

NOTES ON TEN ASIAN HORNBILL SPECIES
(AVES: BUCEROTIDAE); WITH PARTICULAR REFERENCE
TO GROWTH AND BEHAVIOUR

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SUMMARY

Predominantly as a result of keeping captive birds over several years miscellaneous observations on behaviour and growth and development of the Asian hornbills (Family Bucerotidae) *Berenicornis comatus*, *Psittolaemus tickelli*, *Anorrhinus galeritus*, *Penelopides panini*, *Rhyticeros undulatus*, *R. narcondami*, *Anthracoceros malayanus*, *A. malabaricus*, *Buceros rhinoceros*, *B. bicornis* are presented and illustrated. As much information on sunning, bathing, plastering, allopreening behaviours and growth and development is new the scattered literature on these aspects is briefly reviewed for comparative purposes. Details of bill and casque growth rates are described for *Rhyticeros undulatus*, *Buceros rhinoceros* and *B. bicornis* and these data represent the first documented account of time required for bill morphology development.

INTRODUCTION

Little is known of the general biology of most species of hornbills, despite the fact that the forty-five or so species in the family (Bucerotidae) represent a most interesting, homogeneous, and unique group of birds, particularly with regard to their peculiar reproductive habits which have been briefly summarized by BANNERMAN (1964), who stated that "no group would better reward further investigation".

Hornbills are very large to medium sized, long-lived, birds that predominantly nest high up in holes of larger trees and seal their nest entrance in such a way as to make field studies of reproductive biology almost impossible without the availability of much time and money (ROOT & ROOT 1969). Moreover, many of these birds travel considerable

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distances in the daily cycle of feeding and roosting activities. As a result of the practical difficulties of studying these birds in the wild almost nothing is known of the Asian species other than what has been learnt from limited, brief, observations at nesting trees (BARTELS & BARTELS 1937, 1956; LOWTHER 1942; MADGE 1969) and from birds in captivity (PRIMROSE 1921; GEE 1933; STOTT 1951; HUTCHINS 1976). We do know more of some of the African species, however, as a result of the works of RANGER (1931, 1949, 1950, 1951, 1952), MOREAU (1936, 1937, 1938), MOREAU & MOREAU (1940, 1941), NORTH (1942), KILHAM (1956), KEMP (1969, 1976) and KEMP & KEMP (1972) and others. In particular, very little data at all are available concerning the growth and development of any hornbill species.

In view of the general deficiency of knowledge of the Asian hornbills we present here data concerning ten such species, most of which information has been gathered as a result of maintaining captive individuals. Casually recorded, and limited, though some of these data are, they do represent much information concerning behaviour, growth and development, previously unrecorded. Included are the first documented data for hornbill casque growth rates in any hornbill species.

It should be noted that the drawings herein are not intended as artistic renderings, but are no more than schematic diagrams presented in order to indicate various body postures or changes in the bill shape of the individual birds. For brevity the authors are referred to by their initials only.

The species accounts following are listed in phylogenetical order according to PETERS (1945). Vernacular names used are those of KING & DICKINSON (1975) unless otherwise stated, as also applies to scientific names.

For general descriptions, habits and distributions of the species dealt with herein see ALI & RIPLEY (1970), KING & DICKINSON (1975), DELACOUR (1947), DUPONT (1971) and SANET (1960).

WHITE-CRESTED HORNBILL, *Berenicornis comatus*.

The vernacular name White-crested Hornbill is used in preference to White-crowned Hornbill of KING & DICKINSON (1975) as the bird is very distinctly crested and not 'crowned' as commonly applied to birds with a cap of coloration differing markedly from the adjacent plumage such as, for example, the Chestnut-crowned Warbler, *Seicercus castaniceps* of KING & DICKINSON usage (1975).

Two young post-fledged individuals of this species were purchased together by CBF in Bangkok on 19 May 1975, and it is considered possible that they originated from the same nest. Both birds were in ill health when obtained, apparently suffering from a bronchial infection of some kind which caused them to sneeze and cough frequently and exude fluid from the nostrils. After intensive care with high protein and vitamin foods, an antibiotic course and vapour baths, they appeared to recover. Any exertion, however, left them panting and wheezing badly. They did not fully recover, as both died within four months.

The two birds showed small differences in their general plumage but their tails differed considerably (Fig. 1) and these differences probably represent individual variation as is common in other hornbills (see FRITH & FRITH, in preparation). Regrettably only one bird could be sexed by dissection and this individual, a female, had almost normal immature white-tipped tail feathers (Fig. 1). In addition this female had the long crest feathers all pure white, save only one feather with a partly black shaft; whereas the crest feathers of the suspected male had obvious jet black shafts to most of the longer, forward pointing, ones. An examination of specimens of the species in the American Museum of Natural History, New York, indicates that whilst immature males do have black shafts to the forward pointing crest feathers these do not usually persist into adult plumage. Thus it would seem that in these two birds the presumed immature male was to subsequently replace his black-shafted feathers with all white ones and the female was to do the opposite, as adult females do have black-shafted feathers. It is possible, however, that both birds were in fact female. In any event plumage variation in this species is worthy of examination.

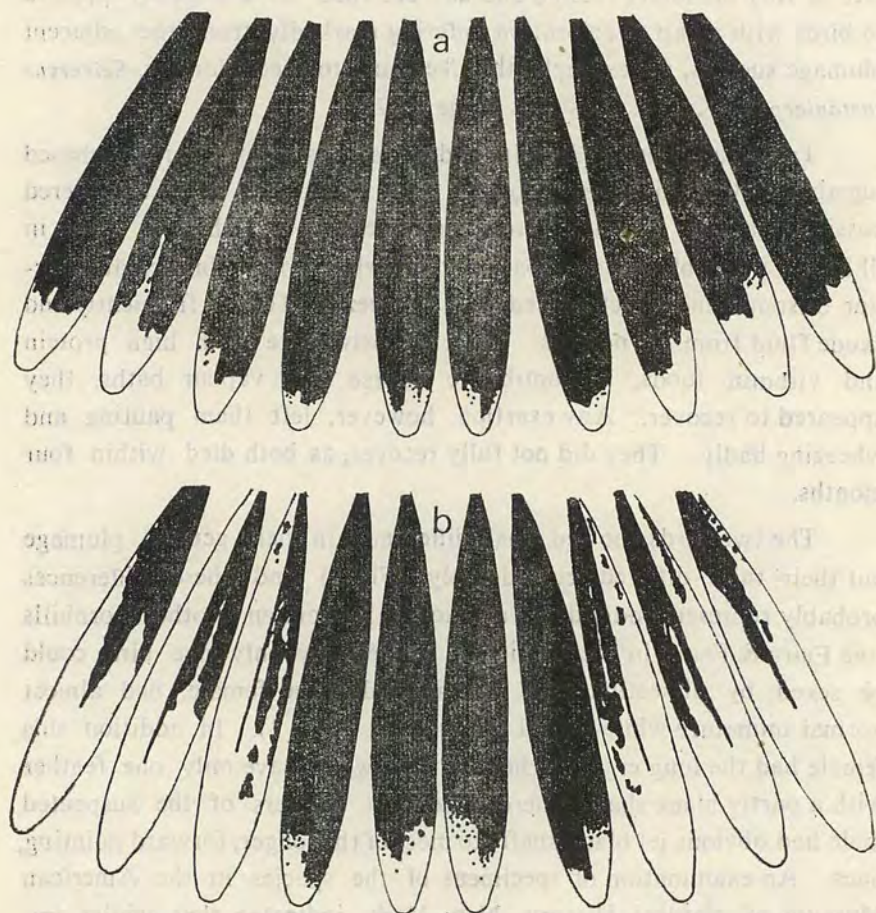


Figure 1. Schematic sketch of ventral tail patterns of two young White-crested Hornbills; a is that of a female, and b of a presumed male. See text for further details.

The bare orbital skin and bare skin at the base of the lower mandible is dark rich blue in adults, and the bill is black or very predominantly so. In CBF's post-fledglings, however, the bill was a pale olive-grey with the mandible tips and upper and lower edges of the mandible ivory yellow; and bare facial skin leaden-grey with a slight tinge of bluish-green.

Due to continued ill health of these birds little behaviour was noted. The call described by ROBINSON (1928) as "hoo-hoo many times repeated" was often given by our birds, and is reminiscent of a number of barbet calls (Caprimulgidae). Whilst giving this call our birds slightly raised and lowered the tail gently.

CBF has seen this species in good primary hill forest just inland of Nakhon Si Thammarat, eastern peninsular Thailand, on 29 June 1975, when at least three birds were observed flying and perching in vegetation at the very edge of a large swift mountain river. The species is undoubtedly far larger in life in comparison with *Anthracoceros* species than is indicated in the plates of BOONSONG & CRONIN (1974) and KING & DICKINSON (1975).

Our birds infrequently sunned themselves in a typical hornbill posture with wings outstretched and tail fanned.

BROWN HORNBILL, *Ptilolaemus tickelli*.

VED has kept an individual, apparently a male, in captivity since 10 May 1977. When obtained this bird was perhaps a month to several months past fledging age. At that time the bird was, obviously, in its first plumage, the crown feathers being pale rufous with conspicuous pale dusky-greyish bases and the cheeks, neck, and upper breast being predominantly pale rufous-brown throughout. At this time the bill was ivory yellowish with a greenish wash towards the base, particularly of the lower mandible. The iris was dark steel grey-blue and the bare orbital skin predominantly pale pinkish with a yellowish hue beneath the eye.

On the 26 August 1977 the bird was in heavy moult and half the crown feathers were new dark grey-brown ones with pale rufous tips and paler centres. The pale rufous-brown cheek, throat and breast feathers were now heavily striated with lanceolate white-tipped pale brown feathers and the odd one or two entirely white feathers giving this area a conspicuously streaked appearance. The iris was similar to that previously noted, but perhaps a little paler; and the bare orbital skin was darker, the previously pale pink area having become predominantly pink suffused with a pale-purplish colour.

This bird has been seen sunbathing in typical hornbill postures. The call is given by DEIGNAN (1945) as *auk-auk-auk*, but DAVISON (in SMYTHIES 1953) notes it as like that of the Pied Hornbills, but less harsh.

BUSHY-CRESTED HORNBILL, *Anorrhinus galeritus*.

VED obtained a bird at about fledging age (Fig. 2a) on 19 April 1975 and it has lived at semi-liberty in her garden since then. Although not regularly measured the development of this bird's bill morphology is indicated in Figure 2.

As the changes in the coloration of facial bare skin areas and the bill are so striking, as previously suggested by WHITEHEAD (1893), they are best indicated diagrammatically on Figure 2. When obtained the bird had a dark sky-blue iris. By August 1975, however, it had become predominantly pale tan with a narrow inner ring of blue-grey against the pupil. In late December 1975 it was a rich light hazel brown; in mid-May 1976 a rich orange-brown; and in April 1977 a deep blood red, becoming only a slightly darker colour by early September 1977.

MADGE (1969), observing a party of wild birds attending a female in the nest in July in Malaysia noted that "two juvenile birds still had yellow facial skin and must, I think, have been birds of the year." As indicated in Figure 2, however, birds may retain predominantly yellow

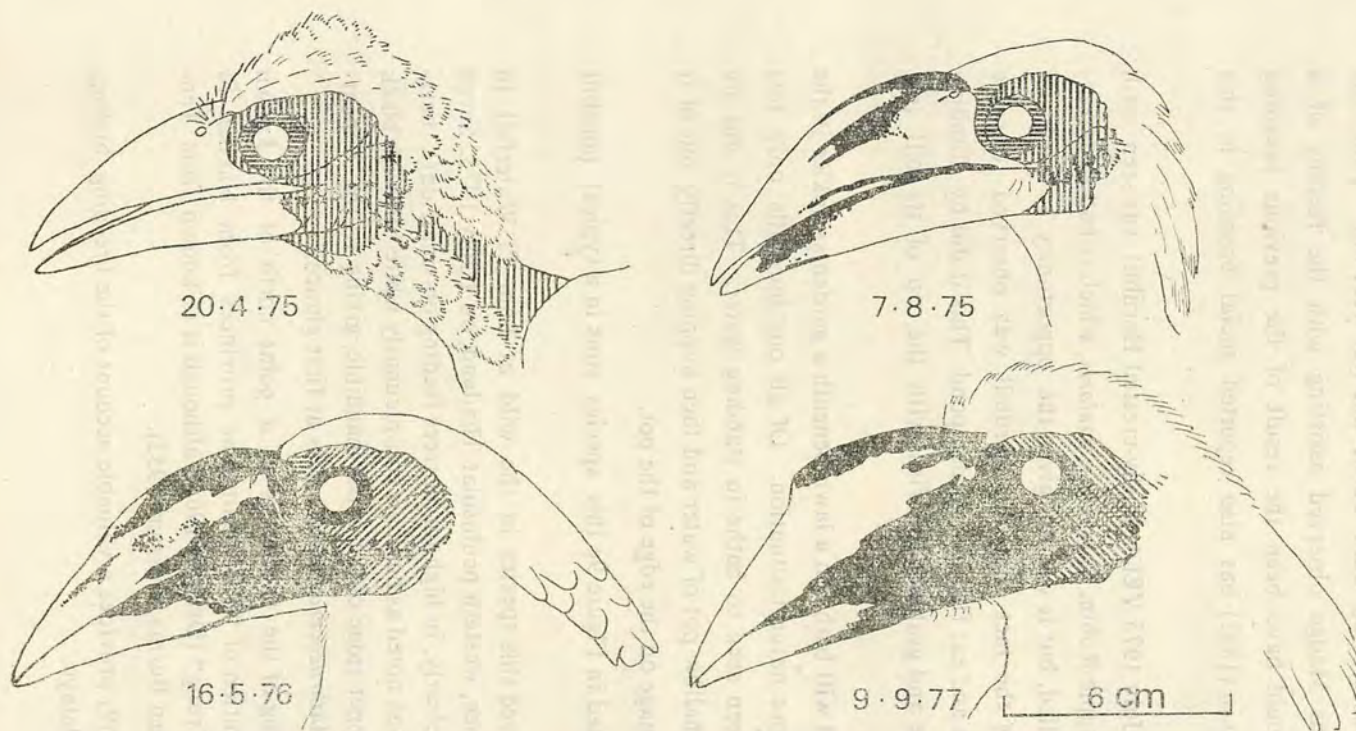


Figure 2. Bill growth and development of a presumed female, Bushy-crested Hornbill. The bird was measured only on 9.9.1977 and therefore the cm. scale applies only to the most recent figure; the size of the others being approximated relative to it. It should be noted that this bird had very nearly the same appearance as in the last drawing on 22. 4. 1977 save that the dark bill areas were not quite completely jet black. Facial bare skin coloration is indicated by: vertical lines = pale yolk-yellow; horizontal lines = pink (the orbital ring of 7.8.1975 being darker than on 20.4.1975); diagonal lines sloping down to left = pale chalky-blue; diagonal lines sloping down to right = blue; crossed diagonal lines = deep blue. Black areas are solid.

facial bare skin coloration until about one full year old. Thus, the yellow-faced birds Madge observed assisting with the feeding of a nesting female could have been the result of the previous breeding season. WHITEHEAD (1893) has also reported social breeding in this species.

In June or July 1975 VED's Bushy-crested Hornbill was seen with a dead adult Magpie Robin, *Copsychus saularis*, which it had apparently caught and killed, but it was not given the opportunity to eat it. Of particular note is the fact that this hornbill was observed to come across and catch and eat fish in a garden pond. This it did by standing on the pond edge and grabbing the fish with the tip of its bill (see Discussion).

VED's bird will bathe on a lawn beneath a garden sprinkler in the absence of a more natural situation. Of all our hornbills only this individual has been seen to bathe in standing water. This it did by hopping into a shallow pot of water and then hopping directly out of it to shake its plumage on the edge of the pot.

As illustrated in Figure 9e this species suns in a typical hornbill fashion.

CBF observed this species in the wild at Lam Pi Waterfall in Phangnga Province, western peninsular Thailand, on 1 July 1975. Seven birds were seen clearly, in high forest trees feeding on small dark berries. One bird was noted as having a conspicuously white bill with black on the central upper ridge of the upper mandible, giving it the appearance of a male *Anthracoseros malabaricus* at first glance.

This sighting of the species is at a point north of the known Thailand distribution of "The peninsular provinces from Nakhon Si Thammarat to Trang" (DEIGNAN 1963); although it is known from Tenasserim, southern Burma (SMYTHIES 1953).

MADGE (1969) provides a valuable account of the breeding biology of this bird in Malaya.

TARICTIC HORNBILL, *Penelopides panini*.

Brief observations of wild birds were made by CBF in Quezon National Park, Luzon, Philippines during March 1976. On 16 March several groups of birds, each involving at least two adult males, a female and a juvenile, were observed in the middle forest canopy feeding on berries, perching on vines and tangles, using slender perches and often going on to far outer twigs to feed on clusters of green berries. STOTT (1947) noted that this species particularly remains in central and lower forest levels.

On 17 March a flock of approximately ten to fourteen birds was watched from 06:45 for over twenty minutes in the forest immediately at the roadside. The birds were calling excitedly for much of the time, producing a distinct loud clear short squeak which the observers at the time likened to the sound produced by a child's squeaking teddybear, but the squeak being short and not drawn out. DELACOUR & MAYR (1946), obviously of more musical childhood backgrounds, liken the same call to "the sound of a child's trumpet: *toot-toot, tut-tut.*" This squeak note was repeated often and the flock produced a considerable noise as a whole. Much excited flying about, chasing and apparently fighting was seen between individuals of the same sex. Pairs of birds (one of each sex) were often seen to perch quietly next to each other when lulls in the general excitement permitted them to do so. A male was seen on two occasions to direct and perform a display to another male by leaping up and down on a leafy branch in the upper foliage whilst continuing to grasp the perch, thus shaking the twig violently. During this violent shaking performance the head and neck were lowered to a horizontal position and the bill directed at the other male. There is little doubt that this is a threat display, as it is identical to the threat display of the Wreathed, Great and Rhinoceros Hornbills. Moreover, the flock observed appeared to be involved in some sexual activity, possibly pair formation, a time when one would expect frequent aggressive encounters.

The following were noted as conspicuous field characteristics: pink bare gular skin and pink lines on upper mandible of males; chestnut brown patch on the upper tail surface of all birds,

WREATHED HORNBILL, *Rhyticeros undulatus*.

CBF has kept two males, at liberty and subsequently in an aviary, for 26 and 24 months respectively, the former from a nestling (Fig. 8a) and the latter from an age not very much older than fledging age (Fig. 3a). In addition he has kept a wild-caught mature female for 19 months, and VED has kept a female for 5 months.

Behaviour of a nestling

Particular attention was paid to the young nestling male obtained on 28 June 1975 (Fig. 8a). During the entire first month this bird was kept in a cardboard box, as an artificial nest hole. This bird's bare gular pouch was invariably fully inflated and most of the time areas of skin on the back, neck and adjacent regions were well inflated by subcutaneous air sacs, giving the bird a pronounced puffed-up appearance (see also Rhinoceros and Great Hornbill species accounts). Whilst no experiments were carried out to conclusively prove the point, the distinct impression was that this subcutaneous inflation provides a means of the bird much enlarging its body surface area, which thus functions as a cooling device, it being noted that the bare gular pouch and these other areas were deflated when the bird was in a cool situation in early morning. The gular pouch is, however, permanently inflated throughout adult life, except during, sleep, and would thus appear to have evolved into an important social/sexual signal character (see below).

Until it became fully feathered and active the nestling maintained the tail vertically against the back, although when asleep it tended to droop the tail to near horizontal, droop the wings to the ground, bow the head down directly forwards and rest the bill tip on the ground. The bird's 'heel' was conspicuously swollen, and it frequently rested and pivoted on this, but no spike-like or other peculiar structures were present as are known to occur on the heel-pads of the young of some other hole-nesting birds. On 9 July this nestling, upon being taken out of the box for cleaning, attempted to perform indirect head scratching (a leg being raised over the wing in order to scratch the head with the claws) and leg-and-wing stretch (Fig. 5c) as do adult hornbills.

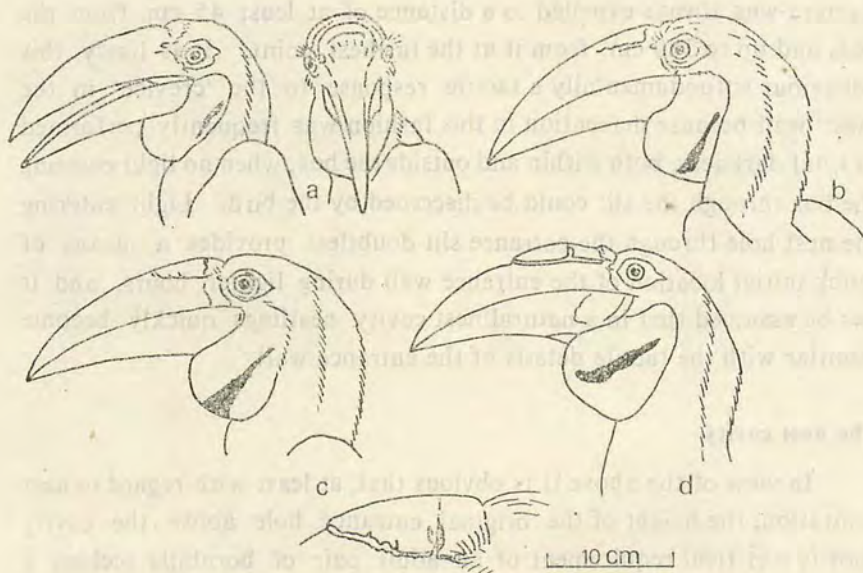


Figure 3. Bill growth and development of a male Wreathed Hornbill over a two year period; drawn to scale. For details see Table 1 and text.

From 28 June to 15 July 1975 the nestling was kept in a box with only a small opening at the top. His excreta always accumulated in the corners of this and never in the middle of the walls. This suggested that the bird always directed its anus into the irregularity of a corner to defecate in the absence of a nest entrance hole such as would be available to a nestling in a natural nest cavity. A simple experiment was, therefore, carried out by placing the bird in a fully enclosed and dark box 48 cm. high with a base of 28 X 24 cm. and by cutting a vertical slit 7 X 2.5 cm. in the centre of one side wall, with the lower edge of the slit 11.5 cm. above the box floor. From the moment the nestling was placed in this artificial nest cavity it excreted through the vertical slit. The nestling normally sat with its bill facing the slit. When about to defecate, however, it turned about, pushed its anus against the 'entrance' wall, and swayed it from side to side until the (pulsating) anus projected out of the slit. The bird then gave a final

backward thrust, pushing its anus an inch beyond the slit, and excreted. Excreta was always expelled to a distance of at least 45 cm. from the box, and up to 180 cm. from it at the farthest point. It is likely this behaviour is fundamentally a tactile response to the 'crevice' in the 'nest' wall because defecation in this fashion was frequently performed in total darkness, both within and outside the box, when no light entering the box through the slit could be discerned by the bird. Light entering the nest hole through the entrance slit doubtless provides a means of quick initial location of the entrance wall during lighter hours, and it can be assumed that in a natural nest cavity nestlings quickly become familiar with the tactile details of the entrance wall.

The nest cavity

In view of the above it is obvious that, at least with regard to nest sanitation, the height of the original entrance hole above the cavity floor is a critical requirement of an adult pair of hornbills seeking a nesting site. Presumably an adult female in search of a nest cavity must either select one with an entrance hole at a suitable height above the cavity floor or she, and perhaps her mate, must modify the cavity by raising the floor with materials (see Discussion). With respect to the experiments with the nestling it was found that the distance of 11.5 cm. from the cavity floor to the lower edge of the entrance slit was about as high as the bird could manage to reach and use easily.

Growth and development

It will be noted in Figure 8a that the nestling male Wreathed Hornbill clearly had the black crescent-shaped mark on the bare gular skin, and whilst this was not as dark as in adult birds it was conspicuous. The other young male obtained by CBF had an equally obvious black gular mark.

The bill growth of one male, from post-fledging age, is summarized in Table 1 and Figure 3. In this species adults develop ridges on the basal part of the upper mandible to form a low and serrated 'casque' (see Plate 1). As is obviously clear by comparing CBF's male at

approximately two and a half years old (Fig. 3d) with a mature female (Plate 1) the former is far from well, let alone fully, developed with respect to a casque. RILEY (1938) was correct when he wrote of this species "It is probable that it takes several years for the bill and casque to reach full development." It has been suggested that the number of ridges on the casque in this species is indicative of age, one ridge counting for each year of life. The first and second year of life of CBF's male, however, barely formed one complete ridge. Moreover, an examination of numerous specimens in various museums indicates that the forward-most ridges in very mature older birds break off as forward growth continues, the newly formed posterior ridges forming and growing as the anterior old ridges are lost. In the smaller Naroncondam Hornbill, however, one ridge might indeed form annually, or very nearly so (see species account below). Nevertheless the number of ridges on very mature old birds of any species with such a ridged casque could not be considered indicative of the age of the bird with any degree of certainty at all, due to the possibility of early ridges having been lost in the above described fashion.

Soft-part colour changes

The following facial soft-part colour changes were noted in the bird described in Figure 3 and Table 1:

4 August 1975. Gular pouch; pale yellowish-green with faint greyish mark. Bare orbital skin; fleshy pink. Iris; pale blue-grey, darker against pupil and at extreme outer edge.

6 October 1975. Gular pouch; bright yellow with greyish-black mark. Bare orbital skin; deep, dark pink. Iris; pale chalky-blue, darker against pupil.

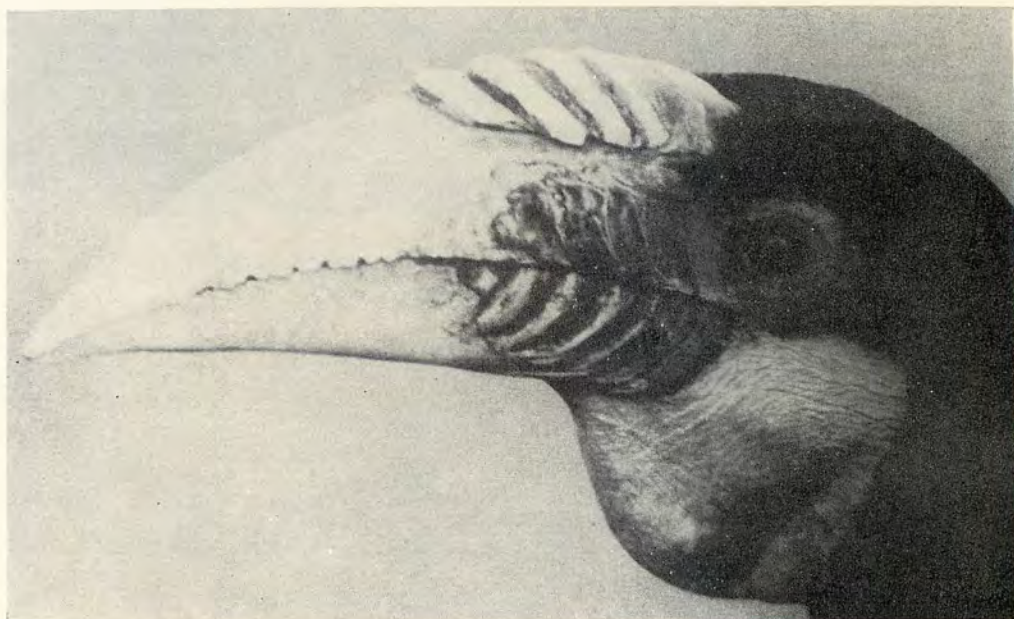
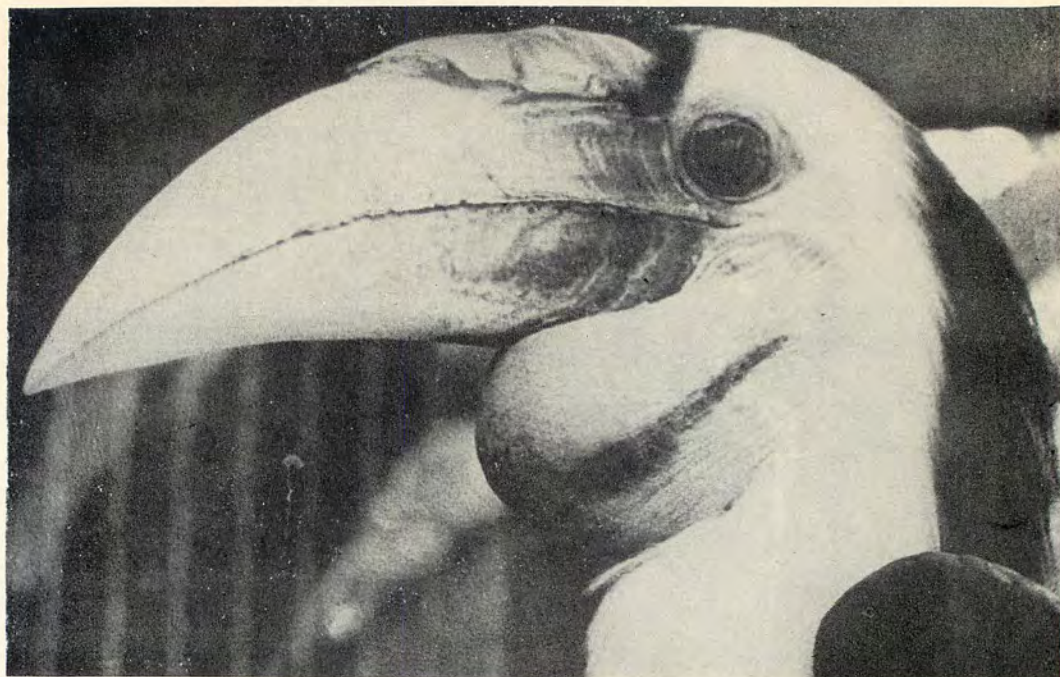
10 November 1975. Gular pouch; bright yellow with blackish mark. Bare orbital skin; deep, dark pink. Iris; pale chalky-blue with wide mid-grey ring around pupil.

16 May 1976. Iris; pale chestnut brown, greyish against pupil and greenish-grey extreme outer ring.

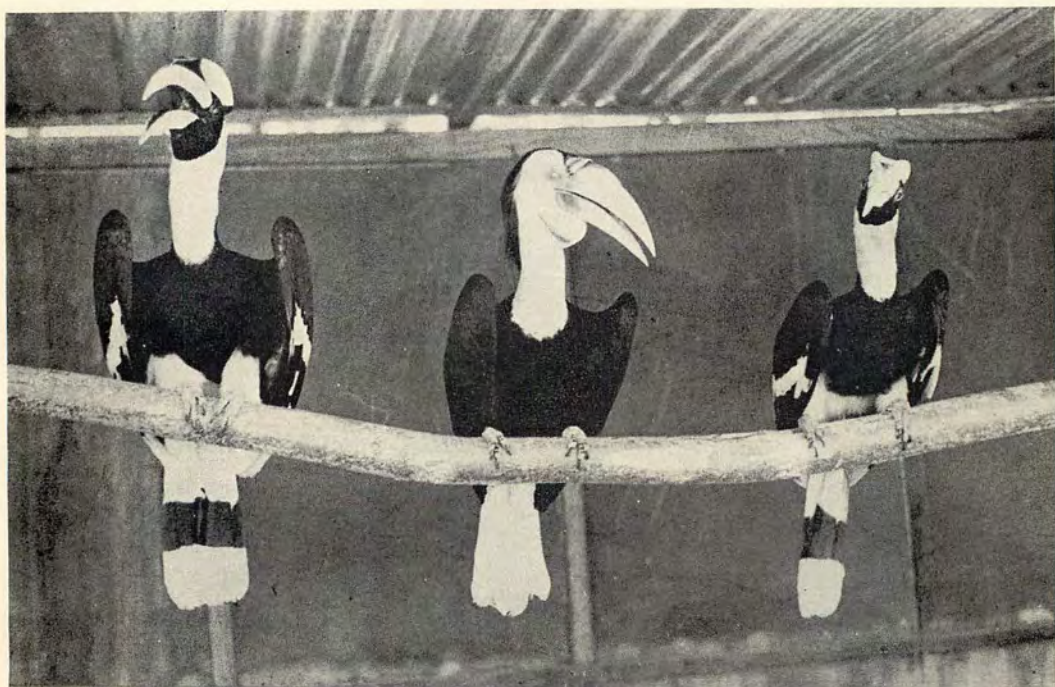
16 August 1977. Gular pouch; bright yellow with black mark. Bare orbital skin; deep crimson-pink. Iris; rich orange-chestnut brown, darker against pupil and a fine extreme outer ring of very pale tan.

Calls and associated behaviour

The loud call-note of the Wreathed Hornbill has frequently been described as like a dog bark (SMYTHIES 1968; MANNING in KING & DICKINSON 1975) or yelp (MEDWAY & WELLS 1976). This is a suitable description and we would interpret the usual call-note as *wuff-wurff*, inadequate though textural interpretation of birds calls usually are. The complete double note is only distinctly audible when fairly close to the bird, the initial *wuff* being a rather softer introduction to the loud and sharp *wurff*. Thus, at a distance, one usually hears the last note clearly. This call is often repeated in a series of 3 or 4 or more. It is noteworthy that both sexes perform a stereotyped head movement when giving this call. The bill tip is thrust sharply upwards almost to vertical as the call is produced and then lowered equally sharply. This sudden movement fully exposes the colorful and inflated bare gular skin, bright yellow in adult males and blue in females, which is clearly visible as a flash of colour from very considerable distances. CBF has frequently watched wild birds perched in the uppermost bare branches of a forested ridge on the opposite side of a valley flashing their coloured throats in this way the call-note reaching the ear an instant later. The typical habit of this bird perching in bare uppermost forest branches and accompanying the loud bark-like call with sudden conspicuous head movements which fully expose the sexually dimorphic and colourful throat, leads us to conclude that the call movement is a very significant social signal. In this respect it is interesting to note that in captivity the birds call loudly and frequently as food is brought to them. Possibly in the wild display-calling at least functions to indicate to others of the species the availability of food. This is, however, mere speculation.



Heads of captive Wreathed Hornbills, *Rhyticeros undulatus*. Above; a male approximately 29 months old. Below; a mature female of unknown age.



Heat-loss, or cooling, posture of male (left) and female (right) Great Hornbill, *Buceros bicornis*, and male Wreathed Hornbill, *Rhyticeros undulatus* (center).

Other notes

The nestling bird kept in a box was observed to eat its own excreta, as was a nestling Rhinoceros Hornbill. The Wreathed Hornbill performs an aggressive perch-leaping display identical to that of the Tarric, Rhinoceros and Great Hornbills. Our birds often allopreen between the sexes, and feed one another.

A flock of at least 25 to 30 birds of this species was observed by CBF on 12 July 1975 in good hill forest in the centre of Phuket Island, where only limited good forest remains. TICKELL (1864) records a flock of this species hopping about a sandy river bank and feeding by delving their bills into the water. Some of them stood in the water up to their bellies, which Tickell implies was a bathing activity.

Plate II shows a male Wreathed Hornbill in a posture typically performed by some hornbills when excessively hot. As previously noted by DEIGNAN (1945) captives of this species do not drink.

NARCONDAM HORNBILL, *Rhyticeros narcondami*.

We are able to include a brief note on this species as CBF briefly observed a live pair in captivity at the Bombay Natural History Society, India in November 1975. This hornbill must be considered the rarest and potentially most endangered species of the family, being confined exclusively to the small island (less than 3 square miles) of Narcondam, which lies east of North Andaman Island in the Andaman Sea, Indian Ocean. In 1905 the world population was estimated to be about 200 birds (OSMASTON 1905).

The pair at Bombay was taken as nestlings from a sealed nest hole on 14 March 1972, and at that time both birds wore the rufous-brown head and neck plumage of the male (pers. comm., staff of the Bombay Nat. Hist. Soc.).

The Narcondam Hornbill has in the past been considered a subspecies of the Wreathed Hornbill, but it is in fact a very different and most distinct good species. It is very much smaller than the Wreathed, and unlike it both sexes of the Narcondam have blue bare facial skin. Moreover, the gular pouch skin of the Narcondam is far

less extendable and inflatable than is that of the Wreathed. Almost certainly the Narcondam Hornbill represents a long-isolated and well speciated population of *Rhyticeros undulatus/plicatus* origin, which has considerably diminished in body size and has lost the sexually dimorphic characters of bare facial skin. The latter situation strongly supports the conclusion that conspicuous sexual dimorphism functions as a species-isolating mechanism where a species is sympatric with congeners (see SIBLEY 1957 and THOMSON 1964). Thus, the Narcondam Hornbill, lacking sympatric congeners, apparently no longer requires complex sexually dimorphic facial characters and has lost those of its ancestral stock.

The fledgling period of the Narcondam Hornbill is unknown but we estimate it at very approximately 60 days (derived from that of a captive *Anthracoceros* species of 55 days given by HUTCHINS 1976). Thus when CBF examined the pair at Bombay they were approximately $46\frac{1}{2}$ months old; in any event just under 4 years old. It is interesting to note, therefore, that both birds had developed by this time very nearly four fully formed casque ridges. ST. JOHN (1898) suggests that the number of casque ridges "probably indicate the age of the birds."

The facial soft-part colours of this pair when examined were as follows. *Male*: Bill white with the basal half of each mandible, and the basal ridge only, being a deep dark crimson. Gular pouch; very pale chalky-blue, almost white. Bare orbital skin; ring directly around eye pink and the rest chalky sky-blue. Iris; orange-brown (much the same colour as the neck feathering), darker towards the pupil, and with a very fine inner yellowish-brown ring actually against the pupil. *Female*: Bill; as the male. Gular pouch; as the male, perhaps slightly darker. Bare orbital skin; ring directly around eye dark purplish-grey, and the rest dark sky-blue. Iris; light olive-brown but darker, almost blackish-brown, towards pupil, and with a fine inner yellowish ring actually against the pupil.

In view of the soft-part coloration given by CORY (1903) for wild adult birds these colours are obviously variable, doubtless with age as in the Wreathed, and other, hornbills.

BLACK HORNBILL, *Anthracoceros malayanus*.

VED has kept a male Black Hornbill at semi-liberty since 22 May 1976. We estimate the bird to have been about three to four months old at the time it was obtained. Although not measured its bill development, as observed and drawn directly from a series of photographs, is illustrated in Figure 4. Facial soft-part coloration changes, with reference to the dates given in Figure 4, were as follows:

25 May 1976. Bill; greenish-yellow, white at tips and upper and lower edge of upper mandible. Bare orbital skin; directly around the eye deep yellow-orange smudged blackish, rest yellowish. Iris; very dark brown.

12 September 1976. Bill; dirty whitish, trace of black about nostrils. Bare orbital skin; all dark grey. Iris; dark brown.

6 January 1977. Bill; white, black about nostrils and base of mandibles. Bare orbital skin; blackish. Iris; rich dark chestnut-brown, darker against pupil.

22 April 1977. Bill; as previous. Bare orbital skin; black. Iris; rich dark chestnut-red, darker against pupil.

9 September 1977. Bill and bare orbital skin; as previous. Iris; rich reddish-brown, more dark brownish against pupil.

Although the age of this bird is only known approximately the bill development indicated in Figure 4 suggests a casque growth rate rather similar to that of the Northern Pied Hornbill, *Anthracoceros malabaricus* (FRITH & FRITH 1978). It can also be seen that this bird's bill and casque at approximately one and a half years old is far from well developed compared with an adult male (see plates in LINT 1972; BARTELS & BARTELS 1937).

This bird performs typical sunning (Fig. 9h) and foliage bathing. This male carried out plastering activity in various situations, using excreta and other matter of suitable consistency, when still considerably less than a year old. This appears to be one of the few hornbill species actually observed drinking which HARRISON (*in* SMYTHIES 1968) reports a tame individual doing (see Discussion).

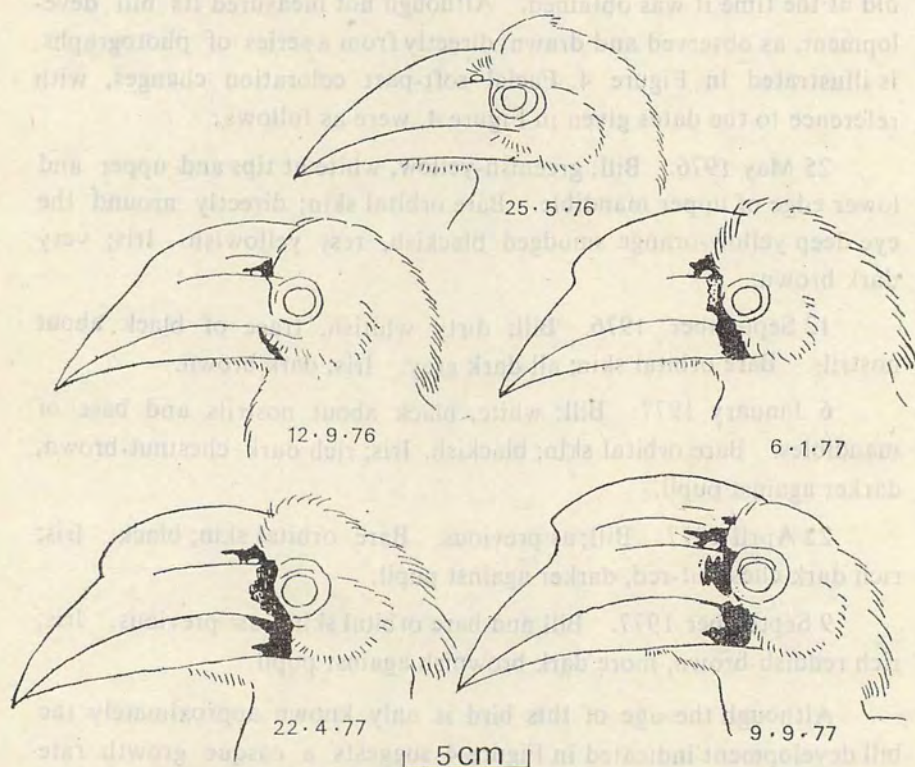


Figure 4. Bill growth and development of a male Black Hornbill over a fifteen month period. The bird was measured only on 9.9.1977 and therefore the cm. scale applies only to the most recent figure; the size of the others being approximated relative to it. Developing black pigmentation is shown by solid areas.

NORTHERN PIED HORNBILL, *Anthracoceros malabaricus*.

We have kept a total of five individuals of this species in captivity. Of two males CBF has kept, he has had one for over three years and another exactly two years from nestlings; and a female which he obtained as an adult he has had for almost two years. The bill and casque growth and development and facial soft-part colours of the two males are described elsewhere (FRITH & FRITH 1978). As has been noted previously (TICKELL 1864; PRIMROSE 1921; Gee 1933a, 1933b) this hornbill becomes very tame and amusing when reared from a nestling; which is indicative of the bird's highly social disposition, as it typically is in the wild.

The above vernacular and scientific names are used for reasons given elsewhere (FRITH & FRITH 1978; FRITH & FRITH in preparation).

Allopreening

Birds of this species are extremely fond of allopreening (the preening of the plumage of one bird by the bill of another). Hand raised birds like to have their feather bases about the crown, eyes, throat and neck scratched, but are not so eager to be scratched elsewhere. They solicit this attention from their avian or human companions by turning their head away and raising the head and neck feathering (see Fig. 5a & b and Plate II for postures). Numerous captive birds have been observed preening one another in this fashion in addition to our own. Our birds actively solicited such attention even as nestlings. HUTCHINS (1976) has described a male of this species preceeding copulation by appearing to "induce contact by allopreening his mate's head, pushing at the base of her bill and nudging the side of her tail with the dorsal portion of his bill and casque." KILHAM (1956) found allopreening to be important in maintaining the pair bond in the African hornbill *Bycanistes subcylindricus*.

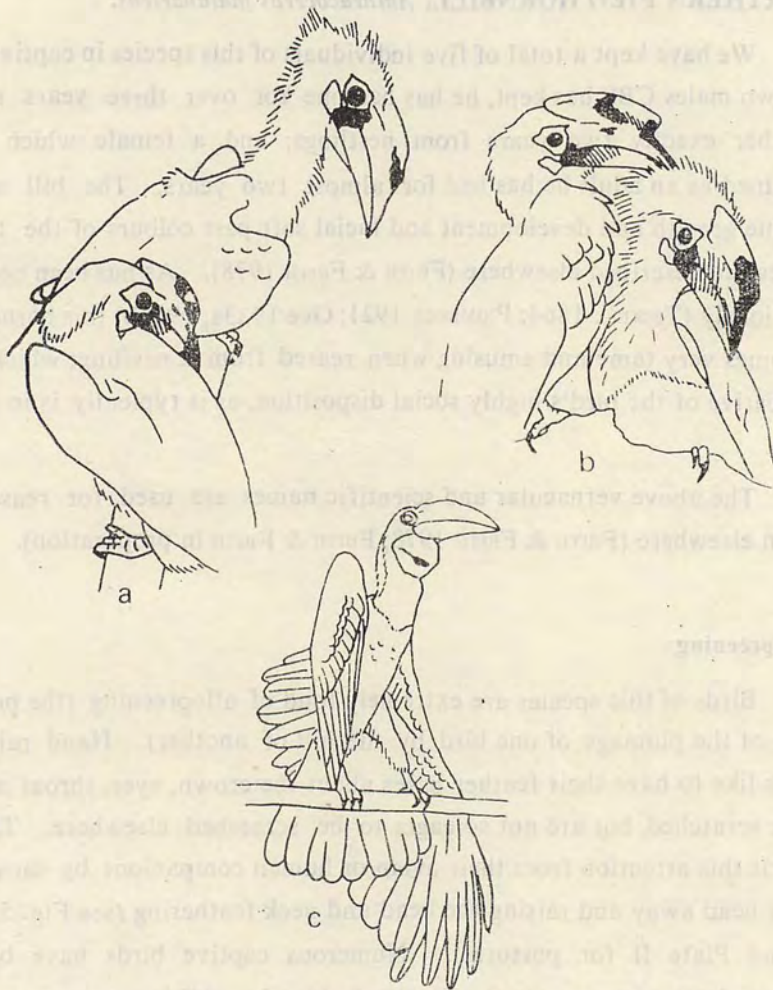


Figure 5. Hornbill allopreening and stretching. a; an immature male solicits allopreening from a mature female Northern Pied Hornbill in CBF's collection. b; a female allopreens another female Northern Pied Hornbill in the Bronx zoo collection. c; a male Wreathed Hornbill performing typical hornbill wing and leg stretch with fanned tail. Not drawn to scale, but all drawn directly, from photographs.

Sunning

Sunning is frequently performed. Most often this involves turning the head to one side to expose the profile and crown to the sun rays, lowering one or both wings and raising much of the feathering, particularly about the head, neck and rump (see Fig. 9 f & g). On occasions, however, intensive sunning posturing is performed which usually results when a bird moves from a shaded area into direct sunlight. Such postures (Fig. 9 g) can invariably be induced by taking a bird from shade into direct intense sunlight. Sunning is obviously an important behaviour in this species.

Foliage bathing

The typical bathing activity of this hornbill is perhaps best termed foliage bathing (of RANGER's usage 1950) in preference to rain bathing, as wet foliage is apparently the primary requisite for this behaviour. PRIMROSE (1921) describes a bird bathing by jumping about the dew-soaked foliage of trees. Birds frequently react to a sudden rainfall by flying into a well foliated tree, grasping a sprig or branch in the bill, and thrashing about in the wetted foliage with fanned tail and flapping fully opened wings. During this frenzied activity the bird may release its foothold on the perch or foliage and, thus, flap and swing about the grasping bill tip, like a boat swinging about its anchor. This thrashing about in rain-soaked foliage is an extremely effective means of thoroughly soaking the plumage rapidly.

Our birds adapted their foliage bathing behaviour to aviary life very quickly despite limited available arboreal foliage; a sudden rainfall now brings them down onto the grass where they similarly grasp a tuft of grass and thrash about. A simple, often repeated, experiment clearly indicates the association the birds have between bathing and foliage. They eagerly jump beneath a running garden tap and soak themselves. When thoroughly wet they leap onto the available foliage, a very short and completely dry lawn. Here the bill is thrust into the grass and soil and the bird thrashes about in the above described fashion. This of course has the opposite to the desired effect, the bird becoming covered with dirt and pieces of dried grass. This completely unsuitable 'foliage' appears adequate, however, to satisfy an obvious 'need' to foliage bathe subsequent to plumage wetting.

Foliage bathing is invariably followed by sunning postures in direct sunlight when available. In this respect it is noteworthy that birds do not commonly bathe on generally rainy dull days. Almost all such bathing takes place during brief showers on otherwise bright sunny days. Birds little more than fledged will foliage bathe. According to PRIMROSE (1921) this bird "is very fond of dust-bathing in the wild", but we have not observed our birds doing so (see Discussion).

Calls

The loud cackling call commonly heard performed by wild and captive birds, and well described by MEDWAY & WELLS (1976) as *kleng-keng*, *kek-kek-kek-kek-kek*, is produced by both sexes. Birds also frequently emit a low soft sound reminiscent of the clucking of a domestic hen, *kuck-kuck-kuck* etc. (described by METSON in KING & DICKINSON 1975, as *puck*, *puck*, *puck*) or a softer still *kiew-kiew-kiew* etc.....

It is convenient to note here that a captive *Anthracoseros marchei* observed by CBF in Manila produced a soft clucking *kiew-kiew-kiew* call identical to that of *A. malabaricus*.

Social feeding

All five of our birds frequently offer each other, and ourselves, unwanted food items. This is performed when a bird has in the tip of its bill a piece of food not liked, or not wanted. In these circumstances the food is thrust at another bird, or ourselves, and a low growling produced simultaneously. This call-sound usually continues until the food is accepted or the calling bird drops or swallows it. This form of feeding of one bird by another takes place at all times of the year and is performed by both sexes. There is no doubt, however, that it also functions as a very important courtship ritual in many hornbills (see Discussion).

On several occasions CBF's most human-imprinted bird has flown down from a tree to the house and tried to thrust a grasshopper or the like into his mouth, ear, or nostril with accompanying growling noises. HUTCHINS (1976) considered the feeding of the female by the male in *A. malabaricus* the most important activity during courtship preliminaries.

Display

The only display we have seen this species perform would appear to be self-assertive (of GOODWIN 1976) in nature. It involves no more than the bird lowering the neck and head downward and forward to near horizontal and rapidly jerking the bill upward in a repeated sharp flicking motion whilst directing the bill at the bird displayed to. This movement possibly emphasises the casque shape and markings when viewed from directly ahead, and is frequently performed in situations such as one bird wishing to displace another.

Plastering

From an age of about eight to nine months both CBF's males were noted to infrequently plaster crevices and holes when confronted by them and the availability of suitable material, such as excreta, overripe banana, mud etc. Movements and methods involved were exactly as those described for the Rhinoceros Hornbill.

Moult

The order of primary and tail feather replacement was noted during the first flight feather moult of CBF's older male. Numbering primaries from the proximal primary outward the replacement order on the right wing was 3-4-2-1-5-6-7-10-8-9; and the left wing 1-2-3-4-5-6-10-8-9-7. Moult in the right primaries commenced at least three weeks prior to that of the left wing. Thus, when primaries 1 to 5 on the bird's right wing were all at least half new grown in length, only primaries 1 and 2 were just beginning to burst out of pin on the left. KEMP (1976), writing of *Tockus* species, stated that flight feather moult is in fact highly asymmetrical. The fact that this particular single moult of a captive bird might have been in some way peculiar cannot, however, be entirely ruled out. Its tail feather (retrices) moult was, numbering them from the central pair outwards, 1-5-2-3-4, as is normal in *Tockus* species (KEMP 1976). This bird's first flight feather moult (it having replaced body feathers in a moult during September) commenced at the beginning of November, when the bird was about seven months old, and was completed by the end of March. Simultaneous body moult started in late November/early December and was completed with

primary moult in March. Secondary replacement commenced in mid January; tail moult did not commence until the last week of January and was completed shortly after that of primaries and body feathers.

Other notes

The bare body skin colour of two nestlings only just beginning to grow feathers, kept briefly by VED, was flesh pink with slightly more purplish coloration about the head.

We have not seen our birds drink, despite the availability of water. They frequently take flying termites, moths and butterflies by catching them in flight. PRIMROSE (1921) provides the remarkable record of a bird catching swallows as they flew past it; and eating four munias, presumably a *Lonchura* species. VED's male was observed to catch and eat frogs and wild-caught young 'pink' mice. Animal prey such as lizards, snakes, scorpions etc. are always manipulated in the bill tips and squeezed predominantly at either end in typical hornbill fashion before being swallowed. INGLIS (*in* HUME 1877) states that this bird is "Passionately fond of live fish which it catches in shallow pools. Fish bones found in stomachs of several shot". WILDASH (1968) also reports fish eating, possibly with reference to the record of Inglis. Our adult birds eagerly eat live and dead small fish.

HUTCHINS (1976) provides a useful account of the breeding biology of a pair of captive birds which included much detailed information on nidification.

RHINOCEROS HORBILL, *Buceros rhinoceros*.

CBF has kept a male of this species in captivity for almost three years, and raised it from a nestling. When young it inflated subcutaneous air sacs as did the Wreathed Hornbill. For the first twelve months it lived at liberty about the house and garden and subsequently in a very large aviary. The animal dealer from whom it was obtained said it originated from Yala Province, extreme southern Thailand, and was three months old. Figure 6 and Table 1 summarise the bill and casque growth and development of this bird to date. It should be noted that the casque of this bird at the present time is far from fully developed. That the bill and casque of this large bird takes possibly more than four

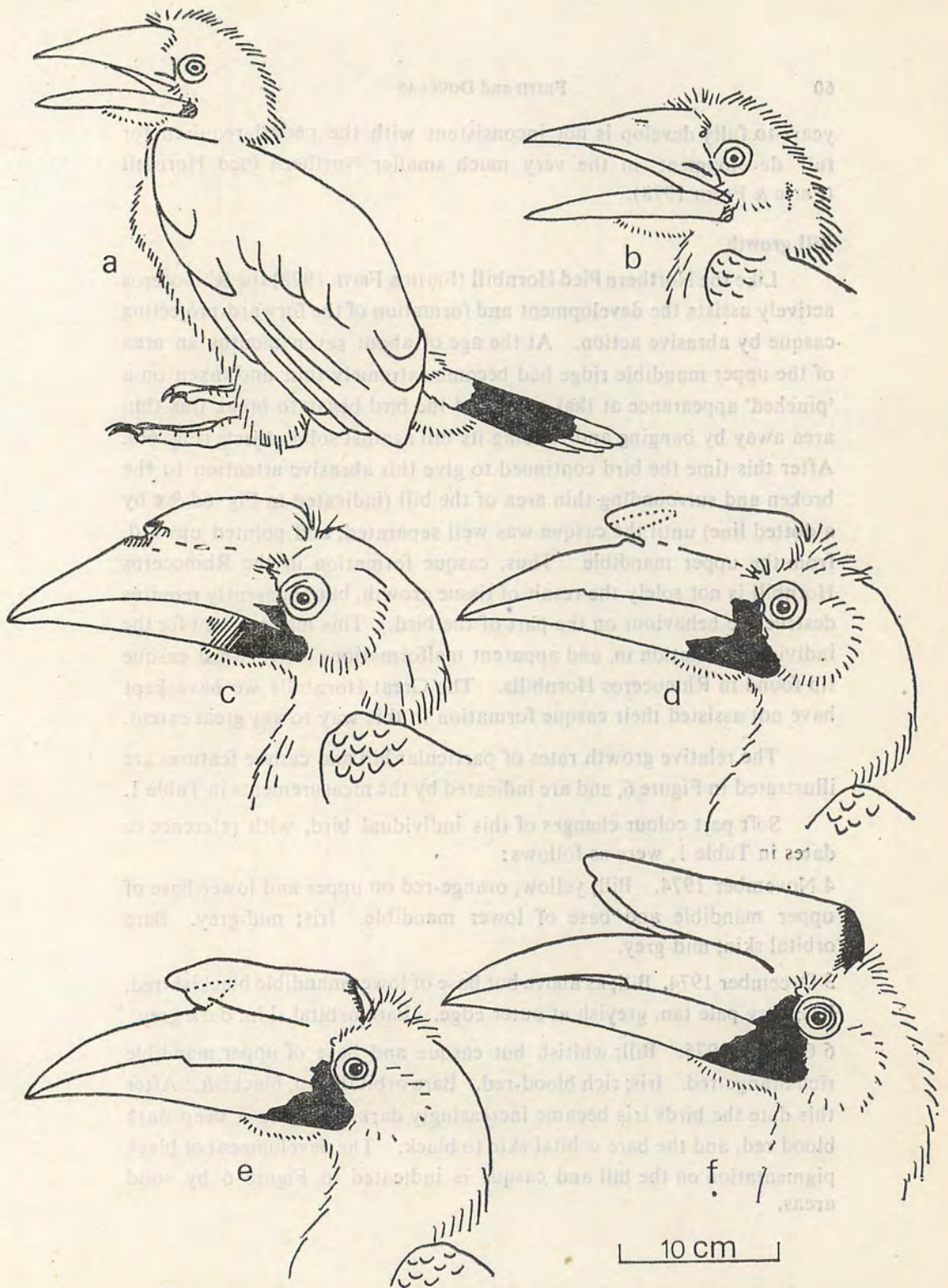


Figure 6. Bill growth and development of a male Rhinoceros Hornbill over a two year nine month period. For details see Table 1 and text. All drawn to scale except a.

years to fully develop is not inconsistent with the period required for full development in the very much smaller Northern Pied Hornbill (FRITH & FRITH 1978).

Bill growth

Like the Northern Pied Hornbill (FRITH & FRITH 1978) the Rhinoceros actively assists the development and formation of the forward-projecting casque by abrasive action. At the age of about seven months an area of the upper mandible ridge had become extremely thin and taken on a 'pinched' appearance at that point and the bird began to break this thin area away by banging and rubbing its bill against solid objects (Fig. 6c). After this time the bird continued to give this abrasive attention to the broken and surrounding thin area of the bill (indicated in Fig. 6d & e by a dotted line) until the casque was well separated, and pointed upward, from the upper mandible. Thus, casque formation in the Rhinoceros Hornbill is not solely the result of tissue growth, but apparently requires destructive behaviour on the part of the bird. This may account for the individual variation in, and apparent malformations of, forward casque tip found in Rhinoceros Hornbills. The Great Hornbills we have kept have not assisted their casque formation in this way to any great extent.

The relative growth rates of particular bill and casque features are illustrated in Figure 6, and are indicated by the measurements in Table 1.

Soft part colour changes of this individual bird, with reference to dates in Table 1, were as follows:

4 November 1974. Bill; yellow, orange-red on upper and lower base of upper mandible and base of lower mandible. Iris; mid-grey. Bare orbital skin; mid-grey.

3 December 1974. Bill; as above but base of lower mandible blackish-red. Iris; very pale tan, greyish at outer edge. Bare orbital skin; dark grey.

6 October 1975. Bill; whitish but casque and base of upper mandible rich orange-red. Iris; rich blood-red. Bare orbital skin; blackish. After this date the birds iris became increasingly darker red, to a deep dark blood-red, and the bare orbital skin to black. The development of black pigmentation on the bill and casque is indicated in Figure 6 by solid areas.

The nestling

For the first two months the young Rhinoceros Hornbill was kept for much of the time in a large box with an open top. He apparently enjoyed being scratched about his head and neck (allopreening) whilst within the box, but resented this attention outside it. Whilst being scratched the bird lowered his wings, raised most of his head and neck feathers and closed his eyes. He spent much time preening himself when alone. Of particular note is the fact that throughout his confinement in the box he picked from the 'nest' floor and ate his excreta. This is obviously a most advantageous behavioural pattern in terms of assisting or maintaining nest sanitation in a confined nest hole. Indicating another valuable aspect of this behaviour is the fact that it was noted that certain foods, such as the kidney of Asian Water Buffalo, fed to this bird initially passed through his digestive system very much unaltered. Subsequent ingestion, however, appeared to enable the bird to fully digest such foods. Until shortly after taking the bird out of the box his tail was always kept 'hinged' vertically up against the back.

Like the young Wreathed and Great Hornbills, the nestling Rhinoceros Hornbill frequently inflated subcutaneous air sacs about the neck, shoulders and back (see Discussion).

Sunning

On 20 November 1974, when the bird was approximately four months old, he was placed in direct sunlight for the first time. This immediately resulted in him adopting a spread-wing, fanned-tail, head turned and feathers raised, sunning posture (Fig. 9d) as also performed by some of our other hornbill species (Fig. 9). Ever since that time he occasionally suns himself in this way.

Plastering

On 15 September 1975, when approximately fourteen months old this young male carried out extensive plastering activity. He spent most of an hour filling a very narrow slit at the junction of some wood and brick work on a house, exclusively using his excreta. Like the plastering activity of all our other birds for which it has been noted this

exclusively involved the extreme tips of the mandibles, the 'plaster' being patted well into place by a very rapid sideways tapping of the sides of the bill tips. This bird has subsequently been observed plastering on numerous odd occasions.

Displays

An aggressive, or threat, display is frequently directed by this bird at strange people, dogs and other animals approaching it, and was described by HOSE (*in* SHELFORD 1899) as a "very curious habit." This display is identical to that performed by the Wreathed, Tarictic and Great Hornbills. It also performs the bill twitching, self assertive, display as is described for the Northern Pied Hornbill, in similar circumstances.

Calls

The normal loud call note of this bird, given most frequently by our captive in the early morning, is a single sharp very bugle-like blast; rather bark like and adequately described by Wells (*in* KING & DICKINSON 1976) as a "deep, loud, resonant g-runk" sometimes repeated three or four times. MADOC (1956) reports that wild birds also call most frequently in the early morning. As do the Wreathed and Great Hornbills when giving loud call notes, the Rhinoceros throws the head and bill upwards as it calls. Such movements during calls may have a signal significance, as is discussed in the Wreathed Hornbill account. When offered unwanted food the bird attempts to place it into its keeper's hand or face with a peculiar nasal coughing sound which may be a social feeding note (see under Northern Pied Hornbill) or simply a sound produced when rejecting food,

Other notes

This captive Rhinoceros Hornbill foliage bathes in exactly the same way as does the Northern Pied and Great Hornbills. It sleeps in typical hornbill fashion, with bill pointing directly forward and the head and neck drawn down between the shoulders, and does not apparently need to drink.

When obtained the young bird (Fig. 6a) had two tiny head markings of rufous-tipped feathers; one just behind the ear coverts and one on the upper forward neck just behind the throat feathering. At the time of writing subsequent moults of the bird have almost totally replaced the marking behind the ear coverts with wholly black feathers, but the rufous-tipped feathers on the upper neck remain. It seems very possible these peculiar markings on this individual are indicative of the very close relationship between this bird and the Great Hornbill, as these lighter lines of feathering occur at points on the head of the Rhinoceros Hornbill exactly where the black facial feathering meets the white feathering in the Great Hornbill. Moreover, this particular Rhinoceros Hornbill replaced its original all black primaries with a white-tipped second primary in the left wing and second primary in the right wing, and returned to all black primaries in its subsequent moult! White-tipped primaries are normal in the Great Hornbill, whereas they are normally all black in the Rhinoceros.

It is noteworthy that HOSE (*in* SHELFORD 1899) observed what would appear to be co-operative breeding (of ROWLEY 1976) by this bird. Having shot a male attending his mate in the nest he observed several young male birds fly to the nest and feed the female. Co-operative breeding is also known in the Bushy-crested Hornbill (MADGE 1969) and the African Ground Hornbill *Bucorvus cafer* (VAN SOMEREN 1922; RANGER 1931) and is not infrequent in members of other families of Coraciiformes (GRIMES 1976; PARRY 1973).

GREAT HORNBILL, *Buceros bicornis*.

CBF has a male and female of this species which were obtained in Bangkok when they were just fledging age, and has kept them exactly two years to date. Like nestling Wreathed and Rhinoceros Hornbills, the young birds inflated subcutaneous air sacs (see Fig. 8c). The female has always remained a little runted, having never gained normal bill and casque coloration, and having suffered from poor feather replacement throughout. We do not, therefore, refer to her growth and development. The male, however, is a fine specimen which appears to have developed perfectly normally. The growth and development of his bill and casque are summarised in Figure 7 and Table 1. As will be seen by comparing

the figure of this male at over two years old with that of an adult male also from Thailand (Fig. 7d & e), its bill and casque development is apparently far from complete.

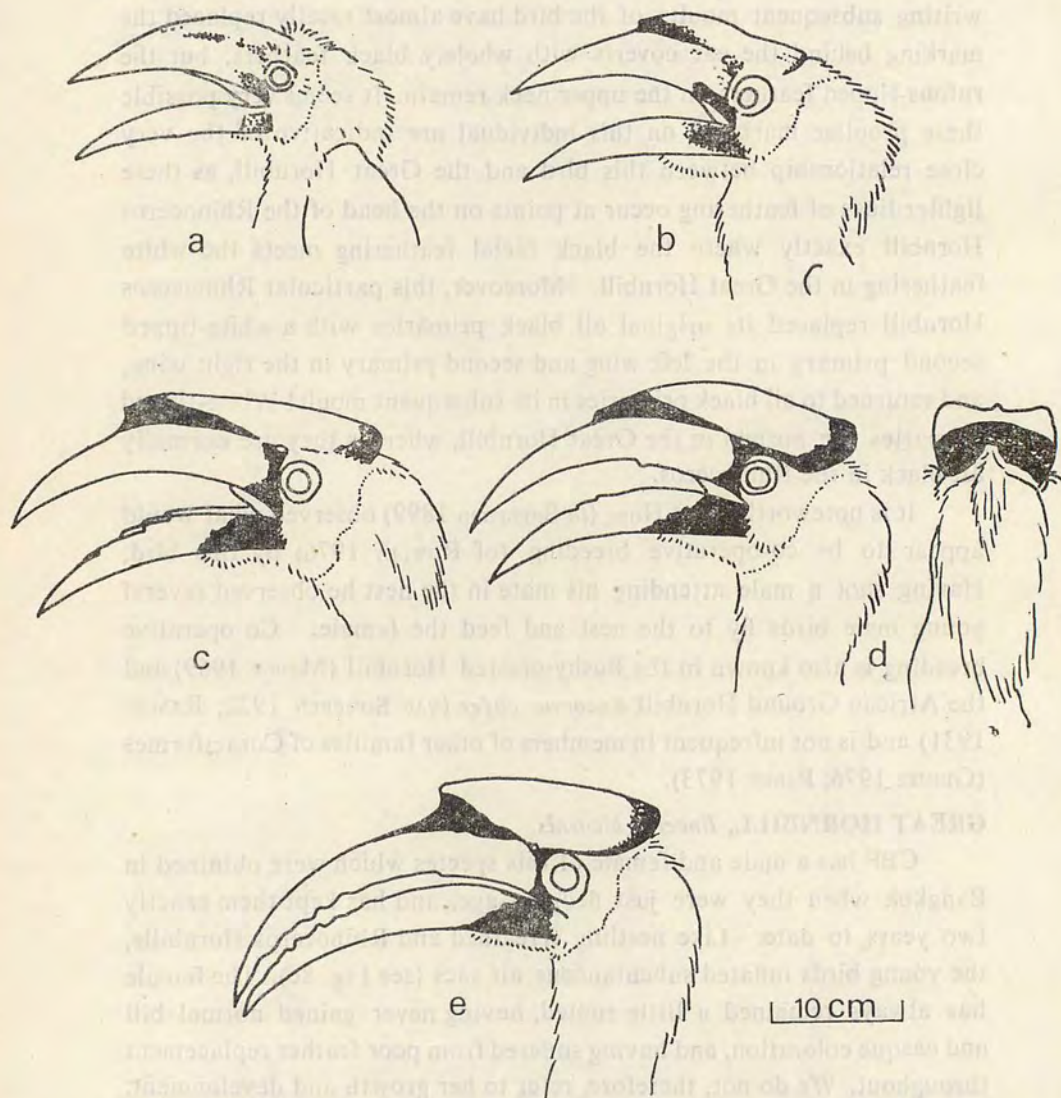


Figure 7. Bill growth and development of a male Great Hornbill over a two year period (a to d), and a mature male from Pak Jak, Takuapa, peninsular Thailand for comparison (e). For details see Table 1 and text. All drawn to scale.

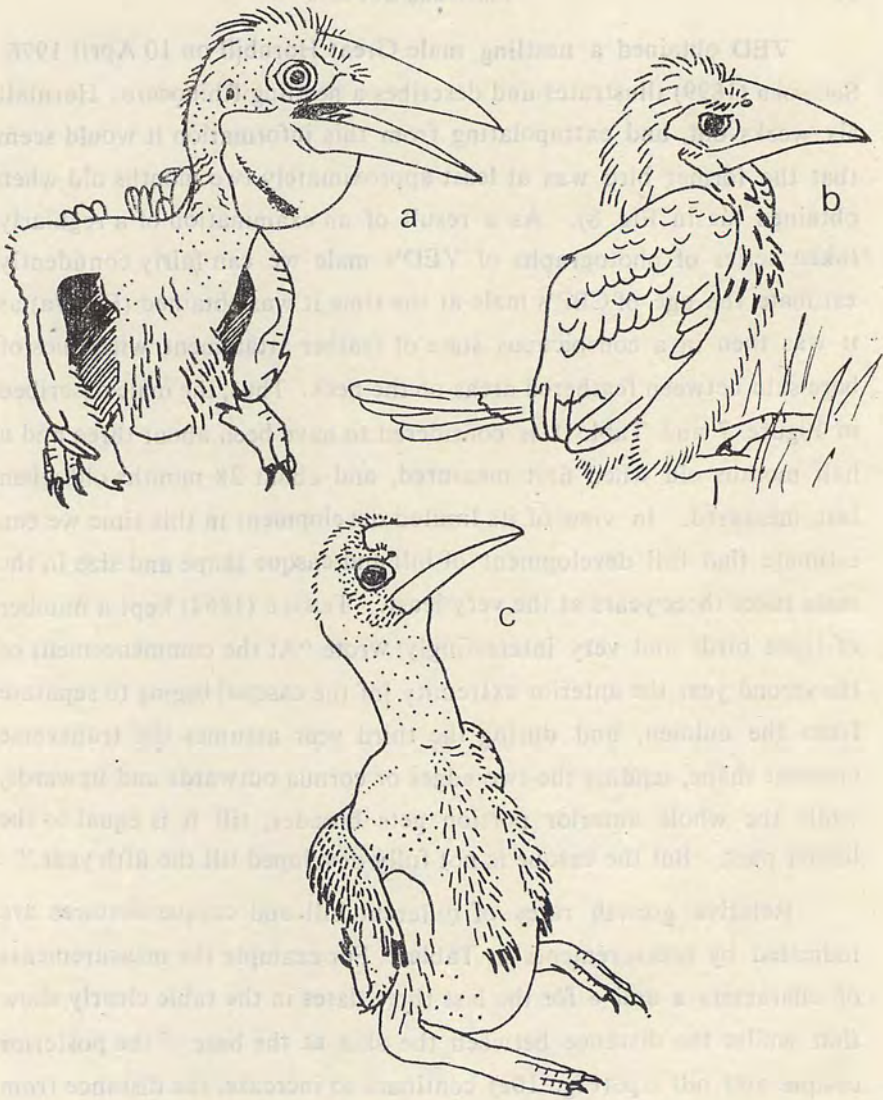


Figure 8. Nesting hornbills, not drawn to scale. a = male Wreathed Hornbill.

Body skin blue-grey except fleshy-yellow gular pouch and pinkish-flesh orbital skin. b = male Northern Pied Hornbill. Bare skin at neck blue-grey and bare facial skin whitish-blue. c = male Great Hornbill. Bare body skin flesh-pink except forward face area and upper back which was blue-grey. At this time all the bird's primaries, secondaries, and wing coverts had just burst out of pin and the retrices were very near to doing so. Note the far backward-leaning posture, the bird resting on it's 'heels' with tail vertical behind and much inflated neck and shoulders.

VED obtained a nestling male Great Hornbill on 10 April 1976. SHELFORD (1899) illustrates and describes a nestling Rhinoceros Hornbill six weeks old, and extrapolating from this information it would seem that the former bird was at least approximately two months old when obtained (as in Fig. 8). As a result of an examination of a regularly taken series of photographs of VED's male we can fairly confidently estimate the age of CBF's male at the time it was obtained (Fig. 7a) as it was then in a conspicuous state of feather attainment, with lines of bare skin between feathered areas on the neck. Thus, the male described in Figure 7 and Table 1 is considered to have been about three and a half months old when first measured, and about 28 months old when last measured. In view of its limited development in this time we can estimate that full development of bill and casque shape and size in the male takes three years at the very least. TICKELL (1864) kept a number of these birds and very interestingly wrote "At the commencement of the second year the anterior extremity [of the casque] begins to separate from the culmen, and during the third year assumes the transverse crescent shape, sending the two edges or cornua outwards and upwards, while the whole anterior portion gets broader, till it is equal to the hinder part. But the casque is not fully developed till the fifth year."

Relative growth rates of different bill and casque features are indicated by measurements in Table 1. For example the measurements of characters a and e for the last three dates in the table clearly show that whilst the distance between the skin at the base of the posterior casque and bill tip (Fig. 10e) continues to increase, the distance from the rear casque to bill tip (Fig. 10a) increases at a greater rate to it than previously. Thus, whilst mandible length continues to steadily increase the back of the casque is rising upwards and backward from the skull at an increased rate of growth.

Soft-part colour changes in this species were not particularly noted. As a result of the availability of a series of colour photographs

of both CBF's and VED's birds, however, it can be stated that in the male the nestling iris colour is steel blue-grey which changes with age through brownish-grey, brown, rich chestnut-brown, deep red-brown to deep rich red in the adult. Bare orbital skin in the nestling was pinkish-flesh, changing with age through pale-grey, mid-grey, blackish to black. The development of black pigmentation on the bill and casque is indicated in Figure 7 by solid areas.

Our Great Hornbills perform sunning (Fig. 9a & b), foliage bathing, plastering, roosting and aggressive and self-assertive displays in an extremely similar fashion to the Rhinoceros and Northern Pied Hornbills. Vocalizations, however, are different, the loud call note being a coarse guttural *Whaaa*, and the sound produced when rejecting food a variety of strained nasal wheezing/whistling noises. This species apparently does not drink. The heat-loss, or cooling, posture of this species is illustrated in Plate II.

During a visit to the Bronx Zoo, New York, in late January 1976, CBF was fortunate enough to see an adult pair of Great Hornbills engaged in nesting activity. The female sat inside a large cavity in an artificial tree bough and was plastering the edges of the entrance hole. She frequently picked up soft matter, presumably excreta, from the cavity floor and added this to the plaster-work with the extreme mandible tips as described for the Rhinoceros Hornbill. Between bouts of plastering she would hammer vigorously at the cavity walls, perhaps in an attempt to chip off pieces which are then incorporated into the plaster or left on the cavity floor. In this particular cavity, however, the female was apparently wasting her energy, as the walls were not of wood. The male showed great interest in his mate's plastering activity, frequently inserting his head into the nest cavity to watch, and often passing plastering material to her, some of which appeared to be regurgitated.



Figure 9. Some sunning postures of five Asian Hornbills. a = an immature and b = a young juvenile Great Hornbill. c & d = a juvenile Rhinoceros Hornbill. e = a juvenile, moulting, Bushy-crested Hornbill. f = a juvenile and g an adult Northern Pied Hornbill. h = a young juvenile Black Hornbill. The direction on the sun's rays is indicated by shadow, or by arrows.

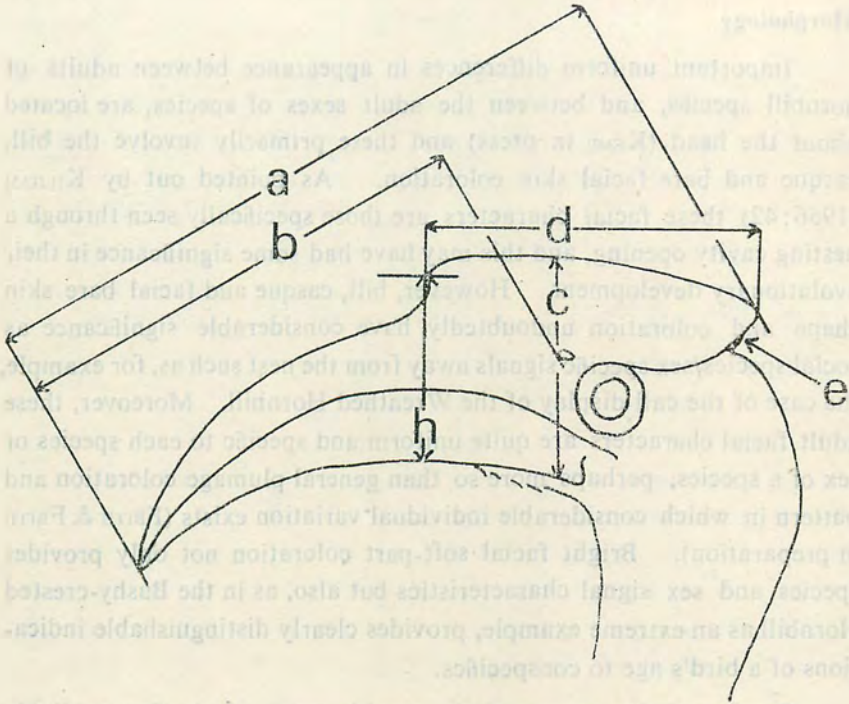


Figure 10. Diagram indicating some of the measurements given in Table 1: **a** = rear casque to bill tip; **b** = anterior nostril to bill tip; **c** = depth of bill at anterior nostril; **d** = casque maximum length; **e** = the location of termination of the skin on the rear casque, the measurement being taken from this point to the bill tip. The measurement on the upper mandible directly behind the ridged casque: **h** = depth from anterior casque to lower mandible.

DISCUSSION

Morphology

Important uniform differences in appearance between adults of hornbill species, and between the adult sexes of species, are located about the head (KEMP in press) and these primarily involve the bill, casque and bare facial skin coloration. As pointed out by KILHAM (1956:42) these facial characters are those specifically seen through a nesting cavity opening, and this may have had some significance in their evolutionary development. However, bill, casque and facial bare skin shape and coloration undoubtedly have considerable significance as social species/sex specific signals away from the nest such as, for example, the case of the call-display of the Wreathed Hornbill. Moreover, these adult facial characters are quite uniform and specific to each species or sex of a species, perhaps more so than general plumage coloration and pattern in which considerable individual variation exists (FRITH & FRITH in preparation). Bright facial soft-part coloration not only provides species and sex signal characteristics but also, as in the Bushy-crested Hornbill as an extreme example, provides clearly distinguishable indications of a bird's age to conspecifics.

Results of the present study provide some of the first available data concerning growth and development rates of the bill and casque structure unique to hornbills. Growth of a male Rhinoceros and two male Great Hornbills under semi-captive conditions suggest that in these very large species the casque may take four to five years to fully develop. With regard to the Great Hornbill this agrees with TICKELL (1864) who, as a result of keeping captive birds, stated that the casque is not fully developed until the fifth year. In the much smaller Northern Pied Hornbill casque development reaches a 'mature' state at about twelve to fourteen months of age; but continues to grow and emphasise the fundamental casque characteristics after three years (FRITH & FRITH 1978). It is not known whether a fully developed casque indicates a sexually mature bird and is, thus, a prerequisite to breeding. Whilst there can be no doubt that the full attainment of these conspicuous species and sex specific characters must have considerable significance

to the individual (FRITH & FRITH 1978) it is probable that individuals can in fact breed with only a partly developed casque under certain circumstances; as other bird species with peculiar 'mature' secondary sex characters do in, for example, circumstances whereby fully developed birds are locally absent or sparse such as those described by GILLIARD (1969:227) for the birds of paradise (Paradisaeidae).

Amongst other explanations, it has been suggested that the casque of hornbills functions as a shock absorber (WHISTLER 1949) and that this structure might prevent "injury to the brain" otherwise resulting from the birds banging the bill against objects (LOWTHER 1942:391). In view of the very pronounced sexual dimorphism in casque size and shape in some species, and the almost total absence of a casque in others this suggestion cannot be seriously entertained, however, unless we assume considerably differing degrees of 'banging' activity between species and the sexes of a single species. Moreover, such supposed shock-absorbing structures are not found in groups of birds that would appear to have a greater need for them (whilst it is acknowledged that many other shock absorbing adaptations do exist) such as oyster catchers (Haematopodidae), barbets (Capitonidae), woodpeckers (Picidae) which hammer into wood or hard prey animals; pelicans (Pelicanidae) and boobies (Suidae) which plunge into water from a height; and numerous other birds which vigorously beat prey on branches such as kingfishers (Alcedinidae). Whilst the bill and casque structures of hornbills are indeed bizarre and peculiar there seems at present no good reason to consider them anything but species specific and/or secondary sexual characters, such as are rather similar bill protruberances (and bare facial skin) found in the South American curassows of the family Cracidae (VAURIE 1968; DELACOUR & AMADON 1973).

The Helmeted Hornbill, *Rhinoplax vigil*, is unique in having a partly solid casque, so solid that it is used as a carving ivory (see HARRISON in SYMTHIES 1968; LINT 1972), and associated strong skull structure (MANGER CATS 1961). Not only is the bird's bill extremely heavy, it is, unlike all other hornbills, very short and woodpecker-like and in view of this it seems quite possible that both features enable the bird to dig into wood with effective heavy blows in search of food

(KEMP in press) or even to excavate or modify a nest cavity. In addition it has rather extensive naked areas of skin about the head and neck. BARTELS & BARTELS (1937) observed this bird trying to break into the nest of a smaller hornbill species, possibly in an attempt to reach the nestlings therein or to take over the cavity. That the heavy pointed bill and bare head have developed as adaptations for predating tree-hole nesting birds is, perhaps, a possibility.

The nestling

Plastering behaviour performed by nestlings is discussed below. Worthy of particular note here, however, is the fact that peculiar subcutaneous air sacs were noted in our Wreathed, Rhinoceros and Great Hornbill nestlings. KEMP, during his very thorough study of *Tockus* hornbills (1976), found that nestlings develop an air sac over the shoulder region when about one day old which then extends over the whole back and on to the upper breast by six days old and remains until about thirteen days old when it soon disappears. Obviously this air sac, or sacs, remains considerably longer in nestlings of the larger species, probably correlated directly with longer nestling periods. Kemp observed that the air sac was inflated when young birds were handled or prodded and that it may, thus, serve as a protective cushion in the crowded and confined nest as suggested by PROZESKY (1965), or prevent predators from pulling chicks out through the nest entrance. In view of the fact that we noted our nestlings inflating and deflating their air sacs relative to greater changes in air temperature it would seem possible that some thermoregulation might be involved. It is probable that by so considerably enlarging their body surface area the nestlings assist in cooling themselves in the confined and presumably hot nest cavity. Simple experimentation might answer this question, and in this respect it would be interesting to know to what extent the nestlings of the rather more open nesting ground hornbills, *Bucorvus* spp., develop an air sac (s).

Sunning, bathing, and allopreening

These activities are all concerned with the maintenance of feathering or skin (for a pertinent review of which see SIMMONS 1964); and allopreening is additionally performed in a courtship context, possibly in a ritualized form (see below).

Of our captives the White-crested, Brown, Bushy-crested, Black, Northern Pied, Rhinoceros and Great Hornbills performed sunning or sunbathing (Fig. 9). We are concerned here only with the occurrence of this behaviour in hornbills and not with the function or significance of it, for which we refer the reader to the most recent review of the subject by KENNEDY (1969). Of African hornbills KEMP (1976) describes and/or illustrates sunning in *Tockus erythrorhynchus* (Plate 6), *T. flavirostris* and *T. nasutus* (Plate 7), and RANGER (1950) for *T. alboterminatus*. Whilst not mentioning sunning at all, KILHAM (1956) includes in his plates one of a six month old *Bycanistes subcylindricus* in low intensity sunning posture and another of a young bird, only two days from the nest, in what we suspect is a high-intensity sunning posture on the ground. MOREAU & MOREAU (1940) described a *Bycanistes cristatus* intensely sunning from about only two weeks old. Of our captive species observed to sun, all did so from little more than fledging age. Sunning appears to be typical of hornbills and although we have not seen the Wreathed Hornbill do so it may prove to be a behaviour common to all species of the family. In view of the various postures we have seen each species adopt, however, we think the possibility of species specific sunning postures intimated by KEMP (1976) to be unlikely.

Possibly as widespread in hornbills as sunning is foliage bathing, although we record this only for the Black, Northern Pied, Rhinoceros and Great Hornbills. It had previously been described for the Great Hornbill by TICKELL (1864). RANGER (1950) records foliage bathing for *Tockus alboterminatus* and KEMP (1976) for *T. flavirostris*. Whilst we record the Bushy-crested Hornbill bathing in standing water this may have been due to unnatural or peculiar circumstances, and we can find no record of wild hornbills doing so.

Dust bathing was not observed during the present study despite the fact that PRIMROSE (1921) claims that the Northern Pied Hornbill "delights" in doing so in the wild, although he only saw his tame birds foliage bathe. Hornbill species do, however, dust bathe. KEMP (1976) cites records of it in seven *Tockus* species and illustrates it (Plate 7) being performed by an immature *T. flavirostris*. The predominantly

drier habitats occupied by *Tockus* hornbills (KEMP 1976 : 125) no doubt account for this widespread dust bathing in the genus.

It should be noted that the heat loss posture of the Wreathed and Great Hornbills shown in Plate II is very similar indeed to that of *Tockus nasutus* illustrated by KEMP (1976 : Plate 8).

Allopreening

We have observed the Wreathed and Northern Pied Hornbills preening each other, or allopreening. In addition the single Bushy-crested VED has, likes very much to be preened about the head and neck by her which we take as strongly suggesting that the species normally allopreens. MOREAU (1936) described a nesting pair of *Bycanistes cristatus*, of Africa, allopreening and MOREAU & MOREAU (1941) record a pair of the same species preening their nestlings, and a tame nestling enjoying such attention. KILHAM (1956) provides valuable observations of male and female *Bycanistes subcylindricus* preening each other in the wild, and HARVEY (1973) noted that a captive pair of this hornbill spent much time allopreening prior to breeding. Allopreening is apparently performed throughout the year in all these species, although HUTCHINS (1976) noted a male Northern Pied Hornbill allopreening his mates head immediately prior to copulation which might suggest it is a particularly important behaviour to a breeding pair. There is no doubt that it is important in forming and maintaining the pair bond.

RANGER (1949, 1950, 1951, 1952), KEMP & KEMP (1972) and KEMP (1976) make no mention of allopreening in *Tockus* species despite the intensive nature of their studies and the fact that they do carefully describe birds preening themselves, and also describe other activities of birds prior to copulation, which strongly suggests that *Tockus* species do not allopreen. It is particularly noteworthy in this respect that we have found that our Great and Rhinoceros Hornbills strongly dislike being touched about the head and neck, but do like to have their bill tip played with or 'billed'. Moreover, TICKELL (1864) specifically pointed out that his Great Hornbills would not "suffer themselves to be caressed, as the smaller species [*Anthracoceros malabaricus*] is fond of doing", and STOTT (1951) describing the pre-breeding behaviour of a captive pair of Great

Hornbills specifically notes that the pair touched bills frequently, but not allopreening.

It would seem possible that within hornbills there are species that frequently allopreen and there are those that do not. This apparent behavioural difference between species groups might prove a rewarding field of investigation.

Social feeding

The feeding of one bird by another was performed throughout the year by our Wreathed, Northern Pied and Great Hornbills and is performed by a bird when it has unwanted food in its bill. That the feeding of the female by the male is a most important feature of courtship in many, if not all, hornbills is undoubted. KEMP (1976) described it as typical of *Tockus* species, STOTT (1951) observed it in captive breeding Great Hornbills, and KILHAM (1956) and HARVEY (1973) record it for the Casqued Hornbill *Bycanistes subcylindricus*. HUTCHINS (1976) observed the male Northern Pied Hornbill apparently using such feeding to entice the female into the nest cavity and he considered the feeding of the female by the male in *Anthracoceros malabaricus* the most important activity during courtship preliminaries. Moreover, STONOR (1937) and KILHAM (1956) considered this to be true of *Bycanistes buccinator*, and RANGER (1951) did for *Tockus alboterminatus*—both hornbills of Africa. In view of the fact that this activity is not restricted to the breeding season, however, it is perhaps undesirable to call it courtship feeding, unless reference is actually being made to a courting or mated pair.

Plastering

Our male Black, male and female Northern Pieds, male Rhinoceros and male and female Great Hornbills all plaster crevices and holes with excreta, and the Black and Northern Pieds were observed doing so when very young. Such information obtained from captive birds may prove of value as the role of the adult sexes and nestling birds in plastering or replastering the nest cavity entrance is a useful systematic character. It is known that, at least in captive hornbills, both male and female Great (STOTT 1951) and Northern Pied (HUTCHINS 1976) Hornbills plaster

the nest entrance. It yet remains to be conclusively shown if plastering is an innate or learnt behaviour.

Drinking and fish-eating

We have not seen any of our hornbills drinking despite the availability of water. KEMP (1976) points out that drinking has never been recorded for any hornbill in the wild. HARRISON (*in* SMYTHIES 1968) reports a tame Black Hornbill drinking subsequent to swallowing a bat, but this may have merely been as an aid to ingestion rather than drinking.

As many hornbills are omnivorous the eating of fish is perhaps not surprising. Records of it are, however, rare. In addition to our observation of a Bushy-crested catching and eating fish, the only other undoubted record appears to be that of INGLIS (*in* HUME 1877) who states that the Northern Pied Hornbill is "Passionately fond of live fishes which it catches in shallow pools. Fish bones found in stomachs of several shot." It is presumably this observation that WILDASH (1968) alludes to. HOOGERWERF (1971) writes of the Wreathed Hornbill "Once this species was seen in a low tree above a coral reef apparently preying on crabs and on another occasion one almost landed on a reef to take a crab but was disturbed by the author's approach." It is noteworthy that pieces of crab were found in the nest of the African hornbill *Cerategymna atrata* (CHAPIN 1939).

VED has found that her captive Brown, Bushy-crested, Wreathed, Rhinoceros, Greater, Black and Northern Pied Hornbills will eat dead fish. Her Bushy-crested will readily take and eat live fish as will, to a lesser degree, her Northern Pied. The captive Rhinoceros Hornbill has killed and eaten fish, but the larger species appear much less eager to take live fish.

Aviculture

Until recently (STONOR 1937; STOTT 1951; HARVEY 1973; PENNY 1975; OLNEY 1975; HUTCHINS 1976; JENNINGS & RUNDEL 1976; PORRITT & RILEY 1976) few hornbills were bred in captivity, doubtless due to a lack of detailed knowledge and understanding of their peculiar breeding requirements. The results of simple experiments CBF carried out with a

young Wreathed Hornbill strongly support the logical and helpful suggestions given by HUTCHINS (1976) that the height of the nest entrance above the floor of the cavity might be critical to potential hornbill parents seeking a nest with a suitably situated entrance to permit normal nest sanitation behaviour of the female and young. Another very important point is that the original nest entrance provided should not be too large. It is frequently recorded in the literature that a pair of wild hornbills choose a tree cavity with an original entrance hole barely large enough for the female to, literally, squeeze through. Moreover, the edge of the entrance cavity should be thick, providing a broad base for the birds' plastering. Some species of hornbills apparently accumulate quantities of sticks, tree bark and other matter in the nest cavity (SHELFORD 1916; BARTELS 1937) and the provision of such 'nest material' by the aviculturalist may be useful. For other suggestions see HUTCHINS (1976).

Little is known of the breeding biology of many hole-nesting birds, particularly hornbills, due to the difficulty of direct observation. For this reason aviculturalists should make every effort to record all possible details of captive breedings of these birds. All too often interesting hole-nesting species are merely reported as having been bred, and no more.

ACKNOWLEDGEMENTS

We thank Jeffery Boswall for very kindly taking photographs of some of our birds. For helpful information we thank M. Hutchins and Dr. A.C. Risser Jr. Particular thanks is due to Michel and Annick Hendrickx who kindly cared for and photographed CBF's birds in his absence. Dawn W. Frith has been deeply involved throughout the study, has assisted throughout with feeding, measuring, photographing and observing the birds and we are particularly grateful to her for typing much of the drafts.

VED thanks Mom Kob Kaew Abhakara for making her part of the study possible by kindly allowing the presence of hornbills on her property. Marshall C. Douglas must be thanked for his understanding, and skill in aviary construction.

Table 1. Bill Growth Measurements (in mm.) and Approximated Ages of a male Wreathed, Rhinoceros and Great Hornbill

Date	Measurement ¹								Approx. Age in Months	Fig. Ref.
	a	b	c ²	d	e	f	g	h		
Wreathed										
4. 8.75	—	139.6	66.7	—	155.4	39.1	—	—	3	3a
6.10.75	—	152.9	69.0	—	168.0	43.8	—	—	5	—
10.11.75	—	155.5	71.1	—	171.2	44.9	—	—	6	3b
16. 5.76	—	163.3	71.9	—	179.0	45.4	—	—	12	3c
16. 8.77	—	165.9	73.5	—	182.4	47.3	—	—	27	3d
Rhinoceros										
4.11.74	126.5	112.0	59.4	—	—	46.1	—	—	3	6a, b
30.12.74	169.4	148.7	82.8	—	—	53.0	—	—	5	—
17. 2.75	192.9	165.6	91.1	—	—	55.6	—	—	7	6c
14. 4.75	207.0	175.5	95.8	111.3	—	57.0	—	—	9	—
14. 7.75	221.8	185.8	101.7	126.8	—	58.4	—	74.3	12	6d
1. 9.75	229.2	191.5	104.1	133.6	—	58.4	—	75.7	13.5	—
6.10.75	232.7	194.3	106.0	137.0	—	58.4	—	77.4	14	6e
16. 5.76	244.2	203.3	110.6	156.4	—	58.9	—	83.5	21	—
17. 1.77	225.7	211.7	119.1	173.6	—	60.0	—	94.1	29	—
16. 8.77	264.4	218.1	122.1	183.9	—	61.9	—	100.9	36	6f
Great										
4. 8.75	—	138.0	69.9	—	166.0	42.7	—	—	3.5	—
18. 8.75	—	143.8	73.4	—	177.4	43.8	—	—	4	7a
1. 9.75	186.7	149.6	73.5	—	185.0	44.2	—	—	4.5	—
15. 9.75	197.9	154.5	76.8	—	196.9	45.0	—	—	5	—
6.10.75	208.8	159.3	77.2	—	208.3	45.6	—	—	6	7b
10.11.75	223.3	168.6	80.8	—	222.0	46.9 ³	—	—	7	—
16. 5.76	258.8	186.9	86.1	165.4	253.4	—	69.1	—	13	7c
16. 1.77	273.4	194.2	92.4	172.9	271.2	—	75.2	—	21	—
16. 8.77	284.8	198.4	95.4	175.5	273.6	—	77.3	—	28	7d

- Note: 1. Measurements a to e and h are indicated in Figure 10. f = the distance across the upper mandible from nostril to nostril. g = casque maximum width.
 2. In the Wreathed and Rhinoceros this measurement was in fact the depth of bill at anterior nostril to the highest point of the upper mandible or casque.
 3. After this point it became impossible to measure from nostril to nostril (f) due to casque growth and the measurement thus became casque maximum width (g).

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