var. <i>rostratum</i> (observed), and <i>Heliotropium ovalifolium</i> (observed). Leaves of <i>Echinochloa stagnina</i> (1 and observed) and <i>Vossia cuspidata</i> (observed)

and the flocks fed along the peripheral floodline, grazing on the fruits of aquatic plants or filtering seeds, especially of the terrestrial herb *Ambrosia maritima*. The fruit of *Nymphaea capensis* was the most important food for males in April and May and as the supply dwindled in May the number of geese on the lagoon declined. In June and July the remaining birds fed largely on pods of the aquatic legume *Aeschynomene fluitans*. However, pod production was erratic: few were produced in 1971 or 1973 and few geese remained; more pods were produced in 1972 and the number of geese was higher.

Twelve crops from birds of both sexes were examined between January and May; on average, the ripening fruits and seeds of grasses and herbs accounted for 96% of the dry weight of food. Between June and December Knob-billed Geese filtered, grubbed and grazed for a wider range of foods including seeds, rhizomes and grass leaves. Negligible amounts of animal matter were found in the twenty-five guts examined.

#### *Spur-winged Goose Plectropterus gambensis*

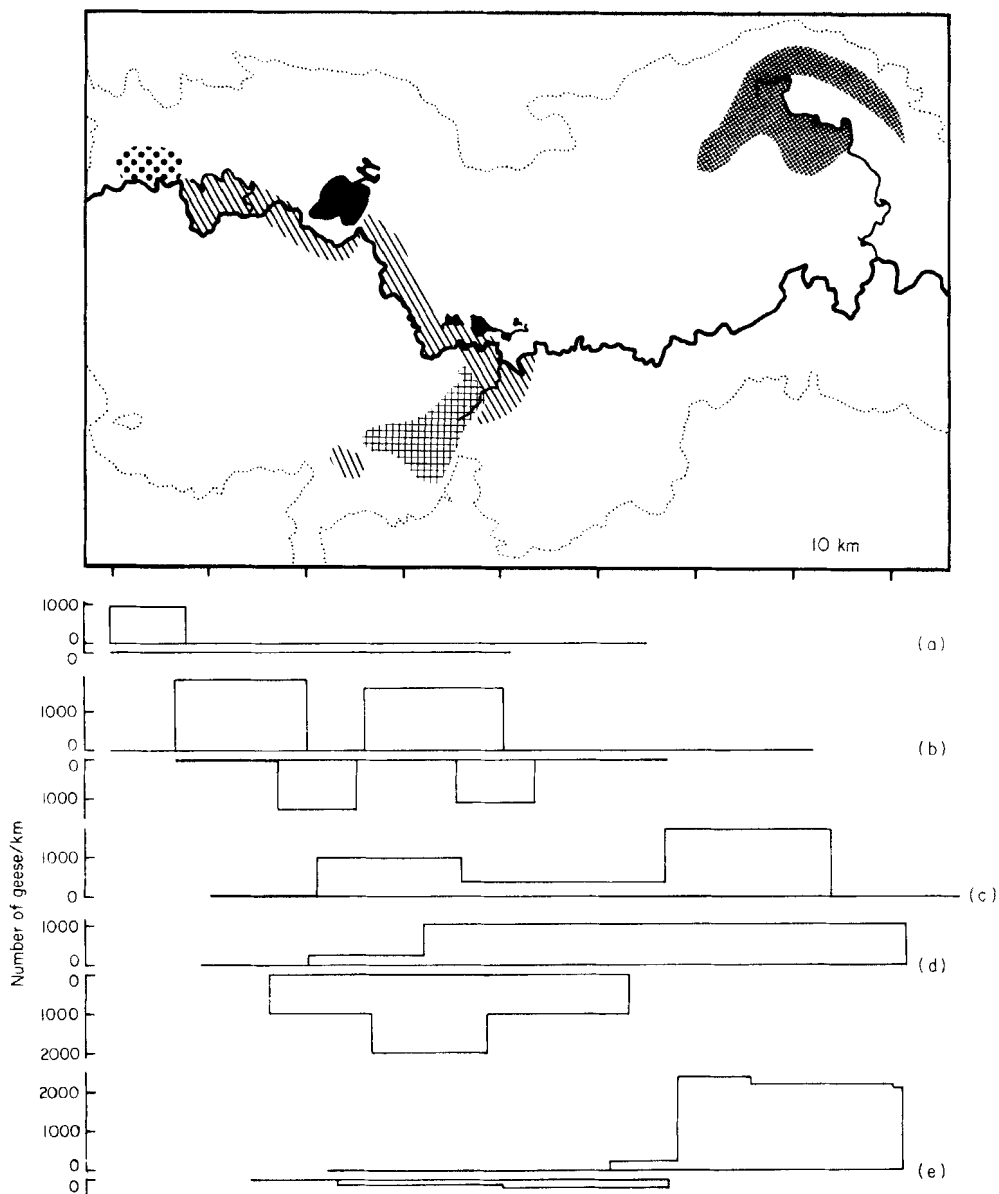
The Spur-winged Goose was the most widespread anatid and, seasonally, the most abundant. Groups usually dispersed in shallowly flooded or damp grassland, but compact flocks were also seen, especially at drying pools. During the rainy season the widely scattered population of the floodplain in the Survey Area probably numbered

a few thousand. At Lochinvar many birds used the fringing zone, but in late February and March those no longer involved with breeding gathered in flocks and moved westwards, leaving a residual population of 200–300 in the Park. Early in the dry season numbers at the western end of the Survey Area increased and as flood levels dropped the population moved progressively down-river (Fig. 6). The movement may have originated above the Kafue Flats, for early in April 1971 large numbers of this species were seen on the Busanga floodplain (J. Uys personal communication). Large numbers returned to Lochinvar in June or July, earlier in a year of low flood levels like 1973 than in a year of high levels like 1971. The population in the Survey Area reached a maximum in the dry season, numbering 60 000–90 000 (Table 5). Under natural conditions numbers were probably reduced at low flood levels, but in 1973 retention of water at the Kafue Gorge dam enabled many birds to remain at the eastern end of the floodplain despite the very low flood earlier in the year. Numbers on the floodplain declined early in the rains and the arrival of Spur-winged Geese in Balovale District in western Zambia during October (Britton, 1970), and in the Luangwa Valley during the rains (Benson *et al.*, 1971) may be indicative of a wide dispersal.

This species was the commonest breeding anatid at Lochinvar. Early in the rains males, either in small groups or alone, began to visit the wet, lightly wooded grasslands fringing the floodplain. At first most of them continued to roost on the floodplain and feed there during dry spells, but by mid-January many had become resident, having established territories and been joined by females. The population was dispersed as bachelor groups of two or three males and breeding groups of one male with one to five females. Courtship chases were observed between 10 January and 5 February, and fresh intact eggs were occasionally found on roads between 19 January and 8 February. Two broods encountered in 1971 had hatched from eggs laid in January. From mid-February the numbers of geese on the breeding grounds declined and it was apparent that most breeding occurred in the latter half of January and first half of February, in agreement with records in Benson (1960) and Benson *et al.* (1971). More birds bred in the wetter years of 1971, 1972 and 1974 than in the drought year of 1973. The association of several females with one male in the breeding season, and reports of up to 18 eggs in one clutch (Benson 1960) suggest that this species is polygynous like the ecologically similar Magpie Goose *Anseranas semipalmata* of Australia (Frith, 1967).

In June 1972 and July 1971 flightless birds were seen in the meander belt to the west of Lochinvar, and this was probably where most birds usually moulted. However, in 1973, when most of the meander belt remained dry, thousands of birds moulted in the peripheral floodplain immediately to the west of Lochinvar, in an area dominated by the sedge *Eleocharis dulcis*. Probably, the first birds became flightless in early May and the last completed their moult at the end of July. Several hundred birds also moulted in the Park in 1973. The largest group associated with a herd of forty hippo *Hippopotamus amphibius* and could not be rounded up for ringing. Any bird which was separated from the rest refused to be driven, but dived beneath the boat to return to the protection of the hippo.

*Feeding habits.* The feeding habits and foods of the Spur-winged Goose were perhaps the most diverse of all. Usually geese fed by grazing, digging, foraging or filtering as they walked over damp or shallowly flooded ground. Less often they would swim in deeper water and, if necessary, feed by upending. Greatest feeding activity occurred in the early morning and late afternoon.



**Fig. 6.** Distribution of Spur-winged Geese in the Survey Area in relation to water levels at Nyimba. Top: main concentrations at 6.3 m, rising (coarse stippling)

6.2 m, falling (hatching)  
 5.0-3.3 m, falling (cross hatching)  
 2.9 m, falling (fine stippling)

Bottom: density of geese in each stratum at water levels of:

- (a) 6.3 m, rising (survey: April 1972)
- (b) 6.2 m, falling (June 1972)
- (c) 3.9 m, falling (October 1971)
- (d) 3.3 m, falling (November 1972)
- (e) 2.9 m, falling (August 1973)

Densities, north and south of the river, are indicated by histograms above and below base lines which show the east-west limits of the surveys.

Table 5. Censuses of the Spur-winged Goose in the Survey Area

	North bank		South bank		Total	95% confidence limits
	No. of transects	Estimated population	No. of transects	Estimated population		
6-13 October 1971	46	54 000	—	—	—	—
19-21 June 1972	66	48 100	62	20 800	68 900	23 000
1- 3 November 1972	73	55 400	30	48 900	104 300	29 000
21-22 August 1973	66	54 800	37	5 200	60 000	24 000

## Notes:

1. Estimates of groups which could not be counted were corrected for bias by dividing by the following factors:

Census	Estimate	Factor
October 1971; June 1972	10-19	0.5
	20+	0.4
November 1972	10-19	0.8
	20-30	0.7
	31-49	0.5
	50-100	0.4
	100+	0.3
August 1973	30+	0.5

2. Numbers outside the surveyed areas were probably small, except in August 1973 when some birds may have moved further east.
3. In November 1972 the fortuitous inclusion of several flocks at residual lagoons led to a considerable over-estimate of the South bank population (perhaps by 50%).

In the early rains grass leaves provided the bulk of the diet but birds on the floodplain also foraged a good deal for water-lily rhizomes and filtered out grass seeds, while those in the fringing zone were seen to eat winged termites and dig for rhizomes of the sedge *Cyperus usitatus*. The fringing zone became the main feeding ground in early January as grass fruits began to ripen. A wide range of fruits was grazed but in January and February those of *Panicum coloratum*, *Echinochloa colonum* and *Brachiaria xantholeuca* were the most commonly taken. Little grass leaf was eaten. In the latter half of February flocks began to gather and move westwards, and from mid-March until after the post-nuptial moult few birds were present. The sexes were partially segregated at this time; thus only thirteen (16%) of the seventy-nine birds sexed in the fringing zone were male compared with 464 (76%) of the 611 sexed at the peripheral floodline (Chi square=116;  $P<0.001$ ). In the fringing zone birds fed largely on the rhizomes of *Cyperus usitatus* during wet weather in late February and March, but the fruits of the grasses *Echinochloa colonum* and *Eriochloa fatmensis* were also eaten, particularly as conditions became drier. Later, the flocks fed at pools, possibly on water-lily rhizomes. At the peripheral floodline during March and April birds fed amongst fairly high, shallowly-flooded grassland which had been heavily trampled by lechwe. Examination of excreta showed that the bulk of their food consisted of grass seeds, especially of *Echinochloa colonum* and *Paspalum scrobiculatum*; they were probably obtained by filtering. On their return in June or early July, large flocks in the peripheral floodplain and meander belt were seen grazing on grass leaves, principally those of *Panicum repens* and *Acroceras macrum*, but grass seeds and rhizomes were also eaten. As water levels fell below 4.5 m at Nyimba many birds began to feed in the lagoon, and in an area of *Eleocharis* marsh on the western boundary

of the Park, where rhizomes of *Nymphaea* and *Eleocharis* were accessible. Some grass seed continued to be eaten by birds in the meander belt but water-lily rhizomes remained the most important food at Lochinvar until the early rains. At low flood levels (i.e. below 3 m at Nyimba) most birds moved down-river. The remainder, mostly males, foraged for water-lily rhizomes lying on the surface of the drying mud of the lagoon.

#### *Egyptian Goose Alopochen aegyptiaca*

A resident population at Lochinvar was augmented by immigrants between January and September; maxima of 700 and 850 were counted on 15 May 1972 and 10 April 1973 respectively. Counts at the end of the dry season and in the early rains showed that the resident population declined from 160 in 1970 to 30 in 1972 and 1973. Few Egyptian Geese have been recorded elsewhere on the Kafue Flats (Fig. 7).

Most breeding records for Zambia, originating mainly from the Luangwa Valley, occur between June and September (Benson *et al.*, 1971). However, the five records for the Kafue Flats, all from Lochinvar and the adjacent Chulwe Lagoon, fall between August and January. Flightless birds in moult were recorded annually at Lochinvar between 1 February and 13 May, but few were seen, most birds arriving in fresh plumage. Birds in moult have been seen on Lake Kariba, in the Matusadona Game Reserve, Rhodesia, between late December and early February (T. O. Osborne, personal communication).

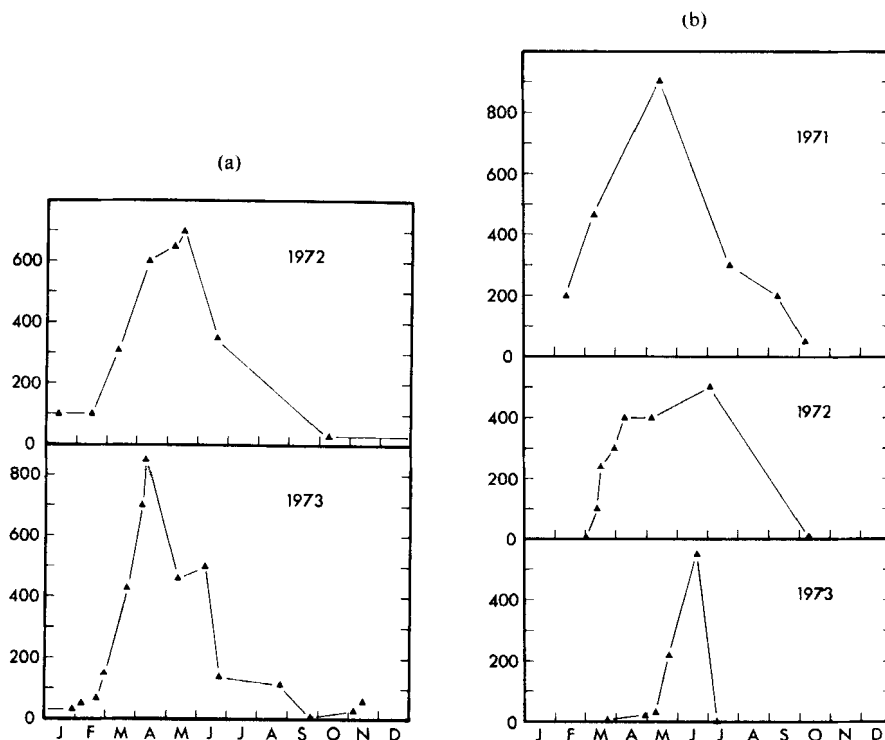


Fig. 7. Counts of (a) Egyptian Geese and (b) Red-knobbed Coot at Lochinvar. Records of Egyptian Geese on the Kafue Flats outside Lochinvar are: 6 sector I, June 1966; 5 sector I, June 1967; 6 sector I, May 1968 (Osborne, 1973); 2 sector E, August 1971; 2 sector E, and 2 sector N, September 1971; 8 sector R, January 1973; 8 sector O, 8 sector I and 67 sector R, May 1973.

*Feeding habits.* Egyptian Geese were the least aquatic of the anatids, usually feeding above the floodline in scattered flocks. Between January and June they were almost restricted to the short grasslands of the peripheral zone where they grazed mainly on the leaves of *Panicum repens*. However, from mid-January through March they also fed on the ripening fruits of *Panicum subalbidum* and to some extent on the fruits of *P. repens* and *Brachiaria xantholeuca*. Food from the crop of a downy gosling, examined in January 1974, consisted almost equally of animal and vegetable material. The main components were ants, caterpillars, beetles (*Heteronychus* sp.) and seeds of *Digitaria ternata* and *Panicum subalbidum*. Between August and December the population was restricted to the meander belt, where birds grazed on the leaves of *Echinochloa stagnina*. The lagoon was seldom used except in May and June 1973 when several birds were seen feeding on the leaves of *Aeschynomene fluitans*, while others waded about filtering for food in a scything motion.

#### *Red-knobbed Coot Fulica cristata*

In 1971 and 1972 Red-knobbed Coot were recorded at Lochinvar between February and October, the maximum count being 900 in May 1971 (Fig. 7). None were seen outside the Park apart from two in sector O in October 1972 and 20 at the same place a month later. In January 1973, however, about 1200 were seen in sector O and another 80 in sector N. None were seen in sector O in March or May but in May numbers in sector N had increased to 400. In 1973 coot were recorded at Lochinvar from late March to June. Elsewhere in Zambia the species has an irregular distribution, seldom occurring in parties of more than ten (Benson *et al.*, 1971).

I shot a juvenile with incompletely grown remiges at Lochinvar in October 1971 but found no other evidence of breeding. Four records of laying given by Benson *et al.* (1971) for Zambia fall between April and July. Several flightless birds, in moult, were seen in June 1973 and July 1971 on the lagoon at Lochinvar.

*Feeding habits.* Usually coot fed in compact flocks, holding up to 300 birds; they were entirely aquatic. Early in the year they grazed on the leaves of *Panicum repens*, in areas trampled by lechwe or hippo. As water levels fell to about 6.2 m at Nyimba they moved from the peripheral floodplain to the lagoon, where they grazed on the leaves, stems and other parts of *Aeschynomene fluitans*, *Polygonum limbatum* and, in 1973, *Najas pectinata* (Table 6). As water levels fell below 3.7 m at Nyimba the last birds disappeared.

**Table 6.** Foods of the Red-knobbed Coot at Lochinvar. The number in parentheses after a food refers to the number of crops in which it formed a principal component.

Feeding zone	Period	Sample sizes	Principal components of the diet
Peripheral floodplain	February–May 1971–72	—	Leaves of <i>Panicum repens</i> (often observed directly and in excreta)
Lagoon	May–June 1973	10	Stems, flowers, fruits and chlorophyllous aerial roots of <i>Aeschynomene fluitans</i> (5, and observed). Stems and leaves of <i>Polygonum limbatum</i> (2) and <i>Najas pectinata</i> (2, 1973 only). Grass leaves (1).
	June–October 1971–72		

### Discussion

Benson *et al.* (1971) considered the Pigmy Goose, Spur-winged Goose and Egyptian Goose to be more or less sedentary in Zambia but, like the Knob-billed Goose and Red-knobbed Coot, all three were found to be migrants or partial migrants to the area studied here.

The Pigmy Goose, Knob-billed Goose, Egyptian Goose and Red-knobbed Coot fed largely by grazing and were most abundant between March and June. They differed partly by habitat—Pigmy Geese and Red-knobbed Coot were more aquatic than Egyptian Geese and Knob-billed Geese (excluding older males)—and partly by diet—Pigmy Geese and Knob-billed Geese took mainly ripening seeds whereas Red-knobbed Coot and Egyptian Geese ate mainly leaves. Occasionally such distinctions broke down. For example, both the Knob-billed Goose and Egyptian Goose, and Spur-winged Goose, took ripening grass seed in the rains; however, as they usually fed in different areas and, to some extent, at different levels, on an abundant source of food there was little likelihood of competition occurring. Similarly, both the Pigmy Goose and male Knob-billed Goose fed on water-lily fruits in April and May. However, as their food supply declined a commensal rather than competitive relationship developed between them.

The Spur-winged Goose, unlike the others, often fed by grubbing and was most abundant between June and November. In seasonal occurrence, distribution and diet it was similar to the Wattled Crane (Douthwaite, 1974) although Spur-wing were usually found in wetter areas. The two species also differed in the chronology of breeding and wing-moult: Spur-winged Geese bred in the rains and moulted in the dry season; Wattled Cranes, the converse. In Australia, the Magpie Goose (Frith, 1967) and Brolga Crane *Grus rubicundus* (Walkinshaw, 1973) form a similar species-pair. Both occur on floodplains feeding, in particular, on *Eleocharis dulcis* rhizomes. But compared with the Spur-winged Goose and Wattled Crane their niches are reversed: the Magpie Goose feeds in drier areas and breeds in the dry season on wet floodplains, whereas the Brolga Crane feeds in wetter areas and nests in the rains in rainy-season marshes.

Mitchell & Uys (1961) drew attention to an apparent association between lechwe and waterbirds, suggesting that the latter somehow benefitted from lechwe manure. However, for filter-feeding ducks it was clear that trampling by lechwe, and not their manure, formed the basis of the association (Douthwaite, 1977). Thus trampling creates resting sites along the shoreline; breaks up the grass mat which covers shed seeds and other foods; and suppresses the tall, rank perennial grasses in favour of short, heavily seeding annual grasses and herbs. The present species also benefit from the activities of lechwe. Thus at high water levels Red-knobbed Coot and Egyptian Geese are almost entirely restricted to *Panicum repens* grassland, feeding only in areas grazed by lechwe. Knob-billed Geese feed heavily on the ripening fruits of plants which characterize disturbed ground, and neither this species nor the Pigmy Goose would occur so abundantly on the lagoon at Lochinvar if the lechwe did not suppress *Echinochloa stagnina* grassland in favour of aquatic herbs. The Spur-winged Goose is probably the least dependent on lechwe; however, large numbers feed on water-lily rhizomes produced in the lagoon at Lochinvar, and in the dry season grazing geese may prefer pastures grazed by lechwe to ungrazed grassland.

The hydroelectric scheme consists of a dam and power station below the Flats in Kafue Gorge, and a reservoir above the floodplain. Water will be stored at the upper



dam during the rains and gradually released during the dry season. The Flats will therefore experience smaller floods which will subside more slowly than before; as a result the area of floodplain will be reduced but the area of permanent water may increase. The loss of floodplain will probably effect the Spur-winged Goose, Wattled Crane and lechwe (Sayer & Lavieren 1975) adversely and fewer lechwe may have unfavourable consequences for some waterbirds. On the other hand, an increase in the area of permanent water may benefit some species, including the Pigmy Goose and Red-knobbed Coot, if at the same time the new lagoons become vegetated with submerged and floating aquatic herbs. As many permanent lagoons visited in this study lacked significant growths of aquatic herbs such an outcome is by no means certain.

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### Appendix 1. Sectors surveyed by air.

Those overflowed are indicated with an asterisk. Sectors which were dry at the time of the survey are indicated by a 'd'. Random north-south transects were flown in the surveys of October 1971, June and November 1972, and 21-22 August 1973; at other times the flights followed the floodline apart from detours to other potentially important areas.

		Sectors																				Water level at Nyimba (m)	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T		
1970	4 November	Orientation flight																				1.6	
1971	11 February	*							*	*									*	*	*	*	6.2
	9 March	*	*	*	*										*	*							6.5
	27-30 April		*	*	*	*	*	*	*	*	*	*	*		*		*		*	*	*	*	6.9
	14-15 June	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	6.6
	8- 9 July	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	6.3
	11-12 August	*	*	*	d	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	5.6
	8-14 September	*	*	*	d	d			*	*					*	*	*	*	*	*	*	*	4.8
	6-13 October	*			d	d	*	d	d	*	*					*	*	*	*	*	*	*	3.9
1972	24 February	*				*	*	*								*	*	*	*	*	*	*	6.2
	15 March	*							*	*			*						*	*	*	*	6.2
	18 April	*				*		*	*	*					*	*		*	*	*	*	*	6.3
	19-21 June	*	*			*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	6.2
	1- 3 November	*	*		d	d	*	d	d	*	*		*	*	*	*	*	*	*	*	*	*	3.3
1973	10-11 January	*			d	d	d	d	d				d	*	*	*	*	*	*	*	*	*	2.9
	13-14 March	*	*	*	d	d	d	d	d	*	d	*	d	*	*	*	d	*	*	*	*	*	4.4
	8 May	*	*		d	d	d	d	d	d	d		d	*	*	*	d	*	*	*	*	*	4.6
	22 June	*			d	d	d	d	d	d	d		d		*	*	d	*					3.3
	1 August	*	*		d	d	d	d	d	d	d		d			d	d	*	*	*	*	*	3.0
	21-22 August	*	*		d	d	d	d	d	d	d	*	d	*	*	d	d	*	*	*	*	*	2.9

### Appendix 2. Authorities for scientific names used.

*Acroceras macrum* Stapf

*Aeschynomene fluitans* Peter

*Aeschynomene nilotica* Taub.

*Alopothen aegyptiaca* (L.)

*Ambrosia maritima* L.

*Anseranas semipalmata* (Latham)

*Brachiaria xantholeuca* (Hack.) Stapf

*Cyperus esculentus* L.

*Cyperus usitatus* Burch.

*Digitaria ciliaris* (Retz.) Koel

*Digitaria ternata* (Hochst.) Stapf

*Echinochloa colonum* (L.) Link.

*Echinochloa stagnina* (Retz.) Beauv.

*Eleocharis dulcis* (Burm. f.) Trin. ex Herschel

*Eriochloa fatmensis* (Hochst. & Steud.) Clayton

*Fulica cristata* Gmelin

*Grus carunculatus* (Gmelin)

*Grus rubicundus* (Perry)

*Heliotropium baclei* DC. var. *rostratum* Johnst.

*Heliotropium ovalifolium* Forsk.

*Hippopotamus amphibius* Linn.

*Kobus leche kafuensis* Haltenorth

*Najas pectinata* (Parl.) Magnus

*Nettapus auritus* (Boddaert)

*Nymphaea caerulea* Savigny

*Nymphaea capensis* Thunb.

*Nymphoides indica* (L.) Kuntze

*Nymphula plumbifusalis* Hampson

*Panicum coloratum* L.

*Panicum repens* L.

*Panicum subalbidum* Kunth

*Paspalum scrobiculatum* L., Mant.

*Plectropterus gambensis* (L.)

*Polygonum limbatum* Meisn.

*Sacciolepis africana* Hubbard & Snowden

*Sarkidiornis melanotos* (Pennant)

*Sorghum verticilliflorum* (Steud) Stapf var.  
*latiglume* Snowden

*Utricularia inflexa* Forsk. var. *stellaris* (L.f.)  
P. Tayl.

*Vossia cuspidata* (Roxb.) Griff.