

THE BREEDING BIOLOGY OF CERTAIN EAST AFRICAN  
HORN BILLS (BUCEROTIDAE).

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INTRODUCTION AND ACKNOWLEDGMENTS.

*Bycanistes cristatus.*

The Ngua nest : history 1932-1936.

The Amani nest : history 1934-1936.

The building process.

" Personal relations " between the pair during the building.

The period of nest occupation.

The breeding biology in relation to the maintenance of the population.

*Lophoceros deckeni.*

The Longido nest, 1932-1936.

Discussion of the observations.

*Lophoceros melanoleucos.*

SUMMARY.

Although the habits of hornbills have long been recognised as exceptionally interesting, little in the way of connected observations on their behaviour at the nest has been published for any species. The first concern of anyone finding a nest has nearly always been to cut down the tree or at least break open the hole. Chapin's notes on *Bycanistes albotibialis* (1931) and Hoesch's on *Lophoceros flavirostris leucomelas* (1934) are exceptional; but there still appear to be no records through all the stages of a hornbill's nesting without interference, conclusive if not fatal, by man. Of the three species for which I am able to put forward original observations in this paper, two of them, *Bycanistes cristatus* and *Lophoceros deckeni*, have, so far as I can discover, not had their nesting described in any way before.

The fact that the present observations settle certain main questions, and in some respects approach completeness, is due to the enthusiastic co-operation I have been fortunate enough to secure. For learning the habits of *Bycanistes cristatus* opportunities have been good; one nest has been under observation for a total of about



400 hours in four successive seasons, and another for about 100 hours in two seasons. For much valuable data on this species I have to thank Mr. T. A. Baldock, Mr. L. S. V. Venables, and Mrs. R. E. Moreau, who have most generously given me all their notes. To obtain a long series of data on feeding times I employed Africans, especially an Mzigua named Simon. Their field-notes are excellent and I am satisfied that they are essentially reliable. No European could have spared the time for the dawn-to-dusk watches the Africans kept.

The remarkable facts I have to record about *Lophoceros deckeni* are nearly all transcribed direct from the notes made by Mr. S. A. Child at Longido. Three years ago I was shown a photograph he had taken of a female visiting a closed nest. Realising the exceptionally interesting possibilities I got into communication with him and suggested certain points to which he might give attention. The results are striking; and it will be realised that he is a very good observer.

For the third species, *Lophoceros melanoleucos*, mentioned in this paper, the observations I have to record are more scanty but they suffice to establish certain main points. I am indebted to Col. the Hon. M. T. Boscawen for the greater part of the data.

For chemical analyses I have to thank Dr. R. R. Worsley, and for all the botanical names used, Mr. P. J. Greenway. The plates are from Mrs. Moreau's sketches from life.

#### BYCANISTES CRISTATUS.\*

This, the Silvery-cheeked, is the large Hornbill of the Highland and Intermediate Evergreen Forest from Abyssinia to Mashonaland. In Usambara it is very common, but owing to the great height and close stand of the trees nests are difficult to locate and observe. The birds probably pair for life, as it is the rule for couples to be seen together all round the year. At the same time they are gregarious, not only while feeding, but also for roosting. Once having established a communal roost, often in the crown of a hundred-and-fifty-foot *Albizzia*, the birds return to it, to the number of perhaps two hundred, night after night for several months, although during this period the fruiting trees, to and from which the birds flight morning and evening, may change repeatedly. The hornbills do not leave their roost until about half an hour after sunrise and they seek it again before sunset.† On the average thirteen hours out of the twenty-four must be spent at the roost, a regime apparently not modified during the breeding cycle except by the female while she is immured.

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\* Mr. W. L. Sclater informs me *in litt.* that the series in the British Museum does not support the differentiation of *B.c. brevis* Friedmann (type locality near Amani) on measurements. van Someren, however, admits this form (1932).

† At Amani there is only 37 minutes' difference between the longest and shortest day.

*Bycanistes cristatus* is almost exclusively frugivorous. I have evidence that in Usambara it occasionally eats one of the big forest millipedes and, when swarms are about, a locust. Swynnerton has recorded one at Chirinda (1907) "crammed with locusts," but there is nothing to show that this hornbill ever takes vertebrate prey, especially young birds, as do others of the family.

The Usambara forests, of which some description may be found in Moreau (1934), provide plenty of fruit all the year round and of many kinds. From our observations it is probable that the hornbills utilise them all except the smallest (such as *Trema guineensis*, the size of bilberries). They are very fond of stone fruits about as big as cherries, e.g. *Sersalisia usambarensis*, and equally of *Canthium* fruits the size of a small apple. They eat small nut-like fruits without flesh and even, it appears, the hard heavy nuts of *Odyndea Zimmermannii*, which are as big as plums. These hornbills have taken readily to some of the exotic fruits introduced to Amani, especially *Maesopsis Eminii* and guavas (*Psidium* spp.) Fruits of all kinds are swallowed whole, tossed back into the gullet from the tip of the mandibles with a jerk of the head.

Notwithstanding the equable climate of Amani and the perennial supply of fruit the breeding season is strictly limited for reasons that are quite unknown. In the five cases that have come under our observation nest-building has taken place in October and November. Five adults collected between the end of March and the end of May were all in moult. Young leave the nest between the latter half of February and the end of March, i.e. at the end of the comparatively hot and dry season and just before the break of the "long rains."

#### THE NGUA NEST; HISTORY, 1932-1936.

The Ngua nest was first brought to my attention by Mr. T. A. Baldock on 2/3/33. A male was visiting a hole facing east about 80 feet up in the trunk of a great "camphor" tree (*Ocotea usambarensis*) just level with the point where the first branch sprang off. The tree stood on the edge of an isolated new clearing, excellently situated for observation. In successive years the bird owning the nest showed varying, but on the whole little, concern at the presence of an observer. Most of our observations on this nest we made from a point with a little overhead cover about 100 yards from the foot of the tree.

The natural hole was an irregular oval about 15 inches high by 8 wide, probably where a limb had been dropped. It had been plastered so as to leave a median slit about 10 inches long and barely 2 wide. The material employed was smooth externally except for a few radial cracks, and it was exactly similar in appearance to the soil, pale reddish when dry, surrounding the tree.

A number of African labourers who were questioned separately agreed in stating that the male bird had been visiting the hole alone

when they were clearing the ground round the tree for the first time. Reference to the estate books established this as between 3/10/32 and 4/11/32.

One of the upper quadrants of the plaster was broken away between 25 and 27/3/33, and the birds had left the tree. It appeared then that the female must have been walled in for 159 days  $\pm$  17.

During the latter part of 1933 both Baldock and I were in England. He returned first, at the beginning of November, and found the hole already sealed. Evidence from the sources utilised in the preceding season indicated that the female had gone in between 21/9/33 and 23/10/33. The plaster was broken between 07.00 on 20/2/34 and noon on 21/2/34. As in the preceding year the hornbills left their tree entirely and no one saw them go. A surprisingly small gap had been made in the plaster in the same upper quadrant as in 1933. The period indicated for the female's residence was 136  $\pm$  16 days. This is shorter than that arrived at for the 1932/33 nesting but still probably too long. The beginning dates depend on casual African evidence; and as will be shown it is easy without prolonged and careful watching to mistake the later stages of the plastering process for actual occupation of the nest.

In November, 1934, both male and female were seen at this nest. On 10/11 when the gap made in the plaster in the preceding February had been partly repaired, Venables watched the female squeeze into the hole with difficulty.

“ First she clung like a woodpecker, and put in her head up to the shoulders. . . . She then withdrew and turning half sideways inserted first her expanded left wing (appeared to ‘ hold on ’ with it), then her head, then her body (much wriggling needed), and lastly her expanded right wing and tail.”

On 5/12 Venables observed a most interesting incident, of which I reproduce his notes :—

- “ 06.30 Observer arrived hide. Tip of female's beak frequently protrudes from slit.
- “ 07.02 She pushes head right out and looks about. Presently withdraws.
- “ 07.22 She starts calling loudly. Beak in and out of slit.
- “ 07.24 Male arrives. Small yellow fruit in tip of bill. Sits in tree. Female forces out head, neck, and left shoulder, and calls loudly. In a few moments appears to make an effort and forces out whole body, breaking down a good deal of the wall on her left (in the same top corner as in preceding years). Drops 8-10 ft. and flies into forest followed by male. He seems to show no emotion.”

The pair were seen in the neighbourhood for the next couple of hours but not thereafter. The female had been inside for 2-3 weeks. Venables noted that when she flew out she appeared to be fully fledged.

The hole was not occupied again for a year. Repairs to the plaster began on 2/11/35. On 6/11 Baldock saw what there is good reason to accept as the final entrance of the female. The pair arrived together about 09.00 and sat together for a quarter of an hour. They "began to talk quietly, not the noisy squawk, and hop about till the female went up to the hole. She went in, first one wing, then the head, and then stuck. She pushed for about a minute but could not do it, so came right out. She then had another shot and brought it off. All the time male squawking frantically." When his mate was in he went off to bring more plastering material.

Female and young emerged on 21/2/36, i.e. after the former had been inside for 108 days. Fortunately I had an African on the spot that morning with notebook, pencil, and watch. I append a verbatim translation of his account, which was written in Kiswahili.

- " 06.28 Male arrived and sat in tree till 06.41.
  - " 07.21 Male arrived and sat in tree till 07.35.  
(Questioned: ' He brought no food either time.')
  - " 07.57 Wife inside began to break the wall. She half broke it enough to get her neck out and at 08.08 she rested.
  - " 08.18 He arrived, fed her 12 times and went off at 08.25.
  - " 08.56 Wife inside finished breaking the wall.
  - " 09.04 She came out and at first perched on a branch.  
(Questioned: ' She did not clamber up from the hole but flew straight out and up to a high branch.')
  - " 09.11 Husband and wife went off (literally ' went for a stroll '). They returned 09.19 and settled on a branch.
  - " 09.31 Wife went off by herself, returning 09.34 and settling on a branch.
  - " 09.41 Husband and wife went off again. Their children inside. They returned 09.49 and settled on a branch.
  - " 09.58 Mother and father went off again. They returned at 10.03 and sat on the tree till 10.10. She called three times.
  - " 10.13 One child came out, one only, and sat on a branch till 10.27. (Questioned: ' The child flew straight out of the hole and with some difficulty to a branch about on a level but in the next tree.')
- Wife and husband went off together with their child towards the east. That's all. I sat there till 17.08. When I left the three had still not returned."

It may at this point conveniently be mentioned that a young hornbill collected by Baldock on 21/3/36 out of a flock weighed only 303 grams, less than one-third as much as an adult. It resembled an adult in pattern and colour except that it was browner on the forehead and its iris was whitish instead of brown. Although perfectly well able to fly none of its feathers had broken sheath on the back of its thighs nor on well-defined lines up the back and front of its neck. A juvenile on 1/4/36 was fully feathered. The shape of the bill is shown in Plate 1. Both specimens went to the British Museum in spirit.

#### THE AMANI NEST: HISTORY 1934-1936.

On 30/10/34 I noticed that a female hornbill was working at a hole about 9 by 12 inches 80 feet up in the bole of a big *Parinarium* tree in the forest at Amani. It is so closely beset with other tall trees that it is impossible to watch the hole from anywhere near the base of the tree, but a clear view of it is obtainable from about 250 yards away across a narrow valley. I had passed within sight of this hole on most days for the preceding six years and feel sure it had not been occupied during that period by hornbills. On 30/10/34 a narrow rim of reddish plaster had already been placed in the lower half of the hole. Close by, the coarse epiphytic fern *Drynaria Haudentii* had established itself on the tree trunk.

Male and female worked at the hole with varying assiduity every day for about three weeks, completing a crescent-shaped piece of plaster with its thickest part at the lower right-hand side of the hole. Between 19 and 22/11 they stopped work and for the next twelve months were seen at the nest only occasionally.

For example, on 19/12, when no male bird was about, a female came out and flew off. On 30/1/35 a pair were sitting on the boss above the hole. They kept on bending down and peering in. Eventually they flew away. Later in the same morning two woodpeckers were in and out of the hole. The hornbills were not seen there again until 9/9/35 when the male was sitting in the tree and the female entered the hole for a few moments. On 11/9 the same thing happened, but no regular visits were made by the birds and no building was done until early November. Between 14 and 21/11 they concentrated on the left hand lower side of the hole and made good progress. By 25/11 a rim of plaster had been run up the left-hand side of the hole to the top. By 28/11 the slit had almost reached its final form and the female had the greatest difficulty in forcing her way in and out. But on 29/11 they failed to visit the nest and have not done so since (April, 1936). Instead, the hole has been frequented by a pair of starlings (*Onychognathus walleri*).

It would be very interesting if the reasons for the failure to proceed with the Amani nest in both 1934 and 1935 could be ascertained, but the behaviour preceding the cessation of work is difficult to interpret. In both years building continued after copulation had taken place, and when work had ceased both birds still showed a keen interest in the nest-hole. On reviewing the daily notes of 1934, with their impression of growing indolence, I think that the breakdown in the breeding cycle may have been due to some difficulty experienced by the male in maintaining the supply of building material, a difficulty not unlikely to be connected with his salivation (see next section).

In 1935 there was every prospect that the nesting would proceed normally. The female's entrances during the last week of work were so difficult that we thought every one must be the last. Squeezing in on 24/11 she broke away a lump of plaster, an accident that did not happen on subsequent days; and on emerging that morning she had to push out one wing first. On 25/11 Mrs. Moreau saw her make two unsuccessful attempts to get out. Her head and neck emerged and waved about wildly. She managed it at the third attempt by trying wing first. On 27/11 she apparently required the male's help to get in, and it took her four minutes of furious struggling to get out. The birds' activity thereafter ceased so abruptly that I should have posited an accident to one of them were it not that a pair continued to pay occasional visits.

#### THE BUILDING PROCESS.

Our observations on the Amani and Ngua nests combined cover every stage from the initiation of work on a previously unoccupied hole to the completion of the walling after the female can no longer get out.

Briefly, almost the whole of the actual building is done by the female from inside the hole with material brought to her by her mate. Until the walling is well advanced, this procedure is by no means predetermined by the male's inability to get into the hole.

Our birds never worked for more than five hours. They were only once seen to arrive before 09.00 and on occasion they did not get on business until after 11.00. They always knocked off before 15.00, usually between 13.00 and 14.00. Then they invariably flew right away till the following morning. This time-table meant that they were both able to get a feed before starting work. Once settled in the hole the female as a rule sat there for the whole period, say about our hours, during which time the male only exceptionally brought her fruit.

When the pair did not arrive together in the morning it was the male who appeared at the hole first. He then showed a comical

concern, sitting on the boss above the hole and repeatedly bending down to peer inside. On the arrival of the female she would usually enter with little delay, and the male fly off for material. From the Amani nest he was always lost to sight among the trees, but at Ngua it was possible occasionally to follow his actions in the clearing. After an interval varying up to about thirty minutes—usually not more than fifteen—he would reappear, rising laboriously either straight to the hole or first of all to a neighbouring branch. At Amani the perch from which the male passed in material was always the boss overhanging the hole, so that when he bent down he was in danger of losing his balance. At Ngua the male clung in a vertical position with his feet at the lower rim of the natural hole and his spread tail pressed against the trunk as in Plate 2, where only the top part of the slit is visible above the bird's head.

The staple building material at all stages was pellets disgorged by the male. He would bend his head down and "heave" until a pellet appeared from his throat. It would then be conveyed by a rapid chewing motion to the tip of his mandibles, in which it was passed to the female inside the hole. The movement made me think of a man trying to work some small object, a stud or a button, down inside the sleeve of his jacket from his armpit to his hand. We were struck by the care with which the male conveyed his pellets. We never saw one lost; the tips of the great mandibles held them as if in forceps; and he was not content merely to drop his pellets into the hole. The female had actually to accept the pellet in her bill before he was satisfied to relinquish it. If she was too occupied to accept it at once he would hold it in his bill and repeatedly bend down to proffer it. We have seen him do this as many as 25 times with a single pellet. Besides this he very often bent down to watch how the work inside the hole was getting on and whether the female was ready for another pellet. When he was getting impatient his see-sawing motion was laughable; almost before he had resumed his upright posture after a fruitless inspection down would go his head again for another look.

The pellets were spherical to ovoid, with diameter varying from about half to one inch. (The length of the male's casque provided a convenient measure.) The number brought up by the male at a single visit varied from 3 to 42. When working most consistently he averaged about 20, e.g. 200 in 9 visits on 30/10/34, 142 in 7 on 31/10, 217 in 11 on 1/11, 235 in 15 on 23/11/35, the last being the biggest day's work observed. Owing to the number of profferings made fruitlessly by the male when the female is too busy to accept we found it essential to watch all these actions carefully through binoculars to make sure when pellets actually passed. At the end of a pellet sequence the male often sat quietly for some time.



Occasionally the male had difficulty in producing the pellets and would try several times to disgorge without result. An extreme example was noted by Venables on 3/11/34 at 13.27, i.e. near the end of the day's work.

"Male arrives and gives 15 pellets. Much trouble to produce, e.g. five minutes' gulping with head at all angles for No. 8 and a good deal of bother with Nos. 9-15."

Since learning what his raw material is we are surprised that his difficulties are not always great. From the reddish colour of the pellets we had supposed them to consist of mud, but it was not until 6/11/35 that Baldock at Ngua made the definitive observation:—

"Male goes down on to the ground and picks up about 12 bits of earth [particularly dry at the time] and with one more in his beak flies up to nest and gives 16 pellets. . . . Off to a spot in sight where he picks up earth four times and swallows it, the last time a big beakful which he has difficulty in swallowing. Then with fifth lump in bill flies to hole and gives female the lump and 10 pellets."

This proves that the male forms pellets in his gullet, not solely by rounding individual lumps of earth swallowed, but also by dividing them by some mechanism in his interior.\* The process seems to be a rapid one. We have seen the male disgorge 33 pellets after only five minutes' absence. On the other hand he once started disgorging after sitting inactive on the tree for 35 minutes, a period during which lumps of earth held in the gullet might have been expected to stick together. It should be added that the soil at Ngua, and at Amani as well, is a clay (derived from gneiss) with a considerable content of sand. It does not "bind" when moistened with water and cannot be used to make pottery. Plastering of both the Amani and Ngua nests is always done in a comparatively dry season of the year, although wet soil is available along the numerous streams. Exceptionally, Baldock observed, the Ngua male brought his material from swampy ground.

The pellets that form the staple of the plaster are not the only material used. Objects much larger than pellets were brought by the Amani male once or twice each day. We could not be certain what they were, except that they included pieces of bark of the epiphytic growths at which the birds were sometimes seen hacking. At Ngua in both 1934 and 1935 the male regularly, though not in-

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\* Dr. P. R. Lowe has kindly undertaken to make an anatomical investigation of specimens brought to London for this purpose.

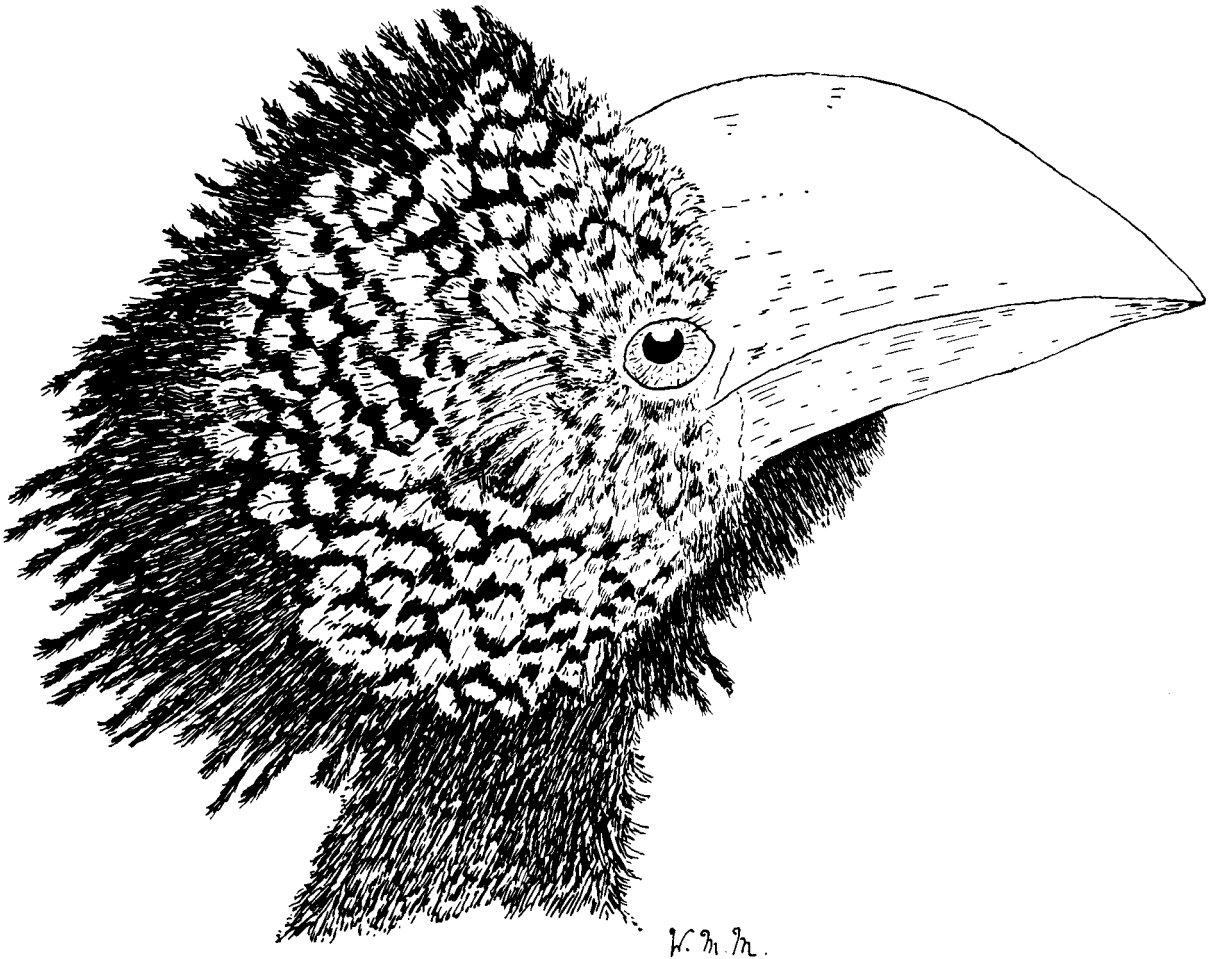
variably, brought something in his bill which he passed into the hole before he began to produce pellets. Thus on 10/11/34 Venables saw "moss or lichen" brought three times and a lump of soil twice. Baldock's notes on the same nest in 1935 show that a lump of dry soil was regularly given to the female before each batch of pellets. On 27/11/35 I saw the Amani male pass into the nest a stick that I estimated to be no less than 12 inches long and 2 inches thick; and Baldock once made a similar note at Ngua.

After the Ngua female had broken her way out in 1936 I obtained a piece of the plaster. It appeared to consist entirely of soil with a few bits of bark embedded in it, but it was astonishingly hard and unfriable, almost like cement. Analysis by Dr. Worsley was negative for nitrogen, including uric acid. This practically proves that there was no admixture of dung, but not so conclusively as it would in most birds, because of the unusual nature of the dejecta of *Bycanistes cristatus* (see next section). Most probably the binder that causes the rather sandy soil to set so hard is the male's saliva, and if so he must need a notable supply of it for the whole building process. As we have seen, the pellets varied between half and one inch in diameter, and when 200 were produced in the course of a morning's work—a number frequently exceeded—it can be calculated on an average diameter of  $\frac{3}{4}$  inch that enough saliva would be required to permeate some 33 cubic inches of earth.

In this connection highly significant observations were made by Baldock at Ngua on 6 and 7/11/35. The female had just made her final entrance and the male was alternating supplies of food for her with cargoes of pellets for the last stage of the plastering. The food consisted of fruits which he carried in his gullet and brought up in exactly the same way as he did the pellets. Several times Baldock saw the male while disgorging at the nest let fall what appeared to be gouts of saliva; and on each occasion it was while he was disgorging a batch of fruits, not pellets. In all our observations on the feeding by the male after the plastering is finished there is no record of similar salivation. This may, of course, be due merely to faulty observation. If not, it points to an abnormal rate of secretion by the male during the building season.

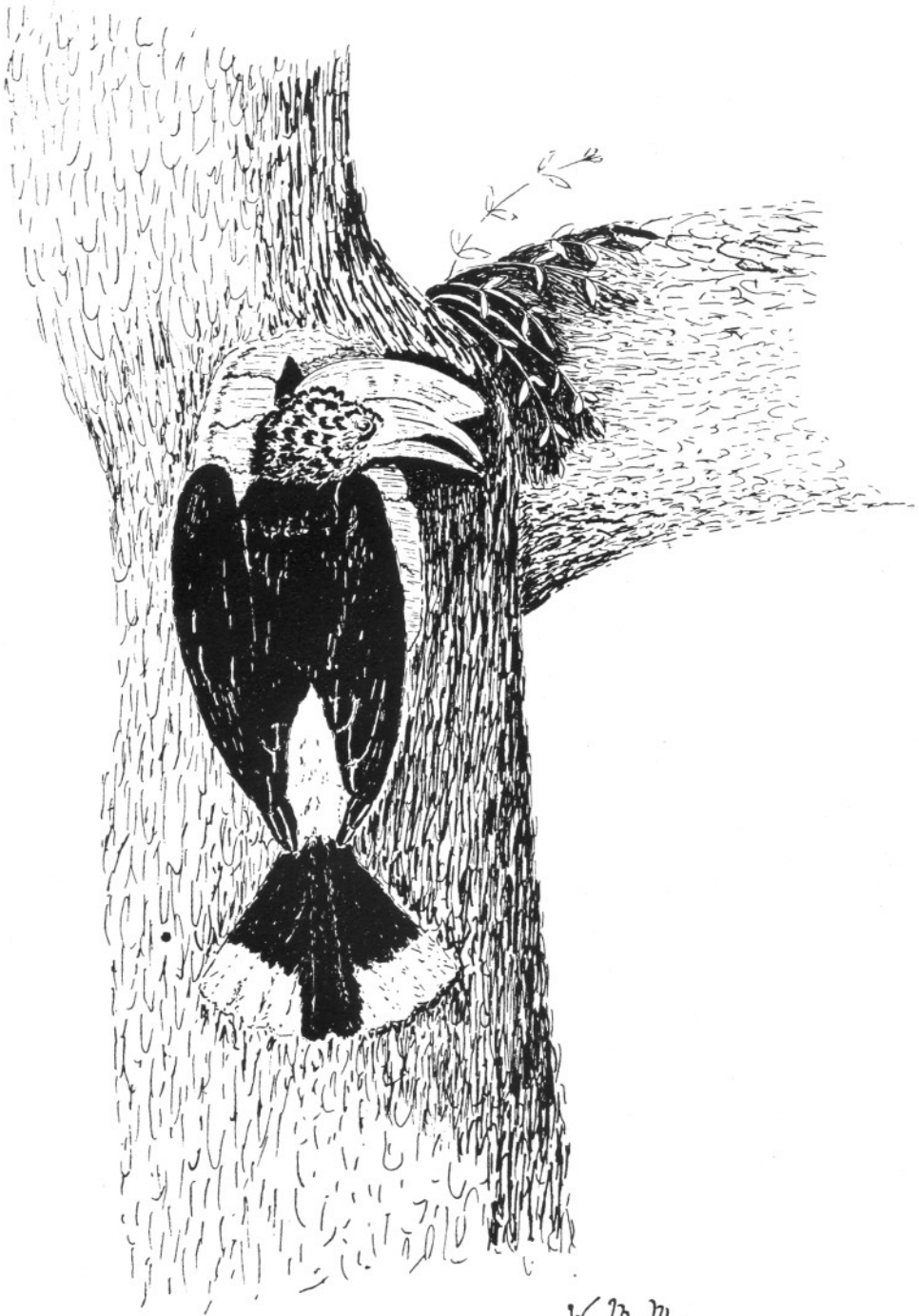
The male's part was confined to "outside work," the bringing of material, except at the very beginning of operations on the Amani hole. Thus, when the female was making the initial clearance of rubbish from the interior the male sitting outside occasionally took it from her beak and dropped it at the foot of the tree. On 30/10/34 the male twice appeared to me to affix something to the rim of the nest and to press it with his casque, but this was never seen afterwards. On this date he also entered several times after giving the female pellets. From Venables' notes this happened only once on the follow-

PLATE 1.



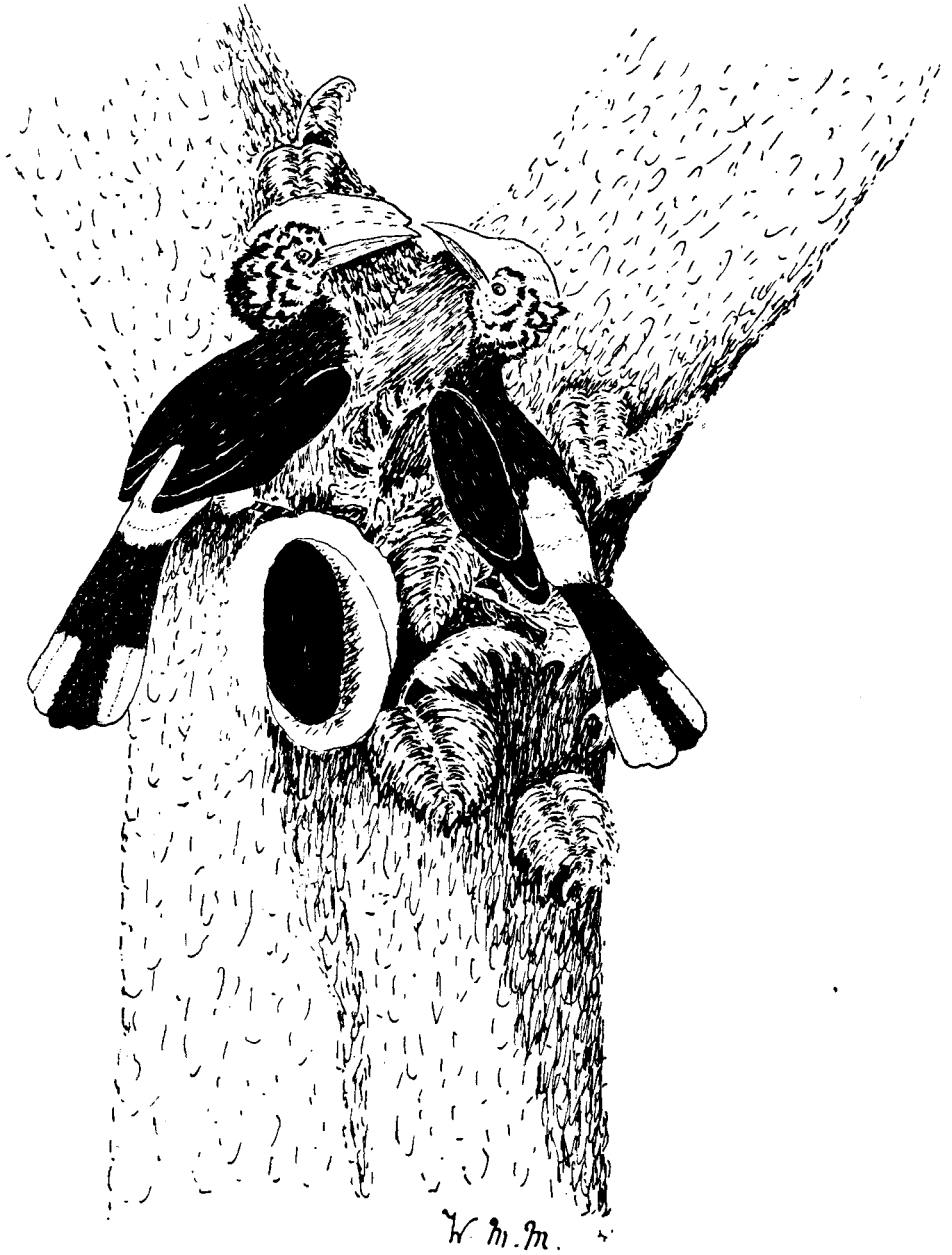
Head of young *BYCANISTES CRISTATUS* showing shape of bill.

PLATE 2.



*H. M.*

Male clinging to entrance of nesting hole.



Male and female perched above nesting hole.

ing day; and in the course of the subsequent extensive watching none of us ever saw the male enter again, although throughout the 1934 spell of building there remained enough room for him to do so and he obviously took a keen interest in the progress made by the female inside.

At both nests she was responsible for practically the whole of the actual construction. On arrival in the morning she often went straight in, but sometimes approached by stages down through the top of the tree with a curious air of circumspection. I particularly noted on the morning of 24/11/35 how when she arrived for the first time she examined the whole exterior of the nest most carefully. Then, contrary to her usual custom, she did a certain amount of work clinging to the outside with her head in through the opening.

It was never possible to observe closely the actions of a female inside the nest. When pellets were being added she could sometimes be seen to smooth and press them with the flat of her bill. But before the male had brought his first pellet of the day her head was often in active movement inside, apparently hammering and scraping.

The only important exceptions to the females' custom of doing their work from inside the hole were seen in the last stages of the building at Amani. On 24/11/35 at 14.09, when the female had emerged with difficulty, I watched her put her head in again and work obscurely inside. While in this position she accepted pellets from the male and placed them inside. After a few minutes' flight together she settled again outside the hole and I noted:—

“ She works from outside as before. Withdraws head with a lump of plaster quite two inches in diameter. Moves to upper boss working lump in mandibles. Bends down as if trying to replace lump. Then jumps back to lower edge again. Male comes to boss and leans down as if to take the lump from her, which she then lets fall to the ground.”

On 28/11/35, the last day they worked at all, she did it first from within the hole, and then, forcing her way out, from outside, I noted:

“ 12.50. Male arrived with large red lump apparently soil. Sat on boss alongside female. She accepted the lump and swallowed it. Male then produced seven pellets which female took and, bending down, added one by one to the walling with a rapid rivetting motion of the head. After peering about inside the hole she hacked off lumps of the brown basal part of the epiphytic fern by the nest and put them inside. At one stage male took a bit from her and held it till she was ready to place it. 12.59 . . . Female dropped fern, refused pellets offered by male, and flew away.”

The fact that on this occasion the female appeared to swallow a lump of soil brought by the male, in conjunction with the regularity with which dry soil was brought to the Ngua nest in 1935, makes it probable that to a certain extent the female is capable of elaborating plaster for herself. On the whole, however, the tempo of building is set by the male, and an exceedingly variable tempo we have found it. Except on the single occasion quoted in the last paragraph, there is no record of her ever refusing material offered by the male, and although she often kept him waiting in the middle of a pellet sequence it always appeared to be because she was busy. She evidently worked with great care; for example when on 6/11/34 she kept him waiting from 10.33 till 10.53 Venables noted that whenever she was visible she seemed to be working. Generally the male's absences varied between a quarter and half an hour, but he often brought very little when he did come. Thus between 09.24 and 13.12 on 6/11/34 Venables saw only 69 pellets given as a result of six visits.

The birds made appreciable progress with their building after that date but there were long spells of indolence. On 19/11, the last day in the 1934 season when the pair spent any long period at the nest, they were there for two hours without doing anything at all towards completing the plaster. As showing the nature of the interest both birds still took in the hole, extracts from Venables' notes may be reproduced :—

- “ 09.14 Pair arrive hole calling loudly. Both frequently look in and sometimes ‘ kiss.’
- “ 09.19 Female climbs up nearby liana but male continues to look into hole.
- “ 09.20 Male also climbs up liana; does not touch female, but she flies away. . . .
- “ 10.04 Pair arrive—male to hole, female to nearby tree. . . .
- “ 10.10 Both to hole. Female clings to entrance, male on usual place [the overhanging boss]. Both often gaze in.
- “ 10.14 Female joins male and sits with back to hole. He continues frequently to look in.
- “ 10.26 Male leaves. She turns round and sometimes looks in.
- “ 10.38 He returns. They nibble each other's bills and look into hole. Later ‘ just sit ’ [on the boss].
- “ 11.02 After further peering alternately female enters.
- “ 11.08 Male looks in, turns tail, and leaves.
- “ 11.11 She comes out and sits on boss.
- “ 11.27 She flies off.”

**" PERSONAL RELATIONS " BETWEEN THE PAIR DURING BUILDING.**

In popular accounts of hornbill nesting—derived from I know not what source—it is usually implied that the male exercises some compulsion.

In our experience of *Bycanistes cristatus* so far from the male's driving the female into the nest he repeatedly arrived there alone. If, as sometimes happened, when she did arrive she merely flew off again without entering, the male followed her with no signs of resentment.

Only twice was he seen to urge or assist her into the hole in any way. At 10.16 on 6/11/34, in an early stage of building, when the pair had "wasted" an hour at the still wide-open hole without doing any work and she was sitting on the rim with her rump and tail out, he "touched" (perhaps nipped) her rump with his beak and she went in" (Venables). "In a few moments her head appeared in the hole and she sat with it outside. He leaned down from his perch, but before his beak touched hers she withdrew, only to re-appear as soon as he sat up." At 10.20 she withdrew her head and began to work inside.

At 11.15 on 27/11/35, by which date the female was having great difficulty in forcing her way in and out, Mrs. Moreau noted :—

"Both arrive. She tries to get in. Unable. She looks up at male [on the usual perch]. He places his bill behind her neck and gently pushes her head into the hole. She tries again unsuccessfully and again lifts her head towards male. He ignores her and she tries again, putting one wing forward. She is almost in when male pushes her vent with his casque and at 11.25 she is in."

No "display" was ever seen; there was much evidence of what may be called affection but little of passion. They frequently nibbled each other's bills and the male was seen to bend down and caress the female's neck on one of the rare occasions when she worked from outside the hole. Copulation was observed once each season about ten days before work ceased, both times when the female emerged after a morning's work. Venables recorded the occurrence on 6/11/34 as follows :—

"Both are side by side on a branch [just above the hole]. He jumps once on and off her back like a House Sparrow. Then on immediately afterwards and mates. Both birds have wings folded to side and male balances by tail only. No display and both silent. Coition takes about eight seconds."

During the building we all gained the impression that the hornbills' actions were more deliberate and less mechanical than those of



many small birds when nesting. Quite apart from their affectionate passages they seemed to be aware of each other personally to an unusual degree. Our impression doubtless owes much to the constant close interest the male showed in the female at work, bending down and peering into the hole at her. But several incidents, slight in themselves, were noted that seem to indicate an unusual relationship between the birds:—

1. In the male's absence the female had come out of the hole about 13.30 after a four-hour spell of work, evidently ready, as usual by then, to depart until the following morning. When, however, he appeared just afterwards, she evidently realised he had pellets; she clambered in again, a thing most unusual at the end of the day's work, accepted them and placed them before flying off with him.

2. As just related, after she had twice failed to get into the hole the male helped her, apparently at her request.

3. He had arrived first and, contrary to his custom, was examining the hole from its lower side. When she came in sight he apparently realised he would be in her way, and he moved, before she alighted, to give her clear ingress.

4. While he sat on the boss above the hole, she, outside, hacked off a lump of fern base. This she gave him to hold for a few moments until she had done a little work inside, apparently preparing a place for it.

5. When the Ngua female made her final entrance in 1935 the male showed great excitement. This was not observed with other entrances of either female, however difficult.

#### THE PERIOD OF NEST OCCUPATION.

Throughout the period of approximately four months during which the female did not leave the nest, the male made a number of visits each day and practically never failed to bring fruit with him. Except that he sometimes carried a large-sized fruit in the tip of his mandibles the fruits were carried in his gullet and disgorged in exactly the same manner as the pellets.

At the Ngua nest it was usually possible to see the size and colour of the fruits the male brought. Occasionally he let one fall which we were able to collect by searching at the foot of the tree. These dropped fruits never showed any signs of digestion even when the male had been carrying them inside him for so long as 35 minutes; and with the help of these specimens we were eventually able to make sight identifications of many of the fruits brought by the male as he passed them in. Year after year the bulk of the fruit brought consisted of stone-fruits the

size of small cherries, *Sersalisia usambarensis* up to about the end of December and thereafter "mbambe."\* But these staples were supplemented with a variety of larger fruits among which Greenway identified *Canthium* sp., *Passiflora edulis* (the introduced passion fruit), *Ficus* sp. (fig), *Odyndea Zimmermannii*, and *Heterophylla* sp.

Owing to the narrowness of the slit we could never observe the actions of the birds inside the nest hole. When the male was offering food or bark at the slit it was always taken immediately, and when he had actually alighted at the hole piping and grunting, presumably of the young and the female respectively, could sometimes be heard. Once I observed that as the male passed a large fruit through the slit the grunting was momentarily strangled. The male himself spent some time each day on the upper branches of the next tree but was always silent. It was remarkable that as observed in every season, the birds inside the nest made no sound except when he was actually at the hole; thus his visits could not have been stimulated by manifestations made by his family.

The birds inside did not push their heads nor even their bills out. Except when the male was at the hole the only sign of occupation was that at intervals some small object which glinted in the sun would come hurtling out and fall to the ground. I conclude that they were fruit-stones, for among the dejecta at the foot of the tree I found "mbambe" stones that were perfectly cleaned but still moist. Almost certainly they were "casts." At my request the authorities at the London Zoological Gardens have kindly tested the hornbills there and I am indebted to Mr. C. R. Stonor for information that they "cast" the stones of fruit they have eaten.

The question now arises of the sanitation of the nest. The excrement of two large birds over a period of nearly four months would, one supposes, have to be got rid of in some way. The male took nothing away from the nest hole. On the ground underneath it, where there was a slight smell of guano, I found four kinds of dejecta:

1. By far the greater part consisted of cleaned fruit-stones, presumably "casts," numbering probably some thousands.
2. One or two "mbambe" stones associated with partially digested skins.
3. A little pale brown faeces.
4. One or two splashes of whitish faeces associated with millipede rings.

Dr. Worsley analysed these: (2) and (4) apparently contained some uric acid, but (3) none.

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\* "Mbambe" = *Polyalthia oliveri*, Bak. (ANONACEAE).

An excellent series of feeding observations was obtained during the 1935/36 season at the Ngua nest by utilising African observers who watched on two days a week from dawn to dusk. Table 1 summarises their field notes. I was occasionally able to check the records of observer S(imon) by independent watching. Observer I(di) was employed when I was away and Simon could not be spared. It will be noticed that on two days remarkably high figures were recorded by Idi. I can only say that there was nothing suspect in the detail of his field-notes, and when I cross-questioned him I could not shake him. Moreover on 18/3/33 I myself saw 77 fruits (62 "mbambe" and 15 of the large *Canthium* sp.) given in four visits between 08.40 and 09.54, i.e. in 74 minutes. If this rate were maintained through the ten-hour working day it would give a total considerably exceeding that recorded by Idi.

Date.	Watcher.	Time of male's first visit.	Time of male's last visit.	No. of visits by male.	Longest interval between visits.	Shortest interval between visits.	Total number of fruits brought.	Greatest number of fruits at a visit.	Average no. of fruits at a visit.	No. of pieces of bark brought.
					mins.	mins.				
19/11/35	S.	06.40	17.05	10	127	10	115	31	11	2
22/11/35	S.	09.00	16.34	12	95	16	111	19	9	—
25/11/35	S.	07.02	16.34	11	110	13	102	21	9	3
28/11/35	S.	07.25	15.35	13	85	11	79	9	6	1
1/12/35	S.	08.09	16.03	14	132	12	89	10	6	—
8/12/35	S.	07.45	16.28	11	99	26	104	20	9	—
11/12/35	S.	07.40	16.04	11	119	9	123	25	11	—
15/12/35	S.	07.15	16.08	11	92	19	143	27	13	—
22/12/35	S.	08.05	16.45	11	91	25	154	30	14	—
25/12/35	S.	07.55	17.16	12	81	16	156	25	13	—
29/12/35	I	07.10	17.10	15	110	14	231	39	15	3
2/1/36	S.	07.10	17.18	14	90	18	237	29	17	1
5/1/36	I.	07.15	17.39	16	73	13	209	30	13	4
9/1/36	I.	07.08	17.12	17	80	6	228	28	13	5
12/1/36	I.	07.11	17.49	16	71	20	248	32	15	5
16/1/36	I.	07.18	17.45	21	72	9	342	35	19	8
19/1/36	I.	07.02	17.05	19	56	11	262	35	14	6
23/1/36	I.	07.20	17.52	24	59	11	569	45	24	1
26/1/36	I.	07.12	17.09	22	57	8	504	42	23	2
30/1/36	S.	07.23	17.41	20	78	11	300	28	15	4
2/2/36	S.	07.27	17.52	17	89	15	313	29	18	5
6/2/36	S.	07.18	17.43	18	80	12	336	33	19	5
9/2/36	S.	07.19	17.49	19	84	11	341	30	18	5
13/2/36	S.	07.09	17.58	18	110	7	332	31	18	—
16/2/36	S.	07.14	17.53	16	76	17	279	27	17	1
19/2/36	S.	07.06	17.51	17	81	9	270	23	16	—

Whether or not we accept the exact numbers recorded by Idi certain facts emerge clearly from Table 1. Until the end of December, when the female had been in about seven weeks, the daily number of the male's visits remained very constant. They averaged 12, and varied only between 10 and 14. Thereafter the number increased steadily to an average of 21 during the latter half of January (maximum 24 on 23/1), followed by a slight but definite decline. During the last three weeks before the birds came out of the hole the male's visits varied from 16 to 19 a day.

Since a variety of different fruits was brought to the nest a comparison of the daily totals of fruits lacks equal exactitude and force; but it is true that throughout the period fruits of small-cherry size formed the bulk, and it is at once apparent from the table that the daily totals of fruits followed a similar curve to that of the daily number of visits. The smallest rations are at the beginning, from 79 to 115 fruits, with an average of 100 for the first five weeks the female was in. Then, nearly three weeks before the daily number of visits rose, a slight progressive increase began in the daily total of fruits. By the tenth week the average number had risen to over 300, where it remained until the week before the birds left the hole.

"Mbambe" fruits were at that time the staple food. I ascertained that they averaged 2.2 gm. in weight including their 1.0 gm. stone. Thus, towards the end of the fledging period the female and (one) young received quite 360 gm. (11 ozs.) of edible material and probably more, since there were some bigger fruits included in the daily total of 300 odd. This compares with a "live weight" of about 1,200 gm. for the two birds combined.

The intervals between the male's visits were variable at all times; there was always at least one interval of from one to 2½ hours during the day when he did not come, but his shortest interval in any one day never exceeded 25 minutes and was sometimes as short as 8.

The table gives a total of 6,176 fruits brought to the nest in 26 full working days. Therefore during the whole period of the female's residence in the hole the male must have passed in about 24,000 fruits, and it appears also that he must have made 1,600 visits with food.

One element in the male's behaviour during this period is at present quite unexplained, namely that he often passed in a piece of bark before beginning to disgorge a cargo of fruits. According to the records he brought bark irregularly during the first eight weeks, and never more than three times a day; but from 5/1 to 9/11 the average was nearly 5, much greater than recorded during the building process.

The male seemed to select the bark with some care, and he often played with it, tossing it about and chewing it for as much as 15 minutes. To pass the bark through the hole he had to get it held

vertically by its edges in his mandibles, and in his endeavour to do that he often broke the bark or dropped it. Thus, during a short spell of watching on 1/1/35 I noted:—

- “ 10.15 Male gave bark and 29 ‘mbambe.’
- “ 10.53 Arrived next tree, tore off lump of bark, carried it to high branch of next tree, played with it and dropped it. At once went to hole and gave seven ‘mbambe.’
- “ 11.06 Landed on (living) Polyscias tree and chipped at epiphytic mass. Passed to nearby dead tree and detached large curled lump which he brought to upper branches of nest tree. He played with it, tossing and chewing it, until it was all broken up. Then picked bark off nest tree and took it straight to hole. Followed by disgorging four large fruits.”

If the table be examined a modification in the male's habits is discernible about seven weeks after the female's entrance. Up till then the time of his first visit in the morning varied between 06.40 and 09.00; for the last eight weeks he was remarkably punctual, always between 07.02 and 07.27. About the same date he also began to work longer in the afternoon, making his last visit between 17.10 and 17.58, whereas previously he had often given the female her last feed before 16.15. In effect the male increased his working day from eight to ten hours.

It will be seen from the table that this change took place between 22 and 29/12/35, and that a marked rise in the daily number of visits and fruits took place between 25 and 29/12. (The supply of bark increased sharply a few days later.) These facts point to a probability that the young bird was hatched about 25/12, but the period of 50 days that elapsed after the female entered seems unreasonably long; the observations collated elsewhere (Moreau in press) tend, however, to explain this in that they show delay and irregularity in laying to be characteristic of hornbills in general.

I commented above on the slight decline in the number of visits the male made in the last few days before his family emerged. Certainly the decrease in the number of fruits he brought on 16/2 and 19/2 looks significant. If now reference be made to the account of the female's exit on 21/2 it will be seen that on that morning the male made his first two visits without bringing any food, although he produced fruits when his mate had begun to break her way out. These observations are important because we have no other record of the male's coming to the tree in the morning without bringing food to the nest. On the whole the points mentioned in this paragraph combine to indicate a slackening in the male's attentiveness and perhaps an

awareness that his family were due to come out and provide for themselves. But previous to that the male had increased the amount of fruit he brought to meet the growing needs of his family, although they did not give him the vocal stimulus often considered important in ensuring adequate attention on the part of parent birds in general.

On the interesting question of the female's condition in the nest, and especially whether she moults so suddenly and completely as to be incapable of flight, like some *Lophoceros* females, we necessarily learnt nothing. It is, however, worth noting that female *B. cristatus* are to be seen on the wing all the year round, and one collected shortly after the nesting season of the species was moulting gradually though irregularly. The possibility that broodiness alters the whole physiology of the moult of course remains.

#### BREEDING BIOLOGY IN RELATION TO THE MAINTENANCE OF THE POPULATION.

There is no evidence that the clutch of *Bycanistes cristatus* ever exceeds two, the number ascribed to it by native informants (cf. also Mouritz, 1914). Since the breeding season is so well defined and a clutch with the accessory repair of the nest occupies the birds for at least four months, it is certain that only one brood a year can be reared.

The biotic potential thus indicated is low; but even so it appears to me that in Usambara it cannot be either external biological controls—still less climatic—that play the chief part in maintaining the stability of the *Bycanistes* population. The hornbills are large, with powerful bills and feet, and they are removed beyond the range of several predators by the fact that they rarely leave the tops of tall trees except when building, and then only the males. The only creatures that can be conjectured as a source of mortality to adult *Bycanistes* are the accipitrine birds *Stephanoaëtus coronatus*, *Gypohierax angolensis*, and, more doubtfully, *Circaëtus fasciolatus*. Perhaps by night the great *Bubo lacteus* may raid a roost. We have seen a male hornbill stop work and "freeze" when a *Gypohierax* landed on the nest tree, but the small eagle *Aquila wahlbergi* was repeatedly chased away. Drongos often mob these hornbills. A pair of the forest species, *Dicrurus l. ludwigii*, constantly worried the Amani male while he was bringing material to the nest, but I do not think they seriously interfered with his activity.

Mortality in the nest-hole from predators is probably ruled out by the powerful combination of protective factors: the position of the holes favoured, the strength of the mud wall, the narrowness of the slit left in it, and not least the uninterrupted presence of the mother bird there with her great beak. In any case, the only nest raider of potential importance in Usambara is the "Blue Monkey," though the several squirrels, including the flying species, *Anomalurus orientalis*,

and locally the Harrier-hawk, *Gymnogenys typicus*, might perhaps have to be reckoned with.

Neither old birds nor young just out of the nest have yielded an appreciable number of ectoparasites, so that I doubt the importance of these as a control.

The really effective control is that a large proportion of the birds do not breed every year. This is proved by the fact that roosting concentrations with no obvious change in the proportion of females are to be seen all through the year, and never more obviously than during the breeding season. Three causes probably contribute to this effect.

1. The very large holes required must be limited in number, especially those of suitable form, even in a forest like that of Amani. And such holes are always liable to be occupied by bees. Moreover, it seems likely that an otherwise desirable hole may temporarily "wear out." Since the Ngua tree was killed by fire in 1932 the male has worn away the bark at his particular perching spot so that it is difficult for him to get the necessary grip where he wants to. This is quite intelligible when it is remembered that in every season he clings just below the hole for several minutes on 1,600 occasions with food and on others besides with material. The sketch in Plate I was done in 1933, when he could perch so that his head was comfortably on a level with the top of the slit. By 1936 he could only get a grip with his feet lower down and he had to stretch his neck to reach the slit at all. He will probably get his position back when the substance of the tree has rotted or cracked enough to give a new grip.

2. The young may not be sexually mature until they are some years old. van Someren (1922) has given reason to suppose that this is the fact with the Ground Hornbill, *Bucorvus cafer*. It appears, however, that in *Bycanistes cristatus* the parents and young cease to form a family unit soon after the latter fly and do not stay together for years as van Someren records of the Ground Hornbill. The young *Bycanistes cristatus* are to be found at the communal feeding and roosting places practically as soon as they fly, and there is a tendency for young birds to keep together. We once saw nine of full size but with the bills of immatures, engaged in horse-play, shoving each other about on the branch of a tree and wrestling with their bills.

3. It is clear from the history of our nests that what may be called internal causes operate powerfully to reduce the rate of reproduction. Of six attempts at breeding that we have had under observation three came to nothing after the birds had spent several weeks on the preliminary stages. In two consecutive years at the Amani nest, they appeared to exhaust the breeding impulse in

the effort of building and to this result defective salivation in the male might have contributed. In the Ngua nest the female broke her way out shortly after entering, perhaps owing to failure of impregnation.

I conclude that in the control of the *Bycanistes* population internal factors are the most important.

### LOPHOCEROS DECKENI.

This hornbill is confined to semi-arid East Africa from Somaliland through Eastern Kenya to just south of the Tanganyika border. Nothing of its biology appears to be on record except for the few notes by Moreau and Moreau (in press). The bird appears to belong to dry *Acacia-Commiphora* bush up to about 4,500 feet. Its food consists mainly of invertebrate animals, and it also eats buds and berries.

#### THE LONGIDO NEST: 1932-1936.

All the observations that follow were made at Longido, north of Kilimanjaro, by Mr. S. A. Child, except for a few I was able to make at the same nest in January, 1936. The hole was about 12 ft. from the ground in the trunk of a big acacia tree, and its entrance was hardly more than 2 ins. in diameter, impossibly small one would think for the passage of a bird the size of this hornbill.

In 1932 it was frequented by a pair of starlings, *Spreo hildebrandtii* which probably laid eggs there. A pair of Van der Decken's hornbills paid occasional visits which were fiercely resented by the starlings. In January, 1933, the hornbills took possession, clearing out the hole and apparently enlarging its interior. The female did most of the work from outside.

The date she entered that season is unknown, but she emerged on 7/4/33. The hole was re-sealed, leaving a vertical slit no more than  $\frac{5}{16}$  of an inch wide. Both parents brought food to the young until they flew on 30/4. The young themselves began to pick away the plaster on 28/4 and the old birds appeared to give them no assistance. Thus the young remained by themselves for 23 days after the mother had left them.

In February, 1934, the hornbills were mating again. Unfortunately Child was away on duty for most of March; but when he returned on 28/3 the hole was closed and there is reason to believe that the female made her entrance between 12 and 20/3. She emerged on 27/4 and the hole was re-sealed at once. Judging by what little he could see through the slit, Child thought that the young might then be about three weeks old. They squalled and pecked energetically at the



slit if he touched it. Both parents brought food till 24/5, when the young pecked their way out.

In the 1935 season Child learnt the complete story, recorded as follows :—

25 and 26/2. Pair at hole.

27/2. 09.00. The hole which was completely open the preceding afternoon is now sealed.

29/3, 17.00. Child removed two-thirds of the plaster. Female at once began re-sealing with fibres torn off the inside of the nest hole. No material from outside was used. While she was working she could be heard tapping like a woodpecker.

30/3, 12.00. Hole completely re-sealed.

17.00. Child broke away a piece of the new plaster. He also bored a hole in the tree-trunk about six inches below the slit and with the aid of an electric torch saw two eggs in the nest cavity, one of them chipped and squeaking. He re-plugged his observation hole.

17.10. Female began re-sealing again, using the side of her bill to press the material into place and tapping quickly.

2/4. Nest contained one egg and one perfectly naked young bird, which in the light of a torch looked creamy white.

4/4. Second egg hatched.

10/4. Both young still practically naked.

24/4. 09.00. Female seen out for the first time. Her plumage very fresh. Hole already re-sealed.

25/4. 15.00 Child removed sealing and saw young were partially feathered.

16.00. Hole already partly re-sealed from inside. One young bird, obviously bigger than the other, seemed to be doing most of the work, using exactly the same methods and material as the mother had when she sealed originally. The young birds' bills were already quite hard and they bit vigorously when Child poked a finger into the hole.

The bills of the two young were already coloured differently. One, presumably the female, had the whole bill dark with a few paler flecks. The other showed the same pattern as the adult male, but what would become the red part was paler than the future white part.

26/4. Child removed some of the plaster and it was repaired in a few hours, just as it had been a few days before.

14/5. The young began to peck away the plaster.

15/5. 08.30. Only the female young bird was left in the hole. The young male had gone right away.

16/5. Young bird in the hole kept putting her head out, peering up and down and pecking at the sides of the hole.

17/5. Child wished to photograph the young bird as it came out and tied a string across the hole until he was ready.

18/5. He removed the string but the young bird stayed in. Afterwards he re-strung it.

19/5. He found the string pulled away and the young bird gone.

From late November, 1935, onwards a pair of *Lophoceros deckeni* again frequented the tree, courting and copulating. They put their heads into the hole frequently but were not seen to enter until 3/1/36, when the female sealed herself in again.

When I examined the hole with Child on 15/1/36, we found that the twigs with which he had blocked his observation hole in the previous season had been removed. In their stead bits of bark, on which the two white eggs were lying, had been piled in from the inside. The nest gave out a sour smell, but from the strip of white dung at the foot of the tree it was evident that the bird voided outwards through the slit. She was capable of much expelling power, for the dung extended up to three feet away. On analysis Dr. Worsley found this dung to contain plenty of both urea and other nitrogenous matter.

At 09.15 on 15/1 I chipped away the whole of the walling, the bird inside remaining perfectly quiet while I did so. The plaster was dark grey, sour smelling, and very hard. Under the microscope it could be seen to contain much fibrous material, mixed with fragments of insects. Worsley's analysis showed that it might contain some dung.

By 08.00 on 16/1 little had been done towards re-sealing. Eight hours later good progress had been made. During the greater part of this period I had the nest under observation, and I saw the male visit it frequently. On each occasion he held a single small morsel, apparently an insect, in the tip of his mandibles. He passed this through the slit and always flew away at once without disgorging anything. Once only he brought a scrap of bark which I saw him break off the nest tree. I conclude that the male brought practically no material specially to assist the female to rebuild the plaster I had removed, and that she elaborated it all for herself out of the remains of food and rubbish (chiefly rotten wood) available in the hole.

Between 09.30 and 12.30 the male fed the female 17 times with, among other things, a large grasshopper, a fat white larva (twice), and a very large mantis. He always came gliding up to the hole swiftly and silently, clung to the bark for a matter of seconds only, and departed again as he had come. It is remarkable that when he made

his first visit with food 15 minutes after I had removed the plaster he showed no surprise at finding the hole open, but settled and fed the female without hesitation.

Child's observations in the four seasons may be summarised in the following table. It is unfortunate that his transfer from Longido leaves the history of the 1936 nesting uncompleted.

TABLE II

Year.	Date female entered.	Date young hatched.	Date female came out.	Date young flew.
1933	...	?	...	7/4 ... 30/4
1934	...	15/3 ± 13	...	?
1935	...	27/2	...	(31/3), 4/4 ... 24/4 ... 15/5, 18/5
1936	...	3/1	...	?

DISCUSSION OF THE OBSERVATIONS.

The first young bird was hatched 33 days after the female entered but it is not known what delay, if any, took place before she laid. Almost certainly there was an interval of several days between the two eggs, because one was hatched four days after the other, a difference that persisted to their fledging.

The female left the young after being nearly eight weeks in the nest, when they were only 21 and 25 days old, but they were capable of replacing the broken plaster at once, and apparently of elaborating its substance themselves. After the female's departure the young remained in the nest for periods varying from 22 to 28 days in successive years.

The dates the female entered in the four years show that there is a definite breeding season at Longido, with an annual variation of about 10 weeks. This variation might be expected from the irregularity of the most important element in the local climate, which is the rainfall; but the connection of the breeding date with rain is far from obvious. There was a great deficiency of rain in both 1933 and 1934, associated with complete failure of the "long rains" of March to May, when most of the annual total is expected. But the persistent drought by no means inhibited the breeding of these hornbills, as, according to Child's information, it did for most of the local birds. But in 1936, following the unusually generous rain of December, 1935, the female entered on 3/1, much earlier than in preceding years.

In 1933-1935 the fledging of the young fell within the period when the "long rains" were to be expected. At first sight then the initiation of breeding in this hornbill is timed to secure optimum food conditions; but until we know something of the phenology of the invertebrates on which the birds feed it would be wrong to jump to this

conclusion. It is worthy of note that although the expectation of "long rains" was not fulfilled in either 1933 or 1934 the young were reared. And in 1936 the female entered so early that nearly all the food would have to be supplied to the nest before the "long rains" would normally be expected.

#### LOPHOCEROS MELANOLEUCOS.

This hornbill is more wide-spread both geographically and ecologically than either of the species dealt with above. It is mainly a bird of long-grass short-tree savannah throughout South and East Africa, but it also recurs in semi-arid thorn-bush and in the edges of evergreen forest, up to at least 7,000 feet. It has a wide range of diet, small vertebrates as well as invertebrates and fruit. Nestling birds are eaten, and we have seen these hornbills buffeting a nest of *Ploceus bicolor kersteni* in an attempt to knock the young ones out. Reichenow (1900), Stark and Sclater (1903), and Cowles (1926) have published useful notes on this species.

On 22/1/36 Mrs. Moreau found an occupied nest 25 feet up in a *Piptadenia* trunk in fringing forest at the foot of Kilimanjaro. A natural hole about five inches by four had been blocked with grey plaster to leave a slit about  $\frac{1}{2}$  inch wide. The young birds raised their whickering hunger cry whenever a fair-sized bird passed their side of the tree, whether it was a hornbill or not. The usual fan of whitish dung extended for a few feet away from the foot of the tree.

When we watched the nest it at once became apparent that both the male and the female were bringing food to the young. Instead of clinging to the trunk they regularly used a small branch which hung down at a steep angle within reach of the hole. On 23/1 in the 3 hours 20 minutes between 08.40 and 12.00 they made 18 visits, on 14 of which they passed food (alway a single morsel brought in the tip of the mandibles) into the nest. Fruit and grasshoppers were occasionally distinguishable. At one visit on 22/1 a small bird was brought to the nest, apparently a Paradise Fly-catcher (*Tchitrea viridis*) about ready to fly. The hornbill kept on chewing it to reduce its bulk, but always failed to get it through the slit, and finally flew away with it. On two occasions on 23/1 the old birds brought bark to the nest. The second time, after repeated attempts to get the bark into the slit, the hornbill let it drop, caught it again cleverly before it reached the ground, and flew away with it.

*L. melanoleucos* breeds about the beginning of each year in the garden of Col. the Hon. M. T. Boscawen at Moa (on the coast about 70 miles south of Mombasa). He informed me that in 1936 their usual hole had been occupied by bees and they took over another about  $\frac{5}{8}$  inches in diameter, which they plastered to leave a slit 3 inches by  $\frac{3}{4}$ . On 14/2/36, when the female had been in about a fortnight, he removed

some of the plaster for me and also sent some of the dung, which the female squirted to a distance of several feet out of the hole. As with *L. deckeni* she made no disturbance when the plaster was removed and no attempt to come out. Col. Boscawen tells me that he could see her working to repair the plaster, which was complete again in about four days.

The plaster strongly resembled that of *L. deckeni*, hard fibrous material mixed with fragments of insects, but it was less well compacted and coarser in grain. Dr. Worsley found that it gave only a faint reaction for nitrogen, whereas in the bird's dung the indication for nitrogen was very strong. This made it practically certain that the bird's own dung was not an important constituent of the plaster.

Later Boscawen wrote :—

" The female left the nest 13/4. There seemed to be three young all well grown. Both male and female fed them with large insects, chiefly large mantis, but I also saw cicadas and caterpillars being taken.

" For the first two or three days after female left no apparent attempt made to repair plaster. The young then began to rebuild from inside and by 20/4 the hole was much the same as when the mother was inside.

" 25/4. Plaster again broken and I noticed young looking out of the nest.

" 27/4. Early morning all young had flown."

These observations show that the female was in the nest 60-73 days, probably nearer the latter, and that the young flew about 14 days after she had emerged.

#### SUMMARY.

*Bycanistes cristatus* breeding activity in Usambara starts about the end of October with a regularity difficult to explain in view of the equable evergreen conditions.

In one nest probably three broods were reared in four years. In the remaining year the female burst out and flew away about three weeks after the hole had been closed.

At a second nest the pair worked for a month in 1934 and a fortnight in 1935; but although at the end the nest seemed ready they never occupied it.

Practically all the material for closing the nest was brought by the male and the placing of it was done by the female working from inside. Hours of work were only from about 10.00 till 14.00. At the end of them the female came out so long as she could squeeze through the constricted entrance.

The material consisted mainly of pellets elaborated in the gullet of the male from dry earth and disgorged in series up to 42 at a visit. The biggest day's work was 235 pellets in 15 visits. The plaster set hard, apparently with the aid of the male's saliva as cohesive agent and with scraps of bark as binders.

Since a day's work involves the impregnation of about 33 cu. ins. of dry soil with saliva by the male, no small demand is made upon his secretions. There is some evidence that they are abnormal at this season. Inadequacy of his saliva may well account for failure to complete plastering.

The female was not in any way compelled by the male to shut herself in. The pair gave evidence of much mutual affection and understanding but little passion.

A female remained in the nest for 108 days, emerging with her (single) young. Both were able to fly at once.

During this period the male made about 1,600 visits with food and brought about 24,000 fruits. At first he averaged 12 visits and 100 fruits in an eight hour working day, but after the female had been in about seven weeks these were all increased. Probably the change marked the hatching of the egg.

When the young was nearly fledged and the weight of the two birds inside the hole was about 1,200 gm. at least 360 gm. of edible material was being given them each day.

Besides food the male brought bark throughout the fledging period. Its use is unknown.

Biological control of the *B. cristatus* population is probably of little effect. The biotic potential of the species is, however, low, and a large proportion of them do not breed in any given year for reasons that are indicated.

#### *Lophoceros deckeni.*

The female elaborated her own plaster out of insect casts and rotten wood from the inside of the hole. No special material was brought by the male. When the plaster was removed she made no attempt to come out and repaired the damage in a few hours.

The female came out about 8 weeks after her entrance, the young being then 21-25 days old. They at once replaced the plaster themselves without external aid. They flew after periods of 22-28 days during which both parents fed them.

These hornbills always brought food in single morsels held in the mandibles, and did not disgorge.

The phenology is discussed.

Plaster used to seal the hole on the entrance of a female consisted of fibres and insect casts, without dung.

A female remained in the nest for about 70 days. On her departure the young themselves replaced the plaster and remained in the hole for another 14 days.

I would wish to draw special attention to the precocity of the young. Such technology as displayed by this species and *L. deckeni*, the latter when only 25 days old, is probably without parallel in the world of birds.

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