Flamingo breeding on the Etosha Pan, South West Africa, during 1971

by

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I. ABSTRACT

The Etosha Pan is at present the only known breeding reservoir of Greater Flamingo *Phoenicopterus ruber* and Lesser Flamingo *Phoeniconaias minor* in Southern Africa. A million or more birds of both species were present between February and September 1971, being attracted to the temporary lagoon formed by above average rains. An unknown number of *P. ruber* nested between February and May, whilst 27,000 of this species were at the nests in May. An unknown number of *P. minor* nested in May-June, occupying the same sites as *P. ruber* when the latter species had stopped breeding. In July-August 54,000 *P. minor* nested. Nesting sites were typically isolated by extensive mudflats but could be reached by land in July, enabling a breeding study of *P. minor* to be undertaken for the first time in Southern Africa. At least 50,000 young of *P. minor* were produced and for the first time the flightless chicks, accompanied by a few adults, were observed trekking up to 80 km across the drying pan to reach water. This ability, coupled with adult feeding of young throughout the fledging period, resulted in 70% fledging success.

II. INTRODUCTION AND HISTORY

Flamingoes have probably been attracted to the Etosha Pan over a period far exceeding the relatively short time during which they have been recorded there (50 years). Only recently was it possible to gain access to all parts of the Pan. Before the acquisition of four-wheel-drive vehicles and light spotter aircraft (which could land on the treacherous surface) the Pan remained an area largely closed to investigation. In 1971 an opportunity arose to study the breeding of flamingoes on the Etosha Pan for the first time because the ideal conditions created by good rains induced tens of thousands of these birds to nest there.

Previous Records of Flamingoes

Mr. J. J. Theron, S.W.A. Administration's Tourism Branch, recalls between 1941 and 1946 stories of flamingoes told by the bushmen living on the fringes of the Etosha Pan. They maintained that whenever the flamingoes bred they built their nests near a large island in the eastern area of the Pan. The island referred to is obviously the one situated 15 km northwest of Okerfontein, the main area in which the flamingoes bred in 1969 (Rocher pers. comm.) and again in 1971 (Fig. 1).

The first reliably recorded evidence that flamingoes breed on Etosha Pan was in 1956 when “a pair, accompanied by young birds, not yet able to fly, was encountered on June 22nd at a permanent spring on the Namutoni road” (Bigalke R. C. in litt.).

The earliest published record of both species of flamingo occurring on the Pan and its neighbourhood is by Sauer and Sauer (1959 a, b; 1960) when they identified Greater Flamingo *Phoenicopterus ruber* L. and Lesser Flamingo *Phoeniconaias minor* Geoffroy during November of the 1957 rainy season.

In August 1959 Rocher found old flamingo nests and one desiccated egg on the Pan and in May 1965 he discovered two flamingo eggs near the mouth of the Oshigambo river (Sauer and Rocher, 1966).

During August-September 1963 Winterbottom (1964) reports unfledged birds of both species on the Pan. As a follow-up to the observations, members of Winterbottom's expedition assisted the Division of Nature Conservation and Tourism in the rescue of about 150 flamingo puli. Rescue was necessitated by the drying of the shallow flood areas which left the chicks stranded in the northern part of the Pan, about 50 km from water. More than 80 of the chicks were taken to the Ekuwa river whilst the remainder were ringed and released near Fischer's Pan (Winterbottom 1964).

In November 1964 Sauer and Rocher (1966) came across more than 100 flamingo eggs scattered in a depression in the southwestern section of the Pan, near Gonob (Fig. 1). The nest mounds had apparently been flattened by heavy rains which drifted the eggs and left them embedded in the clay. They also found “countless bits of eggshells” and came to the conclusion that “it may have been several hundred birds that nested here”. From their measurements of whole eggs they are of the opinion that both species of flamingoes had nested at this spot. Inundation of the area must have resulted in the abandonment of the nests. No evidence exists whether the nesting was successful as flamingoes often lay without completing the hatch (Allen 1956, Brown and Root 1971) and randomly dropped eggs are common amongst flamingoes (Allen ibid.).

In 1968 flamingoes also nested on the Pan to the northwest of Okerfontein and unfledged chicks were observed by aircraft (Theron pers. comm.).

Nesting attempts by flamingoes have therefore been reliably recorded on the Etosha Pan five times in the past 16 years, i.e. 1956, 1963, 1968, 1969 and 1971.

Examination of Namutoni's rainfall records since 1956 (date of first breeding record) showed that every time the flamingoes were recorded nesting the annual rainfall had exceeded 500 mm. During the remaining years the rainfall ranged between 257 - 465 mm with the exception of 1966 when 523.3 mm was measured. It may well be that flamingoes nesting in 1966 but were not observed. Present evidence indicates that when more than 500 mm is recorded, flamingoes are likely to nest on the Etosha Pan.
III. DESCRIPTION OF THE AREA

The Etosha Pan is a flat, saline depression of 6,135 km², at an altitude of 1,100 m. It occupies the central and north-western sectors of Etosha National Park (formerly “Game Reserve No. 2”) at lat. 19°S, long. 16°E. It has a maximum east-west extent of 120 km and is up to 35 km broad.

In Pliocene times the Cunene river flowed into the Oshana (Lake) Ekuma, of which the Etosha Pan is a present day remnant. The river later moved its course northwards to the Ruacana Falls area, cutting off the lake’s water supply. In the drying process the Pan’s sandy-clay soil became brackish and wind erosion deepened the depression. Bounded by porous Kalahari calcrete on the southern shore, the floor is now an impermeable clay (Wellington 1938).

The Pan has never been full of water in living memory, but it is subject to periodic, partial flooding during the rainy season which usually extends from December to April. Direct rainfall accounts for only a small portion of the Pan’s water, the majority being supplied by three rivers: the Ekuma, Oshigamo and Omuramba Ovambo (Fig. 1). The Ekuma and Oshigamo draw their water from the adjacent flood plains of Ovambo, the Bantu homeland to the north of Etosha National Park. Their mouths form deltas in the north-western corner of the Pan, about 15 km apart. The Omuramba Ovambo receives its water from a catchment area to the north-east of Etosha, the main depression flowing into Fischer’s Pan which is a relatively small, eastern extension of the main Pan body.

All three rivers are seasonally dry. Depending on the amount of rain falling they flood the Pan to varying degrees and in dry years may not form running rivers at all. They then merely comprise a series of disconnected pools and the Pan consequently will hold only the direct rainfall (Stark pers. comm.).

During the period of partial flooding the Pan holds large sheets of shallow water, usually not exceeding a metre in depth and in places only a film of water a few centimetres deep will cover large areas. When dry the flood area is a hostile stretch of salt-crusted, cracked, sandy-clay blocks. Vast, loose, sandy plains are encountered in those areas not subject to flooding.

The climate of the Etosha Pan can at best be described as harsh. In the late summer months sudden, heavy thundershowers are interspersed with lengthy periods of hot sunshine. In the rainyless winter the days are warm, with cloudless skies, and the nights cold. Easterly winds prevail and gust at speeds of 30 knots over the surface of the Pan. During the winter months they are extremely dry and evaporate the shallow water rapidly. An annual evaporation of 2,700 mm has been measured (Wellington 1938).

Mean annual rainfall of Etosha National Park is about 430 mm. It varies from 419 mm at Okaukuejo which lies on the western edge of the Pan to 440 mm at Namutoni Fort situated on the eastern edge (Weather Bureau, Windhoek). February is the month with the mean maximum rainfall (110 mm). Rainfall records have been kept from 1901 - 1971 (Okaukuejo) and 1902 - 1971 (Namutoni). Occasionally extreme precipitations occur as was the case in 1950 when a total of 795 mm was recorded at Namutoni and again in 1946 when the same area received only 90 mm.

In the summer of 1970/71 the mean maximum daily temperature at Omibka Gate (Fig. 1) was 32.4°C, and 28.4°C the following winter. Peaks of 38.1°C and 32.0°C respectively were recorded. Mean minimum daily temperatures of 1971 were 17.4°C (summer) and 6.8°C (winter), with 0°C the lowest recorded (Weather Bureau, Windhoek).

IV. THE 1969 FLAMINGO RESCUE

Nietherman and von Schwidt (1969) describe the plight of tens of thousands of flamingo chicks on the Pan when the water surrounding the nesting sites dried up, leaving unfeathered birds stranded. Whilst the parents were forced to abandon the area in search of other feeding grounds the chicks began wandering aimlessly over the dried Pan in search of water.

On June 1, 1969 the first masses of straggling, dying chicks made their appearance near Namutoni Fort and the Nature Conservation Branch of SWA Administration initiated the largest bird rescue operation to date in Southern Africa. During “Operation Flamingo” approximately 20,000 chicks out of an estimated 100,000 were caught by a labour force of 52 men. Fourteen vehicles transported the chicks to Fischer’s Pan which still held water, where they were released.

The mortality incurred during capture and transport was only 3% but tens of thousands met their death by thirst, hunger and large scale predation before they could be rescued (Rocher and Stark pers. comm.). A further 450 carcasses were retrieved from Fischer’s Pan within 1 - 2 weeks after rescue. Post mortem examination of a sample of specimens showed that the majority had died of starvation (Ebedes 1969, in litt.). The total mortality after rescue is unknown as many of the dead and dying would have been taken by scavengers.

There is no record whether the parents subsequently found and fed the transported young although Ebedes (ibid.) records adults in Fischer’s Pan during this period.

V. THE 1971 SEASON

An above average rainy season commenced in October 1970 and ended in April 1971. A total of 514 mm was recorded at Namutoni, the measuring point nearest the flamingo breeding grounds. In
addition to the good rains falling on the Pan the three supplying rivers ran strongly from heavy rains north of Etosha National Park. The Ekuma river was the most important contributor. This resulted in approximately 40 per cent of the Pan's area (2 500 km²) being covered by water at the end of March.

The main body of water, coming from the Ekuma and Oshigambo rivers, swept along a natural slight depression in the Pan which commences at their deltas and runs from west to east along the northern section before swinging south at Poacher’s Point. There the water was supplemented by the Omuramba Ovambo's flow and this succeeded in pushing the headwaters westwards along the Pan's southern side to a point directly opposite the “Etosha look-out road” (Fig. 1).

The net result was a vast, semi-circular, shallow lagoon. It reached its greatest depth at the Ekuma-Oshigambo deltas, probably a metre or more, and gradually shallowed to a few centimetres in the Okerfontein-“Etosha look-out road” area. In length it extended 150 km and was 25 km at its widest point where the three rivers' waters joined in the Leecunes area.

Figure 2. Distribution of flamingo breeding colonies near Okerfontein.
1. **Flamingo Nesting Sites**

The floodwaters attracted huge numbers of both species of flamingoes to the Pan. At one stage (May 1971) it was estimated that there were at least one million and possibly more, feeding on the rich supply of micro-organisms which bloom in the Pan’s special conditions.

The flamingoes chose two areas in which to nest: a single colony 4 km south of Poacher’s Point (Fig. 1) and a second area 8 km offshore westwards of Okerfontein where seven distinct nesting colonies were established over an area of about 5 km² (Fig. 2). About 80—90% of the breeding took place at the Okerfontein site, the remainder being at the Poacher’s Point colony.

The nesting colonies were barely visible from the edge of the Pan at Okerfontein and then only from an elevation of 4 m using 8x binoculars. They could best be seen in the early morning but by 10h00 the mirage effect made visibility poor and in the afternoon the suspended dust raised by the frequent easterly winds usually hid the colonies from sight. From Poacher’s Point which is a peninsula rising steeply above the surrounding Pan the single breeding colony could be seen throughout the day owing to the relative proximity of the nests.

2. **Breeding of Greater Flamingo**

The presence of large numbers of birds prompted the use of a light aircraft for undertaking reconnaissance flights over the Pan. The main purpose of these flights was to ascertain whether breeding was taking place and, if so, to keep a constant watch on the progress made by the young. With the memory of the 1969 flamingo rescue still fresh the Nature Conservation Branch of the SWA Administration required forewarning of any similar condition appearing in 1971.

I did an aerial survey on May 8 after being informed of the existence of large breeding colonies at Okerfontein and Poacher’s Point in April (du Preez pers. comm.).

The aircraft used was a Piper PA 18 with a minimum flying speed of 72 km/h. An altitude of 300 m above the nest colonies was maintained initially so as to lessen the likelihood of the adult birds taking to flight. At this height the breeding birds remained virtually undisturbed and it was possible to assess the numbers present.

Brown and Root (1971) observe that “aerial surveys appeared to disturb the flamingoes very slightly, if at all”. Certainly, when the aircraft flew below 300 m, many brooding birds rose from their nests, but they tended to run first, followed by their chicks. They only flew if the aircraft continued circling. This disturbance appeared short-lived, for when it had passed over the colonies the birds resettled almost immediately.

Using hand tally counters and a counting unit of 1 000 birds it was estimated that at the Okerfontein nesting site a total of about 22 000 adults were present. Since some birds will have been absent from the breeding colonies during the count (i.e. feeding) the number actually breeding is almost certain to have been greater.

The distribution amongst the colonies was:

<table>
<thead>
<tr>
<th>Colony No.</th>
<th>Estimated No. of Adult Birds</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2 500</td>
</tr>
<tr>
<td>2</td>
<td>7 500</td>
</tr>
<tr>
<td>3</td>
<td>5 000</td>
</tr>
<tr>
<td>4</td>
<td>2 500</td>
</tr>
<tr>
<td>5</td>
<td>250</td>
</tr>
<tr>
<td>6</td>
<td>250</td>
</tr>
<tr>
<td>7</td>
<td>4 000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22 000</strong></td>
</tr>
</tbody>
</table>

At Poacher’s Point a single breeding colony estimated at 5 000 adult birds was seen.

From the air and viewed through 8x binoculars all the birds breeding at this date were identified as Greater Flamingo. On subsequently examining enlargements of photographs taken of these breeding colonies the occasional Lesser Flamingo was seen amongst them although it could not be determined whether they were breeding at this time.

Both at Okerfontein and Poacher’s Point large numbers of chicks were seen but no attempt was made to count them because they had not grouped together into masses but were scattered amongst the colonies. Eggs were also observed but no number could be estimated because many adult birds remained sitting on the nest even when the aircraft flew below 300 m.

The survey was continued along the flooded area and from a point opposite Leeuwen vast numbers of feeding flamingoes were found. They were grouped in small and great flocks, extending 100 km to the Ekum-0shigamo deltas. The numbers were so great that it became necessary to use a unit of 10 000 for counting. A total of 1 050 000 adult flamingoes of both species were estimated to be present with *P. ruber* very much in the minority (roughly 5 — 10%).

The breeding colonies, situated where they were, ruled out the possibility of access by land at this stage. A boat would have been impractical because of the shallow water and further flights to check on the drying out of the area surrounding the nests was the only method available.

3. **Breeding of Lesser Flamingo**

The next survey flight could not be undertaken before July 5. It showed that the water around the Okerfontein breeding colonies had dried up noticeably and large patches of mud were appearing in several areas of the Eastern lagoon.
The aircraft landed on one of the driest areas next to Colony 1, a hazardous undertaking.

Inspection of the nests showed nearly all breeding stages present, from freshly laid eggs to mobile young. The water still present was very shallow and in many places only a film of moisture covered large areas which had turned into slushy mudflats. The danger of a repetition of the 1969 situation was evident and preparations were made to commence a rescue operation as soon as the young flamingoes showed distress.

I did a further aerial survey on July 8 and found a radical change at the Okerfontein colonies compared to the survey in May. Firstly, the area was drying out rapidly and the waterline had receded beyond the nests of four of the seven original colonies. These four “dry” colonies showed breeding activity, while no birds remained on nests at the three colonies still partly surrounded by water.

Secondly, only Lesser Flamingo were to be seen at the breeding sites and thirdly, a large mass of young had formed about 2 km to the east of the nesting colonies in an area which still held some water. Smaller bands of chicks were scattered around the nesting areas.

Visual estimates gave a total of 48,000 adult birds present, these being divided amongst the colonies as follows:

<table>
<thead>
<tr>
<th>Colony No.</th>
<th>Estimated No. of Adult Birds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5,000</td>
</tr>
<tr>
<td>2</td>
<td>27,000</td>
</tr>
<tr>
<td>3</td>
<td>10,000</td>
</tr>
<tr>
<td>4</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48,000</strong></td>
</tr>
</tbody>
</table>

The number actually breeding was almost certainly greater since some birds would have been absent during the count.

The largest mass of chicks which had broken away from the nests and formed to one side was estimated to contain 10,000 – 12,000 in number with not more than 80 adults amongst them (Pl. 1). There were at least the same number of chicks as one side in smaller, tightly packed groups which were distributed between the nesting colonies so that altogether as many as 20,000 – 30,000 Lesser Flamingo chicks were present in addition to the birds still incubating eggs.

Continuation of the survey showed that the waterline of the main lagoon had receded some 10 km north-east of the Okerfontein colonies and commenced at a point opposite Leeunes. From here it curved in an unbroken stretch to the Ekuma-Oshigambo delta. The Omuramba Ovambwa held no water and Fischer’s Pan had dried up by mid-June. At Poacher’s Point there were again only Lesser Flamingoes nesting: a single colony estimated at 6,000 adult birds with a grouping of chicks, about 2,000 strong, formed to one side.

a) Access to the Nests

Until July access to the breeding colonies had been limited to aerial surveys. It now became necessary to have a route prepared for vehicles in the event of a rescue.

An amphibious, two-passenger, motor-powered vehicle was made available for this purpose. It had six wheels, all of them driven by the engine, and weighed 200 kg. The tyres were designed for low-pressure driving and could be deflated to 0.1 bar (1.5 psi).

On July 10 an attempt was made to reach the breeding colonies from a point on the southern shore of the Pan near Okerfontein (Fig. 1). At a distance of 6 km into the Pan the mudflats were encountered. They became progressively more slushy until, after a further 400 m, the vehicle became ineffective. Here the clay assumed a consistency of porridge and the vehicle bogged down so that its belly lay on the slush. Further progress on foot was not attempted because of the ever-increasing depth of mud.

The nearest breeding colony was estimated to be 3 km distant and it was decided to find a route around the mud in an attempt to reach the colonies from the northern side. The laying of a route over this type of surface must be attempted with extreme caution as a heavy four-wheel-drive vehicle can become inextricably bogged down.

It was found practical to send the light amphibious vehicle on a series of zig-zagging forays along the edge of the mudflats to test the firmness of the surface.

Thereafter a standard four-wheel-drive vehicle was driven at a speed of at least 50 km/h into the mudflats at an angle to allow for a curving return to solid ground if the mud became impassable.

In this manner a route was laid by crossing firmer mudflats 16 km to the east of the original attempt. It began at the “Etosha look-out road” and led north into the Pan for 8 km before swinging north-east for another 16 km (Fig. 1). It was thus possible to drive by vehicle from the edge of the Pan to Colony 1 in a matter of half an hour.

b) Observations on Breeding of Lesser Flamingo

Detailed observations on the nesting of the Lesser Flamingo commenced on July 11 at 17h00. A camping site was selected 150 m from the nests at the edge of Colony 1. It was the closest distance at which camp could be made without visibly disturbing the birds, apart from the initial reaction they invariably displayed to human presence. From the camp a slow approach by vehicle permitted the observer to come within 20 paces of some brooding birds as they appeared to largely lose their natural fear of man, especially at hatching time.

For most of the following 24 hours the estimated 4,800 adult flamingoes in this colony were kept under close observation. At the same time photographs were taken and sound recordings made.
(i) Voice and Activity

From a distance the noise coming from the colony sounded similar to surf or a waterfall. The birds showed alarm at the arrival of the camping party but soon thereafter the colony came to rest.

At sunset (18h28) there was a general upsurge in noise intensity and activity. Several flights of adults flew off across the mudflats. The activity continued into the evening and at intervals throughout the night flamingoes could be heard calling as they flew overhead. By moonlight these groups were seen to comprise between 40 and 100 birds per flight.

From 23h30 to 01h00 a microphone was laid well into the nesting area by crawling on hands and knees amongst the birds. Disturbance was limited to the nearest birds retreating temporarily. Within a short time the person recording was surrounded by flamingoes returning to their nests. At this close range the noise emanating from the colony was deafening. The high-pitched, two-syllabled “quh-reep” of the chicks could be easily separated from the deeper nasal “gharronk” of the adults. An incessant calling-and-answering between chick and adult appeared to lay the general noise pattern in the colony. It was interspersed by frequent adult bickerings which were a change of tone to several short, nasal “gha-gha-gha’s”, uttered in quick repetition.

Towards sunrise (07h23) there was a heightening of the noise in the colony and several flocks of birds landed, presumably on return from feeding in the lagoon. The “flyways” mainly followed the curve of the mudflats to water and to a lesser extent the birds flew directly over the dry Pan on a shorter link-up route. As the day warmed the colony gradually settled down to a low-intensity calling and reduced activity.

Any sudden movement from observers immediately brought reaction. Brooding birds would rise from their nests and move away from the colony, accompanied by mobile young. Sometimes flocks of several hundred adults would take to wing in fright and circle overhead before resetting themselves.

(ii) Adult Behaviour at Nest

Breeding birds very often, though not always, perform a ritualistic mounting of the nest before settling on the egg. In these instances the bird approaches the nest with a normal, upright walking gait. On reaching the nest the neck is lowered so that the bill is poised over the egg in an "orientation" position. Thereafter one foot is placed on the rim of the nest to take the bird’s weight and the wings are spread wide as a balance. The "free" leg is then extended beyond the tail and vigorously shaken well away from the nest.

Leg positions are exchanged and the shaking repeated. The neck is held low throughout the leg-shaking. Thereafter the bird settles normally on the nest, ruffling its feathers and swaying slightly from side to side to bed itself down firmly over the egg, its legs folded and extending beyond the tail.

Altogether several thousands of this leg-shaking ritual were observed. It was performed equally at colonies where the surface was still slushy and at colonies which were completely dry.

Lumps of wet clay adhering to the parents’ webbed feet, which would otherwise be transferred to the nest cup and accumulated onto the egg-shell, are in this way shaken free. An egg coated with layers of hardened clay would have its porosity affected as well as presenting a physical barrier for the hatching chick. The leg-shaking of the adult therefore certainly appears to have survival value for the embryonic young. Gallet as quoted by Allen (1956) recorded that flamingoes in the Camargue colony, France, shook their feet clear of mud when they mounted the nest. Brown (1957) also mentions a similar behaviour in a breeding colony in Northern Rhodesia.

Adults returning to a nest were often seen to nudge the egg, shifting its position, before settling on it. When hatching occurred parent birds paid increased attention to the egg and adopted an alert attitude, replying frequently to the shrill calls of the emerging chick (Pl. 2). It has been suggested by Brown (in press) that the voice is imprinted on the chick while it is hatching and immediately afterwards. This may enable the chick to recognize its parent by sound alone.

On one occasion a mobile chick was seen squatting on its parent’s back whilst the latter sat on the nest. The chick’s head protruded through the furling wing of the adult.

Defecation by brooding adults was often found to be directed at a particular side of the nest. This was proved by the concentration of droppings which were eventually piled in a strip on the outside surface. Where three or four nests formed a tight group the droppings were mostly accumulated in a single area at a point where the nests adjoined. This indicates that the adult bird may always face in the same direction when incubating the egg or brooding the chick. In the case of grouped nests it will certainly have an advantage if all occupants face outwards from a central point. Their vigilance towards the surrounding area will increase whilst the likelihood of continuous territorial displays towards each other will decrease.

(iii) Alarm, Territorial and Threat Displays by Adults

In a tightly packed nesting colony adult bickerings are frequent but were never seen to develop beyond lunging with the head and neck or an occasional peck. Open fighting in a flamingo breeding colony seemingly never occurs. Nest mounds often adjoin each other and brooding birds can be seen squatting peacefully in very close proximity, their bodies almost touching.
The territory which an adult defends when nesting is limited to the area it can cover from the nest with neck extended. When a flock of adults return from flying they settle on the outskirts of a colony, requiring several paces to run when alighting. Birds from a returning flock then split up and, walking through the colony to their respective nests, often inadvertently pass too close to a brooding bird. The latter will immediately assume a threatening attitude by raising its long scapular feathers in the typical “chrysanthenum” posture, (Ali 1945 cited by Allen 1956 and Uys et al. 1965, Brown and Root 1971). The neck is extended, swaying sideways, and the bill held open in a scything movement. These bickerings are short-lived and after “squaring-up” to each other the intruder will continue on its way.

Avian scavengers such as the Grey-headed Gull Larus cirrocephalus often visit the Etosha Pan flamingo colonies and perch amongst the nests. They are tolerated by the breeding birds but when they venture too close the flamingoes assume a similar threat posture (Pl. 3). No attack by a Lesser Flamingo on a gull was seen and the latter, being a more agile bird, did not allow such a situation to develop.

“Mass alarm” was noticed whenever the colonies were approached and also when aircraft passed low overhead. The “chrysanthenum” posture would be adopted and the majority of birds would rise simultaneously from their nests to walk off and resettte a short while later.

(iv) Age at First Breeding

At the Okerfontein breeding colonies several adult Lesser Flamingos still showed the distinctive grey plumage on head and neck of the young bird (Pl. 3). They were seen sitting on eggs and with chicks. Brown (in litt.) mentions that partly grey, young Lesser Flamingoes have been seen building nests and laying eggs at Lakes Hanngton and Nakuru. The colonies at Lakes Magadi and Natron which produced young were without exception full pink adults.

The Etosha observation gives rise to two possibilities: either the Lesser Flamingo is capable of reproduction the season following its hatching or the adult retains its immature plumage until the second year or longer.

No flamingoes bred on the Etosha Pan during the previous season (1970) but they did in 1969. Therefore the birds under discussion must have bred elsewhere in 1970 and migrated to the Pan for the 1971 breeding if they were in their first year. Alternatively they could be the Etosha chicks from 1969 which had partly retained the immature plumage into the second year.

(v) Colony Size and Nesting Density

After the last breeding birds had left the Okerfontein area it was possible to estimate the number of nests in each colony and to determine the density of nest groupings.

A total count of the nests in Colony 1 was made by dividing the area into blocks with stakes and recording the nests in each block on a hand tally counter. The following totals were obtained:

<table>
<thead>
<tr>
<th>Nests in concentrated area adjoining main group</th>
<th>Nests in main group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 327</td>
<td>5 281</td>
</tr>
<tr>
<td><strong>Total</strong> 7 426</td>
<td></td>
</tr>
</tbody>
</table>

The nests in the remaining large colonies were estimated by counting the number in a 100 m² sample area in the main group of each colony and multiplying by its total area. Outlying nests which invariably surround a group were added. In the small colonies (5 and 6) a total count was made.

The sizes of the Okerfontein colonies were:

<table>
<thead>
<tr>
<th>Colony No.</th>
<th>Total No. of Nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7 426 (actual count)</td>
</tr>
<tr>
<td>2</td>
<td>22 100</td>
</tr>
<tr>
<td>3</td>
<td>12 000</td>
</tr>
<tr>
<td>4</td>
<td>4 200</td>
</tr>
<tr>
<td>5</td>
<td>476 (actual count)</td>
</tr>
<tr>
<td>6</td>
<td>413 (actual count)</td>
</tr>
<tr>
<td>7</td>
<td>8 700</td>
</tr>
<tr>
<td><strong>Total</strong> 55 315</td>
<td></td>
</tr>
</tbody>
</table>

Comparing the number of birds counted from the aircraft when detailed survey began on July 8 (48 000) it can be seen that about 45% of the total number of nests at Okerfontein were occupied at that time. The number of nests in the single colony at Poacher’s Point was later calculated at 4 500 and on July 8 there were 6 000 birds present, giving an occupancy of about 65%.

A total of almost 60 000 nests, made by both species of flamingo, were therefore built on the Etosha Pan during 1971.

Nesting density of Okerfontein Colonies 1 to 4 was determined by counting the nests in five random 100 m² areas in each colony. The results are reflected in Table 1.

A wide range of nesting density occurred within the colonies and between the colonies. It is higher than recent figures from Lake Magadi, Kenya where Brown and Root (1971) recorded a range of 14 - 153 nests per 100 square yds. (average 55). Colonies with this nesting density were termed “grouped” by Brown and Root (op. cit.). On an earlier occasion Brown (1935) found the average density of nests on Lake Hanngton to be 1.4 per square yd. which tallies with the overall average of the Okerfontein colonies.

(vi) Nest Measurements

Colonies 1 and 4 contained two extreme nest structures. The former had small, worn and crumby
structures because it was the first colony to become dry whilst the birds were still breeding. The latter, situated further out in the mudflats, stayed wet for a longer period, allowing the birds to maintain the nests in better condition.

Ten nests, taken at random from each colony, were measured. The data are set out in Table 2.

Table 1. Nesting Density: Okerfontein Colonies.

<table>
<thead>
<tr>
<th>Colony No.</th>
<th>No. of 10m x 10m Samples</th>
<th>No. of Nests in 100 m²</th>
<th>Colony Average</th>
<th>General Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>66</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>40</td>
<td>146</td>
<td>140</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>62</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>118</td>
<td>218</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Nest Measurements at Okerfontein.

<table>
<thead>
<tr>
<th>Colony No.</th>
<th>Mass (kg)</th>
<th>Height (cm)</th>
<th>Base (cm)</th>
<th>Nest Cup (cm)</th>
<th>Angle of sides (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>40</td>
<td>17</td>
<td>26</td>
<td>3.0</td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>42</td>
<td>16</td>
<td>25</td>
<td>3.0</td>
</tr>
<tr>
<td>23</td>
<td>20</td>
<td>43</td>
<td>17</td>
<td>28</td>
<td>3.5</td>
</tr>
<tr>
<td>27</td>
<td>20</td>
<td>47</td>
<td>16</td>
<td>25</td>
<td>3.5</td>
</tr>
<tr>
<td>19</td>
<td>19</td>
<td>35</td>
<td>16</td>
<td>25</td>
<td>4.0</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>40</td>
<td>15</td>
<td>26</td>
<td>3.5</td>
</tr>
<tr>
<td>18</td>
<td>17</td>
<td>38</td>
<td>14</td>
<td>24</td>
<td>2.5</td>
</tr>
<tr>
<td>20</td>
<td>17</td>
<td>39</td>
<td>16</td>
<td>25</td>
<td>3.0</td>
</tr>
<tr>
<td>32</td>
<td>21</td>
<td>50</td>
<td>18</td>
<td>30</td>
<td>2.0</td>
</tr>
<tr>
<td>20</td>
<td>19</td>
<td>42</td>
<td>17</td>
<td>25</td>
<td>3.5</td>
</tr>
<tr>
<td>Average</td>
<td>22</td>
<td>42</td>
<td>17</td>
<td>25</td>
<td>3.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Colony No.</th>
<th>Mass (kg)</th>
<th>Height (cm)</th>
<th>Base (cm)</th>
<th>Nest Cup (cm)</th>
<th>Angle of sides (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>71</td>
<td>40</td>
<td>14</td>
<td>25</td>
<td>3.5</td>
</tr>
<tr>
<td>52</td>
<td>38</td>
<td>40</td>
<td>14</td>
<td>23</td>
<td>2.5</td>
</tr>
<tr>
<td>55</td>
<td>37</td>
<td>54</td>
<td>17</td>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td>85</td>
<td>38</td>
<td>51</td>
<td>17</td>
<td>24</td>
<td>2.5</td>
</tr>
<tr>
<td>55</td>
<td>39</td>
<td>47</td>
<td>17</td>
<td>24</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>38</td>
<td>14</td>
<td>22</td>
<td>3.0</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>38</td>
<td>19</td>
<td>26</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>36</td>
<td>16</td>
<td>25</td>
<td>1.5</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>40</td>
<td>15</td>
<td>25</td>
<td>4.5</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>41</td>
<td>16</td>
<td>25</td>
<td>3.0</td>
</tr>
<tr>
<td>Average</td>
<td>37</td>
<td>44</td>
<td>16</td>
<td>24</td>
<td>3.0</td>
</tr>
</tbody>
</table>

The nests in Colony 4 are 15 kg heavier on average than Colony 1. They are also taller, but the bases, nest cups and angle of sides are virtually the same. It will be noted that the last five nests measured in Colony 4 showed a sharp drop in mass and height. They were built on a “platform” raised 30 – 40 cm above the surrounding pan. The platform was formed by the clay of previous closely grouped nests which were flattened and compacted by the weight of subsequent breeders. (It will be seen from Table 1 that Colony 4 did in fact reflect the highest nesting density.) The platform accounted for 60% of the colony’s area.

Proof of older nests existing in this platform was obtained by digging down to its base. At least six layers of previous nests were found; the levels being distinguished by egg-shell fragments and feathers. A raised platform, created over the years, will have a very real advantage when unusual floods or wind-blown surface waves occur. Allen (1956) refers to a flamingo nest whose vertical section revealed a sequence of six shallow cups, complete with feathers and egg-shells.

(vii) Weather Conditions and Nest Temperatures

At the Okerfontein colonies shade temperatures ranged from 1°C (06h00) to 32°C (15h00) while the relative humidity (whirling hygrometer) dropped from 85% to 23% during this period. The prevailing winds were easterly and started to blow from 09h00 to 14h00 after which it calmed. There were no clouds. Visibility was generally poor due to the fine powdery clay in suspension and at 5 km the breeding colonies were lost to sight. Mirage effect was great: at 3 km an Ostrich on the Pan could be mistaken for another vehicle. Temperatures (°C) measured at the nests and on the surrounding Pan are given in Table 3.

Table 3. Nest and Pan Temperatures.

<table>
<thead>
<tr>
<th>Position</th>
<th>Colony 1 (dry)</th>
<th>Colony 3 (wet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nest cup</td>
<td>Nest cup</td>
</tr>
<tr>
<td>Shade</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>Sun</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>3 cm depth</td>
<td>19.5</td>
<td>21.5</td>
</tr>
<tr>
<td>18 cm depth</td>
<td>14.5</td>
<td>15.0</td>
</tr>
</tbody>
</table>

The nest cup was cooler by 2 – 8°C than the surrounding Pan. This is probably due to two factors. Firstly the cup is raised above the Pan’s surface and receives cooler air and secondly the underlying mound was wet 3 cm below the surface, exposing a greater area to cooling evaporation. Although probably not critical in a late breeding season, already past midwinter, a cooler nest cup will definitely have survival value in the hot summer months (Brown and Root 1971). The survival value of a cooler nest cup is clearly illustrated by Brown and Root (op. cit.) who report a temperature difference of 25°C (25°C – 50°C) between the top
of the nest and nearby mud on Lake Natron. The East African flamingo breeding colonies are apparently exposed to far higher temperatures than those on the Etosha Pan.

(viii) Inundation of Nests
Colonies 5 and 6 each contained between 400 - 500 flamingo nests. This is low in number for a bird usually nesting in large groups. The nests showed inundation by rising waters earlier in the season. They were situated well to the east of the larger colonies in an area which was more under water. It appears that the rising flood had partially integrated the nests, discouraging the birds. Aided by the prevailing easterly winds the eggs had been drifted towards the other colonies. Several hundred added eggs were lying on the surface, partly embedded in the clay. The eastern part of Colony 7 also showed some water erosion.

(ix) Water Analyses: Physical and Chemical
Samples of Pan water were taken on July 14 in an area where the majority of Lesser Flamingoes had gathered to feed. Similarly, water from the Ekuma river was sampled where these birds were present. The sampling was repeated on September 19 when the Pan had almost dried up and the birds were leaving, some resettling in the Ekuma river.

The analyses are given in Table 4.

The earlier sample of Pan water is chemically unfit for consumption by man or animal because of the high amount of total dissolved solids (> 3 000 unacceptible) and the high sulphate and fluoride content (Dept. of Water Affairs — S.W.A. Branch, Report No. C. 8031). Nevertheless, Lesser Flamingoes fed in this area of water in their greatest numbers (c. 1 000 000).

The corresponding sample of Ekuma river water is chemically fit for consumption by man or animal and can be classified as "soft water" (Water Affairs No. C. 8030). Only a few hundred Lesser Flamingoes were present at this part of the river.

The later samples show that the Pan's water contained nearly twice the salt of seawater and precipitation of calcium salts had already begun (Water Affairs No. C. 8283). The water in the Ekuma river had at this stage reached the salinity of seawater and also showed calcium salt precipitations (Water Affairs No. C. 8284). At this time there were still large numbers of Lesser Flamingoes on the Pan (c. 200 000) whilst the Ekuma river and its blind side branches held about 30 000.

Brown (1958) has found that Lesser Flamingoes require a constant source of relatively fresh drinking water, apparently more so than Greter Flamingoes. It is therefore of interest to note that the Ekuma river contained potable water until July but by September no fresh water existed. Yet the Lesser Flamingo was apparently able to subsist on this highly alkaline and salty liquid only. It again underlines this species' ability to exist under conditions which would be intolerable to other animals.

Water Analyses: Hydrobiological
On July 14 separate 0.8 litre samples of water and sediment were taken from an area in the Pan where the greatest number of Lesser Flamingoes had gathered to feed. Ten per cent formalin and 50% alcohol were used separately as preserving fluids. The analyses appear in Table 5.

Cyanophytes (blue-green algae) were dominant in both the water and sediment and were especially plentiful in the former. The dominant genus is Anabaena. The only diatom species observed (sediment) was Navicula halophila (Granov) Cleve and is a brackish water species, recorded on a number of occasions from SWA (Schoeman in litt.).

The East African lakes, Magadi and Elmenteita, also contain amongst other cyanophytes Oscillatoria spp. whilst the stomach content of Lesser Flamingoes collected on Lake Naivasha was rich in Navicula spp. (Ridley et al. 1955).

The water samples were repeated on September 16 when the Pan held mainly slush. Samples of Ekuma river water were also taken then because a movement of birds to the river system was evident. The analyses appear in Table 6.

---

Table 4. Water Analyses of Pan and Ekuma River.

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample</th>
<th>Physical examination</th>
<th>Chemical analysis (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14/7/71</td>
<td>Pan</td>
<td>pH 9.2 Conductivity 26 000</td>
<td>Sodium (as Na) 7.820</td>
</tr>
<tr>
<td></td>
<td>Ekuma</td>
<td>7.6 1 900</td>
<td>Potassium (as K) 111</td>
</tr>
<tr>
<td>19/9/71</td>
<td>Pan</td>
<td>pH 9.2 Conductivity 67 000</td>
<td>Sulphate (as SO₄) 104</td>
</tr>
<tr>
<td></td>
<td>Ekuma</td>
<td>9.4 45 000</td>
<td>Nitrate (as N) 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Silica (as SiO₂) 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fluoride (as F) 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chloride (as Cl⁻) 10 400</td>
</tr>
</tbody>
</table>

---


Table 5. Hydrobiological Analyses of Pan Water and Sediment.

<table>
<thead>
<tr>
<th>Date</th>
<th>Analysis</th>
<th>Sample</th>
<th>Contents</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pan Water</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>Macr</td>
<td></td>
<td>Pan Sediment</td>
<td>Muscid pupa (aquatic?)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small ostracods + shells</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cladoceran ephippia</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chironomid (head only)</td>
<td>1</td>
</tr>
<tr>
<td>14/7/71</td>
<td>Micro</td>
<td>Pan Water</td>
<td>Cyanophytes</td>
<td>plentiful</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>— Anaabaena</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>— Nodularia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>— Oscillatoria</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pan Sediment</td>
<td>Small nematodes</td>
<td>few</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cyanophytes</td>
<td>less plentiful</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>— Anaabaena</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>— Nodularia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>— Oscillatoria</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Navicula halophila</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 6. Hydrobiological Analyses of Pan Slush and River Water.

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample</th>
<th>Contents</th>
<th>Total number of individuals present in 0.8 litre water</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/9/71</td>
<td>Pan slush</td>
<td>Moina sp.</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moina sp. ephippia</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Daphnia sp. ephippia</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ostracoda</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyanophyta Oscillatoria sp.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Daphnia sp. ephippia</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diaptomus sp.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ostracoda (several spp.)</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diptera, Chironomid larval head capsules</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ceratopogonid — Bezzia type larvae</td>
<td>1</td>
</tr>
</tbody>
</table>

It is interesting to note that whilst a film of water still overlies the slush, Lesser Flamingoes will remain. An estimated 200,000 were still on the Pan when it contained about 150 km² of this slush while 30,000 were present along 20 km of river which held open water.

(x) Hatching

At 08h00 on July 12 a hatching egg at the edge of Colony 1 was taken and kept under observation. A roughly circular peck-hole of 10 mm had already been opened and the egg-tooth of the chick was visible. Repeated, high-pitched calls were emitted frequently. At 11h00 the chick had succeeded in breaking open about one third of the shell but by 14h00 had made no further progress and appeared exhausted by its effort.

The chick was then aided by removing the remainder of the egg-shell carefully by hand.

Its hatching position was with feet tucked against the body, neck twisted to the right and head and eyes sheltered between the right wing and the body (Pl. 4).

By 16h00 this chick was sitting upright and the down, hitherto sleeked and damp, had taken on a fluffy appearance. It was marked, returned to the nest and could be found on the following two days when it appeared to be quite healthy. The fact that assistance was required by the hatching chick supports observations on the Greater Flamingo where the parent actively aids the hatching with its bill (Brown and Root 1971).

Another egg showing a peck-hole was marked and left in the nest. It took 24 hours to hatch completely and the chick was healthy when observed a day later. This appears to be an extraordinary length of time for hatching and may have been related to the disturbance which my presence caused to the parents during part of the time. Brown (1958) recorded a similar hatching time for Greater Flamingo although he later mentions that the species may hatch in only three hours (Brown and Root 1971).

A total of 31 nests which formed a group at the edge of Colony 1 were each marked and their positions noted. The contents of these nests were examined daily over a period of three days, after which the mobility of some chicks made further observations unreliable.

From the data the following facts were obtained:

a) Egg length varied 10 mm (75 — 85) and width varied 6 mm (47 — 53). None of the eggs showed noticeable discolouration due to the light colour of the surrounding Pan soil.

b) Weight of newly-hatched chicks (less than 24 hours old) ranged from 73 g to 98 g and was probably influenced by the fact that some had already been fed or had eaten part of their egg-shell. These chicks had an average culmen and tarsal length of 23 mm and 36 mm respectively.

c) Two out of 23 chicks died within 24 hours of hatching and a further 5 were missing from the nest after 72 hours.

d) Of the 21 chicks 9 were light grey and 12 were distinctly darker grey to varying degrees.

e) Four days after the last observations a check showed that a further 3 of the 8 eggs remaining had hatched. When the colony was finally deserted the remaining 5 eggs were opened. Two were infertile (weights of 90 g and 81 g) and 3 contained well-developed embryos. Thus a total of 5 out of 31 eggs failed.
Although the data obtained are indicative of the composition of a nest group within a colony, the human factor must be considered. It caused the adults to leave the nests for considerable periods and especially disturbed the young approaching mobility.

(xii) Chick Development

The natal down of a newly-hatched Lesser Flamingo is one of several shades of grey. The straight bill is not yet hardened and is reddish-pink with the white egg-tooth surrounded by a black-tipped upper mandible. Most striking of all are the legs and feet: they are bright coral red and puffy, giving them a rubbery appearance. This tallies closely with Brown and Root's observations (1971). The author also found distinct shades of grey amongst individuals in first down (Pl. 3). Gradations from the palest grey to a dark charcoal were seen and remained distinguishable until the appearance of the second down which was a darker grey. Brown and Root (1971) found Lesser Flamingo chicks generally to be a darker grey than those of Greater Flamingo in the early stages but that in many individuals the young chicks of the two species were indistinguishable.

Chicks less than 24 hours old were unable to support themselves on their legs. At 48 hours they could stand albeit very shakily and for only short periods. Seventy-two hours after hatching, chicks tried to escape the approach of a human but they tumbled and fell off the nest and only managed a few metres before squatting down again, usually sheltering in one of the hollows adjoining another nest. A chick's strength appeared to increase markedly after the fourth day and it would run away rapidly if approached. By the time chicks were a week old they could move with surprising agility over the hard, cracked surface of the Pan. This age coincided with a hardening of the tarsi which turned a dull black.

These observations on the transition from immobility to mobility by Lesser Flamingo pull run parallel to what Brown and Root (1971) witnessed in the East African breeding colonies.

(leads to the conclusion that they were water-soluble salts, possibly Na and K salts (Easton, in litt.).

The reason for the apparently low particle size totals is because the free lime and organic matter have not been included in the particle size analysis. Thus by adding 6.3% and 8.2% to the totals for the Pan and nest soils, they would read 87.3% and 87.2% respectively. This indicates an organic matter content (including moisture) of about 12.7% (Easton, in litt.).

The soils are almost identical in some respects but differ somewhat in others. The nest soil has a higher phosphate, CaCO₃, and nitrogen content which is probably due to the presence of drop-

Table 7. Mineralogical Analysis by X-ray Diffraction (*A)

<table>
<thead>
<tr>
<th>Soil untreated</th>
<th>Clay fraction (washed)</th>
<th>Minerals possibly present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan soil</td>
<td>Nest soil</td>
<td>Pan clay</td>
</tr>
<tr>
<td>12.8</td>
<td>12.8</td>
<td>12.8</td>
</tr>
<tr>
<td>5.7</td>
<td>5.7</td>
<td>5.7</td>
</tr>
<tr>
<td>4.5</td>
<td>4.5</td>
<td>—</td>
</tr>
<tr>
<td>3.54</td>
<td>3.54</td>
<td>5.45</td>
</tr>
<tr>
<td>3.05</td>
<td>3.05</td>
<td>(2.9)</td>
</tr>
<tr>
<td>a = X-ray diffraction results (degrees Angstrom) of the samples without any pretreatment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b = X-ray diffraction results (*A) of the samples after separating and washing the clay fraction only.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8. General Soil Analysis.

<table>
<thead>
<tr>
<th>Type</th>
<th>Pan Soil</th>
<th>Nest Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>coarse sand (2-0.5 mm)</td>
<td>1.5 %</td>
<td>0.7 %</td>
</tr>
<tr>
<td>medium sand (0.5-0.2 mm)</td>
<td>0 %</td>
<td>0 %</td>
</tr>
<tr>
<td>fine sand (0.2-0.02 mm)</td>
<td>22.3 %</td>
<td>17.9 %</td>
</tr>
<tr>
<td>silt (0.02-0.002 mm)</td>
<td>38.8 %</td>
<td>34.6 %</td>
</tr>
<tr>
<td>clay (&lt;0.002 mm)</td>
<td>18.6 %</td>
<td>25.8 %</td>
</tr>
<tr>
<td>pH (1:1 soil/distilled water)</td>
<td>10.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Resistance (soil paste, 15.5°C)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>6.3 %</td>
<td>8.2 %</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.04%</td>
<td>0.21%</td>
</tr>
<tr>
<td>Moisture</td>
<td>7.75%</td>
<td>7.13%</td>
</tr>
<tr>
<td>Water-soluble cations (me/100 g)</td>
<td>Mg 0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Ca 0.10</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Na 66.71</td>
<td>94.19</td>
</tr>
<tr>
<td></td>
<td>K 1.37</td>
<td>2.77</td>
</tr>
<tr>
<td>Plant-available nutrients (me/100 g)</td>
<td>Mg 0.25</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Ca 15.75</td>
<td>17.25</td>
</tr>
<tr>
<td></td>
<td>K 26.90</td>
<td>46.10</td>
</tr>
<tr>
<td>(ppm)</td>
<td>P 37</td>
<td>420</td>
</tr>
</tbody>
</table>
pings, egg-shells and feathers. The high sodium content of the Pan soil appears to be a feature of flamingoes' breeding lakes (cf. Brown and Root 1971). The sodium and potassium content of the nest soil is greater and could be due to accumulation of salty slush used in nest construction.

The chicks also pecked at and ingested considerable amounts of their egg-shell within the first few days of hatching (Pl. 6). This behaviour seems typical of the species (Allen 1956, Brown 1958). A freshly hatched chick is surrounded by egg remnants. These gradually diminish and by the time the chick vacates the nest very little, if any, egg-shell remains. Egg-shells from adjoining nests are later also taken when, for example, the neighbouring occupant has died. Ingestion of egg-shell by the chick is probably associated with its need for a substantial reserve of calcium because the stubby tarsi and short neck of the young bird must, for survival purposes, rapidly grow out of all proportion to the rest of its body (Prof. L. M. Smith, Orange Coast College, California, by personal communication).

Older chicks, which had been deserted by their parents and raised in captivity at Okaukuejo, fed freely on crooked egg-shells of flamingo and domestic fowl. This habit continued until their bill curved to an extent which precluded pecking from the ground (Berry and van Preez unpublished).

Strong ejection of faeces by the chick occurs and from the time it can stand on the nest the watery excreta is squirited as much as a metre away. This bowel action leaves the nest cup relatively clean.

Chicks pecked one another when they came into contact at the nests but did not inflict injury beyond the loss of some down. Whether this reaction was continued when they later grouped together in tightly concentrated masses could not be determined due to the distance these groups kept from the observer.

(xiii) Stomach Contents

Ten newly hatched chicks, abandoned by their parents, were killed and the contents of their alimentary canals taken for floristic analysis. Similarly, samples were taken from ten mobile chicks (age about one week) (Table 9). The samples were preserved in two separate mediums, alcohol and formalin, final concentrations of 80% and 4% respectively being desirable (Schoeman in litt.).

<table>
<thead>
<tr>
<th>Chick Age</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 24 hours</td>
<td>Algae <em>Naticula halophila</em> 1 copepod egg-shells</td>
</tr>
<tr>
<td>Older than 24 hours</td>
<td>Algae <em>Naticula halophila</em> egg-shells down</td>
</tr>
</tbody>
</table>

The analyses are disappointing as most of the algae had been partially digested and damaged by the action of gastric acids. With regard to sampling procedure it is therefore necessary to slaughter the chicks immediately after a feed. The alimentary canal must then be immediately removed and its contents rinsed with distilled water in order to counteract digestive juices (Schoeman in litt.).

The stomachs of ten chicks, just mobile (3 - 4 days), were found to be hard and packed with egg-shell fragments. Average weight of egg-shells per stomach was 0.8 g (0.1 g - 1.7 g).

(xiv) Rectal Temperatures

Rectal temperatures of ten chicks were taken immediately after death and averaged 40°C (39.2 - 40.4°C). This is somewhat lower than the body temperature of captive young flamingoes in Nassau (42.2 - 43°C, average 42.7°C) (Dr. A. Solys cited by Allen 1956).

(xv) Feeding of Chicks

When a chick is fed by an adult on the nest it lies on its belly or squats on its tarsi. Feeding is preceded by a rhythmical side-to-side swaying of the chick's head and neck which is held upwards and extended slightly forward, the beak open. The chick usually emits loud calling before the feed and during the feed the call softens into a continuous gurgling. The parent gives the food, standing motionless, its head and neck arched below the level of the body. The adult usually faces in the same direction as the chick when feeding it. Occasionally a chick is fed by the parent facing towards it. The parent's bill tip appears to touch the opened lower mandible of its chick and the feed is often temporarily interrupted by the adult which pauses to shake its head at intervals, apparently to get rid of accumulated liquid.

Feedings last 2 - 5 minutes and are seen relatively few times in the day. Those that were seen took place in the late afternoon (17h00 - 18h00) and only two feedings were observed towards midday (11h00). The Etosha breeding colonies were most active at night during which period the adults flew frequently to the feeding grounds. It is therefore likely that the young are fed mainly at night.

Once a chick was observed to repeatedly nuzzle the feathers at the base of the neck of a brooding parent. The adult then rose and commenced to give the food.

After feeding the adult straightens itself, shakes its head and may flap its wings. Very often thereafter it commences preening.

(xvi) Grouping of Young

Chicks older than one week tend to form small bands within the nesting area. As these grow larger they detach themselves from the nests and form
compact, bigger groups some distance away (Brown and Root 1971).

By mid-July a huge mass of unfledged flamingoes had formed about 2 km east of the Okerfontein colonies, drawing its supply of chicks from all four of the breeding colonies simultaneously. This “nursery” had first been observed by aircraft on July 8 and was then estimated to contain 10 000 – 12 000 chicks. It subsequently increased to between 20 000 and 30 000 young.

A sharp division between older and younger chicks in the nursery was apparent. The older chicks had advanced to the stage where their black primary feathers were visible when they exercised their wings, which was often. In height they were about two-thirds the size of an adult and had developed whitish plumage on the scapulars, sides and tail which showed up clearly against the dull grey of the secondary down. Their head and necks however remained totally grey. The younger chicks did not mingle with the feathered puli although together they formed one composite nursery. The effect of the division between feathered and downy chicks was so distinct that when viewed from the ground the nursery resembled a field of tall grass which had been cleanly mowed halfway across its diameter (Pl. 7). The young chicks were about 20 cm in height and adults were mostly seen amongst them during an afternoon of viewing. Only an occasional adult was observed amongst the partly-feathered young.

The two distinct age groups of the chicks in the main nursery support Brown (1955) and Brown and Root (1971) who consider the Lesser Flamingo to be a highly-synchronized breeder. The Etosha nursery indicates that at least two “waves” of breeding (the term is taken from Allen (1956)) by this species occurred on the Pan in 1971 with each synchronized colony occupying and re-using the existing nests.

Approaching the nursery on foot was attempted but at about 500 metres it merely moved off deeper into the mudflats, escorted always by only a few adults. The nursery retreated to mud which became progressively more slushy and it was found that flamingo chicks can run across this quagmire a good deal faster than a human. I had therefore to content myself by studying the nursery at a distance through binoculars. Owing to the distance no feeding of chicks by adults could be observed.

Later that afternoon a small party of adult birds detached themselves from Colony 1 and escorted their progeny across the mudflats towards the nursery which was about 2 km away. Both parents must have accompanied their chicks because there were 12 adults and 6 puli. When a chick lagged behind the group two adults would remain with it and were identified as male and female on the strength of their size alone (Brown and Root 1971).

Chicks rested at intervals during this march, squatting on their tarsi. These breakaway groups would continue slowly on their way until they reached and became absorbed by the main nursery (Pl. 8).

(xvii) Abandoning of the Nests and Hatching Success

Okerfontein Colony 1

At the time of the first close quarter observations (July 11) 4 800 adults were estimated to be present. By July 14 this number had reduced sharply to 2 800 adults. The impression gained was that this colony had almost completed its hatching. On July 18 there were only 168 adults remaining. They were restless and flights of 20 – 30 birds flew up and circled for lengthy periods.

At 12h00 about 90 adults took to wing and did not return, leaving 80 adults at the nests. Fifty chicks, deserted by the flown birds, afterwards started moving in two groups into the Pan. By 17h00 they were still squatting 200 metres away from the edge of the colony and some showed signs of distress. Ten were caught and taken to Halali and Okakuejo for observation.

Two days later (July 20) Colony 1 had been deserted by all adults and the chicks remaining had either succumbed or been taken by avian predators. Fifty-five freshly dead puli were found at the nests together with 152 eggs as yet unbroken by bird scavengers. The hatching success must nevertheless have been high if account is taken of the fact that nine days earlier there were 2 400 breeding pairs present. Egg breakage during incubation can be considerable and has been calculated at 10% – 20% (Brown 1958) while Allen (1956) considers a loss of 20% – 30% of eggs and small chicks quite normal. Hatching success is therefore lower than would seem apparent at first. Thus from the number of unhatched eggs left in Colony 1 (152) and the presence of 2 400 pairs when the colony’s hatching was near its peak, the hatching success would appear to be more than 90%. A figure of between 70 – 80%, taking breakage into account, will be nearer to correct.

Colony 2

On July 12 a first brief visit by vehicle was paid to this colony. It was the largest grouping of nests on the Pan in 1971, with about 25 000 birds present and remained so until July 15. Yet on July 18 not a single adult was seen and inspection showed that they had deserted en masse leaving an estimated 12 000 eggs and about 50 chicks.

The surface around this colony was dry, as at Colony 1 but with only a thin crust which often broke, causing me to sink up to the knees in underlying slush.

No simple explanation can be given for the mass desertion. Only Colony 1 had been used for observation, with five days spent in close proximity to it. Colony 2 was visited once prior to its desertion and then not more than half an hour was spent there. The aircraft had flown over all colonies and human interference could therefore not be a governing factor. The distance and extensive mudflats to the south made access by mammalian predators most unlikely.
It seems likely that the desertion of Colony 1 between July 14 - 20, after peak hatch, influenced Colony 2 which lay 0.8 km away. The synchronized nature of flamingoes' breeding must be taken into account in such a case and the desertion of nests by a colony which has successfully concluded its breeding, such as Colony 1, may well trigger off the same response in an adjoining colony, such as Colony 2, which has still to reach peak hatch. This tendency will be heightened if conditions for breeding are becoming unfavourable, in this case the drying of the nesting area. When a large sample of eggs from Colony 2 was opened it was in fact found that 70% held young and developed embryos with 2% starting to hatch.

The net result was the total failure of Colony 2 during the latter part of the breeding season, although it had probably been occupied by successful breeders earlier in the year. The chicks which were present were taken by predatory birds or died of hunger and exposure. The vast field of abandoned eggs was thereafter gradually reduced by avian scavengers until no whole egg could be found a month later.

Colony 3

On July 23 there were about 9,000 adults with eggs and chicks of varying sizes. Some juvenile birds, already strong fliers, remained attached to this colony. It still held water in its centre due, it was later discovered, to small saline fountains.

By July 27 the colony had decreased to 6,500 adults and eggs were still plentiful.

Only 1,000 adults remained on August 7 and during the observation period small groups of older chicks, accompanied by the parents, broke away and moved off in the direction of the main nursery, which was by now out of sight of the breeding colonies. The remaining birds were markedly apprehensive when approached and groups of 100 and more took readily to flight, circling and resettling nervously at the edge of the nest area. No scavenging or predatory birds were seen.

On August 8 a cautious approach was made. Five hundred adults remained and it was evident that they were on the verge of abandoning, being the last flamingoes breeding at Okonfontein.

The colony held 350 adults a day later and these were restless, with flights constantly rising and settling. A significant occurrence took place at 1700 when a lone adult was observed about 1 km away on the Pan, walking towards the nests. As the bird slowly approached it was seen to be escorting a small chick, apparently back to the colony. A Tawny Eagle Aquila rapax hovered overhead and eventually drove off the parent, which was by now close to the colony, and took the chick. A second Tawny Eagle joined it. This incident added to the colony's restlessness as all birds left their nests, mostly flying off and only 50 remained, milling about in confusion. At 1700 on August 9 these last adults flew off and by that evening it was apparent that they would not return. Closer inspection revealed that the fountains erupting amongst the nests had created a death-trap for young chicks. About 120 young had become caught in thick, foul-smelling black mud and their efforts to free themselves had only embedded them further in the slush. Twenty of the stronger chicks managed to extricate themselves on approach and most of these were taken to Halali for care. The remaining chicks could not be reached and slowly became mired down. They were later shot.

The late season hatching success here was probably higher than Colony 1 (85 eggs left by 4,500 pairs) and could have reached 80%. Because of the treacherous slush not all dead young could be accounted for, having been trampled under the surface by other birds. Nine feathered young, probably near fledging, were found dead in a single clump in the mud.

Colony 4

Between July 8 and 22 the number of adults declined from 6,000 to 3,000. A rapid decrease followed and a day later 1,500 adults remained. This dwindled to 250 on July 24, when hatching had been virtually completed.

No adults remained when the colony was inspected on July 26. Twenty-eight chicks were found in deep, dry hollows created by earlier nest-building. Unable to escape, most of these had succumbed, leaving 8 chicks in a weak state. They were removed for care.

A total of 62 whole eggs, mostly containing developed embryos had been left. Colony 4 therefore had a high hatching success, estimated 80 - 90%.

(xviii) Egg Sampling

One hundred eggs were sampled at random by taking 50 along each of two diagonals crossing Colony 2. These eggs were measured (Figs. 3, 4 and 5).

Similarly, a further 300 eggs were opened and their contents examined (Table 10).

Table 10. Egg Contents of Colony 2 (300 eggs)

<table>
<thead>
<tr>
<th>Stage of Development</th>
<th>Embryonic Phase</th>
<th>Pipped Eggs</th>
<th>Undeveloped Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pregastrula</td>
<td>Differentiation</td>
<td>Late Embryonic</td>
</tr>
<tr>
<td>Number</td>
<td>41</td>
<td>62</td>
<td>149</td>
</tr>
<tr>
<td>Percentage</td>
<td>14</td>
<td>20</td>
<td>50</td>
</tr>
</tbody>
</table>

* Undeveloped Eggs = infertile = decomposed = newly-laid
The marked variation in egg size prompted a search for the smallest and largest eggs which could be found. The smallest had a mass of 22 g, measured 46 x 54 mm and a tiny, undeveloped yolk. The largest had a mass of 123 g, measured 90 x 55 mm and contained a developed embryo. Average size of a sample of eggs collected at Lake Natron was 78.5 x 49.3 mm (Brown and Root 1971). These and the Etosha eggs are both well below the average for *P. minor* of 87.2 x 54.4 given by Allen (1956).

In the course of looking at thousands of nests not one nest cup was seen to hold more than a single egg although often a second egg, usually added, lay near the base of a nest.

(xix) The Trek to Water

It is characteristic of flamingo puli to congregate in the vicinity of the nesting area in large groups (Brown 1955, 1958, Meinerzhagen 1958, Brown and Root 1971). The groups contain mobile chicks of distinctive age classes and these later move several kilometres away from the nests, accompanied by fewer and fewer adults.

Previous reference has been made to the formation of a typical clustering or “nursery” of chicks at the Okerfontein colonies and a proportionately smaller one at the Poacher’s Point colony.

Until July 23 the Okerfontein nursery remained visible from the nesting colonies and was 3 km distant. Thereafter it disappeared from sight and could not be seen even by scanning with binoculars from the vehicle’s roof (4 m). The following day I set out on foot from a point where the vehicle could go no further in the mud, in an attempt to locate the vanished nursery, but no sign of it could be found.

An aerial survey was requested and on July 26 showed a radical change in the nursery’s position and its numbers. It was 8 km from the nests, moving northwards as shown by tracks which were easily distinguishable as broad bands in the soft clay. In size it had decreased to contain 10 000—15 000 young.

Flying towards Poacher’s Point the broad trails of spoor were encountered, leading towards the single flamingo nesting colony which existed there. At the perimeter of these nests a mass of 15 000—20 000 chicks had congregated, far more than the 6 000 birds there could have produced. It was evident that the majority of the Okerfontein nursery had trekked 30 km across the mudflats, following the curve of the receding water-line which by then only just encompassed the Poacher’s Point colony.

Between Poacher’s Point and the Ekuma peninsula no sign of chicks was found and areas of mudflats were already exposed. At this stage it appeared as though the majority of young would become stranded at Poacher’s Point because of the shallow lagoons on the Pan disappear with astonishing rapidity in the dry months.
Envisaging that a rescue of the chicks still remaining near Okerfontein was imminent, it was decided to lay a provisional rescue route from there diagonally across the Pan to a point near the mouth of the Ekuma river. Here water would be available well after the rest of the Pan had dried.

The projected route was first flown over by aircraft to obtain a compass bearing to be followed on the ground. Apart from the twin dolomite hills at Halali no other objects can be used as landmarks when driving across the flat expanses of Etosha Pan.

On the 7th of August four-wheel-drive vehicles, equipped with a two-way radio, left the Okerfontein colonies on a 310° compass bearing (NW). The Pan’s surface, although appearing completely smooth from its edge, becomes very uneven with ribbed ridges of wind-blown sand, making it difficult to maintain a straight course. Hardened salt eruptions appear at intervals along the way. After 50 km all land is lost to sight when the Halali hills disappear in the haze.

Abandoned ostrich eggs were seen occasionally, some lying 20 km from the Pan’s edge. A single, adding flamingo egg was found 15 km north of Gobob.

The distance from the Okerfontein nests to the Ekuma mouth totalled 90 km and took 1½ hours non-stop driving. A subsequent aerial survey showed that the tracks followed a semi-circular curve, and that a bearing of 270° (W) had been inadvertently followed due to a tendency to favour a course too far south.

The problem of access by land vehicle to the Okerfontein nursery remained however, due to at least 5 km of wet clay separating the chicks from the nearest dry ground.

In order to maintain a constant check on the condition of the chicks a helicopter survey was undertaken on August 6. It confirmed the nursery sightings made on July 26 and also reported unfledged flamingo chicks between Poacher’s Point and the Ekuma peninsula (Ebedes pers. comm.).

This was verified by the author on August 9, when another aerial survey proved beyond doubt that a long-distance trek was being successfully undertaken by the chicks. Fewer than 1000 remained near Okerfontein and these were 15 km north of the nests. All appeared to be in strong condition. At Poacher’s Point the number of unfledged young had also decreased, from over 15 000 to 4 000 and the nesting area had been occupied by White Pelicans Pelecanus onocrotalus.

Examples of the chicks’ movement was provided between here and the Ekuma peninsula: a compact group of 500 young were found moving away, 5 km west of the Poacher’s Point nests. On approach about 150 scattered, half running, half flying in the direction of the water which was at least 40 km distant. The rest, unable to fly, followed running. A second group of 250 unfledged and 200 parry fledged young was encountered 8 km before the start of the water which by now extended east of the Ekuma peninsula for only 20 km. They too reacted to the aircraft’s presence by making directly for the water.

The sighting of four separate nurseries containing in all more than 20 000 chicks at the edge of the water confirmed that unfledged young of Lesser Flamingo are capable of walking a total distance of 80 km to escape unfavourable conditions. During the 1969 flamingo rescue some unfledged young reached the waters of Fischer’s Pan by walking 25 km (Nature Conservation report 1969).

A day later another flight was made. Six small groups of chicks (less than 100 each) were seen between Poacher’s Point and Ekuma peninsula. All were marching westward to the water (du Preez pers. comm.).

Poacher’s Point, usually attainable overland, affords a good elevation from where to watch the flamingoes at a distance. At 15h00 on August 19 a group of chicks detached from the sedentary nursery there and moved slowly to the west.

Approach to the nests was limited by a narrow ring of water similar to Colony 3 at Okerfontein. No active fountain was found but the nesting area is slightly elevated above the Pan, suggesting either an area compounded by previous nest building or a hardened salt eruption. Smooth, rounded, small stones are plentiful in this elevated area.

The next day I undertook an aerial survey with Mr. de la Bat, Director of Nature Conservation, SWA, along the entire area between Okerfontein, Poacher’s Point and Ekuma. Fewer than 100 young of the original Okerfontein nursery remained and they were near Poacher’s Point. The latter area held 1500 unfledged young and three groups of 20–50 chicks were found moving 12, 20 and 40 km respectively west of Poacher’s Point towards the water. All groups which had completed the trek to water were again massed together and now formed two nurseries totalling an estimated 25 000 chicks. These later merged into a single nursery.

A flight on September 14 showed that the trek had been successfully completed. No living chicks remained between Okerfontein and Ekuma peninsula. The surface was sufficiently dry to permit a landing at the Poacher’s Point nests where only a few hundred carcasses could be found in the area previously occupied by the migrating young.

A continual fledging of young from the nursery at Ekuma peninsula was observed during many subsequent visits by land. By September 20 there remained only a small percentage which could not fly well (2 000 out of 25 000-plus). The Pan was virtually dry and the Ekuma delta’s lagoon on the adjacent side of the peninsula held the last remaining water.

The breeding season was considered complete on October 17 when no unfledged flamingoes could be found at the Ekuma delta.
The total mortality of Lesser Flamingo chicks between hatching and fledging is difficult to estimate as the breeding colonies could only be reached by land when hatching was well advanced. When the nesting areas became accessible there was no evidence of unusual mortality amongst chicks. During the remainder of the breeding season which included the 80 km trek undertaken by the chicks, no mass mortality was observed, although numbers of weaker chicks must have succumbed en route to the water. Before trekking started the original nursery at Okerfontein was estimated to contain 50 000 unfledged birds. When this nursery had moved to the Ekuma delta area it contained about 25 000. Therefore 5 000 unfledged chicks could have perished but this figure will be reduced when account is taken of the fact that a number of young will have fledged during the trekking period (about 30 days). I am of the opinion that no more than 3 000 out of 50 000 chicks died during the nursery period.

It can be assumed that the normal mortality of small chicks (i.e. at the nests) is in the region of 20% (Allen 1956). Add to this a further probable 10% mortality during the nursery period. The fledging success of the Lesser Flamingo on the Etosha Pan during 1971 can thus be estimated at about 70%.

VI. GENERAL DISCUSSION

1. Parental Feeding of Young

A few adults which perform the function of “nursenmaid” (Brown 1958) are always in the sedentary nurseries as well as in the trekking groups of chicks. As most of the observations on movement of young were done by aircraft it was not possible to witness adults feeding chicks.

If adult birds feed the chicks throughout their development and whilst the young are massed in a more or less stationary nursery (Brown and Root 1971) there is no reason why this should not occur when the chicks are trekking. It is more likely that feeds are delivered by adults than the possibility that the young can walk a great distance to water without nourishment. They certainly could not have fed themselves at such an early age and even had they been able to, no water existed en route.

Whether each parental pair attended only to its own chick during the sedentary nursery period at Okerfontein, the trek and finally the second sedentary nursery period at Ekuma is a moot point. At the nest chicks are attended by their parents (Brown and Root 1971) and this is substantiated by observations in Etosha during 1971.

2. Moulting to Flightlessness

The phenomenon of nuptial moulting in Lesser Flamingoes has been observed during at least four seasons at Lake Natron, East Africa (Brown and Root 1971) whilst observers of Greater Flamingo breeding colonies have not found it (e.g. Uys et al 1963).

I found about 6 000 adult Lesser Flamingoes in a flightless condition near the Ekuma delta on August 9. All nesting had ceased at this date. The inability of these birds to become airborne was noticed during a routine survey. At 150 m altitude all other flamingoes along the route flew off at the aircraft’s approach and a flock remaining on the ground was conspicuous. To test the sighting further a low sweep was made over them but they could only scatter by running with wings outstretched and flapping. They were unable to fly and gaps could be seen in the black primary and secondary flight feathers, giving the wings a scraggly appearance.

3. Migration

Both species of flamingoes frequent the SWA coastal lagoons, particularly Walvis Bay and Sandwich Harbour. They do so regularly during the last half of the year when Etosha Pan is dry and leave again, flying a northbound course when the rains start (Guerdes 1971 and personal observation).

At Walvis Bay lagoon they seem to vary around 15 000 to 20 000 individuals with occasional high influxes occurring. A peak of 40 000 individuals of both species was present on October 20, probably due to the successful season on the Etosha Pan. At Sandwich Harbour lagoon I have observed a maximum number of 5 000 of both species, also in October. P. ruber is usually in the majority.

Reports of flamingoes throughout Southern Africa are numerous and the first record of successful mass breeding by P. ruber was recorded in 1960 (Uys et al., 1965). None of the literature indicates flamingo numbers approaching the size of the Walvis Bay flocks, although Maclean (1960) reported seeing P. ruber in “huge flocks at the Orange River mouth”. During a recent survey of estuaries and lagoons of the South African coastline the largest gathering of flamingoes (c. 20 000) was seen at Walvis Bay (Dr. J. R. Grindley, Director of Port Elizabeth Museum and Oceanarium, by personal communication).

The developed nature of Southern Africa leaves no area, except Botswana, where large numbers of flamingoes would not soon become known and it must be concluded on present information that only a small percentage of Etosha’s flamingoes migrate south of the Pan. If the combined number of flamingoes in South and South West Africa (Etosha apart) is taken at between 50 000 and 100 000 it is only 5—10% of the numbers present on Etosha in 1971.

Migration between Etosha, Lake Ngami and the Makarikari pans seems likely (Fig. 6). These are the areas in Southern Africa where massing of flamingoes on the scale of a million or more takes place. Migration between South-western and East Africa possibly exists although Brown (in litt.) feels that the absence of records between these areas indicates separate populations.
4. Ringing

Two separate ringing operations on flamingoes have been undertaken in Etosha National Park. In 1963 some 60 rescued young were ringed (Winterbottom 1964) and during the massive 1969 rescue operation 1500 near-fledged birds of both species were ringed (Ebedes and Dixon pers. comm.).

Two birds have to date been recovered, both from the 1969 ringing. One dead bird was recovered in Walvis Bay lagoon on 27/vi/69 having flown 530 km to the south-west of Etosha within 15 days. A second bird was found dying near Môwe Bay, West Coast one month after ringing and had covered 450 km (S. A. Ornithological Society communications, 1969), (refer Fig. 6).

Figure 6. Main probable migration routes of flamingoes from Etosha Pan.
Ringing of flamingo pulli in Etosha has been made possible by rescue operations and this was also the case at Lake Magadi, East Africa (Brown and Root 1971). Large scale ringing may solve some of the mystery still surrounding these birds but apart from the opportunity afforded by a rescue it will be very difficult to reach healthy young flamingoes on foot. It will also be advisable to create the disturbance at the breeding grounds which such activity will cause.

5. Predators and Scavengers

Few predatory animals venture far into the Pan but the flamingoes are unable to escape the attention of predatory and scavenging birds. Loss caused by these however was minimal as their numbers were small.

The predators, in order of importance were:

- Tawny Eagle Aquila rapax. The regular presence of only two birds during the observation period at Okerfontein made it likely that a single pair was frequenting the colonies. They probably caused more damage by the apprehension their presence created amongst the breeding colonies (an example has been mentioned) than by the few chicks they took. No adults were seen to be killed by them.

- Grey-headed Gulls Larus cirrocephalus. These were occasionally seen to peck a newly-hatched chick to death when human presence caused an adult to leave the nest. They were the most numerous predators and about 30 were at times seen at a colony. There were always a few present until mid-August.

- Pied and Black Crows Corvus alba and C. corvus. Not more than a pair of each species was seen at once and they were irregular visitors. They killed small chicks at the perimeters of the colonies but did not venture in amongst the breeding birds.

- Bataleur Eagle Terathopius ecaudatus. A pair was observed once, circling above the Poacher's Point colony but were never seen alighting on the Pan.

The only scavengers present were:

- Lappet-faced Vulture Torgos tracheliotus. Eight vultures were the most seen together at the nests. No other vulture species was found near the flamingoes. They played a passive role, sitting about 200 m from the edge of the colonies. Occasionally they would fly closer to scavenge a corpse. They were not seen to take a healthy bird although they have been recorded killing chicks at Lake Magadi (Brown and Root 1971).

Once three vultures were found amongst the nests and the nearest flamingoes had merely moved 10 m away. The rest of the colony appeared undisturbed by the vultures' proximity.

A group of trecking chicks often had one or two vultures in attendance and sickly or weak young were probably taken as soon as they dropped out of the march.

- Grey-headed Gulls and crows. Because the availability of dead chicks always exceeded the demand by scavengers, the gulls and crows were disinclined to eat anything more than the soft viscera of freshly dead chicks. The carcasses which lay untouched soon desiccated and mummified on the salty surface of the Pan. Their scavenging abilities were emphasized at Colony 2 where 12 000 eggs lay abandoned. They relinquished the carcasses in other colonies and concentrated on the eggs, leaving not one whole within a month.

6. Allied Breeding Species

Bird species sharing the hostile conditions of the Etosha Pan with the flamingoes undoubtedly do so because its isolation affords them protection.

Ostrich Struthio camelus. Along the route to the Okerfontein colonies a cock and his retinue, presumably three hens, was observed from time to time. They later began nesting about 2 km from the track and 10 km from the Pan's edge, on dry ground. Their nest was visited briefly to avoid disturbance and 24 eggs were present. The male was mostly seen incubating during the day. Several other incubating cocks were seen offshore from Gonub when doing aerial surveys. Their nests were about the same distance into the Pan.

White Pelicans Pelecanus onocrotalus were the most closely allied breeding species. At Poacher's Point hundreds of pelicans appeared at the flamingo nests during the Lesser Flamingo's breeding cycle. Their numbers later grew to more than 2 500 breeding pairs and it is possible that they may have terminated the flamingo’s occupancy of the nests (Brown, in press; Berry, Madoqua to be published).

- Grey-headed Gulls, Grey Heron Ardea cinerea, Sacred Ibis Threskiornis aethiopicus, Glossy Ibis Plegadis falcinellus and Spoonbill Platalea alba. These five species nested together in the Pan, on a small island at the edge of Okerfontein, well apart from the flamingo colonies.

7. Human Disturbance

It cannot be overemphasized that human interference at flamingo breeding colonies must be restricted to as few persons as the collecting of essential data will allow.

Sightseeing parties seeking sensational photographs of flying birds cannot be condoned as they will invariably cause severe disturbance to breeding birds. This is valid throughout the breeding cycle but especially so with late breeders who become very apprehensive at the sight of intruders and may desert hatching eggs and young en masse.

My study periods at the Okerfontein colonies were responsible for a percentage of mortality to unhatched eggs and immobile chicks. Fortunately this was small. Studies should be carried out quietly, taking the utmost care to move slowly.
Aircraft over the breeding colonies must be strictly limited to essential surveys, for although disturbance is temporary, it unsettles the birds. Allen (1956) includes low-flying aircraft in the types of human disturbance most likely to cause a flamingo breeding colony to desert its nests completely. In his words “the result is stark terror”. Various civil aviation authorities in North and Central America have prohibited flying at an altitude below 2 000 ft over flamingo colonies (Allen ibid.). The Etosha Pan forms part of a proclaimed game reserve and the breeding and feeding places of the flamingo should be sacrosanct.

8. Insecticides in Eggs

Lake Nakuru in Kenya forms one of the key points in the ecology of the East African flamingoes. Recently, due to pollution of the lake by the inhabitants and industry of Nakuru town, the flamingo’s position has become jeopardised (Thomason 1971). A similar parallel can be drawn in the case of the Etosha flamingoes due to the threat of pollution from Ovambvo.

The Etosha Pan’s water comes largely from the drainage supplied by rivers originating from that territory.

Since 1965 health officials have conducted an anti-malarial spraying campaign in Ovambvo, using chlorinated hydrocarbon insecticide. A yearly amount of 120 000 kg of 5% DDT is now applied as an indoor spray to the upper walls of tribal huts (Health Services communication 1971).

To monitor the possible build-up of insecticide in the food chain, eggs of the Lesser flamingo were sampled at the Okerfontein nests in 1971 and submitted for analysis.

The results indicate that in relation to world standards extremely low quantities of insecticide residues are present, but that there are nevertheless at least three different insecticides and their metabolites already present in the eggs. They are DDT (<0.013 ppm), TDE (0.097 ppm), DDE (0.19 ppm), diephrin (<0.03 ppm), Α-BHC (<0.01 ppm), Β-BHC (0.01 ppm), Y-BHC (<0.01 ppm) (Gibbs and Plieaar, unpublished results).

It is not known at what level insecticides will become hazardous to the flamingo or its ability to reproduce successfully. Eggs will have to be monitored in future breeding seasons.

VII. CONCLUSIONS

The Etosha Pan is presently the only known, regularly used mass breeding ground of flamingoes in Southern Africa. It experiences periodically favourable conditions for flamingo breeding. Both Phoenicopterus ruber and Phoeniconaias minor have been reliably recorded there since 1957 and unfledged young were observed in 1956. On two subsequent occasions abandoned puli were rescued on the drying Pan.

In 1971 ideal conditions attracted more than a million of both species of flamingo to the Pan where at least 10% bred. P. ruber initiated the breeding and estimates give 27 000 birds breeding in May. The total number of P. ruber present could not be assessed because both species intermingled at the feeding grounds. However they were far fewer in number than P. minor and were roughly estimated at 50 000 — 100 000. A total of 54 000 P. minor were seen breeding in July and August. Thus the total number of flamingoes known to have bred was 81 000.

If the number of nests present (c. 60 000) is an indicator then it means that a further 40 000 flamingoes could have bred. It must however be remembered that nest building does not always result in egg-laying (Brown and Root 1971).

Chicks hatched from April until August and, judging from later observations on fledged young, P. ruber hatched its chicks until mid-May. Similar observations on P. minor indicate that their chicks hatched between the end of May and August 9, the latter being an exact date.

The greatest loss was the desertion of 12 000 eggs by P. minor in one of five colonies.

There are some imponderable figures (number of eggs laid, number of eggs broken during incubation) which preclude accurate estimations on the breeding success of P. minor. However, I have set out the figures available so as to give some idea of the results of P. minor’s breeding from the time when close range observations became possible in July until the end of the 1971 season. (Breeding success by both P. minor and P. ruber prior to this was not recorded).

Breeding success of P. minor:

| No. of birds present | . . . . . | 1 000 000 |
| No. of birds at nests | . . . . . | 54 000 |
| Percentage breeding | . . . . . | 5 — 6 |
| No. of eggs | . . . . . | ? |
| No. of chicks hatched | . . . . . | 30 000 |
| Probable percentage hatching success | . . . . . | 50 — 60 |
| No. of chicks reared | . . . . . | 22 000 |
| Percentage chicks fledged from hatching | . . . . . | 70 |

* percentage calculated from number of eggs deserted at four out of five breeding colonies minus an assumed egg breakage of 10-20% during incubation.

After reaching a peak of more than one million in May the number of flamingoes declined gradually to 200 000 (including juveniles) by September and all birds had left the main Pan by mid-October, partly resettling in the Ekuma river system.

The reasons for the apparently exceptional breeding success in 1971 are:

(i) good rains which converted a large area of the Pan into a temporary lagoon,
Tourist Officers N. L. Kroon and W. F. Bezuidenhout of Halali restcamp who were prepared to spend their off-duty hours assisting me at the Okervfontein breeding colonies. Mr. Kroon and his wife also cared for abandoned chicks.

Mr G. Kahan of Lüderitz for kindly making available the amphibious vehicle which was most useful in laying a route across the mudflats to the breeding colonies.

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SNEYD TAYLOR, J. 1957 Notes on the birds of inland waters in the Eastern Cape Province with special reference to the Karoo. Ostrich XXVIII, No. 1.


Plate 1. An aerial view of the main nursery of Lesser Flamingo chicks on July 8.

Plate 2. At the time of hatching the parent birds' attention to the egg increases. The peck-hole in the egg-shell can be seen.
Plate 5. An intruding Grey-headed Gull arouses a threat display from a brooding Lesser Flamingo which adopts the typical "chrysanthemum" posture. The flamingo still shows immature plumage on its head and neck.

Plate 4. The hatching of a Lesser Flamingo may take up to 24 hours.
Plate 5. Two newly-hatched Lesser Flamingoes from adjoining nests. Although they are almost identical in age, their natal down is markedly different in its shade of grey.

Plate 6. A newly-hatched Lesser Flamingo, still immobile, eats its egg-shell vigorously.
Plate 7. In the nursery there was a sharp division between downy young (with adults) and partly-feathered young.

Plate 8. When chicks become sufficiently mobile the parents escort them from the nests to join the main nursery.