DEVELOPMENT AND BEHAVIOUR OF A YELLOW-BILLED HORNBILL (Lophoceros flavirostris leucomelas) CHICK

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INTRODUCTION

The nest from which the chick under discussion was obtained, was found in the trunk of a dead tree with a diameter of approximately half a metre. The nest was about two metres above the ground. The nest was made in a natural cavity about 60 cms long and having an average diameter of 20 cms. A third of the cavity was filled with nesting material consisting of dry leaves, snail shells, hornbill tail and wing feathers, insect remains and moist decayed material having the consistency of humus.

The hole through which the bird had originally entered the cavity was situated in the middle of the cavity. It was roughly elliptical, having a major axis of 15 cms and a minor axis of 5 cms. This opening had been plastered up leaving a narrow slit of approximately 5 cms by 8 mms, through which the male fed the imprisoned female and chicks. The plaster consisted entirely of the birds' excrement mixed with vegetable material. No mud had been used in this case.

This nest was opened on the 23rd. December 1962. It contained the imprisoned female, two chicks, one of them newly hatched, and a pipped egg. The female had undergone an induced moult of all the flight and tail feathers. The body feathers on the other hand did not show an excessive moult. She had lost all the claws of one foot and two of the other. *PLATE I, (1).* It is a known fact that claws grow again after having been removed. Does this not perhaps indicate that while imprisoned with the young chicks she sheds the claws in order not to injure them in the dark nest cavity? More information is needed to explain this phenomenon.

The larger of the two chicks was already able to take food. The abdomens of small grasshoppers were greedily taken when the bill was touched. I kept it alive during the night of the 23rd by placing it in cotton wool and keeping it in my cupped hands against my body. The day temperature of the 24th was high enough to keep the chick comfortable in a small cardboard box during the 200-mile journey back to Pretoria. It was fed occasionally

PLATE I

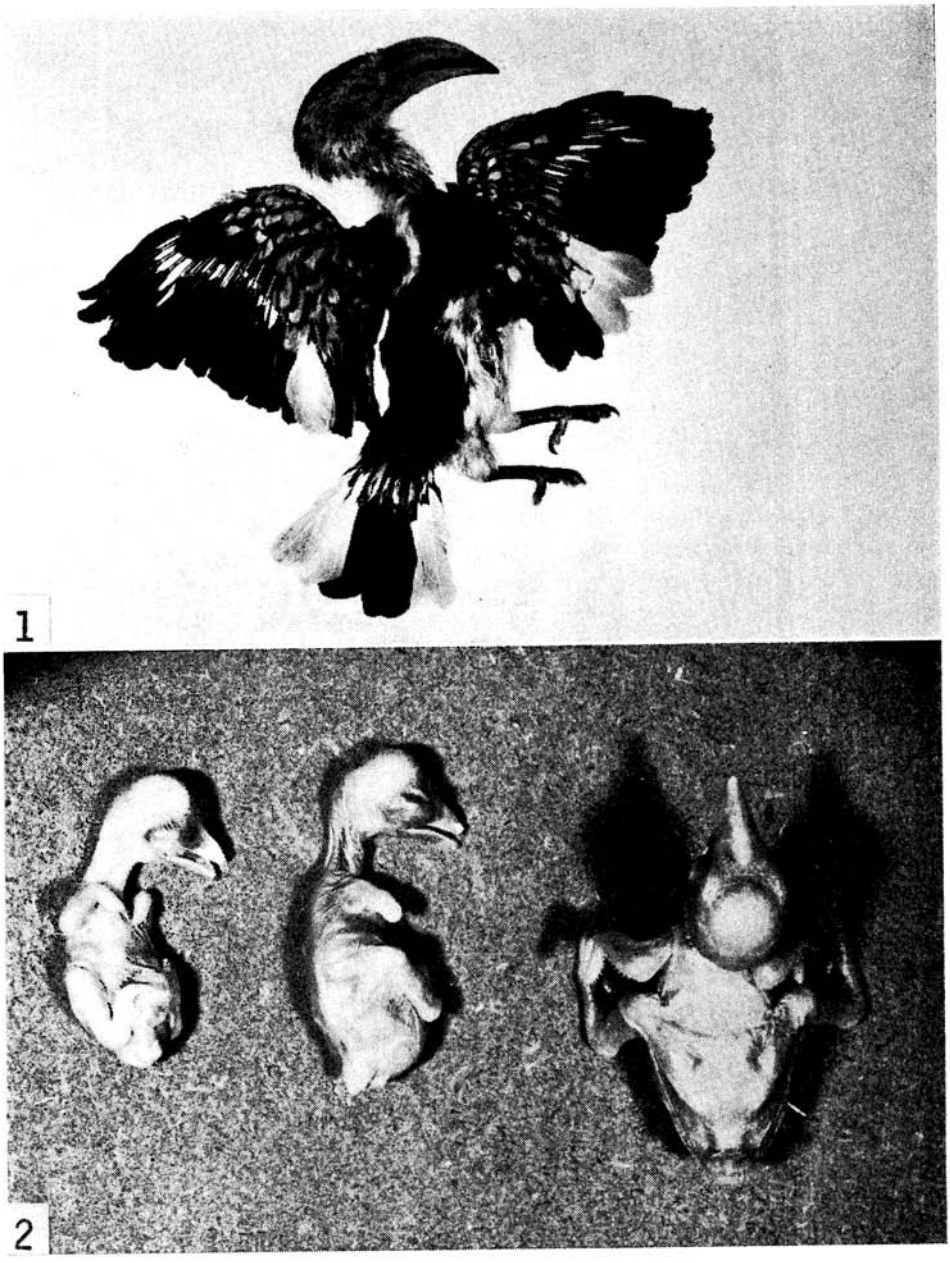


Plate I.

1. Adult female showing similar development of flight and tail feathers after induced moult and also the clawless toes.
2. (Left to right). Embryo from pipped egg; newly hatched chick; surviving chick aged five days on 25 Dec.

en route. From the evening of the 24th of December until the 11th of January an electric heating pad was wrapped round the artificial cardboard nest. It was kept switched on for most of the time. Between the 11th and the 27th of January it was switched on at night only. After that it was discarded.

The chick was kept until the 9th of February when it was taken to the National Zoological Gardens. Constant observations were made during the entire period of over 40 days. It was weighed every morning and the length of the bill, the tarsus and the radius-ulna measured. These findings will be discussed under two main headings: Development and Behaviour.

A. DEVELOPMENT

(a) *Increase in body weight.*

The increase in body weight is represented by Graph I. The weight of the chick on the 24th was 26 gms. The weight of the chick in the pipped egg was 10 gms. Assuming that the weight of the chick increased at approximately the same rate before the 24th as after that date, it can be deduced from the graph that the chick was three days old when it was obtained. (See point A on Graph I.)

During the first fourteen days the body weight increased from 26 to 126 gms, giving an average increase of 7.1 gms per day. The period indicating a loss of weight and denoted by B on Graph I will be discussed under innate behaviour. From the seventeenth to the thirty-fourth day the weight increased fairly constantly, except at point C on Graph I. The chick as a rule brought up a pellet during the night. No pellet was found on the morning of the eighteenth day, but two were found on the next morning. The abnormal increase on the eighteenth day was due to the weight of the unregurgitated pellet. The total increase in weight for this period was 53 gms, giving an average of 3.1 gms per day.

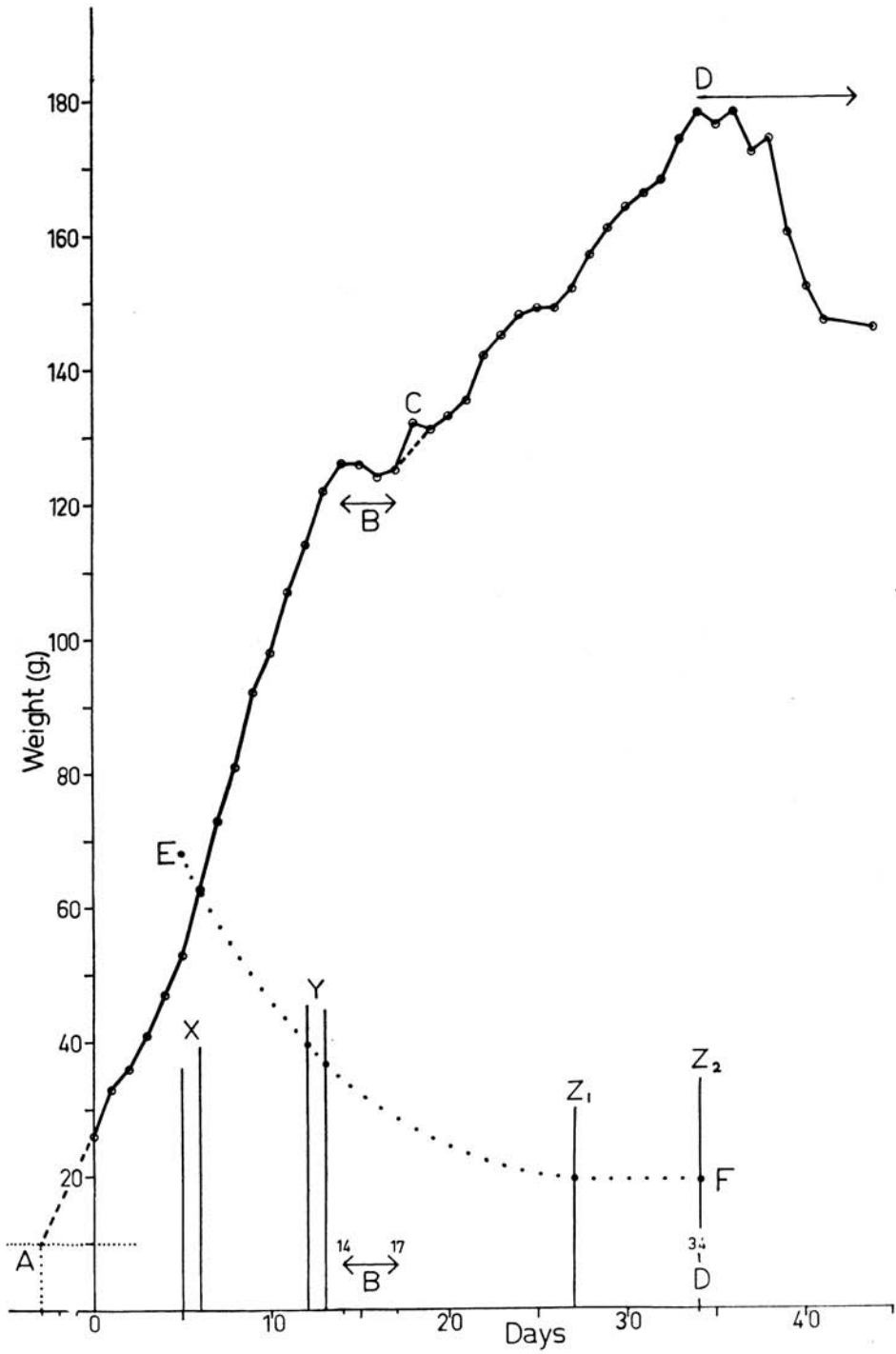
The reason for this decrease in the rate of change of the body weight is twofold:

(1) The chick was much more active since it was plastering up the hole again. (See behaviour.)

(2) The tarsus stopped growing on the twenty-fourth day. (See Graph II).

It can be assumed that the legs, pelvis girdle and the greater part of the skeleton, except the wings, (See Graph II) were about fully developed at that stage. The size of the body probably did not increase very much after that.

From the thirty-fifth observation, point D on Graph I, there was a remarkable decrease in body weight. This phenomenon has also been observed in pelicans, owls, kingfishers, swallows etc., at the stage just before fledglings begin to fly. The chick was very active during this period and showed little interest in its food.


Weight (g)
180
160
140
120
100
80
60
40
20
A
B
C
D
E
X
Y
Z1
Z2
F
14
17
B
34
D
0
10
20
30
40
Days

GRAPH I

The maximum weight attained by the chick was 178 gms and when weighing terminated 146 gms. The average weight of 25 adult female Yellow-billed Hornbills was found to be 172.3 gms and the average weight of 5 sub-adult females which had just started flying was 154.5 gms, the lightest one weighing only 137 gms.

(b) *Food and Pellets.*

The chick was fed on insects, mainly locusts, grasshoppers, crickets, mealworms, beetles and their larvae, cockroaches, millipedes, centipedes, scorpions, lizards, small snakes, termites and spiders. Fruit was given on a few occasions, but was taken reluctantly. Earthworms were rejected and thrown viciously out of the nest. When no insects were available small pieces of lean raw meat were given. Once a week the chick was given a "Multitive" tablet. During the first 2 weeks I broke off the hind legs of the locusts since the small chick experienced difficulty in swallowing the whole insect.

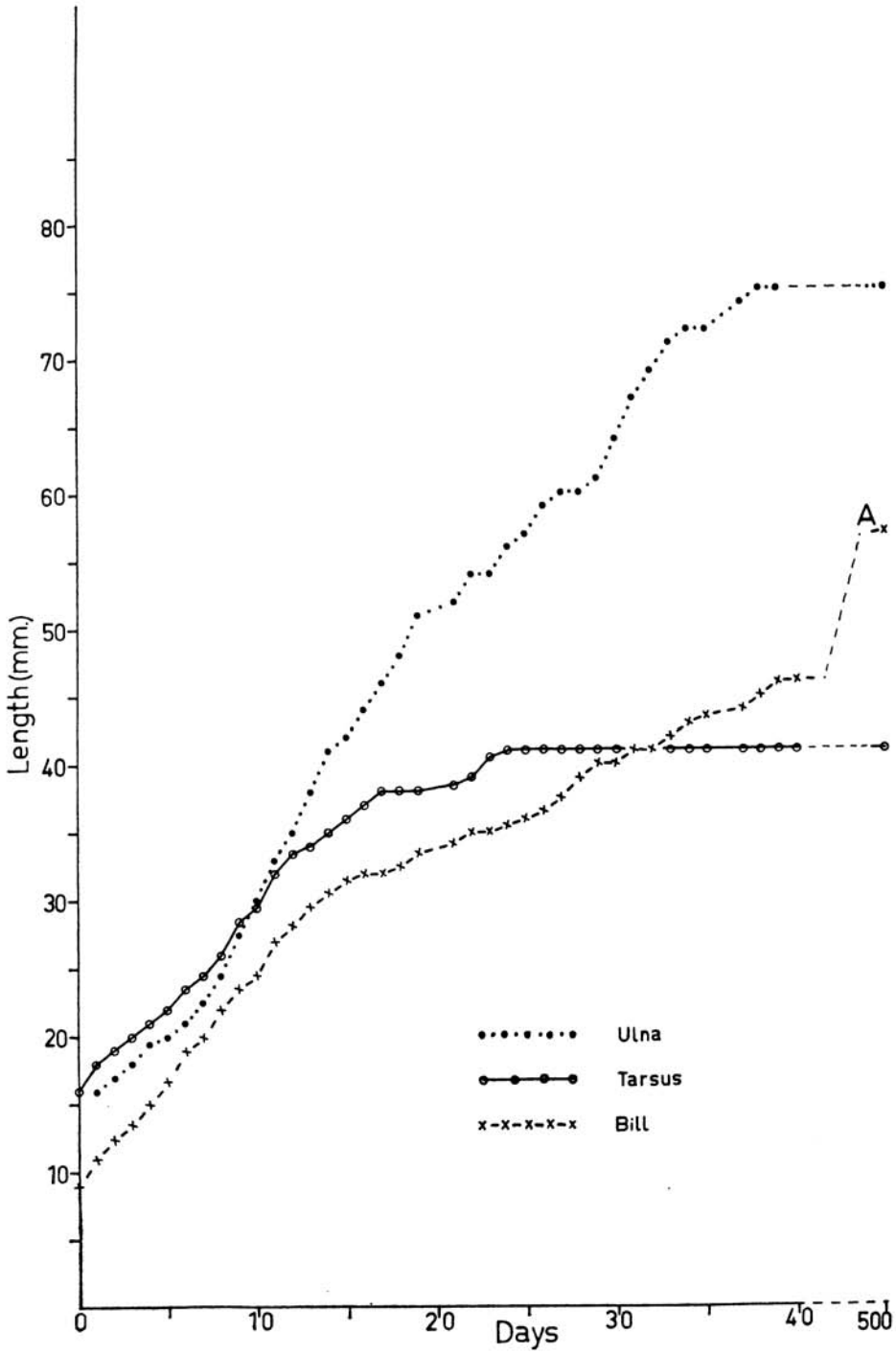
The feeding was continuous but not regular. The chick would accept one large or a few small insects at a time. Once it had refused food it could never be induced to take more. Chicks cared for by their parents would by this behaviour all get an opportunity to be fed, as the satisfied chick would show no interest in the food presented to it.

The following table represents feeding schedules.

Date	No. of feeds	No. of insects	Wgt. of insects in gm
Dec. 24	30	—	—
25	32	—	—
29	20	71	36.2
30	18	73	39.4
Jan. 5	25	75	45.5
6	26	69	45.0
20	31	144	30.0
27	26	54	34.5

NOTE: 120 of the 144 insects fed on the 20th Jan. were flying termites, to which the chick was very partial.

The weight of insects eaten on specific days is denoted by the vertical columns X, Y, Z_1, Z_2 on Graph I. The chick was fed whenever it called for food, as I was in constant attendance during the first month. Feeding conditions were thus ideal for the chick and it may be assumed that its growth and increase in body weight were at a maximum. The curve EF on Graph I represents the weight of the food eaten expressed as a percentage of the body weight plotted against time (age of the chick). From this graph it is evident that under conditions which are assumed to have been optimal


80
70
60
50
40
30
20
10
Length (mm.)
A
Ulna
Tarsus
Bill
0
10
20
30
40
500
Days

GRAPH 11

for maximum growth the relative amount of food required diminishes as indicated.

By 28 January when the chick was about one week old four pellets had already been brought up. Pellets were brought up regularly. Sometimes pellets were found on consecutive mornings and on one occasion no pellet was found over a period of six days. The formation of pellets was dependent on the nature of the food eaten. After the original nesting material had been put into the artificial nest, most pellets were formed round a piece of stick or portion of a feather shaft. One large pellet weighed 3 gms and was wound round a stick with a diameter of 3 mm and 5 cms long. For roughage the chick swallowed a large amount of dry leaves from the nesting material. The pellets consisted mainly of this material mixed with undigested pieces of insect chitine.

All the pellets were deposited in the nest and not dropped through the slit, even the smaller ones which could have passed through the narrow opening. The pellets do not befoul the nest as the faeces would do and there is therefore no need to dispose of them outside the cavity. Over a period of thirty-six days 20 pellets weighting from 0.8 to 4.0 gms were found.

(c) *Development of legs and feet.*

The rate of growth of the tarsus is shown on Graph II. The tarsus of the embryo was about 10 mms long and that of the five-day-old chick 18 mms, giving a rate of growth of approximately 2 mms per day. This inititally rapid growth is of the utmost importance. As seen on PLATE II, (1), its long legs enable the chick to sit in a squatting position in which the legs functioned as supports preventing the chick from toppling over sideways. From the fifth to the twelfth day the average rate of growth was 1.37 mms per day. On the twelfth the tarsus was 33 mms long. The legs had at this early stage attained more than 70% of their ultimate size and as the female breaks out of the nest at this stage, the chick would be able to move about freely in the nest. From the thirteenth to the twenty-fourth day, when the tarsus stopped growing, having reached a length of 41 mms, the rate of growth was only 0.67 mms per day. At 4 weeks the chick was taken out of its nest and put on the lawn. Although its legs were fully developed it made no attempt either to stand or hop or walk. It only crawled along for a short distance with its body touching the grass.

The development of the toes and the claws during the first few days was very rapid indeed. The colour of the legs of the embryo was pinkish. After the sixth observation the toes started turning blackish and traces of a dark pigment were visible on the tarsus. After twenty-four days the legs were a uniform dark slate.

(d) *Development of the wings.*

The rate of growth of the radius-ulna is indicated on Graph II. The length of the radius-ulna of the embryo was approximately 11 mms and

of the chick at ten days old 21 mms, giving a rate of growth of about 1 mm per day. As the wings at this stage serve no function a faster development would serve no purpose. From the tenth day until the thirty-seventh when the radius-ulna reached its final length of 76 mms, the average rate of growth was just more than 2 mms per day. The wings were thus fully developed at precisely the time when the bird was ready to leave its nest. In the confined space of the nest a more rapid development of the wings wuold be a definite disadvantage to the chick.

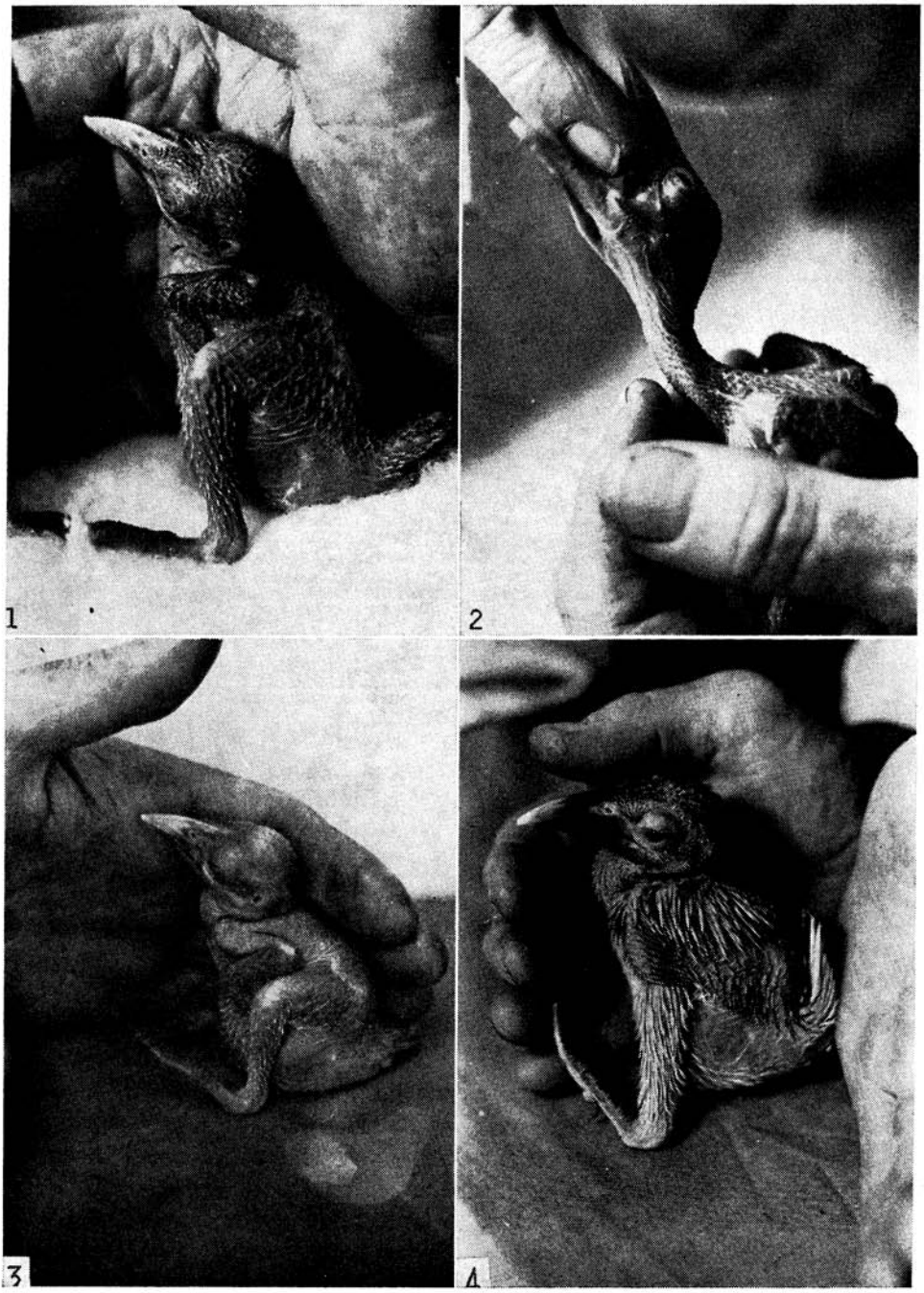
For the first thirty-eight days of its life the chick was never seen to stretch or otherwise exercise its wings, but on the thirty-ninth day there was a sudden commotion in the nest as the chick attempted to flap its wings. When the bird was finally taken out of its nest on the fortieth day it was immediately able without any preliminary practice to fly a distance of about five metres. During the next few days its flight was rapidly perfected.

(e) *The development of the bill.*

The rate of growth of the bill is indicated on Graph II. The bill was measured from the nostril to the tip as this was found to be the most satisfactory method when working with live material. Up to the fifteenth observation the bill grew 1.5 mms per day and from then until the fortieth observation the rate of growth was only 0.5 mms per day. The young chick had a relatively straight bill (Plate IV, 1.) and only after about a week did the bill develop a slight curve. This was mainly due to the formation of the casque ridge; the maxilla itself showed only a slight curvature. When the chick was two weeks old the bill itself started curving appreciably. The difference in the rate of change in the bill length could partially be ascribed to the method used in measuring the bill length. Though the bill itself started curving rapidly at that stage its length was still measured along the straight line from nostril to tip and not along the curve of the maxilla. It should nevertheless be noted that this change in growth rate coincides with the time the female normally breaks out of the nest. From Plate 1, 2, it can be seen that the maxilla of both the dead chicks was shorter than the mandible. This was also the case with the surviving chick. When measured on 25 Jan. the maxilla was 1.5 mms shorter and on the 28th, four days later it was only 0.5 mms shorter. Two days later they were of the same length. A yellow egg tooth, (Plate 1, 2. and Plate II, 3.) having an area of about 1 sq. mm when the chick was three days old became smaller and smaller and ultimately disappeared after eleven days. It did not fall off, but was reabsorbed.

The colour of the bill changed from flesh-colour in the embryo to yellow in the young chick. When the chick was ten days old the base of the bill began to turn dark. After two weeks half the maxilla and a third of the mandible were black. When the chick was seventeen days old only 17 mms of the tip of the maxilla and 4 mms of the tip of the mandible were still yellow. After three weeks only 4 mms of the maxilla and only the very tip of the mandible were still yellow. The casque which terminated 10 mms

PLATE II



1. Age ten days: showing difference in leg and wing development.
2. Feeding by sight.
3. Age nine days: showing extent of air-sac.
4. Age sixteen days: showing position of pygostil.

from the tip was black.

From this stage onward the base of the bill, the area round the nostrils and the casque were turning yellow again. (Plate III.) When the chick was a month old at least half the bill was yellow again and a yellow line extending towards the tip was forming along the maxilla. The bill still showed traces of black for many months and only after more than a year had turned completely yelow. The yellow colour of the bill is probably essential to the feeding process during the first few weeks when the female is imprisoned with the chicks. The yellow tip of the bill was clearly visible in the dark interior of the artificial nest.

PLATE III

Age two weeks: showing shape and colour of bill, eyelashes and patch of bare skin on the throat.

From Graph II, A, it can be seen that the bill continued to grow after the fortieth observation. The keratin covering the bill keeps on growing to replace the tip which is worn off. The length of the bill could in certain cases depend on the habitat in which the bird is found.

The chick was eventually found to be a female. Its sex could only be established by observing the shape of its bill when it was about a year old. In the case of a female of this species the casque is approximately three quarters the length of the maxilla and leaves an exposed straight edge to the tip of the bill, whereas in the case of the male the casque runs along the entire length of the maxilla forming a smooth arc.

(f) *Development of eyes and ears.*

The first change in connection with the eyes was that on the seventh day a dark ring was found to have formed round the eyes. The eyelids of the still closed eyes were thickening. On the eighth day a slit of about 1 mm was visible. The slit only opened occasionally. At this stage the chick could already see, as it now grabbed objects that were brought near its bill (Plate II, 2). On the ninth day the opening was round and had a diameter of 1.5 mms. The eyes were now kept open for most of the time. On the tenth day the diameter of the eyes had increased to 2 mms and they were kept open constantly. After two weeks the eye lashes began to grow. (Plate III.) The eyes of the chick were blue and only after three months did they begin to turn amber. The eyesight of the chick, even at the age of two weeks, was very acute. It could see and pick up insects which had dropped into the nest though the only light was that coming in through the slit.

The only observation in connection with the ears was that on the seventh day a dark ring began to form round the ear opening Two days later it had become a double ring. It was later observed that the ear-coverts grew from these circular pigmented areas.

(g) *Air-sacs.*

On 24 Dec. it was observed that when the chick became active or when it exerted itself as a result of being touched or handled, the sub-scapular air-sac that covered about half of its back became inflated. When the chick settled down and fell asleep the air-sac was deflated and became invisible. Two days later, on the 26th the air-sac had about doubled its size. On the 29th the air-sac not only covered the whole of the back but extended along the entire length of the humerus. (Plate II, 3). The inflated air-sac at this stage was so large that the chick looked quite deformed. As the feathers started developing the air-sac rapidly disappeared. By the time the chick was sixteen days old on 5 Jan., no visble sign of it was left (Plate II, 4).

The purpose of this air-sac is apparently to protect the bare body of the chick. In the confined space of the nest cavity the chick might easily be injured by the feet of the female. The air-sac acts as a protective cushion. The fact that the air-sac only became inflated when the chick was touched or disturbed seems to bear out this assumption. Once the body was protected by the feathers this air-sac was no longer necessary and hence diminished greatly in size.

(h) *Development of the feathers.*

On 25 Jan. small knobs that resembled pimples became visible under the skin of the head, back and thighs. On the 27th the spikes on the thighs had penetrated the skin. Two pigmented areas in the form of two lines were forming from the forehead towards the base of the bill. On the 28th the feather tracts on the ventral side of the body were visible as white lines. At

the age of ten days the upper tail-covert spikes were penetrating the skin. The top of the head, cheeks and upper neck showed a distinct pattern as a result of pigment layers under the skin.

On 2 Jan. when the chick was just over two weeks old the feathers of the ventral tracts and on the thighs were the first to break out of their sheaths and the spikes had also penetrated the skin on the head and neck. Three days later these feathers began to break out of their sheaths. By the time the chick was three weeks old all the body feathers were breaking out. When the chick was a month old all the body feathers except those on the furcula and chin were fully developed. It was observed that the pigmented areas showed the heaviest growth of feathers.

On 25th Dec., at the age of five days, the tail-feather spikes of the chick were 1 mm long. (Plate I, 2). When it was two weeks old the spikes were 8 mms long and at three weeks 25 mms long. At this stage they were just beginning to break out of their sheaths. At four weeks the tail feathers were 50 mms and a week later 85 mms long. By the time the chick was taken out of the nest the tail feathers were approximately 140 mms long and nearly fully grown.

On 3 Jan. the oil gland started developing. The pygostil now grew very rapidly and was kept parallel to the back. (Plate II, 4). This position of the pygostil not only kept the tail out of the way in the confined cavity but also served to protect the chick's back. This position of the tail is also essential for the defecating process which will be discussed under behaviour.

The growth of the wing feathers needs special mention. On 24 Dec. when the chick was four days old the spikes of the primaries and secondaries were clearly visible and about 1 mm long. (Plate 1, 2). Two days later the skin on the dorsal side of the radius-ulna started turning black. When the chick was two weeks old this skin was completely black. (Plate II, 1). The spikes of the lesser, median and greater wing-coverts had also pierced the skin. The development of these feathers was very rapid. (See Plate IV). By the time the chick was three weeks old these wing-coverts together with the tail offered complete protection to its back. (Plate IV, 4).

Notwithstanding the fact that the primary and secondary feather spikes were already present when the chick was four days old, these feathers had not grown by the time the chick was sixteen days old. Plate IV, 3 shows the heavy growth of the lesser, median and greater wing-coverts, the small short spikes of the primary wing-coverts and just a sign of the flight feather spikes. At the age of three weeks on 9 Jan. (Plate IV, 4), the lesser, median and greater wing-coverts were just breaking from their sheaths. The primary wing-coverts were still in their sheaths and the flight feather spikes were approximately 10 mms long. Four days later on 16 Jan. the primary wing-coverts as well as the flight feathers were breaking from their sheaths. (Plate IV, 5). The scapulars were the last feathers to develop and are seen as small spikes

PLATE IV

1. Age eleven days: spikes of lesser, median and greater wing-coverts and of primaries visible. No sign of primary wing-covert spikes.
2. Age fifteen days: primary wing-covert spikes appearing.
3. Age sixteen days: spikes of primaries appearing.
4. Age three weeks: " porcupine " stage. Wing-covert spikes raised in defence.
5. Age 25 days: primaries and primary wing-coverts breaking from their sheaths. Small scapular spikes seen under chick's bill.
6. Age 35 days: about ready to fly.

just below the bill of the chick. (Plate IV, 5). When the chick was forty days old the flight feathers were fully developed and the chick was able to fly.

B. BEHAVIOUR

(1) *Instinctive behaviour.*

(a) *Sounds.* (1). Vocal.

The chick made the first sound, a high-pitched squeak, on 6 Jan., when it was sixteen days old as it was taken out of the nest to be weighed. From this date onward this squeak, which later became a squawk, was emitted whenever it was handled. From 8 Jan. when the chick was nearly three weeks old, it answered my call, a high-pitched " kook-kook-kook " with a similar but softer and more melodious call. When it was a month old the chick gave a call resembling that of an adult bird and its voice started " breaking " whenever a loud call was uttered. When taken from its nest at this stage and put down on the lawn to be photographed the chick gave a very plaintive " kook-kook-kook ". The chick seemed greatly upset at being taken out of its usual element, the dark nest cavity. At the age of five weeks it gave a very loud, raucous " creeé " when some choice titbit like a lizard or scorpion was brought to it. After its first short flight on 31 Jan. it uttered a call, while climbing about in a shrub, which sounded like the " kirr-kirr-kirr " given by a rooster when a bird of prey flies overhead. From this stage onward it would occasionally give a call similar to that of an adult bird during its bobbing display act.

(2) Non-vocal.

On 12 Jan. when the chick was answering my feeding call, its call was accompanied by a soft, very rapid rattle-like sound, which was produced by the vibration of its tail feathers — now over 40 mms long — against the side of the nest. This sound was occasionally made for the next few days and was then not heard again. (The reason was probably that the tail feathers had become too long).

(b) *Reaction to noise, light and temperature.*

The young chick reacted violently to sudden loud noises, as observed for example on 25 Jan., when a door slammed. When I scratched lightly against the nest the then still blind chick reacted by moving but did not beg for food.

The artificial nest was open at the top and kept closed by means of an old black beret. When the beret was silently removed the blind chick reacted to the increased light-intensity. It moved and shifted its position and then settled down again after a while.

Temperature affected the chick's activity even up to the age of about four weeks when its body feathers were nearly fully developed. When the chick was three days old it remained lethargic until about 9 o'clock when it became warmer. Only after that did the chick accept food. Until it was

four weeks old the chick was kept warm continuously by an electric pad wrapped round the artificial nest.

The morning of 12 Jan. was cold and wet. The pad was switched off and after a few minutes the chick began to huddle down against the side of the nest. It did not respond to my feeding call and could not be coaxed to accept food. The pad was switched on again afier an hour. After a short while the bird responded to the feeding call again and took food greedily. In the wild state parent birds would not be able to find insects readily while it was cold and rainy. The chick's reaction to low temperatures would fit in with these conditions. When the chick was between five and six weeks old it ceased to be affected by temperature changes to such a marked extent, as the fully developed feathers now provided sufficient insulation. At five and a half weeks on a very hot evening the chick kept its bill sticking out of the nest. Its breath came in rapid hisses. When the nest was opened and the temperature in the nest became lower the breathing became normal and the bill was withdrawn.

(c) *Feeding.*

During the time the chick's eyes were still closed — i.e. before the ninth day — the chick only opened its bill to be fed when the bill itself was touched. There was no feeding response when the body was touched or the feeding call uttered. As I have already pointed out the colour of the bill is important at this stage. On the tenth day, the day after the chick's eyes had opened the food was taken from the forceps. The urge to feed was from this time onward dependent on sight and not on a tactile stimulus. Although its bill was occasionally stuck through the slit, food was never taken outside the nest. When an insect was presented, the chick withdrew its bill and took the insect only when offered through the opened top of the nest. (In the wild the female would still be feeding the chicks in the nest at this stage).

On the seventeenth day the chick showed little interest in iis food and was very restless, even at night. Some of the insects that had been eaten were brought up again. On the eighteenth day the chick ate hardly anything, I was obliged to force-feed it. When the nest top was opened it huddled down, buried its head in the nesting material and squawked. Its behaviour could be compared to that of a child in a tantrum. Its faeces were quite normal and it can be assumed that the chick was not suffering from any physical ailment. On the nineteenth day it seemed as if the chick was partially paralized. It had " tantrums " whenever the nest was opened and showed not the slightest interest in food. When the chick was taken out of the nest for about ten minutes it seemed perfectly happy. It pecked at my moving finger, ate a locust and also showed an interest in its surroundings. When returned to its nest it immediately went into " tantrums " again.

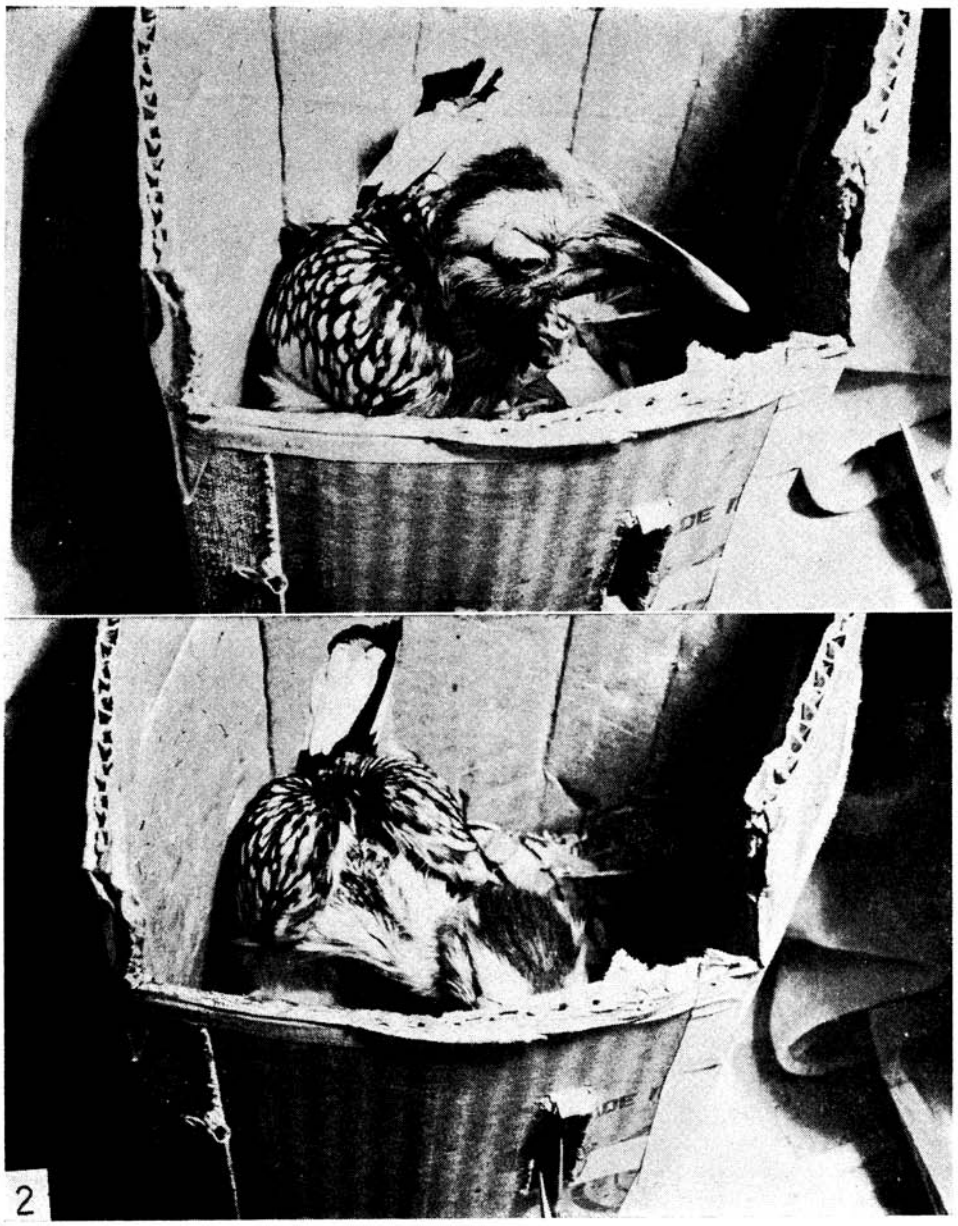
At 17.00 hours, while I was driving home, I glanced at the nest on the seat beside me and it occured to me that the reason for the chick's behaviour might be some disturbing factor in connection with the nest itself. Was it not possible that this was the time at which, in the wild state, the female would break out of the nest? And should there not be a larger opening now in the place of the narrow slit? I stopped the car and with my pocket-knife cut the slit open to a fairly large elliptical hole. The reaction of the chick was immediate. Before I had replaced the knife in my pocket its head was thrust through the opening and it started begging loudly for food. During the next two and a half hours the chick ate more than during the previous three days. The effect of this behaviour on its growth is shown at B on Graph I. (Observations 14 to 17).

The chick did not attempt to enlarge the hole at this stage, this was obviously the function of the female only. To resume normal feeding the chick was dependant on an external stimulus, the larger opening, which was the result, not of its own activity, but of the female's breaking out of the nest. After this stage the chick fed readily through the opening, but was loath to accept food when it was offered through the opened top. It now grabbed food eagerly through the opening as insects were brought near the nest. In the wild state it would at this stage have been competing with the other chicks whenever either parent brought food to the nest. When the nest top was now opened the chick crouched down in the nest in either a fear or defensive attitude and would not accept the offered food.

Whereas until now the chick had taken food in the tip of its bill, depositing the insect in its throat with a quick forward thrust of its head, it now began to use a new technique. When it was twenty-six days old it was seen throwing short sticks found in the nesting material into the air and trying to catch them again in its bill as they fell, in a manner reminiscent of the feeding of adult hornbills. The chick was still very inexpert and seldom succeeded in catching the object. On 17 Jan. when the chick was four weeks old it threw an insect into the back of its throat for the first time. Whereas the chick had until now still accepted food presented through the open top on a few occasions it preferred at this stage to take it through the slit as shown in Plate V. It would now also sit in the nest with its bill protruding, waiting to be fed.

On 30 Jan. when it was forty days old it was taken from the nest and placed in an aviary. During the first day in the aviary it was seen to take food from the feeding tray. During the following week the chick was very active, hopping from perch to perch and flying short distances. It showed little interest in its food, taking insects from the forceps and also feeding from the tray in the true hornbill fashion by throwing the food into the back of its throat. The fact that the chick still accepted food after it had been taken out of the nest seems to indicate that in he wild state the chicks are still cared for by the parents for some time. This fact has since been verified by observation. The loss in weight during this stage has been discussed under

PLATE V



1. Chick raising its head as food is brought to the nest.
2. Bill pushed through slit to take food.

development. By the time it was seven weeks old it could fly fairly well and was feeding normally again.

(d) *Defecation.*

Hornbills do not befoul their nests: their faeces are ejected through the slit. The moulting of the tail-feaihers of the imprisoned female serves to facilitate this process. When the nest was opened on 23 Jan. no excrement of the young chicks was found in the nest. It was observed that the chick only started ejecting its faeces on the tenth day. This would seem to indicate that the female swallows the faeces of the young chicks as is found in the case of many species of insectivorous birds.

The chick did not eject its faeces before it was able to see. By that time the legs were sufficiently well-developed to enable it to raise its vent as high as the slit. In ejecting its faeces the chick turned to face away from the slit then moved backwards until it touched the side of the nest near the slit. Its body would then be raised and moved from side to side against the inside of the nest until the slit was locaied. The vent was then pushed through the slit as far as possible and the faeces ejected with great force. The faeces sometimes landed more than a foot from the slit though the slit was no more than 25 cms above table level. The pygostil lay parallel to the chick's back at this stage as shown in Plate II, 4 — a necessary adaptation in this connection. As no feathers were in the way, the slit could be found by touch. The tail feathers were also held over the back and were therefore not befouled or damaged against the side of the nest.

The faeces were regularly ejected even at night. As no light entered the room in which the chick was kept it is clear that the bird was able to find the slit without actually seeing it. Normally the location of the slit is dependent on a visual as well as a tactile stimulus but under certain circumstances on the latter only.

From the moment the slit was enlarged to form an elliptical opening the faeces were no longer ejected but deposited in one corner of the nest. The faeces were immediately mixed with the nesting material to form a plaster with which the chick began to plaster up the hole. The cardboard from which the nest was made was so thin that the plaster did not stick to the sides of the opening. On the twenty- fourth day I closed the hole with masking tape, leaving a slit about 25 mms wide. From this stage the faeces were sometimes ejected during the night but not during the day when all the faeces were used for plastering. On the twenty-sixth day the slit was closed to 15 mms. The chick still continued to plaster but after the slit had been narrowed down to 8 mms on the twenty-seventh day all the faeces were again ejected.

While plastering the chick would take a bill-full of plaster, put its bill diagonally through the opening and tap the bill sideways. The base of the bill thereby caught the inner edge of the one side and the tip of the bill the outer side of the other. The bill pointed left and right alternately during the

plastering operation. This method used by the chick explains the wedge shape and symmetrical form of the plaster forming the slit. On 22 Jan. three days after the chick had stopped plastering up the opening, the top of the nest was accidentally left open for about an hour. During this period the faeces had again been deposited in the nest, made into the plastering mixture and the chick was industriously trying to close up the open top. As soon as the beret was put on the nest all the faeces were again ejected. Any opening, except the narrow slit through which feeding takes place, irrespective of its size and position, acts as stimulus for the chick to deposit its faeces in the nest. Light intensity may be the chief factor in this connection.

When the chick was forty days old it attempted to peck open the slit. The nest was cut open, the chick was taken out of the nest and placed in an aviary together with the nest. It made no attempt to sleep in the nest again but slept on a particular perch in the aviary. Its faeces were dropped at random.

(e) *Defence behaviour.*

At the age of sixteen days, i.e. a few days before the female would normally break out of the nest, the chick pecked viciously at any object, such as a finger or forceps, brought near the slit of the nest. At the age of three weeks, when the female would just have broken out of the nest and the chicks would have been more vulnerable as a result of the larger opening, the chick defended itself by hiding its head in the nesting material and placing its wings and tail over its back. The feathers had not yet broken out of their sheaths to any great extent and this stage has been referred to by some authors as the " porcupine stage " (Plate IV, 4).

At four and a half weeks when most of the feathers were fully developed the chick changed its defence attitude: it now tucked its head firmly under one wing and covered its back with its tail, now 15 cms long. The wings were not raised as was the case during the " porcupine stage ". It would now also raise the feathers on its forehead when alarmed.

(f) *Displacement activities.*

When the chick was offered an earth worm or an Oryctes larva it showed its disgust by throwing it out of the nest with a rapid jerky movement. The head was then quickly brought back sideways and an attemped was made to preen the base of its tail. It appeared to be touching the oil gland. When annoyed a similar sideways and backward movement of the head was observed, but no attempt was made to preen.

(g) *Other activities.*

At the age of thirteen days the chick was seen to scratch and preen itself. As the feathers developed more and more time was spent in preening. At this stage it also started taking an interest in its surroundings and pecking at

objects in the nest. At seven and a half weeks when the chick could already fly quite well it would often look for a patch of loose soil in which to take a dust bath.

(II) *Acquired behaviour.*

As conditions under which the chick was reared were kept as " natural " as possible, very little was observed in connection with acquired behaviour. A close bond existed between the chick and myself while it was living in its artificial nest. It responded to my call — a fairly high-pitched " kook-kook-kook ". It not only recognised me by sight; it also recognised my normal speaking voice. It would not call for food when other people were talking but as soon as it heard my voice it would start begging. After two years the bird still recognises my call and takes food from my hand, although two or three months may pass between visits to the bird.

When the chick was three weeks old I was called out of town and could not take the chick with me. I asked my young son to feed it during my absence. During the morning it hardly fed at all, but took a few insects during the afternoon. It did not respond to his imitation of my call and did not give the begging call at all. After my return at 17.00 hours it fed greedily, responded to my call and begged. When the chick was transferred from the nest to the aviary the bond between us weakened to a marked degree. It now accepted food readily from members of my family.

The chick's response to a human voice may be regarded as a form of conditioning. When it was about three and a half weeks old, it showed in another way that it was able to learn by conditioning. It accompanied me on a journey of two hundred miles. I stopped every half hour to feed it. The fourth time I stopped the chick began to beg for food as soon as the engine was switched off. This it did throughout the journey, whenever I stopped the engine. It did not beg while the engine was running even after the car had stopped. It had learnt to accept a new stimulus.

Only once during the whole period of rearing the chick did it show any outward sign of affection towards me. At the age of six weeks the top of the nest was left open for a while. I came towards the nest, calling, and as I approached the chick saw me, lifted its wings vertically above its back, called and gave a bobbing display similar to the courting display of adult birds.

The chick disliked being handled or touched. It would not even allow me to scratch its head. After being handled every morning for weighing and taking measurements the chick was apparently afraid of me for a short while. It crouched at the bottom of the nest and would not respond to my call.

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