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Source: Acta Ornithologica, 42(2) : 186-190

Published By: Museum and Institute of Zoology, Polish Academy of Sciences

URL: https://doi.org/10.3161/068.042.0201

ACTA ORNITHOLOGICA
Vol. 42 (2007) No. 2

Effects of vocal behaviour on abundance estimates of rainforest galliforms

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Nijman V. 2007. Effects of vocal behaviour on abundance estimateas of rainforest galliforms. Acta Ornithol. 42: 186–190.

Abstract. A comparative study was undertaken to assess the effects of the vocal activity of a target species on its density estimates made using line transect counts and point counts. In Kayan Mentarang National Park (Indonesian Borneo) the Great Argus Pheasant *Argusianus argus* displayed different levels of calling activity. The study was conducted at a period when the birds were highly vocal, and again, at the same site, when the birds were significantly less vocal. Transect counts during periods of low vocal activity resulted in 13–20% lower density estimates compared to periods of high vocal activity, but these differences were not significant. Estimates derived from five-minute point counts during periods of low vocal activity, however, were 52% lower than those from periods of high vocal activity. Comparison of the two methods shows that density estimates derived from the point count method were consistently lower than those from the line transects. The lack of a fixed calling season in Argus Pheasants makes year-round censuses possible, yet the distinct temporal differences in calling rates necessitates that caution be exercised when results obtained in different years or at different times of the year are compared. It is concluded that there is an increased need for understanding the behavioural plasticity of species if census methods are to be improved.

Key words: Great Argus Pheasant, *Argusianus argus*, census methods, Galliformes, Indonesia, line transects, point counts, research methods

Received — July 2007, accepted — Oct. 2007

Line transect counts and point counts are two commonly used methods for estimating animal abundances (Bibby et al. 2000). For many animals that are difficult to observe but that do vocalise frequently, such as many birds and certain mammals, the number of calling individuals is used as a measure of abundance.

Vocalising in animals is greatly dependent on, amongst others, 1) time of day, often with each species calling most frequently during a fixed time window (Bibby et al. 2000, Geissmann & Nijman 2006, Geissmann et al. 2005, Nijman 2003), 2) breeding season, with animals calling more frequently during the mating period (Clutton-Brock et al. 1979, van Parijs et al. 2001, Luiselli et al. 2005) and or entire breeding period (Thorpe 1961, Polak 2005), 3) density, with not only more animals calling at higher densities but also more animals calling more frequently (Martinez & Zuberogoitia 2003, Nijman 2004a), and 4) disturbance, with often animals ceasing to call entirely during disruptive periods (Johns 1985ab) or with diel changes in calling frequencies (Nijman 2001). This variation in vocal behaviour may affect the outcome of census methods (cf Woltman 2005, Brauze & Zieliński 2006), and may lead to under- or overestimation of 'true' abundances, and as such may render any conclusion or comparison invalid.

Gamebirds, including pheasants and partridges, are a group of birds that have been studied frequently, and for boreal species detailed assessments of the methods of estimating numbers have been conducted (e.g. Helle & Lindstrom 1991, Swenson 1991, Woodburn 1993). Especially for some of the more elusive species that live in dense (rain)forest environments, that are often difficult to observe directly, data on vocal behaviour have been used to assess abundance and habitat use (McGowan 1994a, Khaling et al. 1999, Fredriksson & Nijman 2003).

The Great Argus Pheasant *Argusianus argus* is resident in the rainforests of Borneo, Sumatra and the Thai-Malay Peninsula. Argus Pheasants are normally solitary, territorial, and have a polygamous breeding system. Males maintain small home ranges in the order of 1.1–6.2 ha (Davison 1981). The males clear dancing grounds on the forest floor removing all leaves, seedlings and stones. They call from these dancing grounds and give a visual display to visiting females. Like many species of pheasant, Argus Pheasants are difficult to observe but unlike many other pheasants the male's loud calls can be heard over distances >1 km and is often given in response to other calling males or other forest noise like falling trees. Little is know about the species breeding biology in Borneo but the scant data we have suggests that breeding can occur at all months of the year (R. Sözer, pers. comm.).

Fieldwork was conducted from 4 October to 2 December 1996 and from 27 June to 7 July 2003, in the lowland forest between altitudes of 300 and 700 m a.s.l. in the valley of the Ngengg Bio River (2°53'N, 115°49'E), Kayan Mentarang National Park, East Kalimantan, Indonesian Borneo. For a complete description of the study area, see Nijman (2004b). The valley has been a restricted area of the nearby village Long Alango since the early 1920s. Cultivation and collection of forest products is mostly prohibited there (Eghenter 2000), and the valley is still covered with mature, tall primary forest. At the study site no snares or traps were encountered nor were hunters met that had trapped or killed pheasants, and hunting or trapping of pheasants or other ground birds seemed genuinely absent (or if not, it must have occurred at a low intensity). Kayan Mentarang National Park is situated near the equator with little or no seasonality. Its climate is warm perhumid and during both study periods it rained on most afternoons with only a few rainless periods of one to three days.

The abundance of Argus Pheasants was assessed using repeat line transect surveys and by point counts located throughout the forest (Bibby et al. 2000), based on the detections of calling males. Both methods were employed in the same 5 km^2 study area. Two permanent transects in primary hill forest (Pr-1: 3.0 km and Pr-2: 2.5 km) were walked between 06.00–12.00 hrs at a pace of ca. 1.5 km/h. In 1996 these transects were repeated six and five times for Pr-1 and Pr-2 respectively, and in 2003 these same transects were repeated four and five times. All calling males within an estimated 500 m distance perpendicular to the transect line were recorded; for caveats and rationale see Nijman (1998).

While in the forest, be it along the transects or elsewhere, and when in a suitable listening position (e.g. on a ridge or hill top and away from noisy rivers), every on the hour on the hour the number of vocalising males within a 500 m radius was recorded for a period of 5 minutes (in effect sampling randomly throughout the study area). In 1996 almost 90% of all calls were recorded between 06.00 and 13.00 hrs, and analysis was limited to this time window. As such 59 h of data were collected in 1996 and 64 h in 2003.

Each transect walk provided a density estimate (number of calling males/km^2) for that particular day and these were averaged for each of the two transects. Likewise point counts were averaged for every hourly period. For comparing density estimates between years or between methods, Mann-Whitney U test were used (where n_1 refers to data collected in 1996 and n_2 to data collected in 2003). Means are reported ± SE.

In 2003 the number of calling male Argus Pheasants was less than in 1996. In 1996, 60 males were recorded along the transect lines (3.0 calling males/h) and 67 during the point counts (1.1 calling males/h) whereas in 2003 these figures were 41 (2.5 calling males/h) and 36 (0.6 calling males/h), respectively. In both years Argus Pheasants were recorded daily, but both the frequency at which individual males were calling (as recognised from fixed calling positions) and the number of males that were calling simultaneously differed considerably.

The line transects revealed that Argus Pheasants were present at a density of between 1.5 ± 0.2 and 2.1 ± 0.1 calling males km^{-2}. Compared to 1996, in 2003 density estimates were 13% lower for Pr-1 and 21% for Pr-2, but these differences are not significant (Mann-Whitney U-test, $n_1 = 6$, $n_2 = 4$, $p > 0.30$ and $n_1 = 5$, $n_2 = 5$, $p > 0.20$ for Pr-1 and Pr-2, respectively).

The point count method gave large diel differences in the density estimates (Fig. 1), with few birds being recorded at dawn and afternoon. The range in the number of calling males recorded per 5-min sampling period was larger in 1996 (0–5) than in 2003 (0–3). However, for 6 out of 7 transitions between two consecutive hourly periods, the difference in the number of calling males (reflected in the inclinations in Fig. 1) was larger in 2003 compared to 1996 (sign test, $n = 7$, $x = 1$, $p = 0.07$), giving the impression of more erratic calling in 2003. For 7 out of 8 hourly periods the estimated density of calling males in 2003 was lower than in 1996 so the likelihood that the Argus was calling at equal rates in both years is small (binomial test, $n = 8$, $x = 1$, $p = 0.04$).

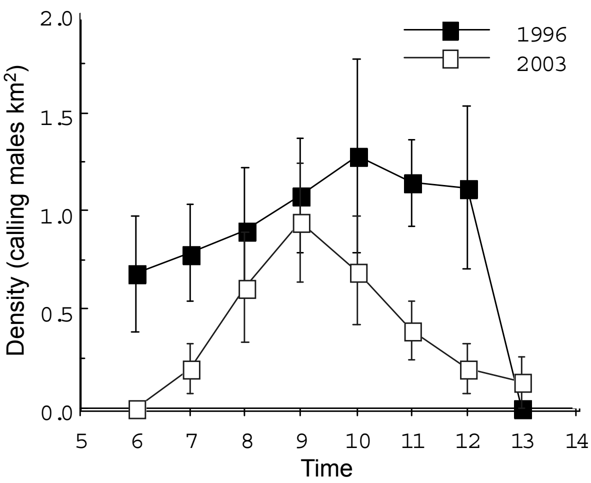

Fig. 1. Average density (+1 SE) of calling male Argus Pheasants in primary hill forest based on point counts in relation to time of the day.

Highest estimates were 1.3 ± 0.5 calling males/km^2 in 1996 (at 10.00 a.m., n = 8) and 0.9 ± 0.3 calling males/km^2 in 2003 (at 09.00 a.m., n = 10). Between 07.00 and 12.00 the average estimate for each hourly period in 2003 was 52% lower than in 1996. These differences were significant for three hourly periods, i.e. 07.00 a.m. (-75%: Mann-Whitney U-test, n_1 = 5, n_2 = 8, p = 0.05), 11.00 a.m. (-66%: Mann-Whitney U-test, n_1 = 11, n_2 = 8, p = 0.02) and 12.00 a.m. (-83%: Mann-Whitney U-test, n_1 = 7, n_2 = 8, p = 0.04).

Comparing the two methods it shows that density estimates derived from the point count method were consistently lower than those from the line transects. When the 07.00–12.00 period was considered, estimates were 47% lower in 1996, and 69% in 2003. Even when for the point count method only the hourly periods when male Argus Pheasant were most vocal (i.e. 10.00 a.m. for 1996 and 09.00 a.m. for 2003) are considered, compared to the line transects, density estimates are 36% and 43% lower for 1996 and 2003, respectively.

Abundance of Argus Pheasants in Kayan Mentarang National Park was between 1.5–2.1 calling males/km and as such are similar to that found in other primary lowland study sites. Bennett & Dahaban (1995) report an average frequency of 1.5 calling Argus Pheasants/km, and Wilson & Johns (1982) and Wilson & Wilson (1975) report frequencies of 1.1 and 2.3 calling Argus Pheasants/km, respectively.

Variation in calling behaviour of Argus Pheasant in Kayan Mentarang gave the impression of large differences in abundance of the species between years, yet, assuming no change in detectability between years, transect counts revealed that densities had not changed over time. Although it is not known what the proximate reasons are for this change in calling behaviour, similar inter-annual differences were noted in the Sungai Wain protection forest, East Kalimantan, during eight study periods in 1999–2004 without, however, revealing a clear pattern (V. Nijman, unpubl. data). Likewise Davison (1981), working in West Malaysia, found the number of calling males to differ more than threefold between years, without a clear indication of a population increase/ decline.

The accuracy of density estimation in part depend on the density of the study species, with often more accurate estimates in areas or during years of greater abundance (e.g. Tomiałojć 2004). In this study the number of calling males was used as a measure for Argus Pheasant density. Male Argus Pheasants often call from fixed display sites (Davison 1980) and, while walking on the transects, the same male could be heard calling from the same position for a longer period of time. Double counting of single males during one transect walk is therefore assumed to be of minor, if any, significance. The large variation between the number of males that were recorded calling even at time period they were most vocal suggests that calling frequencies might be too low as to allow for accurate density estimation. Hence, the densities presented here are likely to be underestimates but some more so than others.

This study clearly demonstrated that during periods of low vocal activity, underestimation using point counts is a larger problem than using line transects. The crucial factor in this is the amount of time a surveyor allows for recording the species of interest. For the line transect method this is dependent on the speed at which the surveyor walks along the transect, and for the point count this is simply the pre-determined duration of the count. Assuming that calls remain audible over a distance of 500 m (this is often considerably larger, up to > 1 km), a calling male Argus Pheasant within a band of 500 m on either side of the transect line, can be detected, on average, over a transect length of 500 m (the two most extreme cases being an individual that is calling on the transect line that can be detected over a length of 1 km whereas a bird that is calling from a distance of 500 m perpendicular to the transect can be recorded at one point of the line only). Maintaining an average speed of 1.5 km/h (as in the present study) allows a surveyor 20 min. time to record an individual bird. Thus a male that is calling once every 20 min. will be detected. With increasing calling frequency the chance of double counting single males increases somewhat, but given that male Argus Pheasants are mostly calling from fixed positions this can be assumed to be of minor significance. When birds are calling less than once every 20 min. the line transect will underestimate true densities.

For the point count method duration of the count should be long enough to detect all the individual birds at the site, before they move significantly. Longer durations are also more likely to record additional birds moving onto the plot, which violates the critical assumption of the point count method, and has led to overestimates of up to ten times (Bibby et al. 2000: 96). In most temperate situations a count duration of perhaps 5 min. is to be preferred (Fuller & Langslow 1984 but see Sorace et al. 2000), whereas longer intervals might be needed in tropical forests (Bibby et al. 2000), typically between 5 and 12 min. (Marsden 1999, Jones et al. 2003) or up to 20 min. (e.g. Thiollay 1997). The present study suggests that even for animals with easily detectable calls such as the Argus Pheasant, longer count periods may be needed, but the exact length of the count period seems to depend largely on the vocal behaviour of the target species.

In many rainforests the animals are year-round residents, and often breeding can occur at all months of the year (Moreau 1950, Voous 1950, Nijman 2004c). In temperate regions vocal behaviour can be strongly linked to the mating period (e.g. birds, mammals, amphibians), and occurs at a predictable time of the year. The lack of a fixed seasonal calling period in rainforest animals makes it possible to census them year-round, but as there can be distinct temporal differences in calling rates caution should be taken when comparing results obtained in different years or at different times of the year. This caution may be more prudent when comparing results from areas that differ in their degree of disturbance as this has been demonstrated to greatly affect calling rates in a variety of rainforest animals (Johns 1985b, Nijman 2001). From the study of the Argus Pheasants in Kayan Mentarang we can conclude that there is an increased need for understanding the behavioural plasticity of species, especially when it concerns threatened species (such as many pheasants: Madge & McGowan 2002, McGowan 1994b). Behavioural studies should therefore play a more prominent role in conservation, and strengthening the link between studies in behavioural biology and conservation biology can benefit monitoring and censusing (cf. Babtista & Gaunt 1997, Beissinger 1997).

ACKNOWLEDGEMENTS I thank WWF-Indonesia for giving me the opportunity to participate in the Kayan Mentarang project, and I thank all staff, for support. I express my gratitude to the Indonesian authorities (LIPI, PHKA, BKSDA) for allowing me to conduct my studies. R. Sözer and S. van Balen unhesitatingly sharing their knowledge on pheasants. Research grants were received from Netherlands Foundation for International Nature Protection, Society for the Advancement of Scientific Research in the Tropics, P. A. Hens Memorial Fund, Martina de Beukelaar Stichting, J. C. van der Hucht Fonds and the Nederlandse Vereniging voor Internationale Vogelbescherming.

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STRESZCZENIE

[Aktywność głosowa a szacowanie liczebności tropikalnych kuraków]

Praca miała na celu określenie, jak aktywność głosowa wpływa na szacunki liczebności wykonywane dwiema metodami: punktową i transektową. Do badań wybrano argusa *Argusianus argus*, gatunek o donośnym głosie, odzywający się przez cały rok. Prace prowadzono na Borneo w ciągu dwóch lat (1996 i 2003), w okresach różniących się aktywnością głosową ptaków (październik–grudzień i czerwiec-lipiec). Dwa transekty miały długość 3 i 2.5 km, kontrolowano je 4–6 krotnie w badanych okresach. W punktach z odpowiednim ukształtowaniem terenu prowadzono nasłuchy przez 5 minut. Szacunki liczebności uzyskane metodą transektową przy niskiej aktywności głosowej były nieznacznie niższe (do 20%) niż przy wysokiej aktywności głosowej. Natomiast wyniki z liczeń punktowych przy niskiej aktywności głosowej były o połowę niższe, nawet biorąc pod uwagę zmienność dobową częstości wydawania głosów (Fig. 1). Szacunki liczebności przy użyciu metody punktowej były znacznie niższe niż przy transektowej.