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EFFECT OF TIMBER EXPLOITATION ON PRIMATE POPULATION AND DISTRIBUTION IN THE BIA RAIN FOREST AREA OF GHANA

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ABSTRACT.

Modern trends show that the preservation of tropical rain forests rich in valuable timber, in practice, is often impossible. Howbeit, the conservation of primates presupposes the availability of suitable habitat. Lowland forests are both, economically important from the point of view of timber production and diversity in respect of both flora and the primate fauna. Primate populations are in general adversely affected by timber extraction, even if selective exploitation methods are applied. If primate populations are to be managed in utilized tropical forests it is necessary to know more about the nature of the impact caused by forest utilization. In this paper we have tried to compare densities of sympatric primate species between areas with different protection status. Three upper canopy species: red colobus, diana monkey and black and white colobus as well as three lower canopy species: (mona) monkey, spot-nosed monkey and olive colobus, were covered. Campbell's

Hunting reduces the density of groups and group sizes in general. The red colobus may be shot out even under moderate hunting pressure. Timber exploitation causes the upper canopy species to disappear, at least temporarily. The red colobus has not been found to reinvade secondary forest. The same is probably true for the diana monkeys.

It is however not clear as to whether this is due to the reduction of the available food plants or extermination by hunters during timber operation before reoccupation could take place. Black and white colobus populations may survive in secondary forest but their density is severely reduced. Though some of the lower canopy species favour underbrush which is enhanced by timber extraction, it appears that mona and spot nosed monkeys do not attain higher individual densities in secondary vegetation.

INTRODUCTION.

The decimation of undisturbed rain forest in West Africa undoubtedly has a drastic impact on primate populations. It is, however, to be expected that different primate species react differently to the various kinds of human disturbance. In this paper three levels of human disturbance are recognised: logging, hunting and farming. Curtin (1977) suggested that the diana monkey (Cercopithecus diana) would not be able to survive in logged areas on long terms even if selective logging techniques are applied, i.e. if only single tree species above a certain girth are extracted. Gartlan and Struhsaker (1972) reported mona monkey (Cercopithecus mona) to be even more successful in secondary vegetation in Cameroon whereas the red colobus (Colobus badius) has been exterminated in such secondary vegetation. Asibey (1976) reports similar findings for red colobus populations in Ghana where the species has been exterminated in secondary vegetation. Whereas some faunal species may be less affected by timber extraction alone, others are particularly susceptible to hunting pressure which becomes higher where there is timber extraction. Primates in general make up for a considerable part of the West African bushmeat crop in the high forest zone: the major habitat of most West African higher primates (Asibey 1976).

Experience in Ghana shows that timber extraction opens up the forest for subsequent slash-and-burn farming of food crops as well as for intensive meat hunting. This happens in forest reserves and

timber protected lands where timber land is not effectively guarded. Therefore the ultimate consequence of logging is often a total eradication of such primate populations that cannot stand heavy hunting pressure and secondary vegetation.

In view of the huge economic interest in timber-rich areas the harm caused to primate and other wildlife population as a result of logging hardly counts at policy levels where such damage is taken lightly. Consequently to ban logging in lowland forest on long terms in order to conserve wildlife is often illusionary even in the case of relatively small areas. Therefore if primate populations are to be conserved in spite of logging activities, where the establishment of national parks is not practicable, one is forced to adopt a pragmatic standpoint. A practical approach to primate conservation in the forest zone might have to aim at the identification and the avoidance of techniques as well as the prevention of influences that are most detrimental to primate populations. In order to do this it is necessary to have a thorough understanding of the effects of logging and its secondary consequences on primates. This paper tries to identify some effects of timber extraction on different primate species on the basis of comparisons of frequency of sighting and group size of primates in forest areas with different protection status and logging activity.

STUDY AREA.

The data for this paper were collected in three areas which, in order of decreasing degree of protection, are the Bia National Park, and the adjacent Bia Game Production Reserve and a part of the Sukusuku area collectively known as the Bia Area or Bia Reserves (Fig. 1). The area is situated in the Western Region of Ghana between 6° 20' and 6° 40' north: near the Ivory Coast border. The vegetation is a lowland rain forest type and falls into the transitional zone between the "moist evergreen" and the "moist semideciduous" type with mean annual rainfall between 1500 and 1750 mm (Hall and Swaine, 1976).

The Bia area belongs to the most valuable timber land presently left in Ghana. The two main conservation areas (Bia National Park and Bia Game Production Reserve) together have an area of 306 km^2 with a record of 627 vascular plants, 169 of which are trees reaching heights of more than 8 m in the centre of Bia National Park (Hall, 1978). The upper crown canopy is between 30 - 50m above ground. Tallest emergents reach heights of about 70m. In most places there are no distinct middle canopies. The lower canopy is usually below 20m above ground level. Often in places where there is a larger gap in the upper canopy enough light penetrates to the ground level and thickets of underbrush and vines grow.

All areas around the Bia conservation area are under timber concessions or have been exploited already and have subsequently been occupied by farmers, whether legally or illegally. The Bia Game Production Reserve used to be part of a larger National Park but it was put under a Game Production Reserve and subsequently came under timber concessions. It is the subject of study and monitoring of effects of logging on wild animals by the Department of Game and Wildlife (Asibey 1976). The timber exploitation method applied is selective logging of marketable species above a girth of 7 feet in accordance with the prescription and control of the Forestry Department of Ghana.

= 67.9 cms dbh

The following eight higher primate species occur sympatrically in undisturbed parts of the forest:- Chimpanzee (Pan troglodytes verus), red colobus (Colobus badius waldroni), black and white colobus (Colobus polykomos vellerosus), olive colobus (Colobus verus), diana monkey (Cercopithecus diana roloway), Lowe's mona monkey (Cercopithecus campbelli lowei), lesser spot nosed monkey (Cercopithecus p. petaurista) and the white crowned mangabey (Cercocebus atys lunulatus). Three of those species: the red colobus, the black and white colobus and the diana monkey are distinct upper canopy dwellers. The other species feed and travel almost exclusively in the lower canopy and thick entanglements of the undergrowth. The mangabey and the chimpanzee

feed also and predominantly travel on the ground. Of the two, mangabey has been identified as the only one of the lot that has a tendency to raid farms (Asibey 1976).

Mona monkeys and spot nosed monkeys frequently associate in mixed groups. Both species inhabit the lower canopy and thickets of the undergrowth. The gross niche separation of Ghanaian forest primates has accurately been outlined by Booth (1956). Polyspecific associations including other species also occur but less frequently. Particularly olive colobus may be seen in association with mona monkey; spot nosed monkey or red colobus groups.

Visibility of monkeys is difficult in places where there is thickets of underbrush and vine growth. In such areas no reliable distinction between mona monkey and spot nosed monkey groups using this type of habit could be made. With the exception of the mona monkey with spot nosed monkey associations, however, groups of the other primates could clearly be identified as being groups of one species or the other.

In the Bia area studied, polyspecific associations were certainly far less frequently met than described for the rain forest of Cameroon where most of the cercopithecoids are very often in polyspecific associations (Gartlan and Struhsaker, 1972). This might be due to the fact that more cercopithecoid species inhabit similar niches in the Cameroon forests. In the Bia forest the canopies are generally distinctly different in physiognomy and species composition. Consequently it is not surprising that associations between upper and lower canopy dwellers were not frequently met with.

The range and feeding ecology of the three upper canopy species of the Bia area have recently been studied: M. Rucks studied two red colobus groups; three black and white colobus groups were studied by D. Olson while S.H. and P. Curtin studied one diana monkey group. All three studies (publication in preparation) were carried out in a 5.4 km^2 intensive study area in the centre of Bia National

Park (Fig. 1). Therefore at the beginning of the study, which included the same intensive study area, the studied primate groups had been habituated to the presence of man and had already been followed between one and three years. Their sizes and group ranges were already well known. The sizes and approximate ranges of other, non-habituated groups of these three species in or ranging into the 5.4 km^2 intensive study-area were also known. Part of the data presented in this paper was collected in the intensive study area. Other areas sampled included the unlogged northern, southern and western parts of the Bia Game Production Reserve and a logged and partly farmed area adjacent to the western side of the Bia Game Production Reserve called the Sukusuku area (Fig. 1). Although like the Bia National Park the northern and western parts of the Bia Game Production Reserve is untouched primary forest, they are less intensively protected against poachers than the Bia National Park, particularly the western part which borders inhabited logged and farmed land. A portion of the southern part of the Bia Game Production Reserve has recently been logged. About 1/5 of the transect line through this area fell into the recently logged portion. Poaching in this area, partly following logging activities, is difficult to control. The transect line in the Sukusuku area passed through about 4-5 year old secondary forest interspersed with food crop farms. This area too has been heavily poached and it is the least protected area of the three blocks.

METHODS.

Transet lines were cut through the study area on compass bearings. The data were collected between January 1977 and February 1978, while walking along transect lines. Time of observation, species and number of individual monkeys that could be seen without leaving the line were recorded. To avoid observer bias all such data were collected by the same observer with a helper on his heels. Average walking speed was 2.4 km/hour including time required for

very fast

No info. on topography of reserves or of census routes.

recording of sightings. Five different transect lines were walked. They measured:

(i) 6.4 km for the intensive study area of Bia National Park;

(ii) 17.5 km for the northern part of the Bia Game Production Reserve;

(iii) 19.8 km for the southern part of the Bia Game Production Reserve;

(iv) 3.2 km for the western part of the Bia Game Production Reserve; and

(v) 3.2 km for the Sukusuku area.

Together there was a running total of 50.1 km of transect lines. These lines were repeatedly walked at different times of the day. Since observation frequency of monkey groups may vary with daytime, observation time of every 2 - hour - period between 6 a.m. and 6 p.m. was equally represented in the different areas studied. The total distance covered per area varied between 122.9 and 235.4 km (Table 1). Frequency of primate group observation per km walked was calculated for every area. It is of note that the samples are only representative of the vicinity of the transect line but not necessarily representative of the total of the respective area.

Mona and spot-nosed monkey groups frequently associated and an attempt to classify the observations for the separate species was found to be unreliable. Consequently in view of the difficulty in separating species, observation records for mona monkey and spot nosed monkey groups were lumped together (Table 1).

Information collected on group sizes and ranges of upper canopy species during and following the aforementioned detailed studies in the Bia National Park intensive study area was used to test observation frequency and density relationships. Group sizes and ranges of these groups were already known during the time of frequency observation in January/February 1978.

Non-habituated groups take to flight and/or show antagonistic behaviour when they detect the observer on the forest floor whereas the habituated groups do not. Groups were therefore recorded as having been habituated or not.

A second set of group frequency records was collected in the intensive study area by a different observer. His data was used to check on the variation of observation frequency caused by different observers.

RESULTS.

Frequencies of group sightings:

Table 1 shows the frequency of group sightings per km according to species and area. The table was subjected to a Friedman Test. Frequency of sighting of one species was significantly different from the frequency of sighting of another species (χ^2_R = 22.29 > χ^2 d.f. = 5, p = 0.05). There was also significant difference in frequency of sighting between the sample areas studied (χ^2_R = 19.53 > χ^2 d.f. = 4, p = 0.05).

In order of frequency of sighting of the various monkey groups in the area are (Table 1):

(1) mona monkey/spot nosed monkey group

(2) black and white colobus monkey

(3) diana monkey

(4) olive colobus

(5) red colobus, and

(6) white crowned mangabey.

Chimpanzees were known to occur in all areas except in Bia Game Production Reserve West and the Sukusuku area. But chimpanzees were not sighted during these investigations. They were occasionally heard but unless carefully tracked they may hardly ever be seen.

Although there are significant differences of observation frequency between species it should not be automatically assumed that actual group densities are likewise different. Observation frequency is largely a function of visibility which was different for different species, particularly for species prefering different strata of the forest. Thus, difference of observation frequency between diana monkey groups and mangabey groups does not necessarily mean that their group densities are accordingly different.

The difference in frequency of sighting between areas was however important to this study. There is a difference between visibility within the lower as compared with visibility within the upper canopy, visibility within each of the canopies between areas is about equal. This is more obvious for the upper canopy. The forest in the Bia area allows a relatively freer sight into the upper stories due to the largely absent middle canopy. Generally an alert observer is not likely to miss upper canopy groups within about 50 to 80 meters on both sides of a transet line and he will detect most lower canopy groups within about 30m of the line. Observation frequencies (Table 1) of groups were generally highest in the most undisturbed and best protected area (Bia National Park) and lowest in hardly protected secondary growth (Sukusuku area). Olive Colobus groups were less frequently met in Bia National Park than in the two parts of the Bia Game Production Reserve. The differences are, however, not significant. The slightly higher frequency of diana monkey group observations in the Bia Game Production Reserve north than in the Bia National Park is also insignificant.

Observation frequency - group density relationship:

The intensive study area of the Bia National Park with its known diana monkey, red colobus and black and white colobus groups was used to relate group observation frequency to true group density (Table 2). A group density was approximated on the basis of the combined home ranges of three black and white colobus groups, one

diana monkey group and two red colobus groups inhabiting the area of the transect system. There was a slight overlap of ranges in the case of the two red colobus groups. Black and white colobus group ranges also overlapped slightly. The number of groups as well as ranges covered in this study is rather small. In order to establish a more accurate relationship it would have been preferable to know more groups and their ranges accurately than it was possible.

Although the figures in Table 2 are insufficient to establish the exact mathematical relationship between observation frequency and group density, the relationship is not likely to be as linear as the figures suggest. Furthermore the figures do not indicate that the observation frequency and/or group density relationship follow(s) different patterns in the three upper canopy species but the relationship may nevertheless be species specific. The consistency however suggests that the skilled observer detects groups of the three species reliably and at roughly equal rates. The extent that group size might influence observation frequency, however, remains unknown.

One would expect that habituation to the presence of man of some monkey groups in the Bia National Park intensive study area could initially increase their observation frequencies. Whereas both red colobus groups in the intensive study area were habituated, only one out of three diana monkey groups and three out of six black and white colobus groups inhabiting or overlapping into the intensive study area were habituated to the presence of man. It was therefore possible to test the hypothesis of the influence of habituation on observation frequency using diana and black and white colobus monkey groups.

The proportion of habituated groups to nonhabituated groups recorded was 7:15 for diana monkey groups and 18:17 for black and white colobus groups. This accurately reflected the actual proportion of the two group types in the area. The hypothesis of influence of habituation on observation frequency was thus rejected in respect of these two species and assumed rejected in respect of the other upper

canopy species too since the behaviour of unhabituated groups elsewher was comparable to the behaviour of the other studies. It was observed that a careful observer apparently does not scare off non habituated upper canopy groups before recognizing them. Consequently Table 2 can be meaningfully applied to other areas where the groups have not been habituated.

This is not likely to be always the case with groups in the lower canopy and particularly in thick undergrowth where visibility is reduced. However it was not possible to test as to whether habituation to the presence of man of the lower canopy group of monkeys will increase the observation frequency of the habituated groups.

Assuming that observation frequency is observer specific, the field data presented here was collected by the same observer. The extent of variation caused by different observers was checked by comparing observations by a second, equally skilled observer walking a sample of 82 km on the transect lines of the Bia National Park. His sample did not yield significantly different observation frequencies for anyone of the species except for the mona monkey/spot nosed monkey group in which case the second observer obtained a significantly lower frequency (χ^2 = 5.405; d.f.=1, p=0.05).

Although several group densities from different areas for every species may be required to establish a highly accurate relationship between group density and observation frequency, it is apparent (Table 2) that an area where an experienced observer comes across one upper canopy group per 10 walking km is inhabited by about 0.5 groups/km^2. An area where the observer meets one group per 4 walking km is inhabited by about 1 group/km^2.

Group size and observation frequency:

While recording groups from the transect lines as many individual monkeys as possible were counted without leaving the transect line. It was rare to be able to count all or nearly all

members of a group. However chances for a fair count used to occur when the group started moving from tree to tree in a definite direction. Otherwise many of the sightings of individual monkeys were not more than short glimpses. It was particularly difficult to get an idea of the group sizes of the lower canopy species where visibility depended largely on the thickness and height of the undergrowth: the thinner and taller the height of the undergrowth the better the visibility. The mean observed number of monkeys per group (Mean observed group size) for the 3 upper canopy species (Table 3) has a similar gradient among areas as in the frequency of sighting groups (Table 1). The largest groups were observed in the centre of the Bia National Park and the least number per group in the most disturbed areas. If even the observed number of monkeys per group is taken as only an index of actual group size, the observed trend among areas reflects a drastic reduction in group size with increasing disturbance.

True group size with observed group size of the upper canopy primates in the intensive study area was compared. It was found that usually between 30% to 50% of the monkeys in large groups and between 50% to 80% of the monkeys in the smaller groups were counted. Approximately the same percentage of the monkeys in habituated and non habituated groups of comparable size could be counted. Therefore there was no evidence that group habituation alters visibility of individual monkeys. It is more a factor of the environment and the observer's powers of observation which improves with practice.

Red colobus groups attain the largest group sizes of the upper canopy primates in the Bia area but only in the National Park. The two known groups in the intensive study area during the time of data collection for this paper comprised 34 and 58 monkeys. These two groups led to the mean observed group size of 19.5 monkeys/group (Table 3). If the two groups are considered in conjunction with their respective group ranges, individual density of 24.8 red colobus per km^2 for the centre of the Bia National Park results. The mean observe

7 Why not 34+58/2 = 46?

group size of red colobus is drastically reduced in the Bia Game Production Reserve West and South. Three red colobus groups made up of 5.15 and 8 monkeys per group were followd in the Bia Game Productio Reserve south. These numbers were the total counts of the groups. The other areas have no red colobus.

Black and white colobus groups within the sampled area of the Bia National Park had sizes of 19, 5, 10 and 25 monkeys, the latter group being the largest black and white colobus group that could be accurately counted within the Bia area. These groups led to a mean observed group size of 9.1 monkeys/group (Table 3). The respective individual density in the centre of Bia National Park was 21.7 monkeys/km^2. There is a less conspicuous difference in group size between areas of different protection status than in the red colobus, but group sizes still become distinctly reduced with decreasing protection status. Eight groups could be accurately counted in the Bia Game Production Reserve South. Their sizes were 7, 3, 10, 11, 4, 14, 7 and 6 monkeys. The respective mean observed group size for this area was 4.3 monkeys/group which is 55% of the mean of the above groups.

The diana monkey group living in the Bia National Park intensive study area numbered 19 animals. The respective approximate density of diana monkeys was 12.8 per km^2. The two other diana monkey groups ranging into the intensive study area had 9 monkeys each. The decrease of mean group sizes with decreasing protection status was found to be similar to black and white colobus. No diana monkey group outside the National Park could be reliably assessed due to the relatively swift movements of the monkeys in those less protected areas.

DISCUSSION.

Prior to the establishment of the Bia National Park and the Bia Game Production Reserve in 1974, surveys had been carried out in various untouched parts of the Bia area (Jamieson, 1971; Rucks, 1973).

They reported differences of observation frequency among different areas but no marked differences in primate density between areas were reported. The primate densities in the centre of Bia National Park reflect a state near that met by Jamieson and Rucks. Further more the group size of red colobus recorded for the intensive study area also compares favourably with group size reported by Struhsaker (1975 for unhunted and least disturbed populations in Ivory Coast, Cameroun and Uganda. Red colobus groups were not represented in the sampled two most disturbed areas. It is therefore deemed reasonable to take the present situation in the intensive study areas as a base line for future comparison.

Since timber extraction primarily removes emergents and upper canopy trees one expects this to affect the upper canopy primates more severely than other species. In 1977 when selective logging was carried out in a part of the Bia Game Production Reserve it was found that all black and white and red colobus groups had shifted into neighbouring, as yet untouched, compartments. This caused a transiently high group density there. There is conclusive evidence that black and white colobus and diana monkeys but not red colobus reinvade young secondary forest after logging operations have ceased. However, the reaction of lower canopy primates is not known as yet.

Apart from the direct influence caused by timber extraction the red colobus has been reported to be very susceptible to hunting pressure (Asibey 1976). Rucks (1974) reported that red colobus are easily shot out by hunters because they are very vocal and can easily be traced. In addition when disturbed they move in a single file one after the other making them easy to shoot.

Diana monkeys are rarely found in secondary forest. Rucks (1976) reported that diana monkeys were generally absent where the susceptible red colobus is absent. This is contrary to the relatively high observation frequency of diana monkeys in the Sukusuku secondary forest. It is however possible that there has been reinvasion from the Park.

The black and white colobus on the other hand is remarkably resistant to habitat disturbance and hunting pressure. Although observation frequency of groups decreases with increasing disturbance small remnant groups of black and white colobus are known to survive in heavily farmed secondary forest of the Bia area, despite hunting pressure. This is probably due to the relative secretiveness of thes monkeys. The black and white colobus appears to be the most resistan to hunting of the three upper canopy primates. Although by the 1950ies it had been exterminated over large areas of Ghana, not solel for its meat but also because its fur was in high demand (Booth, 1956 small groups still survive in pockets of forests in its natural range

The importance of single timber species and the effect of their removal on primate populations cannot be measured species by species. Nor can the effect of logging per se in most cases be separated from secondary influences (hunting and farming) enhanced by the opening up of the forest. Since food crop farming and meat hunting often normally follow logging operations intensively in the Bia area, the farmers and the hunters are all too easily blamed for the extermination of wildlife and timber extraction per se is assumed to have little or no adverse effect that could result in the extermination of some species. Although not yet conclusive, the evidence shows the gross-physiographic impact of breaking up the upper canopy is sufficient to cause the disappearance of at least the red colobus and in general of the diana monkey also. Other fauna whose role in the forest ecosystem is not known may be even more seriously affected.

Asibey (1976) reported that economic timber species, extracted during logging operations, constituted a considerable part of the diet of the red colobus in Bia National Park. Out of 51 tree species recognised as red colobus food species, 54.9% belonged to economic classes. Ten food species even belonged to the 15 most valuable timber species (Class I and II timber species). Curtin (1977) had similar results for diana monkeys living in the same part of Bia

National Park. Diana monkeys were found to utilize 11 out of the 15 Classes I and II species, though diana monkeys feed on a very wide range of trees and climbers. The 15 Classes I and II timber species which constituted only 9.4% of the total available tree species in the Bia National Park were found to be over-representedin the monkey diet by 16% of all feeding trees and 21% of all feeding visits These high percentages were not due to greater abundance of Classes I and II timber species, they rather reflected the fact that both red colobus and diana monkeys are upper canopy primates which find their food predominantly among the taller tree species which belong more often than not to economic timber classes. Curtin (1977) considered some of the economic species e.g. Piptadeniastrum africanu to be key food species. The latter species made up for no less than 8% of the diana monkey feeding visits and up to 80% of the day's visit on some days in February and March. The same author considered other economic species e.g. Antiaris spp. and Chlorophora excelsa to be essential because the succulent fruits of these species provided moisture during the dry season.

Gartlan and Struhsaker (1972) found a less diverse primate fauna in young than in old secondary vegetation or mature forest. It is possible that the upper canopy primates reinvade logged areas after the secondary vegetation has been allowed to mature but reinvasion does, presume effective protection of timber land against hunters and farmers and large enough islands of undisturbed forest with good stock of primates which may come to reoccupy the secondary vegetation.

It is known that olive colobus may survive in secondary vegetation and farmed areas if hunting pressure is not too high. There is no report of red colobus survival in secondary vegetation.

By far the most resistant primates to hunting and logging are the mona monkeys and spot nosed monkeys. They survive in heavily farmed, cut over areas and resist considerable hunting pressure. It seems that secondary vegetation, if not too heavily hunted, could

theoretically even promote mona and spot nosed monkey populations d to their predilection for underbrush. It may, however, be misleadi if only group density is taken as a measure of population status. Although group density in disturbed areas is not so drastically red the observed group size of the three upper canopy species dwindles sharply with increasing human disturbance. This agrees with Collia and Southwick (1956) who found low average group size in howler mon to be a sign of depressed population. When the reduced group size the southern or western part of the Bia Game Production Reserve is considered in conjunction with the lower group density, it is found that the individual density of black and white colobus is between 4-6 times lower there than in the well protected Bia National Park. Almost the same holds for the diana monkey density but the red colobus is either wiped out or where they survived, the density is even more than 20 times lower.

Although, conclusive evidence on the relationship between observed and real group size could be given for only the upper canopy species, a reduction of observed group size with increasing disturbance was, recognizeable in the lower canopy species too. Th available evidence shows that mona and spot nosed monkeys favour underbrush but there is no evidence that any of the resistant speci attains a higher individual density in the secondary vegetation tha in the undisturbed closed forest of the Bia area. Consequently, it is deemed desirable to retain some undisturbed closed forest if the diversity of higher primates are to be maintained and conserved. Further work is however required to determine the size of area that will support a large enough population all the year round and which will maintain a viable genetic pool to serve as a source for future reinvation of the disturbed areas once disturbance stops.

Undoubtedly primate numbers and diversity are reduced in logged areas. In not strongly protected areas timber extraction prepares the way for hunters and farmers. Their influence on

primate populations becomes indistinguishable from the sole imp timber extraction. The end effect is often total eradication c primates. Large forest blocks that will sustain a viable prima population will hold key to future rotational exploitation of t forest and permit the survival of the primate fauna but the siz blocks and felling cycle which will make this feasible is not y known.

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Map of Bia Reserves with surrounding areas.

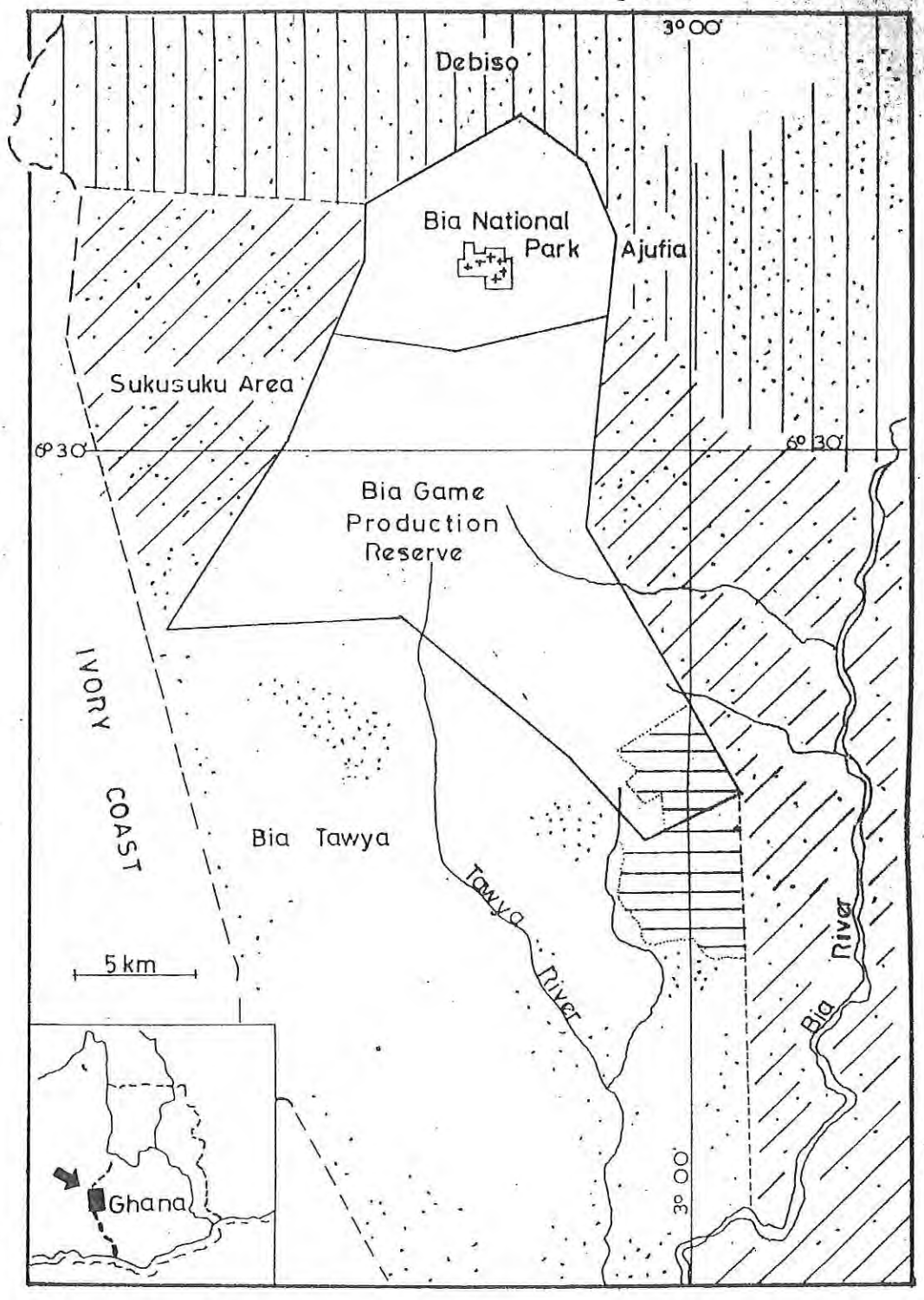

Table 1. Observation frequencies of primate groups per km walked through 5 parts of the Bia Conservation areas*

Transect length	area	mona and/or spot nosed monkey	diana monkey	white crowned mangabey	black and white colobus	red colobus	olive colobus
6.4 km	Bia National Park centre (untouched, well protected) Sample: 122.9 km	0.391	0.179	0.024	0.285	0.098	0.057
17.5 km	Bia Game Production Reserve (north) (untouched moderately protected) Sample: 235.4 km	0.391	0.183	0.034	0.166	0.061	0.110
19.8 km	Bia Game Production Reserve (south) (partly logged moderately protected) Sample: 201.6 km	0.327	0.125	0.015	0.164	0.005	0.084
3.2 km	Bia Game Production Reserve (west) (untouched moderately protected near inhabited land) Sample: 225.4 km	0.319	0.115	0.009	0.155	0.000	0.009
3.2 km	Sukusuku area (young secondary growth interspersed with farms) Sample: 193.2 km	0.259	0.072	0.016	0.098	0.000	0.005
	All areas	0.335	0.133	0.019	0.165	0.029	0.054

*For differences between samples see Friedman Test (in text)
The samples are not necessarily representative of the total of the respective areas (see text).

Table 2. Observation frequency - group density relationship for 3 upper canopy primates in the Bia National Park.

	red colobus	black and white colobus	diana monkey
Observation of groups per km	0.098	0.285	0.179
No. of known group ranges fully or partly in intensive study area	2	6	3
Groups per km^2 (approximated from known ranges)	0.54	1.20	0.68

Table 3. Mean observed group sizes of three upper canopy species with 95% confidence intervals for the mean.

	red colobus	black and white colobus	diana monkey
Bia National Park centre (untouched well protected area)	19.5 ± 4.8	9.1 ± 1.2	8.3 ± 1.7
Bia Game Production Reserve north (untouched moderately protected)	4.9 ± 0.6	5.3 ± 0.5	5.0 ± 0.7
Bia Game Production Reserve south (partly logged moderately protected)	8.0*	4.3 ± 0.7	4.4 ± 0.7
Bia Game Production Reserve west (untouched moderately protected bordering inhabited land)	-	2.8 ± 0.4	2.9 ± 0.5
Sukusuku area (young secondary growth interspersed with farms)	-	1.9 ± 0.4	2.5 ± 0.5

*only one record of group size.

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