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Habitat preference of Great Argus Pheasant *(Argusianus argus)* in Kayan Mentarang National Park, East Kalimantan, Indonesia

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Summary

Habitat preference and abundance of the Great Argus Pheasant was studied over a ten week period in the lowland forests of the Kayan Mentarang National Park, in the remote interior of Indonesian Borneo. Repeat line transect surveys, counting the number of vocalising males, were conducted in four different habitat types. Argus Pheasants were found to be most common in primary forest, and progressively less common in old and young secondary forests. Numbers of calling males were lowest in riverine forest. Argus Pheasant densities were positively correlated with a number of transect characteristics, viz. increasing tree diameter, tree height, height of the first bough and canopy cover, and with increasing remoteness. Dancing grounds were invariably located on ridges. The conservation status of the species on Borneo is briefly discussed. The Great Argus Pheasant is still widespread but thinly spread. The rapid rate of lowland forest clearance, fragmentation of once continuous habitat and increasing hunting pressure owing to increasing accessibility may become serious threats in the near future.

Key words: behavioural ecology, Borneo, conservation, Phasanidae, Galliformes

Zusammenfassung

Habitatpräferenz des Großen Argusfasans *(Argusianus argus)* im Kayan Mentarang National Park, Ost Kalimantan, Indonesien

Die Habitatpräferenz und das Vorkommen des Großen Argusfasans wurden zehn Wochen lang im Flachlandurwald des Kayan Mentarang National Park, tief im Inneren von Kalimantan, Borneo, Indonesien, untersucht. Dazu wurden in vier verschiedenen Vegetationstypen die Anzahl vokalisierender Männchen entlang von Linientransekten festgestellt. Am häufigsten waren die Vögel im Primär-Urwald, seltener in altem und noch seltener in jüngerem Sekundärwald. Am geringsten war die Anzahl rufender Männchen in den flußnahen Wäldern. Die Häufigkeit des Vorkommens war positiv korreliert mit Stammdurchmesser, Stammhöhe, Höhe des ersten dicken Astes, Dichte der Krone und Entfernung zu Ansiedlungen. Die Balzplätze befanden sich immer auf Hügeln oder Hügelrücken. Der Argusfasan ist noch immer weitverbreitet aber nirgends häufig. Das rasche Abholzen von Flachlandwäldern und die zunehmende Jagd, die durch ein neues Wegenetz immer einfacher wird, sind die wichtigsten Gefährdungsfaktoren.

Introduction

The Great Argus Pheasant, one of the largest species of pheasant, is a well known resident of the tropical rainforests of the islands of Borneo, Sumatra and the Malay peninsula as far north as southern Burma (Smythies 1960, Medway & Wells 1976, van Marle & Voous 1988). The species inhabits primary forest as well as tall logged forest on dry ground, on Borneo generally from sea level up to 1000–1200 m a.s.l. (Smythies 1960, Thomson 1966, MacKinnon & Phillipps 1993). Argus Pheasants are difficult to observe but their loud calls can often be

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heard. The males make an explosive, clear, double note *kow wow*, often in response to other males. The call is repeated at intervals of fifteen to thirty seconds or longer (Wayre 1969). Great Argus Pheasant are normally solitary, territorial, and have a polygamous breeding system. Males maintain small home ranges in the order of one to three hectares (measured on a monthly basis) (Davison 1981). Within these home ranges the males clear arenas on the forest floor removing all leaves, seedlings and stones. They call from these dancing grounds and perform a visual display to visiting females. The display consists of raising and fanning the tail and wings showing the occelli on the wings (Delacour 1964, Sözer 1997). Roosting is done in trees near the dancing grounds (Delacour 1964).

The Kayan Mentarang National Park is situated at the headwaters of the Kayan and Mentarang Rivers. Located in the remote north-western part of the East Kalimantan province, Indonesia, and bordering the Malaysian states of Sabah and Sarawak, it is one of South-East Asia's largest reserves (Jessup et al. 1992). Together with adjacent (proposed) reserves (Ulu Sembakung, Ulu Kayan Mutlak [Kalimantan], Pulong Tau [Sarawak], and Ulu Padas [Sabah]) it covers an area of over 25,000 km^2. Gazetted in 1980 as a nature reserve, Kayan Mentarang became a National Park in 1997. In 1990 the World Wide Fund for Nature-Indonesia Programme (WWF-IP), the Indonesian Institute for Sciences (LIPI), and the Directorate General of Forest Protection and Nature Conservation (PHPA) initiated a research and development project for the area. Its location in the far interior, its sheer size, and its large geological, altitudinal and biological diversity, make Kayan Mentarang National Park probably one of the most important conservation areas in Borneo for both flora and fauna.

Apart from a few collectors, i.e. A.W. Nieuwenhuis (Finsch 1905), Baron von Plessen (Stresemann 1938), and P. Pfeffer (1958, 1960), who visited the Kayan Mentarang area in the first half of this century, the only ornithological research conducted so far has been a number of surveys by van Balen in the period 1992–1996 (1993, 1997a,b), although R. Watling (*in* Blower et al. 1981) had already mentioned the occurrence of 97 species, without, however, presenting details. Van Balen (1997a) documented 286 species of birds for the area, including eight (possibly nine) of the eleven Galliformes known from Kalimantan. Van Balen (1993) suggested a number of studies to be initiated in Kayan Mentarang National Park, including a study of Galliformes, and considered the area especially favourable for the study of Argus Pheasants.

This paper reports on habitat preference and abundance of Great Argus Pheasants in the Bahau region, in the eastern part of the Kayan Mentarang National Park.

Methods

Study area

Fieldwork took place from 4 October to 2 December 1996 in the Dipterocarp dominated lowland forest between altitudes of 300 and 700 m a.s.l., at three sites in and adjacent to the Kayan Mentarang National Park [between ca. 115°46'-115°51' E, 2°49'-2°52' N] (Fig. 1). Primary lowland and riverine forest was surveyed in the Nggeng Bio river valley. This valley has been a *tana ulen* (reserved land, restricted forest) of the nearby village Long Alango for at least the last 75 years. Since hunting, fishing, cultivation and collection of forest products have been mostly prohibited, the valley is still covered with mature, tall primary forest. Despite the existence of many rivers in the study area, true riverine terrace forest is rare. In many areas the riverbanks consist of steep, rocky gorges, with true riverine forest only present in the more gently sloping areas. Old and young secondary forest was sampled in the Bua Alat and Tebulo river valley respectively, ca. 5 km downstream of the Nggeng Bio river valley. According to local inhabitants the old secondary forest was last logged 45 years ago, i.e. in 1951. The young secondary forest consists of patches varying between 10 and 20 years in age. The Nggeng Bio, Tebulo, and Bua Alat rivers are all tributaries of the Bahau River, which in itself is a tributary of the Kayan River. In the study area the Bahau River forms the eastern border of the Kayan Mentarang National Park. Forest sites are situated close together and are similar in climate, original forest type, altitude and topography.

Kayan Mentarang has a warm, humid climate throughout the year. The mean annual precipitation exceeds 3100 mm, with the lowest month average above 150 mm. The mean daily temperature (25.2 °C) is equable throughout the year with minimum and maximum monthly temperatures ranging

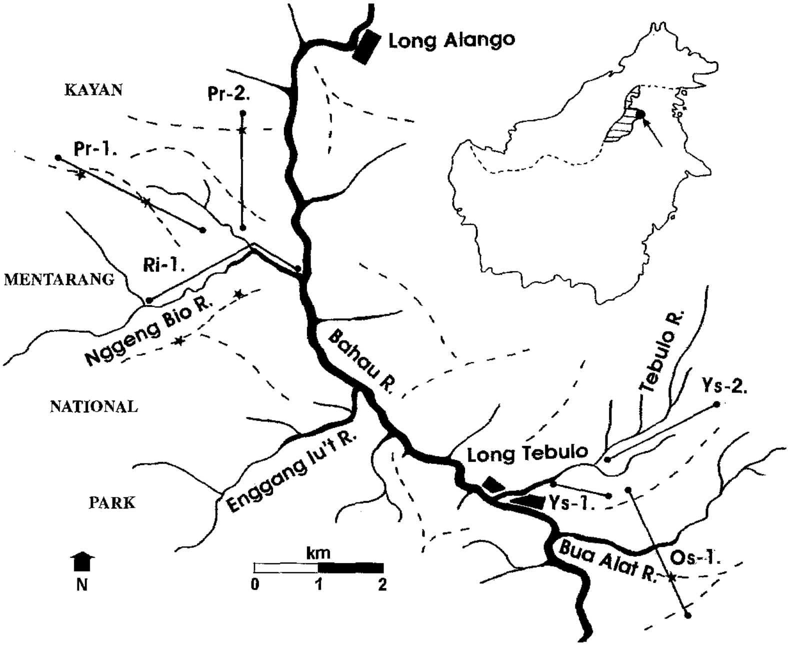

Fig. 1. Map of study area, on the eastern border with the Kayan Mentarang National Park, East Kalimantan, Indonesia, showing large rivers, main ridges (stippled), villages, and the location of the transects: Pr-1. and Pr-2. in primary forest, Ri-1. in riverine forest, Ys-1. and Ys-2. in young secondary forest, and Os-1. in old secondary forest. The asterisks indicate the locations of the six active dancing grounds. The insert depicts the island of Borneo, showing the Kayan Mentarang National Park; the arrow indicates the study area.

Abb. 1. Karte des Untersuchungsgebietes, an der Ostgrenze des Kayan Mentarang National Parks, Ost Kalimantan, Indonesien, mit den größeren Flüssen, Hügelrücken, Dörfern, und der Lage der untersuchten Linientransekte: Pr-1. und Pr-2. im Primär-Urwald, Ri-1. im Flußwald, Ys-1. und Ys-2. im jungen Sekundärwald, und Os-1. im alten Sekundärwald. Die Sterne geben die Lage der sechs Tanzflächen an. Die kleine Karte zeigt Borneo mit dem Kayan Mentarang National Park und dem Untersuchungsgebiet (Pfeil).

between 20.5 and 33.2 °C. (Climatic data from the WWF-IP Lalut Birai field station situated at the mouth of the Nggeng Bio River). The study area has a perhumid climate; the period of data collection nevertheless fell within the wettest period of the year. Rain fell almost daily with only a few periods of one to three days without rain.

Census techniques

The abundance of Great Argus Pheasants was assessed via repeat line transect surveys (Bibby et al. 1992) counting the number of vocalising males. This method does not assume recognition of individual birds, which is very difficult for such an elusive species as the Argus Pheasant, but in the course of the study it was possible to recognise certain 'calling positions', where presumably the same individual was heard calling during the study period. Transects were walked along existing (permanent) transects, and existing trails (young secondary forest only). These were situated in primary forest (two transects of 2.5 and 3.0 km), riverine or stream-side forest on the right bank of the Nggeng Bio River at least 25 m from the river (one transect of 4.9 km), old secondary forest (one transect of 3.3 km) and young secondary forest (two transects of 1.1 and 2.5 km). The habitat types were selected as the Argus Pheasant is forest dependent and, prior to the study proper, had been recorded in all four forest types. Furthermore the forest types were situated in close proximity to each other, thus avoiding regional differences.

While walking the transects at a pace of ca. 1.5 km hr^{-1}, the number of calling males within 500 m distance perpendicular to the transect line was recorded. Experience in the field led to the acceptance that this was an appropriate, albeit arbitrary, detection distance. Males calling from further away were recorded, but not included for analysis. In riverine forest, records came from one side of the transect only. Male Argus Pheasants have different types of vocalisations, including an explosive, double note *kow wow* and a longer territorial call, sometimes erroneously said to belong to the female only (S. van Balen *in litt.,* 1997). The second type of vocalisation is heard less frequently, carries less far, and was considered less appropriate for censusing. In the present study therefore, only the first type of vocalisation was used in analysis of densities.

The surveys took place at different times of the day, always under dry weather conditions. However, as almost 90% of the calls were recorded between dawn and noon, only surveys that ceased prior to midday were included for analysis.

Habitat features were recorded at sampling stations which were established every 150 m along the transects. Ideally these sampling stations should have been located randomly throughout the study area, but as the terrain was rather rugged and not always easy to travel through, it was considered more feasible and safer to restrict habitat recording to the transect lines only. Habitat recording was concentrated within a circle of 15 m radius centred on the sample station. Argus Pheasants were recorded at much greater distances than this but it was not feasible to obtain vegetation data from a wider area. Data were collected at a total of 47 sampling stations, viz. 13 in primary forest, 9 in riverine forest, 12 in old secondary forest, and 13 in young secondary forest.

At each sampling station quadrants were established running perpendicular to the transect line. Within each quadrant the nearest tree was selected, its girth and distance to the centre point measured, and its total height and the height of the first bough estimated. Trees with a diameter of less than 10 cm at breast height were excluded. Girth was measured to the nearest cm and distance to the nearest dm with a tape measure. Tree height and height of the first bough was estimated to the nearest meter, and where possible these were checked with the aid of a clinometer. At each sampling station vegetation cover was estimated at three levels, i.e. ground, low (*c.* 2.0 m above ground), and canopy level. Vegetation cover was estimated to the nearest 5%.

Statistical analysis

Data on densities and vegetation structure were analysed with Mann-Whitney U test and Kruskal-Wallis one-way analysis of variance (Siegel 1956). Each transect was subsequently characterised by the following variables: average tree distance, tree diameter, tree height and height of the first bough; median vegetation cover at ground, low and canopy level (arcsin transformed); mean altitude (median altitude of all transects combined: 380 m a.s.l., range 325–450 m a.s.l.); distance to the nearest village (median distance in straight line of all transects combined: 3.0 km, range 0.5–5.0 km) and to the nearest river (median distance in straight line of all transects combined: 675 m, range 25 m – 2.0 km). These variables were tested as predictors for the observed variation in Argus density.

Results

Vegetation structure

Of the forest types analysed, riverine and young secondary forest were rather similar in vegetation structure, only the average tree height was significantly greater in riverine forest (Table 1). No significant differences were found between forest types in the average distance between the nearest tree and each sample station. Primary forest and old secondary forest only differed significantly in average height of the first bough and diameter (Mann-Whitney U, $n_1 = 13$, $n_2 = 12$, $p < 0.05$, and $n_1 = 13$, $n_2 = 12$, $p < 0.05$, for height of first bough and diameter, respectively). Average tree height did not differ between stations in these two forest types, although the range of values was smaller in old secondary forest (10.4–18.6 m) than in primary forest (10.5–20.8 m). The average tree height and height of the first bough at the sample stations was smaller in young secondary forest than in old secondary forest ($n_1 = 12$, $n_2 = 13$, $p < 0.01$ and $n_1 = 12$, $n_2 = 13$, $p < 0.01$). Estimated vegetation cover at low and ground level was highest in riverine and young secondary forest, and lowest in primary and old secondary forest (Kruskal-Wallis one-way analysis of variance using arcsin transformed data, $H = 13.29$, $p < 0.01$ and $H = 18.97$, $p < 0.001$, for ground and low level cover, respectively). Conversely, estimated canopy cover was higher in primary and old secondary forest, and lowest in young secondary and riverine forest, the differences between forest types however not being significant (Kruskal-Wallis using arcsin transformed data, $H = 4.99$, $p > 0.1$).

Not unexpectedly, vegetation data were significantly correlated with one another, except for distance to the nearest tree. Diameter, tree height, height of the first bough, and canopy cover were all positively correlated with one

Table 1. Vegetation structure in primary, riverine, old secondary, and young secondary forest in Kayan Mentarang National Park, East Kalimantan, Indonesia. Based upon 13 sampling stations in primary forest, 9 sampling stations in riverine forest, 12 sampling stations in old secondary forest and 13 sampling stations in young secondary forest. s.d. = standard deviation. The lower part of the table shows the levels of significance between the means.

Tab. 1. Vegetationsstrukturen im Primär-Urwald, Flußwald, jungen und alten Sekundärwald im Kayan Mentarang National Park, Ost Kalimantan, Indonesien. Die Angaben basieren auf 13 Meßpunkten im Primär-Urwald, 9 im Flußwald, 12 im jungen Sekundärwald und 13 im alten Sekundärwald. s.d. = Standardabweichung. Der untere Teil zeigt die Signifikanzniveaus.

	Primary mean ± s.d.	Riverine mean ± s.d.	Old secondary mean ± s.d.	Young secondary mean ± s.d.
height of tree (m)	15.2 ± 3.0	12.0 ± 2.3	13.5 ± 2.6	9.9 ± 1.1
height 1st branch (m)	11.9 ± 2.5	7.7 ± 1.5	9.6 ± 1.8	6.8 ± 1.0
diameter b.h. (cm)	31.1 ± 9.8	21.9 ± 7.2	23.8 ± 8.8	17.5 ± 4.0
distance to station (m)	3.5 ± 1.2	3.4 ± 1.3	3.5 ± 0.7	3.4 ± 1.0
ground cover (%)	16.5 ± 24.7	54.4 ± 22.8	17.3 ± 18.6	45.4 ± 24.9
low level cover (%)	12.4 ± 6.2	37.7 ± 18.3	16.3 ± 9.1	43.5 ± 16.4
canopy cover (%)	53.0 ± 19.6	38.3 ± 18.7	50.0 ± 19.9	36.6 ± 20.8

	height of tree	height 1st branch	diameter b.h.	distance to station	ground cover	low level cover	canopy cover
Primary vs Riverine	< 0.005	< 0.005	< 0.005	n.s.	< 0.005	< 0.005	< 0.05
Primary vs. Young secondary	< 0.005	< 0.005	< 0.01	n.s.	< 0.005	< 0.005	< 0.05
Primary vs Old secondary	n.s.	< 0.05	< 0.025	n.s.	n.s.	n.s.	n.s.
Riverine vs Young secondary	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Riverine vs Old secondary	< 0.05	< 0.005	n.s.	n.s.	< 0.005	< 0.005	n.s.
Old secondary vs Young secondary	< 0.01	< 0.01	n.s.	n.s.	< 0.005	< 0.005	n.s.

another, as were vegetation cover at ground and low level. Diameter, tree height, height of the first bough, and canopy cover were all negatively correlated with vegetation cover at ground and low level.

Habitat preferences

Altogether 143 calling males were recorded in 94.6 km^2 forest surveyed prior to noon. There were no significant differences in densities within habitat types i.e. primary and young secondary forest (Mann-Whitney U, $n_1 = 5$, $n_2 = 6$, $p > 0.5$, and $n_1 = 9$, $n_2 = 10$, $p > 0.1$ for primary and young secondary forest respectively). The highest density was found in primary forest with an average of almost 2.0 males km^{-2} (pooled data of both transects), followed by old and young secondary forest (for the latter data of both transects are pooled) (Table 2). The lowest density was found in riverine forest with only 0.23 ± 0.37 calling males km^{-2}. Differences in densities of calling males between habitat types were significant (Kruskal-Wallis, $H = 8.7$, $df = 3$, $p < 0.05$); pairwise comparisons between habitats reveal that these are all significantly different as well (Mann-Witney U for all comparisons: $p < 0.05$).

Great Argus Pheasant density was positively correlated with tree diameter, tree height, height of the first bough, and canopy cover

Table 2. Densities of calling male Great Argus Pheasant *Argusianus argus* in different habitat types in Kayan Mentarang National Park, East Kalimantan, Indonesia, October-December 1996. Densities of calling males between habitat types are all significantly different at the 5% level.

Tab. 2. Abundanzen rufender Männchen des Argusfasans in verschiedenen Habitattypen im Kayan Mentarang National Park, Ost Kalimantan, Indonesien, Oktober bis Dezember 1996. Alle Unterschiede sind signifikant.

forest type	number of repeats	area surveyed (km^2)	density calling males km^{-2} ± s.d.
primary forest	11	30.0	1.99 ± 0.38
riverine forest	6	5.4	0.23 ± 0.37
old secondary forest	11	36.3	1.66 ± 0.31
young secondary forest	19	22.9	0.89 ± 0.53

(Spearman rank correlation coefficient, for all variables $r_S > 0.612$, $p < 0.05$). The further inland the transect was located, i.e. the further away from large rivers and the more uphill, the more Argus Pheasants were observed ($r_S = 0.599$, $p < 0.05$ and $r_S = 0.851$, $p < 0.05$ for altitude and distance to river, respectively). Note that the correlation coefficients do not necessarily indicate causal relationships between habitat features and Argus Pheasants; they merely indicate the type of environment in which the species was found at highest densities. Correlations do not take the interactions between the variables into account either. For example, areas with large trees may be important for the species, but perhaps because these areas are less disturbed rather than because tree size itself is important.

The results were subsequently explored using a stepwise linear regression with transect characteristics as predictors. As most of the vegetation variables were highly correlated, as were the location variables, i.e. altitude, distance to the nearest village and distance to the nearest river, only one of each was selected at a time. The stepwise regression analysis revealed that height of the first bough and distance to the nearest village acted as the best subset of predictors for the observed Argus density. The regression equation with these two variables as predictors has a coefficient of determination (r^2) of almost 70%. (density = 1.85 + 0.409 height of the first bough –0.228 distance to the nearest village; r^2 adj. = 69.7%; ANOVA, $F_{32,2} = 40.08$, $p < 0.001$). It follows that roughly a third of the variation in Argus density is not accounted for by the regression analysis with the above mentioned transect characteristics as predictors.

Six active arenas were found along the transect lines (including some additional permanent transects situated in primary lowland forest in the Nggeng Bio valley, which were not surveyed for Argus Pheasants) (Fig. 1). Although the larger part of the transects did not follow ridges, all arenas were situated on ridges, never in valleys or on slopes (cf. van Balen, 1993). Of these six arenas five were located in primary forest (total transect length 10.75 km), and one in the old secondary forest (transect length 3.3 km). Assuming that all active arenas were recorded within 20–25 m of the transect line (each transect was repeatedly walked while dancing grounds are several meters across and easily detected), the number of arenas per km^2 is in the order of 9–12 and 6–8 for primary and old secondary forest, respectively. Great Argus males are known to have a preference for constructing their arenas on wildlife trails (Pieters 1935) and it is very well possible that the permanent transects are disproportionately more frequently used by Argus males than are other parts of the forests. Alternatively, more non-calling males are present in the area, but these are missed along the transect.

Discussion

In this study the number of calling males was used as an index of Argus density. Male Argus Pheasants often call from fixed display sites (Davison 1981) and, during the walks along the transect, the same male could be heard calling from the same position for quite a long period of time. Double counting of single males during one transect walk is therefore assumed to be of minor, if any, significance. It is inferred that higher calling rates, i.e. the number of calling males recorded per km of survey walk, indicate higher densities. Calling rates of Argus Pheasant were highest in primary forest, followed by old and young secondary forest and were lowest in riverine forest. However, Bennett & Dahaban (1995) suggested that higher calling rates might be due to habitat disturbance only. If this were the case, then overestimation of densities would increase with increasing disturbance. As male Argus Pheasants often respond to other calling males, the reverse might be as valid, i.e. calling frequencies of individual birds might increase with increasing density, thereby increasing the likelihood of recording its presence. Calling rates in riverine forest were much lower than in the adjacent primary lowland forest. Aural cues might have been somewhat masked by the rushing sound of the adjacent Nggeng Bio River, but as the explosive call of the Great Argus can be heard over relatively long distances, this effect is considered to be of minor importance.

The observed densities of Great Argus Pheasants and differences in abundance between habitat types in the Kayan Mentarang National Park generally correspond with the results of previous studies. Davison (1981) found densities within a 4 km^2 study site at Pasoh (Malay Peninsula) to differ between years between 0.15 and 0.54 calling males km^{-2}. Densities at four sites in Malay Peninsula in 1976 varied between 0.5 and 2.25 calling males km^{-2} (Davison 1981). Total densities, i.e. calling and non-calling males and females, ranged between 1.0 and 3.5 individuals km^{-2} (Davison 1981). Sözer (*in* Sözer et al. 1997) reported total densities of between 2 and 8 individuals km^{-2} in East Kalimantan. Population density in Mulu National Park, Sarawak, was probably less than one adult male km^{-2} (Davison 1979).

A number of studies have been conducted on the relative abundance of Argus Pheasants by recording the number of calling males per km of transect surveyed. Although the results of these studies are not directly comparable with those described in the present study, they do indicate which of the habitat types sampled is favoured above the other, provided that recording conditions between habitats are not too dissimilar. Wilson & Johns (1982), working in East Kalimantan, observed male Argus Pheasants in frequencies of 1.1 ± 0.92 and 0.1 ± 0.28 km^{-1} in primary and young (3–5 year old) secondary forest. Wilson & Wilson (1975) reported densities of 2.3 ± 3.7 and 2.0 calling Argus Pheasants km^{-1} surveyed in primary and selectively logged (logging took place 1–1.5 yrs previously at an intensity of 8 trees ha^{-1}), respectively. The species was relatively rare in secondary forest along the Sengatta River in Kutai National Park (Wilson & Wilson 1975). In contrast to the findings of the present study, and of Wilsons' surveys (Wilson & Wilson 1975, Wilson & Johns 1982), Bennett & Dahaban (1995) found significantly higher calling rates, and hence probably higher densities, of Argus Pheasants in two thirty year old secondary forest sites compared to six primary forest sites in Sarawak and Brunei (ca. 6.7 vs. ca. 1.5 calling Argus Pheasants km^{-1} surveyed, see figure 5.10 in Bennett & Dahaban 1995).

Apart from the studies by Davison (1981, 1979) and Sözer (*in* Sözer et al. 1997, pers. comm. 1997), the above cited studies were aimed at collecting data on the effects of disturbance, either due to logging, hunting, or shifting cultivation, on wildlife, adding relative few new data on the behavioural ecology or habitat preferences of Argus Pheasants. Still, the studies conducted so far indicate that, in general, Argus Pheasants seem to be species typically associated with dry primary lowland rainforest (e.g. Thomson 1966, Smythies 1960, Holmes 1989, Showler 1992) and, to a lesser extent, tall (selectively) logged forest (e.g. Wilson & Wilson 1975, Davies & Payne 1982, Wilson & Johns 1982, MacKinnon & Phillips 1993, Bennett & Dahaban 1995).

Davison (1981) showed that, in Malay Peninsular, the Argus Pheasant population probably approaches the carrying capacity of the habitat imposed by food abundance. Argus Pheasants forage solitarily, pecking at fruits, flowers, bits of shoots, and small invertebrates in the surface of the leaf litter layer (Davison 1981; McGowan 1994). The plant families Annonacae, Palmae, and Leguminosae, predominate in the diet, and a relative high proportion of fruits taken derive from climbers (Davison, 1981). In the Nggeng Bio River valley, trees of these plant families are relatively rare in primary forest (11 of the 301 trees identified), and almost absent in riverine forest (none of the 192 trees identified: data from Anon. 1996). Furthermore, in the study area, climbers are common in undisturbed forest areas, while they are relatively rare in old secondary forest and virtually absent in the young secondary forest (pers. observ.). Compared to secondary forests, the undisturbed primary forest probably offers a greater food supply for Argus Pheasants, possibly owing to differences in vegetation structure and species richness, resulting in a greater carrying capacity, and hence greater densities.

The present study indicates that Argus Pheasants prefer tall forests in areas located away from the main rivers and in the more rugged parts of the study area, possibly partially due to the more pronounced influence of human presence in other parts. A preference for hilly areas has been noted before. Wells (1985) considered the Argus Pheasant to be a so-called slope specialist, i.e. a species restricted to the upper limit of the lowland forest, pushed up by a congener occurring lower down. Pfeffer (1960) mentioned that Argus Pheasants seem to prefer humid areas with plenty of undergrowth. In the present study, the highest densities were generally found in forest types with the least vegetation cover at ground and low level. However, as many variables are not independent it is difficult to assess whether or not it is vegetation cover *per se* that influences Argus density.

In this respect it might be worth noting that, although the present study did find significant correlations between the abundance of Argus Pheasants and the recorded habitat features, as stated before the results do not indicate causality. The choice of which habitat features to record is subjective, possibly having an effect on the outcome of the study. Furthermore, the choice of which area and, more importantly, which habitats to study, was subjective, as it is in most studies. In the present study the sample of habitats ranged from old and virtually untouched primary to young and heavily degraded forest, so the positive correlation between Argus Pheasants and, for example, closed canopy cover, can be interpreted as a 'preference' for less disturbed forest types. If, however, the study had sampled only in primary forest, which always has a dense canopy cover, then the species might have been associated with canopies below the mean value of the habitat. Had this been the case, there might be a tendency to suggest that Argus Pheasants have a preference for disturbed, or even, by extension, secondary forests. Subsequently, had we, in the present study, also sampled bush land or even dry rice fields, the inferred preference for a closed canopy is likely to have been much greater than at present.

Densities of Argus Pheasants in and near the Kayan Mentarang National Park were significantly higher in the more remote parts, i.e. the further away from large rivers and the further uphill. Distance to the nearest village itself was not significantly correlated with Argus density, but was included in the best subset of predictors for the observed variation in Argus density. Villages and dry rice fields are mostly located in the lower areas near the rivers, and boats are the main mode of transportation in the region. Argus Pheasants are reported to be easily snared, either for their meat or for their feathers (Pfeffer 1960, Smythies 1960, MacKinnon et al. 1996), and in a number of villages adjacent to the Kayan Mentarang National Park Argus skins were seen mounted on the wall (pers. observ.). Bennett & Dahaban (1995), working in Sarawak and Brunei, observed that the calling frequency of Argus Pheasants declined with increasing hunting pressure although, owing to the variation among sites, differences were not significant. Caldecott (1992) inferred that the Great Argus Pheasant was among a number of species especially vulnerable to extermination by hunting. The relentless search for meat by rural people could in time result in over-exploitation (Caldecott 1992).

It is probably safe to assume that humans can have a profound effect on populations of Argus Pheasants locally, either by modifying the habitat or directly by hunting; the two factors often operating concurrently. Whether or not this is particularly the case in Kayan Mentarang National Park, remains to be seen. Human population density in and around the park is in the order of less than one person per km^2. Approximately 10,000 people live in or around the Park in East Kalimantan, and a few thousand more live close to the border in Sarawak and Sabah (Jessup et al. 1992), while according to the data available to the WWF-Indonesia Programme in December 1997, the National Park proper covers an area of ca. 13,500 km^2. Furthermore, over the last hundred years there has been a heavy out-migration, generally as a result of better health facilities, better education and better living conditions elsewhere. Most of the migrants move more to the coast, while especially the last few decades many have gone to seek their fortune on the other side of the border in the Malaysian states of Sabah and Sarawak (Sirait et al. 1994). This makes it unlikely that human population pressure would affect the numbers of Argus Pheasants in Kayan Mentarang National Park as a whole. Unfortunately, the Argus Pheasant's preferred habitat, like that of many other specialised lowland rainforest species, coincides with those areas in Borneo that are first to be colonised, farmed, industrialised, and least protected by man. In and around Kayan Mentarang National Park villages are generally situated along rivers in relative low lying areas, while probably over half of the National Park consists of montane forest above 1000 m a.s.l. This is a situation similar to that of a number of other large terrestrial reserves both in Kalimantan and Sumatra (Sujatnika et al. 1995). Although perhaps beyond the scope of the original study it seems warranted to make a few comments on the conservation status of Argus Pheasants in Borneo.

Great Argus Pheasants are largely restricted to lowland forest, although the altitudinal range may differ between parts of its range. On Borneo the species ranges from sea level up to 1000–1200 m a.s.l. (Smythies 1960, Thomson 1966, MacKinnon & Phillipps 1993), exceptionally much higher as Mjöberg (1928) sighted an individual as high as 2170 m a.s.l. on Gunung Murud, Sarawak. The population size over its entire range is estimated to number more than 100,000 individuals (McGowan & Garson 1995). Great Argus is not included in BirdLife International's list of threatened birds (Collar et al. 1994, Shannaz et al., 1995). Although the species has quite an extensive range, on a large scale it consists of three isolated populations, viz. those on the Malay peninsula, Sumatra and Borneo, each of which in turn are made up of numerous sub-populations, divided by high mountain ranges and cultivated land. The species is protected by Indonesian and Malaysian law, but law enforcement is weak or, especially in the interior of Kalimantan, but probably comparably so in similar areas in Sabah, Sarawak and Brunei, virtually absent. Although, owing to its noisy behaviour, the species might seem relatively common, it in fact occurs at low densities of only a handful of individuals per km^2 in the best preserved forest areas, with lower densities in the more disturbed forest types. On the island of Borneo, only 3% of the original natural habitat has been protected within reserves, another 8.7% is proposed for gazetting, much of this within Kalimantan (MacKinnon et al. 1996). The montane rainforests are well represented in the existing conservation area network, most large reserves are (partially) situated in montane areas; this in contrast to lowland forests (e.g. MacKinnon & Artha 1981; Sujatnika et al. 1995). The rapid decline of lowland forest throughout its range leads not only to the loss of habitat, but also to extreme fragmentation of once continuous lowland forest, and hence populations of Argus Pheasants. Once inside these isolated forest areas, the species is more or less 'trapped', unable to move out. Small populations are prone to extinction, especially when hunting becomes more severe and easier owing to decreasing forest area and increased accessibility. Argus Pheasants seem to have been exterminated from many areas where it formerly occurred (e.g. Brunei: Mann 1987, Kalimantan: Pieters 1935; R. Sözer, pers. comm. 1997), and the species does not seem easily to (re)colonise areas (McGowan 1994). The threats to the Argus Pheasants have been recognised at the Galliformes Conservation Assessment Workshop and, based on rates of lowland forest clearance, the species is given the status of 'vulnerable' (McGowan & Garson 1995). Regrettably, Holmes (1989) may be right in stating that in the long-term, the Great Argus Pheasant may be secure in reserves and well managed production forests only.

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