# Fruiting Phenology and the Conservation of the Great Pied Hornbill (*Buceros bicornis*) in the Western Ghats of Southern India<sup>1</sup>

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#### **ABSTRACT**

The phenology of principal fruits consumed by the endangered Great Pied Hornbill (Buceros bicornis) was monitored for two years in a wet forest habitat in southern India. Lipid-rich fruits, produced by several interior forest trees mainly of the family Lauraceae, were highly seasonal in their availability, and their production in the dry, hot season coincided with the breeding of the hornbill. Sugary fruits, produced mainly by several species of Ficus, were available year-round due to aseasonal fruiting patterns. Because Ficus fruited even at times of low fruit resource availability, and was heavily utilized by hornbills and other frugivores, it played a keystone role in the maintenance of the avian frugivore community. Overall fruit production was scarce between July and January during the southwest and northeast monsoon seasons. Vitex altissima produced berries abundantly during much of this time (September–December) and thus was another important fruit resource for avian frugivores. To safeguard the fruit resource base for the Great Pied Hornbill, we recommend: (1) The protection of Ficus and Vitex trees from overexploitation, and (2) the conservation of forest integrity to maintain compositions and densities of the lipid-rich fruit tree species utilized by the hornbill.

Key words: Buceros bicornis; Ficus; frugivory; hornbills; India; keystone species; nesting; phenology; Vitex; Western Ghats.

The Great PIED Hornbill (GPH) (BUCEROS BICORNIS), a large and endangered bird of the humid hill forests in the Western Ghats of southern India, is the largest (male: ca. 130 cm long, 3 kg) of the nine species of hornbills (Bucerotidae) found on the Indian subcontinent (Ali & Ripley 1987, Kemp 1995). It subsists principally on forest fruits. The possible causes for its endangered status are varied: large-scale habitat loss, forest fragmentation, and poaching of adults and squabs from nests by local tribal people are some of the proposed factors (Ali & Ripley 1987). Prior to this study, no information was available regarding the seasonal dietary requirements of the GPH, nor on the temporal pattern of availability of its fruit resource.

Large-bodied tropical frugivores are thought to be especially vulnerable to extinction in the face of deforestation because of the spatiotemporal patchiness of their fruit resources (Terborgh & Winter 1980). This, and the fact that they have large home ranges, makes them rely on vast contiguous tracts of forests for their year-round existence. The intensity of forest destruction in the Western Ghats over the past few decades (Chattopadhyay 1985) has jeopardized the survival of many arboreal frugivores

Research on fruiting phenology of tropical forests has introduced the concept of pivotal plant species (Howe 1977) and keystone plant resources (Leighton & Leighton 1983, Terborgh 1986, Lambert & Marshall 1991). These species are vital in sustaining frugivore populations over periods of resource scarcity. Identifying these fruiting species may have important conservation implications for the entire food web because many frugivores act as key seed dispersal agents, and thus play a crucial role in forest dynamics (Gilbert 1980, Kinnaird 1998).

Fruiting phenology of principal fruits consumed by the GPH was monitored in a rain forest habitat in southwestern India for two consecutive years to assess the year-round pattern of fruit availability for the bird, and to identify any keystone plant taxa vital to the survival of the bird and the avian frugivore community. Fruit diets and tree visitations of the GPH and several common avian frugivores were also monitored to identify the relative

<sup>(</sup>Borges 1989, Joshua 1992, Menon 1993). A knowledge of the fruit resources used by these vertebrates is urgently needed to prescribe management guidelines for their protection. Because fruit preferences of different frugivorous animal taxa diverge widely, information on fruiting schedules must be gathered from the perspective of a focal consumer species or guild, rather than that for the entire frugivore community.

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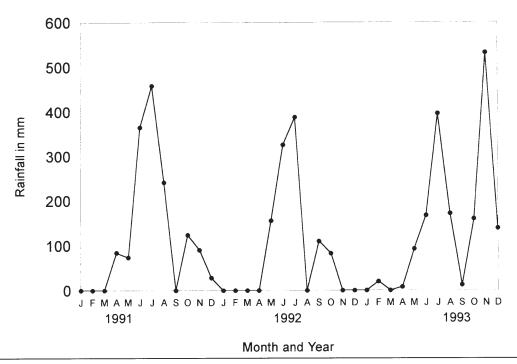


FIGURE 1. Monthly rainfall (mm) in Top Slip, Anaimalai hills, from January 1991-December 1993.

importance of various taxa of fruit trees over time for each species.

## STUDY SITE

The study was conducted from August 1991-July 1993 in the forests of Indira Gandhi Wildlife Sanctuary near Top Slip in the Anaimalai hills of the Western Ghats (10 25'N 76 60'E) of southern India. The forest vegetation of the study area has been classified as southern tropical wet evergreen forest (Champion & Seth 1968), the elevation varies from 700-750 m, and annual rainfall measurements for the years 1991, 1992, and 1993 were 1464, 1402 and 1696 mm, respectively. Precipitation patterns showed two seasonal peaks each year: one during the southwest monsoon in June-August, and the other during the northeast monsoon in September-November (Fig. 1). Typically, the southwest monsoon brings more rainfall to the Western Ghats than the northeast monsoon, and this pattern held in 1991 and 1992 but not in 1993.

### **METHODS**

Fruiting phenology was monitored as described below, using modifications of the area-based sampling methods of Leighton and Leighton (1983). A focal animal approach was used in quantifying fruit abundance and availability by choosing only horn-

bill-preferred fruit taxa for sampling. Ten 1-ha plots were established within a 3 km<sup>2</sup> area of forest, and all plants with stems >20 cm in diameter at breast height (DBH) known to produce fruit consumed by GPH (instead of the comprehensive sampling of fruiting and flowering done by Leighton and Leighton 1983) were marked with paint, assigned a number, and tagged. Tree identifications were made provisionally in the field using vernacular Tamil names obtained from the local tribal people, but herbarium specimens of the important taxa were collected whenever possible and botanical names determined based on Gamble (1967), Pascal and Ramesh (1987), and Ramachandran and Nair (1988). Most of the plants in the sample could be identified only to the genus level due to the difficulty in obtaining specimens. Ficus specimens were exceptionally difficult to identify to the species level because of the confusion prevailing in Asian fig taxonomy. Whenever possible, identifications were confirmed by comparison with specimens at the Botanical Survey of India, Coimbatore, and through the help of several plant taxonomists specializing in the taxonomy of the local rain forest vegetation.

Since fig trees were poorly represented in the plots, and considering the overwhelming importance of these trees to vertebrate frugivores (as was evident from the literature), a 5-km system of trails was established in which all fig trees >20 cm DBH were marked and tagged. Such a small minimum

diameter class was chosen to make the sampling comprehensive, considering the wide variation in minimum size at which the different species bear figs (Lambert & Marshall 1991; Kannan & James pers. obs.). The total number of fig trees in the sample (plots and trails combined) was 100 trees. Because the sample size for each species of Ficus was very small, and since many fig specimens could not be positively identified to the species level, the Ficus phenology results are presented for the genus as a whole. This lumping of all bird-dispersed species of Ficus for the analysis was considered acceptable because GPH appeared to show no particular preference for any species or group(s) of species of bird-dispersed figs. Flocks of feeding hornbills were recorded in fig trees that produced fruits of a wide variety of sizes and colors. Studies on the same hornbill species from Thailand also showed that the birds prefer a wide variety of fig species (Poonswad et al. 1988, Kemp 1995).

The entire phenological sample (plots and fig trails combined) included 652 individual trees of at least 19 genera (see Appendix). Except for two individuals of a liana, *Elaeagnus conferta* (Elaeagnaceae), all the plants were middle or upper story trees.

The abundance of information pertaining to the fruit diets of avian frugivores in general (McKey 1975, Snow 1981, Beehler 1983, Leighton & Leighton 1983) and studies of the GPH from Thailand (Poonswad et al. 1988), along with the excellent knowledge of the local indigenous people, helped to determine a priori the taxa of plants to include in the phenological sample. However, to reduce the risk of overlooking potential hornbill fruit trees, decisions regarding species to include in the sample were made in a liberal manner. Consequently, towards the end of the study, all 57 plants of Palaquium, Artocarpus, Bischofia, Diospyros ovalifolia, and Diospyros microphylla were deleted from the sample because of the lack of evidence, either in the literature or from personal observations in this study, that the fruits of these species were consumed by the GPH. Similarly, two individuals of Ficus beddomei were deleted from the plot samples because this species was found not to be bird-dispersed. Although not all locally available preferred fruit species of the hornbill were represented in the plots, the procedure covered the more important species and thus satisfied the objectives of the study.

With the help of local assistants and volunteers, the trees were monitored monthly from September 1991–July 1993, and the pattern of fruit production for each individual was recorded for each month as "ripe" (several ripe fruits present), "unripe" (all fruits unripe), or "unripe/ripe" (with unripe fruits but apparently on the verge of ripening). Individuals in the last category were monitored further by weekly revisitations for any status updates within that month. In this account, a "fruit patch" is defined as an individual plant with ripe fruit. Observations on fruiting status were made by scanning the canopy with binoculars and checking the litter below for fallen fruit. Animal activity in the canopy was often a good clue to fruiting condition, especially in trees with exceptionally tall crowns.

Information on fruit diets and tree visitation by avian frugivores were obtained opportunistically during daily walks in the study area. For each episode of fruit eating, the species and numbers of the bird involved, and the fruit taxa consumed were noted.

All statistical analyses were performed using SAS (1985) software.

## **RESULTS**

Two distinct fruit types were recognized among the fruits produced by the trees in the sample: relatively odorless, watery, and sugar-rich fruits with succulent pulp and mostly aromatic, oily, and lipidrich fruits with a relatively drier pulp (after McKey 1975, Snow 1981). Sugar-rich and watery fruits were produced by Moraceae (Ficus), Myrtaceae (Eugenia), and Verbenaceae (Vitex). The plant taxa producing nutritious, lipid-rich fruits for the hornbill were Myristicaceae (Myristica and Knema), Meliaceae (Dysoxylum), Lauraceae (Alseodaphne, Cinnamomum, Beilschmedia, and Persea), Annonaceae (Polyalthia), and Burseraceae (Canarium). The fruits of Myristicaceae and Meliaceae were capsular and dehiscent, whereas those produced by the others were huskless and drupaceous. Only the dominant genera in each family have been named above.

LIPID-RICH FRUITS.—Lipid-rich fruits were highly seasonal in availability (Fig. 2) with fruit patches being mostly available in the dry and hot season from February—May, with some fruiting into the monsoon months between June and September. The increase in availability of these nutritious fruits during the hot season coincided with the breeding season of the GPH (Fig. 3; Kannan 1994a, Kannan & James 1997). There was a distinct decrease in lipid-rich fruit production during 1993, brought about mainly by the poor fruiting of *Polyalthia* and

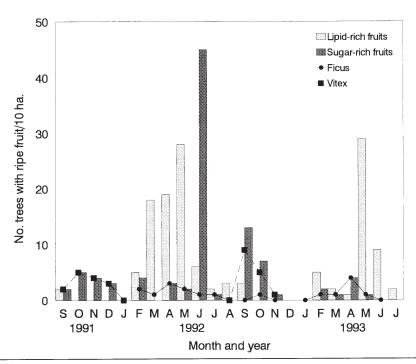


FIGURE 2. Fruiting phenology of major lipid-rich and sugar-rich fruits utilized by the Great Pied Hornbill in the ten 1-ha sample plots. Fruiting patterns of *Ficus* and *Vitex* are shown separately.

the total lack of fruiting in Persea (Fig. 3). In both years (1992 and 1993), the community peak in fruit availability for hornbills occurred in May, during the time when they were feeding their chicks in nest. The rainy seasons were lean periods for nutritious fruit production. There was no production of lipid-rich fruits during and immediately after the northeast monsoon, from October-January in both years (1991-92 and 1992-93; Fig. 2). Very few fruit patches of these nutritious fruits were recorded during the southwest monsoon from June-September. Since these species represented most of the fruit-producing taxa, overall community-wide fruit scarcity prevailed from July-January, a period that spanned both monsoon seasons. The two rainy seasons were therefore lean periods of overall fruit availability for GPH.

The major genera of lipid-rich fruit producers, represented by at least 15 trees across the 10 ha of sample plots, showed staggered and displaced fruiting schedules from February–September 1992 (Fig. 3). These seven genera fruited temporally in such a manner that, in 1992, not more than three genera of trees bore fruits in a given month, and at least one genus was in fruit every month. Except *Cinnamomum* and *Dysoxylum*, which fruited after the chicks fledged, the other five genera fruited during the nesting season of the GPH (Fig. 3), and these fruits were delivered in varying quantities to

the confined inmate(s) of the nests (Kannan & James 1997). In 1992, *Myristica* and *Polyalthia* fruited heavily during the most crucial phase of the breeding season (April) when the female and chick were sealed in the nest, whereas in the following year *Myristica* trees accounted for most of the fruiting patches in this nesting period (Fig. 3).

Sugar-rich fruits.—Sugar-rich fruits were available throughout the year. However, this is not reflected adequately in Figure 2 because of the poor representation of Ficus in the sample plots (just 26 fig trees and only 18 fruit patches during the 2 yr). A better portrayal of the aseasonal, year-round availability of bird-dispersed figs is shown in Figure 4, which represents the fruiting patterns of 100 fig trees, plots, and trail samples combined. Except for August 1992 and July 1993, some ripe figs were produced by these trees during all months of the monitoring period. This included 111 fruit patches of fig trees, generated by the 67 trees that fruited during the 2 years. The proportion of fig trees that bore ripe figs each month varied from 1-12 percent of the total sample, averaging  $5.04 \pm 3.48$  percent (SD) for the 21 fruiting months.

Although the overall pattern of fig availability suggested aseasonality because figs were available essentially year-round, there were significantly more fig fruit patches (plots and trail samples com-

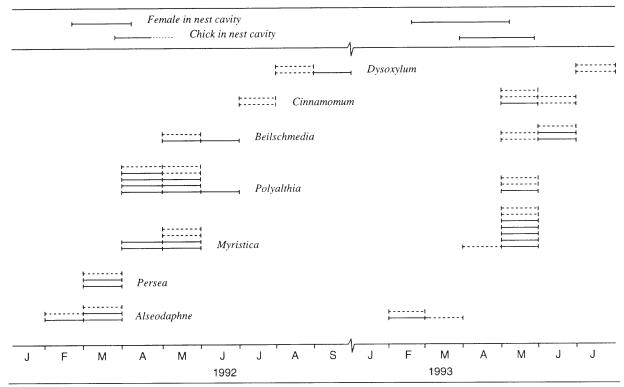


FIGURE 3. Breeding phenology of the Great Pied Hornbill (upper panel) and fruiting phenology of seven genera of lipid-rich fruits (lower panel) during two consecutive years (1992 and 1993). Breeding phenology data is based on observations from a single nest for both years (incomplete in 1992). Fruiting phenology is based on data obtained across ten 1-ha sample plots. For fruiting phenology, each solid line represents three fruiting trees and each dashed line represents one fruiting tree. Stacked lines represent cumulative number of fruiting trees for the respective month.

bined) during the dry, hot months of February–May ( $\bar{x} = 8.1$  patches/mo, N = 8) than during the wetter and cooler months ( $\bar{x} = 3.0$  patches/mo, N = 15) (t = 4.38, df = 21, P = 0.0003; Fig. 4). These peaks in fig availability coincided with the breeding season of the GPH, when the majority of the food items (72.9%) delivered by the parent hornbill(s) to the confined inmate(s) at nests were figs (Kannan & James 1997).

A concurrent study (Kannan 1994a) on the size of fig trees used by the GPH for foraging showed that hornbills selected extraordinarily large fig trees having a mean DBH of 173  $\pm$  45 cm (SD; N =20 trees). This information was used to further analyze the fig phenology data. The temporal pattern of fig availability from trees >83 cm DBH, the value derived from subtracting 2 SD from the mean preferred diameter, is also shown in Figure 4. This gives an indication of fig production in those trees in which hornbills actually forage. The overall fruiting pattern here is almost identical to that of the comprehensive data set, but the peaks are less intense and the number of fig fruit patches was less than in the overall sample in 9/23 mo of observations (Fig. 4). No Ficus in this subset of sample fruited in September 1991. Significantly more trees in this subset fruited in the hot and dry season from February–May ( $\bar{x} = 7.1$  patches/mo, N = 8), coinciding with the breeding season of the hornbill, than in the other months ( $\bar{x} = 2.6$  patches/mo, N = 15) (t = 4.57, df = 21, P = 0.0002).

Unlike lipid-rich fruits, fig trees showed remarkably short crop persistence. No systematic data were gathered on fig crop sizes and crop persistence, but it was obvious that ripe figs were abundantly and synchronously produced within the crown and were available for only 2–4 d. The figs were depleted rapidly by a wide array of vertebrate frugivores. Thirty-one species of birds (Athreya 1993) and at least eight species of mammals in the study area were recorded visiting fig trees to consume figs during the study period. Nearly a quarter (23.6%) of the resident bird species in the study area fed on ripe figs (Kannan 1994a).

The pattern of sugary fruit production showed a steep increase in June 1992, but these fruits were totally absent in the plots in June 1993 (Fig. 2). This striking difference was due to the sharp peak in the number of fruit patches of *Eugenia* in the

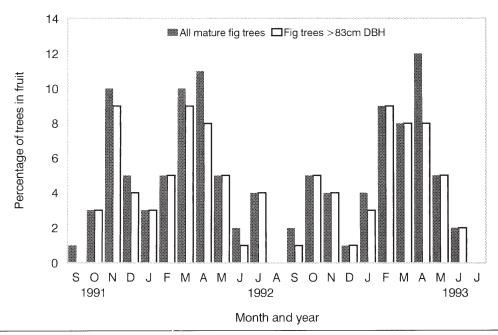


FIGURE 4. Fruiting phenology of bird-dispersed *Ficus* from September 1991–July 1993, based on percentage of trees fruiting out of 100 trees monitored.

sample plots in 1992, and the total lack of fruit patches for this genus the following year. An abundant, commercially important tree, *Vitex altissima*, copiously produced small sugary berries and accounted for all of the fruiting in the plots during September and December 1991 and most of the fruiting from September–November 1992 (Fig. 2). *Vitex* berries were consumed by GPH and ten other

Decentage of visits to fig trees

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FIGURE 5. Relative frequency of fig visitations by Great Pied Hornbills with respect to visitations to all fruiting trees during the five quarters from September 1991–November 1992 (N = 47, 31, 36, 6, and 137 visits, respectively).

vertebrate species, and a number of trees of this genus were found fruiting outside the plots until December in both years. The year-round fruiting of *Ficus*, and the heavy fruiting of *Vitex* for at least 3 mo during the fruit-scarce northeast monsoon, ensured that these two fruit taxa were available at times of poor fruit production by other species.

Importance of Figs in the Diet of Frugivores.— The GPH relied primarily on fig patches most of the year for its fruit requirements (Fig. 5). On average, 78.8 percent of all visitations to fruit trees were to fig trees during each quarter in the 15-mo period from September 1991-November 1992. There was a sharp decline in GPH observations (N = 6) during the relatively fig-scarce period from June-August 1992 (Figs. 4 & 5), suggesting that the birds emigrated to other areas when figs were in short supply. GPH visited figs more frequently than other bird species; >90 percent of all tree visitations of the GPH during one year (September 1991-August 1992) were to fig trees, compared to an average of 55.7 percent for four other avian frugivores during the same time period (Fig. 6).

### DISCUSSION

HORNBILLS AND LIPID-RICH FRUITS.—The importance of a diet of lipid-rich fruits as a source of energy and nutrition has been well documented for many vertebrate frugivores (McKey 1975; Snow

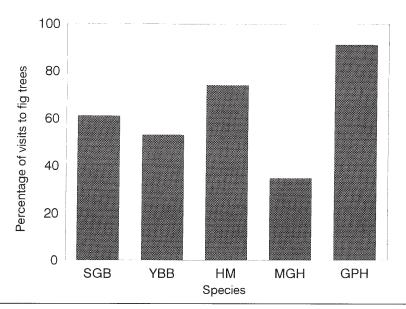


FIGURE 6. Relative frequency of fig visitations with respect to visitations to all fruiting trees in one year (September 1991–August 1992) by the Great Pied Hornbill and four common avian frugivores. The abbreviations and sample sizes are: SGB–Small Green Barbet ( $Megalaima\ viridis$ ,  $N=88\ visits$ ); YBB–Yellow-browed Bulbul ( $Mysipetes\ indicus$ , N=97); HM–Hill Myna ( $Gracula\ religiosa$ , N=262); MGH–Malabar Grey Hornbill ( $Ocyceros\ griseus$ , N=109); and GPH–Great Pied Hornbill ( $Buceros\ bicornis$ , N=139).

1962, 1981) and for hornbills in particular (Leighton 1982). The nutritious quality of the pulp of lipid-rich fruits ensures that even small numbers of these fruits can contribute significantly to the daily energy needs of a hornbill (Leighton 1982). The fact that these fruits increased in availability at a time when GPH (and most other frugivores) were breeding makes them especially important considering the heavy metabolic demands for energy placed on the parents and young birds during this period. Their displaced fruiting schedules yielded a steady supply of nutritious fruit for at least six months (February-July), covering the breeding and postbreeding period of the GPH. Many studies have shown similar positive correlations between breeding activity of frugivores and fruiting peaks (Worthington 1982, Leighton & Leighton 1983, Terborgh 1983, Wheelwright 1983).

Hornbills, with their wide gapes, are able to ingest, process, and transport the large seeds characteristic of lipid-rich fruits like *Myristica* and most members of the Lauraceae. Casual observations during the present study indicated that in addition to the GPH, only two other species of birds, the Grey Hornbill (*Ocyceros griseus*) and the Imperial Pigeon (*Ducula badia*), could ingest intact and disperse the seeds of *Myristica*, ostensibly because of the constraints imposed by the large size and capsular nature of the fruit. All three large-bodied avian species have the morphological trait of wide

gapes associated with specialized frugivory (McKey 1975). Leighton (1986), in his studies on Bornean hornbills, found that some lipid-rich fruit trees were exclusively dependent on hornbills for dispersal. Kinnaird (1998) demonstrated that Sulawesi red-knobbed hornbills significantly influenced forest regeneration by acting as seed dispersers. This interdependence of several plants on a select group of dispersers has important conservation implications in that the local extermination of one or more of the dispersal agents could lead to the disappearance of the different plant species dependent on them. Hornbills, therefore, are likely to play a major role in forest dynamics. This, coupled with their choice of mature forest stands (Kannan 1994a, Mudappa & Kannan 1997), highlights their potential as effective indicators of forest quality.

Lipid-rich fruit producing trees are represented by a number of locally rare species, as demonstrated in Bornean rain forests (Leighton & Leighton 1983). In the Western Ghats, Pascal and Ramesh (1987) identified 21 species of trees of the major lipid-rich genera preferred by hornbills (12 species of Cinnamomum, 2 Myristica, 2 Beilschmedia, 2 Dysoxylum, 1 Persea, and 2 Polyalthia) within the altitudinal range of 600–1000 m, which is the elevation where the GPH is found. The reliance of hornbills on this diverse array of locally rare tree species is of crucial importance to their conservation (Leighton & Leighton 1983). Over 4000 trib-

al people (3.5/km²) live in the Indira Gandhi Wildlife Sanctuary, and all of them are dependent on the forest for firewood and other resources (Kannan 1994b). Heavy removal of forest understory vegetation, along with forest fragmentation, could easily render these rare tree species locally extinct, since low population density is one of the key factors that makes a species vulnerable to extinction (Terborgh & Winter 1980). Management plans for hornbill conservation must, therefore, strive to protect not only the areas under forest cover but also the integrity of the remaining forest patches to maintain compositions and densities of the various lipid-rich fruit tree species utilized by the hornbill.

IMPORTANCE OF VITEX ALTISSIMA.—The seasonal fruiting of Vitex during the fruit-scarce northeast monsoon period, and the preference for its berries by a broad variety of frugivores including hornbills, makes this common tree an important source of food. The commercial value of its wood (Gamble 1922) makes it prone to overexploitation. Forestry practices must carefully consider the ecological value of this species while formulating extraction policies.

Keystone nature of FICUS.—To quote Kannan (1994a): "The well documented aseasonality and year-round availability of bird-dispersed Ficus fruits has often been referred to as the key factor that gives this group keystone importance to frugivore communities (Foster 1982, Milton et al. 1982, Leighton & Leighton 1983, Terborgh 1986, Windsor et al. 1989)." With the indisputable dependence of hornbills on figs (Figs. 5 & 6), and the apparent mutualistic interactions between hornbills and lipid-rich fruit producing trees, it follows that excessive removal of fig trees in any area will have serious effects on hornbill populations, and consequently may have negative effects on populations of other tree species dependent on hornbills for their propagation. This potentially could lead to the type of serial extinctions described by Futuyma (1973), and highlights the importance of shifting the focus of conservation from the single-species level to the maintenance of key interactions in the community (Pickett et al. 1992).

Fig trees have several attributes in addition to aseasonality that make them a unique and extremely important subset of bird-dispersed fruit resources (Lambert & Marshall 1991). In the present study area, fig trees were numerically abundant with a density of 3/ha (Athreya 1993), which translates to

300/km<sup>2</sup>. Also, they were utilized by a diverse coterie of vertebrate frugivores, thereby contributing significantly to local biodiversity. In addition to these features, the fact that Ficus exhibited a significant fruiting peak in the dry and hot season (Fig. 4) coincident with the breeding of the GPH, makes it an exceptionally valuable resource at least in south Indian rain forests. The heavy reliance of hornbills on figs at this time, even when other fruits are available, makes Ficus conservation of paramount importance to the conservation of the GPH. The aseasonality and year-round availability of fig fruits, with the significant peak in fig availability in the dry season, has also been reported from another evergreen forest site in the Western Ghats (Patel 1997).

To quote Kannan (1994a): "Although the spectrum of fig production generally reflects year-round availability to hornbills and other frugivores, it is apparent from the data that figs may be locally scarce at some times of the year, like August 1992 and July 1993" (Fig. 4). This may be more evident when large fig trees are considered separately (adding September 1991 in Fig. 4). Evidence obtained in this study suggests that GPH resort to nomadic emigration movements during such fig-scarce periods, supporting the view that Ficus may be keystone taxa only for wide-ranging frugivores (Gautier-Hion & Michaloud 1989, Lambert & Marshall 1991, Borges 1993). Although GPH are strong fliers, this periodic requirement to emigrate to adjacent habitats may make them especially vulnerable to the effects of excessive forest fragmentation.

Status of fig trees.—Continued forest fragmentation in the Western Ghats poses a threat by potentially reducing populations of fig trees (and their associated wasp pollinators) below the minimum levels at which they can survive (Patel et al. 1993). On a more local scale, fig trees historically have been subjected to unfavorable forestry practices in India (Kannan 1994a). In the Indira Gandhi Wildlife Sanctuary, they are regularly cut or lopped because the leaves are the favored fodder of 30-odd domestic elephants stationed in the sanctuary for teak lumbering operations. This practice has been a regular government policy for several decades not only in this sanctuary, but all over India where elephants are used in logging. In the present study area, many fig trees are mere stumps as a result of the severe lopping. The findings in this study prompted the local forest officers to impose an official ban on the lopping of fig trees, but evidently enforcement is difficult. Unless there is a countrywide recognition amongst forest officials that fig trees are vital for hornbills and other wildlife, this practice of fig lopping will continue and thus threaten the single most important source of food for vertebrate frugivores.

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APPENDIX. List of plants monitored for two years within the ten 1-ha phenology plots.

Serial no.	Family	Scientific name	Vernacular (TAMIL) name	No. of plants
1.	Moraceae	Ficus*	Kallichi, Aal	24
2.		F. beddomei	Aal	2
3.		Artocarpus	Selai	26
4.	Bixaceae	Scolopia	Kodali	6
5.	Meliaceae	Dysoxylum	Vellaigil	24
6.	Myrtaceae	Eugenia	Naval	140
7.	Lauraceae	Cinnamomum	Lavangam	80
8.	•	Beilschmedia		15
9.		Alseodaphne	Mammarudhu	16
10.		Litsea (?)		2
11.		Persea	Kolamaavu	19
12.	Myristicaceae	Myristica	Sadhipatri	56
13.	-	Knema	Sadhikai	15
14.	Annonaceae	Polyalthia	Nedunari	92
15.	Sapotace <b>ae</b>	Palaquium	Pali	18
16.	Burseraceae	Canarium strictum	Karung Kungiliam	2
17.	Ebenaceae	Diospyros microphylla	Chinna Thuvarai	5
18.		D. ovalifolia	Thuvarai	1
19.	Euphorbiaceae	Bischofia javanica	Solai Vengai	7
20.	Elaeagnaceae	Elaeagnus conferta	8	2
21.	Verbenaceae	Vitex altissima	Myladi	26

<sup>\*</sup> Several bird-dispersed species.