Spatial structure of calling sites in the Great Argus *Argusianus argus*

CON FOLEY

The cleaned calling sites of male Great Argus *Argusianus argus* pheasants were mapped and studied in Johor, Peninsular Malaysia. Calling sites tended to occur in clusters, at a geographical scale of hundreds of metres in span, with several kilometres between clusters in the area studied. Rather than strictly one calling site per male, at least some males definitely used two, and in two cases three, calling sites concurrently. Clusters, and some of the particular calling sites within them, persisted throughout the seven-year study period. These observations are relevant to the social system of the species, and to density estimates that assume that males call from single fixed sites.

INTRODUCTION

The Great Argus *Argusianus argus* is a large pheasant of lowland tropical rainforest in South-East Asia, more often heard than seen. Males have been described as calling from fixed points, where they clean away undergrowth and the leaf litter layer, and where vulnerability to predators makes them extremely wary (e.g. Beebe 1922, Davison 1981).

Previous observations on this species (Beebe 1922, Davison 1981, Winarni 2002) have indicated that each adult male maintains a single cleaned display site from which to call, vociferously and alone, for several hours daily during a prolonged season, with surplus adult and young males as well as females moving alone elsewhere in the forest, seldom calling and typically with a different range of call types. Among adult males, fixed sites are thought to be used for the one call type employed during the breeding season, whereas other call types can be given by adult males at any time of year and not necessarily from fixed sites. In forest the calls might carry for up to about 1 km (Davison 1981). During intervals between calls, the adult males perch, walk, peck at the immediately surrounding and overhanging vegetation, and toss or fan away leaf litter so that a space is created that may facilitate the active display (Davison 1981, 1982). As a result, fixed calling sites have also been termed arenas, display sites or dancing grounds, and can still be detected if a bird is not present, and for some time after they are no longer used, less reliably so as the site reverts through leaf and twig fall and plant growth. Based largely on these observations, the species has been considered to show a lek mating system (e.g. Payne 1984, Johnsgard 1994). Definitions of lek systems, however, range from the strict multiple criteria of Bradbury (1981) to the broadly inclusive (e.g. Höglund & Alatalo 1995: 'aggregated display that females attend primarily for the purpose of fertilization'), and their characteristics differ across the array of mammal, bird, amphibian and even insect species that have leks. For situations in which males are in vocal but not visual contact, terms such as dispersed arena, exploded arena or exploded lek have been introduced (Gilliard 1963, Payne 1984, Johnsgard 1994).

Densities of Great Argus have been estimated by camera-trapping (Winarni *et al*. 2004, 2009) and by counting calling birds along transects (Nijman 1998, 2007, Ong-In & Savini 2021, Sengrath 2001) or from fixed observation posts (Gale *et al*. 2009, Kemp *et al*. 2011). Methods that involve counts of calls or mapping of calling positions have depended in part on the assumption in the literature referred to above that males each have a single calling site. However, observations by the author at one Johor locality suggested that this assumption might not be correct. In particular, none of the literature on Great Argus has explored the spatial structure (distances between males) relevant to the concept of leks or exploded leks. Therefore, repeated visits were made to the locality in order to map fixed calling sites. The specific objectives of the study were to pinpoint fixed calling sites across the landscape, map and measure distances between them and, if possible, to determine whether males were or were not calling from single sites. The current study provides new information relevant to the bird's biology and to census methods.

METHODS

A single forested locality in Johor was visited many times over a seven-year period (2009–2015), with more than 100 visits that were either all or partially devoted to studying the Great Argus. Visits occurred at all seasons, but were concentrated in dry weather when birds are more active and vocal. Once mapping had begun, two areas were investigated in greater detail, both consisting of selectively logged lowland dipterocarp forest. One had low hills to about 100 m above sea level, where a 5 km trail was walked repeatedly while listening for and mapping calls and calling sites. The second area, about 5 km away, was flatter and generally wetter, with more streams, where an 8 km trail was walked repeatedly. The two areas are within a single contiguous Forest Reserve under the National Forestry Act (2010) and managed by the State forestry department, within which different compartments have been selectively logged by commercial extraction of large timber trees at various dates. Subsequent to logging, forest regrowth has been encouraged by silvicultural treatments including enrichment planting, and the forest has occasionally been used for military training exercises. Past logging, exercises, and an access route between settlements outside the forest reserve boundaries have resulted in one or two permanent trails (mentioned above) where the forest canopy is broken; over the bulk of the area the canopy is complete but structurally uneven because of differential recovery periods since logging. Our description is deliberately kept general in order to reduce the risks of disturbance to the birds in particular and the forest in general, but all GPS readings have been retained for future reference. Details about forest disturbance are given in the results.

Following the discovery of a first calling site in 2009, a dozen sites were found and mapped using a smartphone app, Gaia GPS®. Key to this was listening to the calls, noting the compass reading, and then tracking the calls to the calling site, which sometimes required triangulation. With a single observer, triangulation could not be done simultaneously from more than one starting point, but triangulation was possible across different days because calling sites are fixed and maintained for weeks or months. Any mapping inaccuracies due to degree of sensitivity of the Gaia GPS software were obviated by the combination of triangulation, software, and personal trekking to and between each calling site. Triangulation and the following precise mapping of calling sites based on compass

bearings was facilitated by the birds' pattern of calling in short bursts every few minutes for several hours on most or all mornings during an extended season. Calling sites that could not be pinpointed by visiting were excluded from measurement.

A single camera trap was used at a few of the calling sites when a cleared site was found but the bird itself could not be seen directly. It was important to arrive before dawn, listen to where the male bird called from his arboreal (uncleared) roosting site, and then where he would call again, about 20 minutes later, on the cleared daytime ground-level calling site he had walked to. One of the males in the study area had a slight idiosyncrasy in his call, and this was helpful in tracking his location in the forest and distinguishing him from other calling males. Nearly simultaneous calling by males in differing directions was also used to distinguish and map individuals. Habituation was not deliberately used, in order to minimise observer effects on behaviour, although others have used it as a technique for research and photography of the species (Davison 1981, Davison & Smart 2010). It was usually self-evident, at the scale of the area studied, when one calling individual shifted to a different calling site, but sometimes this could be confirmed directly: I was able to displace a male from one calling site, rapidly walk to another calling site that I suspected belonged to the same individual, and confirm this by his arrival from the appropriate direction a few minutes later.

RESULTS

Clustering and number of calling sites

Calling sites were not evenly spaced through the forest, either at the slightly hilly locality (A) or the nearly level locality (B) in the study area. At the first locality, a cluster of four calling birds was observed along one portion of the 5 km trail (Figure 1: Cluster A). Three males used at least six calling sites within a total span of 500 m. In Cluster A, Bird 4 did not call as much as the other three birds, which typically responded quickly to each other's calls. Nor did I manage to find a calling site for Bird 4, although the difficult terrain in that direction limited my explorations. I was therefore unable to be sure whether Bird 4 was a male that used a fixed calling site. No other Great Argus was noted calling in close proximity to this trail, although a few distant birds could be heard. Cluster A was in an area of forest with very low human disturbance and little motorised traffic, just an occasional motorbike a few days per month, and occasional hunters. The amount of human trash left in this forest area was very low.

At the second locality one cluster of three calling birds was noted within a 645 m span along the 8 km trail (Figure 2: Cluster B), and two singletons were noted at distances of 1.2 km and 2.9 km from this cluster. Other more distant males were not investigated. In Cluster B, Bird 3 did not call as much as the other two males, which typically responded to each other's calls. Nor did I manage to find a calling site for Bird 3, so I was unable to determine whether Bird 3 was a male with a calling site. No other close Great Argus was noted. Cluster B was in an area with much higher human disturbance, a lot of motorised traffic, human presence, lots of human trash and occasional military exercises.

Where several male Great Argus were present, they tended to be aggregated into a cluster (Figures 1 & 2; Tables 1 & 2). In Figure 1, three males are shown forming a cluster, with a fourth bird not mapped. The minimum convex polygon enclosing seven calling sites of three males covered 5.05 ha. In Figure 2 there are two males, with a third bird not mapped. The minimum convex polygon enclosing four calling sites of two males covered 5.20 ha. The mean distance between calling sites belonging to single individuals was 157.9 m (n=7, range 55–333 m), while the mean distance between calling sites of adjacent but different individuals within a cluster was 301.6 m (n=8, range 123–645 m). The next nearest distance between a cluster and another calling individual was 1.2 km. In each cluster, when one male started calling he was usually answered by the other males within close proximity, and if one male fell silent, the others may too.

Out of seven males detected by their calls, two were each found to use three calling sites concurrently, one used two sites concurrently, two used only one calling site each, and two males used an unknown number of calling sites (but presumably at least one each) because they were not mapped precisely. In no case was there evidence of more than one male at a given calling site. In Cluster A, three calling sites were observed for Bird 1 in 2013. This was the year in which I

Figure 1. Map of male Great Argus calling sites and two roost sites in Cluster A at the first study locality, showing 10 m contour intervals. The calling site or sites of Male 4 (possibly off the map) were not located precisely. Contour lines extracted from Google Maps ® with calling sites superimposed using Gaia GPS ® and checked by field visits.

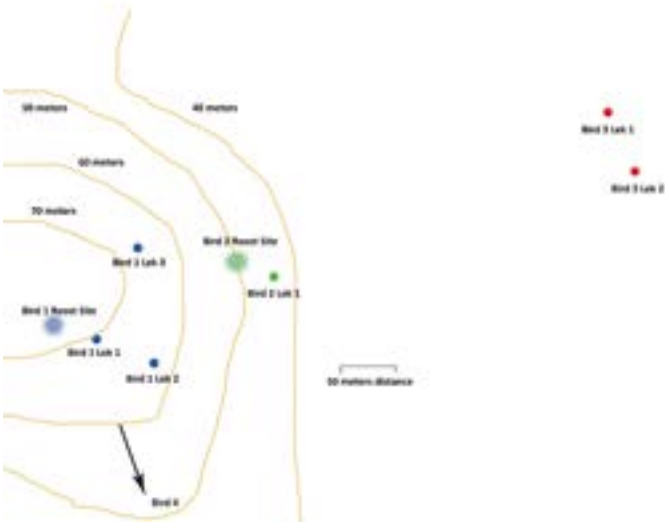

Figure 2. Map of male Great Argus calling sites and one roost site in Cluster B at the second study locality. The calling site or sites of Male 3 (possibly off the map) were not located precisely. Course of stream extracted from Google Maps ® with calling sites superimposed using Gaia GPS ® and checked by field visits. No contours are shown because the area was virtually level ground below 50 m elevation.

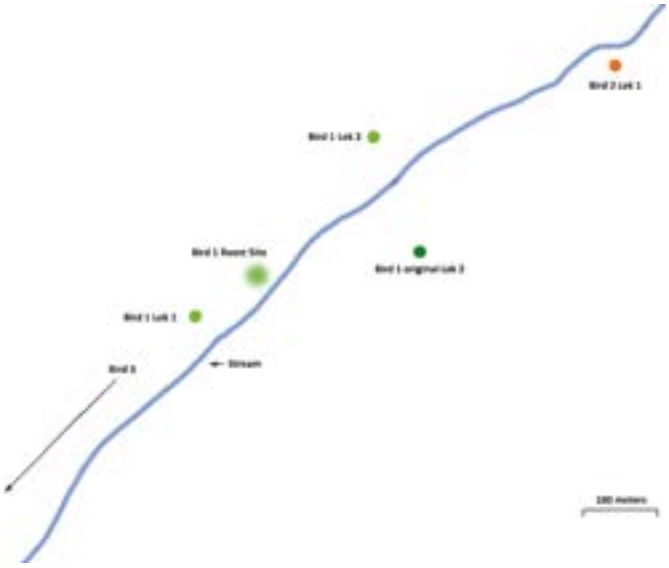

Table 1. Distances (m) between calling sites of three (out of four) male Great Argus at the first locality (Cluster A) in forest in Johor, Malaysia.

Name	Distance from Bird 1 Site 1	Distance from Bird 1 Site 2	Distance from Bird 1 Site 3
Bird 1 Site 1		55	88
Bird 1 Site 2	55		102
Bird 1 Site 3	88	102	
Bird 2 Site 1	166	130	123
		Distance from Bird 3 Site 1/2	Distance from Bird 2 Site 2
Bird 3 Site 1	495	58	330
Bird 3 Site 2	501	58	330

Table 2. Distances (m) between calling sites of two (out of three) male Great Argus at the second locality (Cluster B) in forest in Johor, Malaysia.

Name	Distance from Bird 1 Site 1	Distance from Bird 1 Site 2	Distance from Bird 1 Site 3
Bird 1 Site 1		333	309
Bird 1 Site 2	333		160
Bird 1 Site 3	309	160	
Bird 2 Site 1	645	333	356

made 23 visits to that male. The third calling site may or may not have been created in response to my frequent visits. Two calling sites were observed for Bird 3, the least visited of the three confirmed males in Cluster A. Bird 4 was heard less frequently, perhaps the least frequently calling bird of the four, and his site(s) were never pinpointed. In Cluster B, Bird 1 used two calling sites throughout the study period while a third site (active in 2009) had been abandoned by 2015.

I observed that a male known to use more than one calling site would on some days begin calling at one site and on other days begin calling at the other, without any obvious basis for the choice of site. I observed repeatedly that Bird 1 in Cluster B could be deliberately displaced from one calling site and would then walk along the forest floor to his alternative site to resume calling. I also observed that such movement between sites occurred at least once without any evidence of the male having been disturbed by humans. In such cases the male called from more than one of its sites within a single morning. In other cases a male would revert between calling sites on a day-to-day basis. Concurrent use of more than one site did not signal an abandonment of one site in order to take up a new site, but day-to-day or even within-day swapping between sites, some or all of which were persistent over the entire seven-year study period.

Figure 3. Large clean display site (Cluster B Site 1) of male Great Argus *Argusianus argus*, Johor, Malaysia. CON FOLEY

Site fidelity

Where a given male called from more than one site, the multiple sites were not necessarily used to a similar extent. In the case of Cluster B (Table 2), Site 1 was the one most used by the corresponding male. It was a very large cleaned site and the combined cleaned and open but uncleaned areas provided a lot of room for the male to move unhindered. It was under the natural shade of overhanging large trees and was on a former logging trail in a flat area (Figure 3). For this bird, the less prominent Site 3 was first discovered in 2009. To move between calling sites he would have had to cross an intervening stream either by flight or, as I suspected, via a fallen log. Sometime after 2009, Bird 1 abandoned Site 3 (evidenced by lack of calling from that site, and gradual accumulation of leaf litter through absence of cleaning behaviour) and created a new calling site (Bird 1 Site 2) on the same side of the stream as his Site 1. Both Sites 2 and 3 offered a much smaller area for cleaning and were not on former logging tracks. However, despite the difference in size between Sites 1 and 2, the time spent calling from each was similar: although detailed notes are not available, I visited within hearing of these two sites about 100 times from 2009 to 2015, and the frequency of calling from either site was roughly equal.

The site fidelity for Cluster B Bird 1 Site 1 was remarkable. Over the course of seven years, several military exercises were held in the area and even crossed the calling site, as evidenced by discarded army ration packs. Village children also played in the area. In about 2011 the army built lean-to shelters directly on Site 1. Weather and time caused the collapse of those shelters into a clutter of long decaying poles. Incredibly, through all the years, the male continued to use this site (Figure 4).

When I disturbed a male, it walked or trotted off silently into the forest and only when suddenly startled would a male take flight. A non-habituated male (Cluster B Bird 1) was observed to be very alert while on its calling site, typically moving off at any approach closer than 20 m. It was found that if the disturbance was strong enough, a male might not come back to that calling site until much later, if at all, that day, or even for several days, or even for most of the remaining breeding season.

DISCUSSION

Clustering as evidence of social system

Two categories of explanation for the clustering of calling sites are that they reflect social behaviour of the species, or that they reflect incidental clustering of forest features that happen to be preferred, such as water sources or openness of the understorey, or completeness of canopy cover. Data were not collected on these environmental features. Calling sites mapped in Figure 2 suggest possible alignment along a water course, but sites in Figure 1 do not support that idea at all, so no general conclusion is possible. Microhabitat preferences of the birds have been analysed, for example by Winarni (2002) and Ong-In & Savini (2021), but the clustering or otherwise of the preferred microhabitat features within the forest has not. Another possibility is that birds living between clusters were silent, e.g. because of disturbance (but see below), or that areas between clusters had been depopulated, e.g. due to reduced habitat quality or to poaching. These are all topics for potential investigation.

These observations in Johor confirm that the calling sites of male Great Argus are clustered. The term 'exploded lek system' has previously been used for this species (Davison 1981, Johnsgard 1994, Ligon 1999, Winarni 2002). Isolated males that use calling

Figure 4. Calling male Great Argus (Cluster B Bird 1 Site 1), Johor, Malaysia. CON FOLEY

sites may also occur. The present observations clarify (1) the spatial scale over which the clustering of calling sites occurs, with two such clusters spanning about 0.5 km and 0.65 km; and (2) the approximate number of males per cluster, with two or three and three or four males in the two clusters described here. Each male is highly vigilant, and responds vocally to the calls of his neighbours.

Few studies have detailed the spatial structure of the Great Argus social system. Winarni (2002) conducted a radio telemetry study to determine home ranges of a few males; I interpret her results as probably indicating two or three males forming a cluster (or an 'exploded lek'), but it is not clear whether all birds in that exploded lek were radio-tagged. The current study in Johor covered all the birds that could be heard in close proximity, and also resulted in estimates of two or three males per cluster, with an additional bird that could not be mapped precisely (possibly an adult male, but also conceivably a female or subadult).

Geographical clustering, males calling in response to their neighbours, and males falling silent once another one of them had been silenced (e.g. by human disturbance) indicate that the system does have the characteristics of an exploded lek (Oring 1982, Johnsgard 1994). Our results give the first clear indication of the geographical scale of clustering and the numbers of males loosely associated with each exploded lek.

Multiple sites per male

In Selangor, in the period 1975–1977, some males that abandoned calling sites because of human disturbance were observed to subsequently create new calling sites within a short distance (G.W.H. Davison, pers. comm.). Winarni (2002) appears to describe a similar situation in Sumatra, with some males that abandoned former calling sites (at which they had been trapped for radio telemetry) creating new sites afterwards, and not returning to the original site during the remainder of the year. Those examples entail the sequential use of different sites. The present observations in Johor illustrate that (a) whether or not disturbance is a trigger to move sites, some males are able to maintain more than one calling site concurrently not sequentially; and (b) individual males within a cluster differ in the number of calling sites that each maintains.

A presumed benefit of maintaining multiple sites is that the male may move to the alternative calling site if disturbed and may quickly resume calling. The choice of which site to begin calling from at the start of the day seemed random. Movement to the alternative site has clearly been observed and readily occurs, even sometimes without human disturbance. Concurrently used calling sites have been observed in both areas of the forest studied in Johor. There can be considerable differences between them in the degree of human disturbance (pedestrian and motorised traffic along nearby trails, occurrence of military exercises, camping, and amount of litter), so the presence of multiple calling sites per male does not seem readily explicable only in terms of disturbance.

Maintaining two or more calling sites clearly incurs energy and time in terms of additional clearing activity and additional travel between the sites, but apparently the benefits of resumption of calling at an alternative site outweigh the costs. Davison (1981) observed that a male spent only 0.53% of his time actively clearing the calling

site, out of the total time spent there. So little time required suggests that perhaps the energy expended is not as much as presumed and two display sites can be cleared.

It cannot be shown that every male has more than one display site, but at least some do. Possibly more males in the study area have two (or more) display sites, and I was not able to find them all.

Site fidelity

Winarni (2002) noted in her Sumatran study that some males had more than one calling site, but that usually only one was kept clean, and there was no indication whether two sites can be active concurrently. In the present study I found both sites, and for one male even a third site, to be cleared and active at the same time. A further male used three sites but only two of them concurrently.

There was great stability in each of the two clusters of males. How many years it may take a cluster of males to form is not known, but once a cluster is in place, it has been shown that if a male dies, he can be quickly replaced by another male (Davison 1981). Given the long lifespan of the Great Argus, there could be a number of aspiring males ready to take over an opening. These clusters tend to remain stable over the course of many years, as demonstrated by the persistence of Cluster B throughout seven years of observations, 2009 to 2015.

The social system of this species is evidently much more complex than previous suppositions of vocally interacting but effectively solitary adult males, calling to attract occasional females (Beebe 1922, Davison 1981). The present observations of multiple sites per male, some males having more sites than others, as well as the rather few (two to four) individuals apparently clustering, suggest rich possibilities for further study. More detailed observations of multiple sites, especially in less disturbed forests, may lead to an improved understanding of this behaviour. If more instances of dual and multiple calling sites per male can be found in undisturbed forests, it would tend to support the notion that the fittest males maintain more sites to increase their advantage, either by making themselves detectable to more females, or by demonstrating their higher quality. Furthermore, the clustering rather than even spread of calling males through the forest, and the shifting between calling sites by some males during a single morning, illustrate some of the pitfalls in density estimates that have relied upon vocal detection for this species (Nijman 1998, 2007, Ong-In & Savini 2021, Sengrath 2001).

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