Temporal and habitat-related variation in the activity patterns of black guans (*Chamaepetes unicolor*)

Black Guan *(Chamaepetes unicolor),* picture by Hans Zwitzer (Inaturalist)

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Abstract

Major threats to forest-dependent species in tropical ecosystems are deforestation and fragmentation (Colwell et al., 2008; Brooks et al., 2002; Dinerstein et al., 1995; Ridgely & Gwynne, 1989). It is important to know values that are important for the animals living there, such as the habitat types they use, yet ecological knowledge remains limited for the black guan (*Chamaepes unicolor*). This bird species is endemic to Costa Rica and Panama and lives in the cloudforest. Not a lot is known about this bird, the habitat use and ground activity patterns remain little. With this bird species decreasing in numbers it is important to fill knowledge gaps to come to good management of the black guans.
The objective of this study is to gain insight into the habitat use and activity patterns of the black guan. This study is located in Cloudbride nature reserve, Costa Rica. Habitat use and activity at ground-level is measured with camera traps, from the beginning of 2025 until the beginning of December 2025. The data is analysed using a negative binomial GLMM.

Black guans were only seen during daytime, between sunrise and sunset, with higher occurrence at the end of the day.
Black guan were seen more often on private trails compared to open trails, suggesting avoidance of people. The activity of black guans at ground-level differed between forest age, with higher activity in planted forest compared to natural regrowth or old growth forest. When forest composition was included in the model, forest type (primary or secondary), did not explain additional variation.

These results show that black guan ground activity could be strongly influenced by human disturbance, resulting in more ground activity later on the day and on private trails.
This study provides insights for conservation management in cloudforest.

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Introduction

One of the main drivers of biodiversity loss in tropical regions is deforestation (Giam, 2017). The large-scale removal of forests leads to fragmentation and a significant reduction of suitable habitats for many species (Dinerstein et al., 1995; Ridgely & Gwynne, 1989). As forests shrink and become increasingly fragmented, the availability of continuous habitats decreases, which affects wildlife survival (Weidong et al., 2002; Meffe & Carroll, 1997; Temple, 1986). Species which depend on the forest for breeding, foraging and protection are vulnerable to habitat loss (Colwell et al., 2008; Brooks et al., 2002). This is the case for the black guan (*Chamaepetes unicolor*).

The black guan, a bird in the Cracidae family, is an endemic species to the cloud forests of Costa Rica and Panama (Muñoz & Kattan, 2007; Garrigues & Dean, 2014; Vallely & Dyer, 2018). It primarily lives in montane forest, where it is found across all forest types, but occurs most frequently in old growth forest (Stiles & Skutch, 1989; Garrigues, 2014). However, despite its restricted range, little is known about this bird species (Brooks et al., 2000; Seutin, 2006). Knowledge about the habitat use and activity patterns remain limited.

Such gaps of knowledge of this species make it difficult to assess the current impact of the threats they are facing. One of the biggest threats the black guan is currently facing is deforestation. Because of deforestation and therefore fragmentation of the forest, suitable habitat is quickly dwindling for this species. Therefore the likelihood of local population extinction events significantly increases, highlighting the importance of conservation efforts (Dinerstein et al., 1995; Ridgely & Gwynne, 1989; Brooks et al., 2000).

Although the IUCN status of this animal is 'Least Concern' there is a decrease in the population (Birdlife International, 2021). The Avian Conservation Assessment Database scores the black guan on a scale from 1 to 5 for population size, bird distribution and non-breeding distribution/breeding distribution. Where 5 means high vulnerability and 1 low vulnerability. The black guan scores a 4 for population size, meaning the vulnerability is high. Bird distribution scores a 5 and the non breeding and breeding distributions both a 5, meaning the vulnerability is very high (Avian Conservation Assessment Database Scores – Partners in Flight Databases, 2025).

In order to adequately protect the black guan from anthropological based threats, we must fill these gaps in knowledge by investigating this bird species and understand the species' ecological requirements.
Therefore the objective of this study is to gain insight into the habitat use and activity patterns of the black guan (*Chamaepetes unicolor*) in the Talamanca mountains of Costa Rica, thereby contributing to the limited knowledge available on this bird species and its ecology. Therefore three research questions have been made where the research will focus on:

- What is the difference in the number of black guans that are active between different hours of the day?
- What is the difference in the number of black guans that are active between different habitats?

- What is the difference in the number of black guans that are active between open and private trails?

For the purpose of this study, active individuals are defined as individuals which display ground-level movement and have been seen on a camera trap as opposed to remaining in the trees.The black guans seen during hikes are not taken into account, because it goes along with the human influence. The different habitat types are categorized into two main categories; primary forest and secondary forest. These consist of different forest compositions. Primary forest consists of old-growth forest, while secondary forest includes planted forest and natural regrowth. The open trails are available for people visiting the reserve, while private trails are only open for researchers and therefore less entered.

Hypothesis

The black guans are expected to be observed more frequently in primary forest, compared to secondary forest (Figure 1). This hypothesis is based on the species' preference for more complex canopy covers, dense forest with low levels of disturbance (Stiles & Skutch, 1989; Garrigues & Dean, 2014). Where forest density in secondary forest has a dense understory, primary forest offers a more complex canopy cover and a greater forest complexity.

For activity patterns of black guans, the species is anticipated to be recorded more often during the day than at night, as they spend their daytime looking for fruits on the ground and typically roost in trees after dark (Stiles & Skutch, 1989; Del Hoyo & Kirwan, 2020). Peaks in observed black guans are expected when they move to other parts of the reserve to feed or forage, while the periods in between likely represent resting phases. These peaks are more likely to be in the afternoon, when the amount of visitors is less. Additionally, it is expected to see the black guans more on private trails, with less human disturbance. The possible outcome is shown in Figure 2.

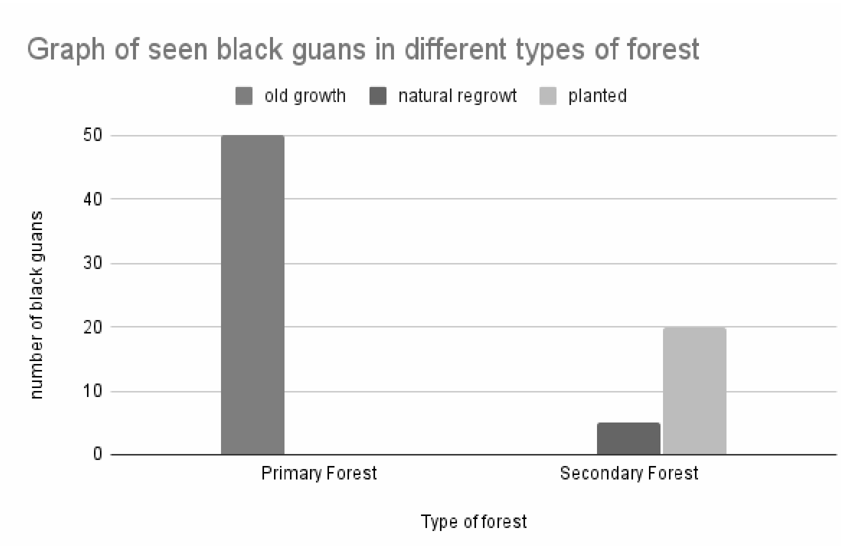

Figure 1: Expected graph of seen black guans in different types of forest

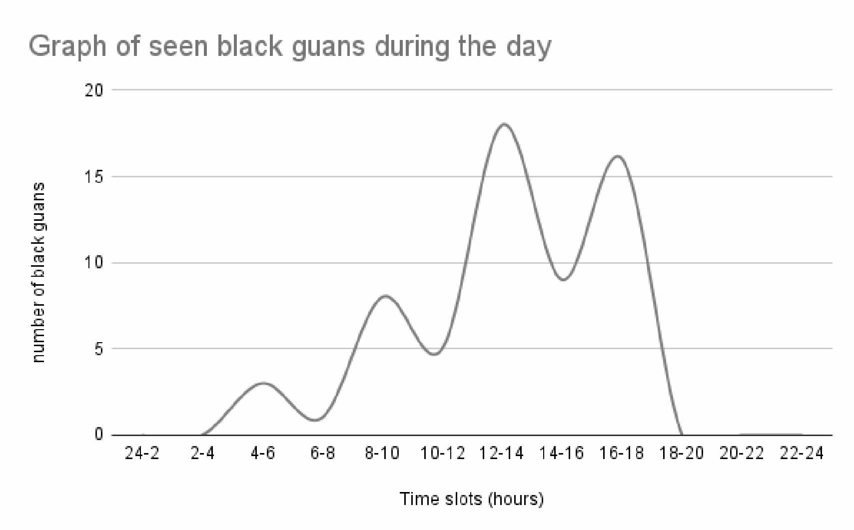

Figure 2: Expected graph of seen black guans during the day

Materials and methods

Study site

This study was conducted in Cloudbridge nature reserve (N 09°28.3270', W 083°34.6537', 220 hectares), a nature reserve in the Talamanca mountains of Costa Rica (Figures 3 and 4). The entire reserve is considered cloudforest, characterized by an almost constantly wet environment caused by the persistent immersion of mist or clouds (Aldrich et al., 2000). Even during the dry season this area remains relatively humid compared to other parts of the country. Cloudforests occur at elevations between 1000 and 3000 meters above sea level (Community Cloud Forest Conservation, 2025). Cloudbridge nature reserve is situated within this band, between 1550 and 2600 meters in elevation (Cloudbridge, 2024). The reserve consists of primary old growth forest (70-150+ years old) and secondary forest, divided in planted (<20 years old) and natural regrowth (30-70 years old). In 2002, approximately 20% of the land consisted of cattle pasture, 30% secondary forest, and the remainder primary forest. At present, most of the former pasture has been reforested and allowed to regenerate naturally (Cloudbridge, 2024).

Cloudbridge is operated by the Cloud Forest Conservation Alliance. The reserve serves as a buffer for Chirripó National Park, which is located right next to Cloudbridge. A lot of visitors to Cloudbridge are therefore people going up or down to Chirripó.

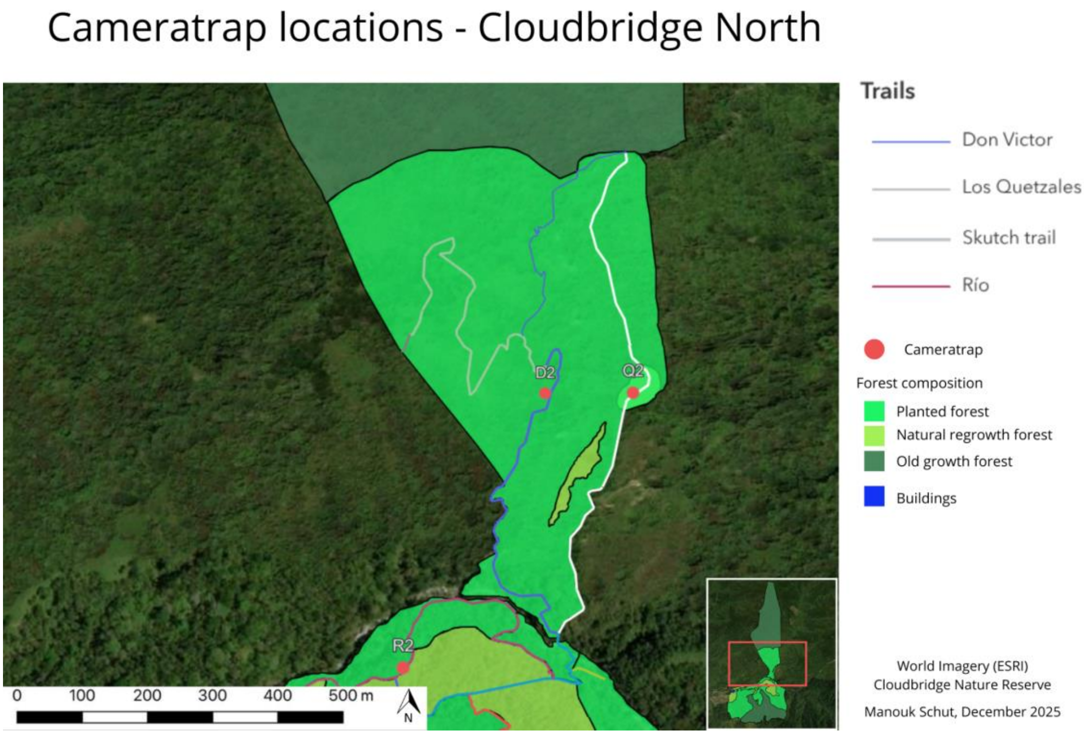

Figure 3: Map of the north part of Cloudbridge, with camera trap locations

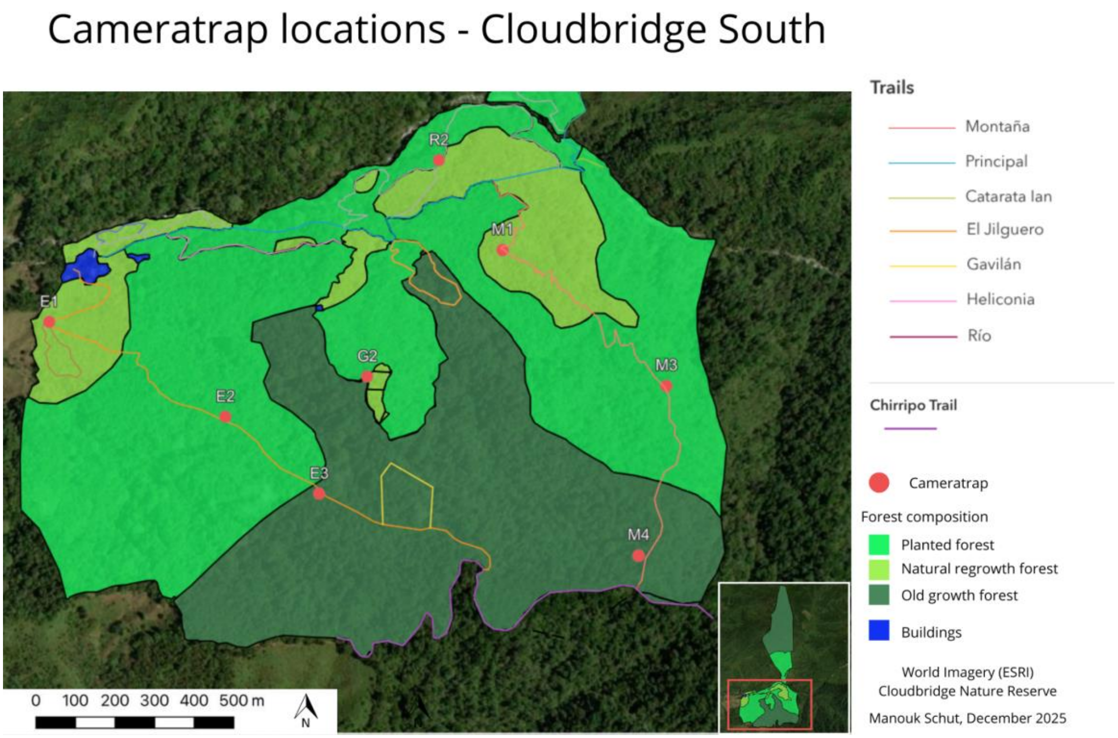

Figure 4: Map of the south part of Cloudbridge, with camera trap locations

Study species

The black guan is a bird in the Cracidae family and is an endemic species from Costa Rica and Panama. The black guan is primary frugivore and feeds on fruits in the trees, but can also come down to the ground to eat the fallen fruits there (Muñoz & Kattan, 2007; Garrigues & Dean, 2014; Vallely & Dyer, 2018). This species roosts in largely isolated trees (Stiles & Skutch, 1989; Del Hoyo & Kirwan, 2020). It is primarily associated with cloudforest and tends to avoid open areas (Stiles & Skutch, 1989; Garrigues & Dean, 2014; Vallely & Dyer, 2018; Del Hoyo & Kirwan, 2020). While this species is adaptable and able to inhabit secondary or more patchy forest, it has a preference for high density montane forest (Stiles & Skutch, 1989; Garrigues & Dean, 2014). The distribution of the black guan extends across mountainous regions, ranging from 3000 meters above sea level down to approximately 1000 meters above sea level (Stiles & Skutch, 1989; Garrigues & Dean, 2014; Vallely & Dyer, 2018), but they do prefer higher elevation above lower elevation (Blake & Loiselle, 2000). For most of the year, black guans are living solitary, but as the breeding season approaches, individuals form pairs and are frequently observed together. They remain in pairs during chick rearing, but once the offspring is old enough, the adults separate and return to a solitary lifestyle (Stiles & Skutch, 1989; Garrigues & Dean, 2014; Del Hoyo, & Kirwan, 2020).

Data sampling

Habitat use and activity patterns were investigated using camera trapping. Camera traps were chosen as the main monitoring method because they allow to observe individual behavior independently of direct human presence. The bird species is difficult to observe when people are present, because they are sensitive to human disturbance and therefore hide in dense forest or up in the trees, so direct observations would lead to a small database. Camera traps are the perfect method to see these birds in different places at the same time within the full 24- hour day, without being disturbed by humans. Camera trapping offers a trustworthy, efficient, and ethical way to study a species that is hard to see and easily disturbed, with the result of a big database of the seen birds.

At the beginning of 2025, four cameras were deployed. When the data collection started, at the end of August 2025, nine cameras were deployed, becoming ten active cameras in October 2025. Where it started with four different trails, the cameras were distributed over six different trails at the end of the data collection. Every camera was checked every two weeks, when the SD card and batteries were replaced. Upon returnal to the field station, data was pulled from the SD cards, uploaded and sorted into an ongoing database.

Of the ten cameras in the field, seven were in secondary forest and three in primary forest. When looking at forest composition, three cameras were placed in natural regrowth, four in planted forest and three in old growth. As for trail accessibility, four cameras are on private trails, whereas six cameras were located on public trails.

The cameras that were used are Browning trail cameras, model BTC-7E-HP5, which have been running in the field 24/7 since January 2025. Data was used from the beginning of January 2025 until the beginning of December 2025, which represents nearly a year worth of data.

The established protocol has the settings of the camera record a 10 second video whenever movement is detected and the smart IR setting was on so the cameras kept recording if the animal stayed in frame. The interval was at 1 second and the cameras were on medium sensitivity and positioned approximately 50cm above ground level, directed towards a trail path.

Data collection

When a black guan is detected by a camera trap, the time and day the black guan was recorded. Habitat characteristics such as forest type (primary or secondary forest) and forest composition (old growth, naturally regenerated, or planted trees) are noted down as well. Additionally, the specific trail name and camera number are documented to ensure spatial referencing and to allow the detections to be traced back to their sampling locations.

Data analysis

Before any statistical test is made, the data were explored following the protocol described by Zuur et al (2010). The number of black guans detected showed overdispersion and a lot of zero counts. Therefore a Poisson model is not correct.

For addressing the objectives, a Negative Binomial Regression Model to test differences in the number of black guans detected between habitat types and hours of the day (i.e. activity patterns). This was done because of the overdispersion of the data. There are more days without a black guan seen, than there are with a black guan seen, which results in a lot of 0 values in the database, which makes a Negative Binomial Regression Model the ideal model for this database.

The selection of the model is based on comparing candidate models with different variables included, such as primary/secondary forest and forest composition. Models were assessed based on their goodness of fit and AIC. The variableses that not improve the model are left out and the model with the lowest AIC (Akaike's Information Criterion was selected.

In R the GLM was made with the glmTMB package, and to assess the significance of fixed effects, a Type II Wald x^2 is made.

This was done in SPSS statistics version 31, Excel version 2410 and Rstudio version 4.5.1.

Results

After 49 weeks of data collection, a total of 116 black guan detections were recorded. These birds were observed from 10 camera traps distributed across six different trails. The deployment duration varied among the cameras, but they were active for a minimum of 58 days and a maximum of 329 days.

The results of the seen black guans are shown in Figures 5 and 6. Figure 5 shows the mean number of black guans seen per camera per 10 weeks for forest composition. Figure 6 shows the mean number of black guans seen per camera per 10 weeks for trail accessibility. The number of seen black guans is higher in planted forest than in old growth or natural regrowth forest. Figure 6 shows that more black guans are seen on a private trail compared to an open trail.

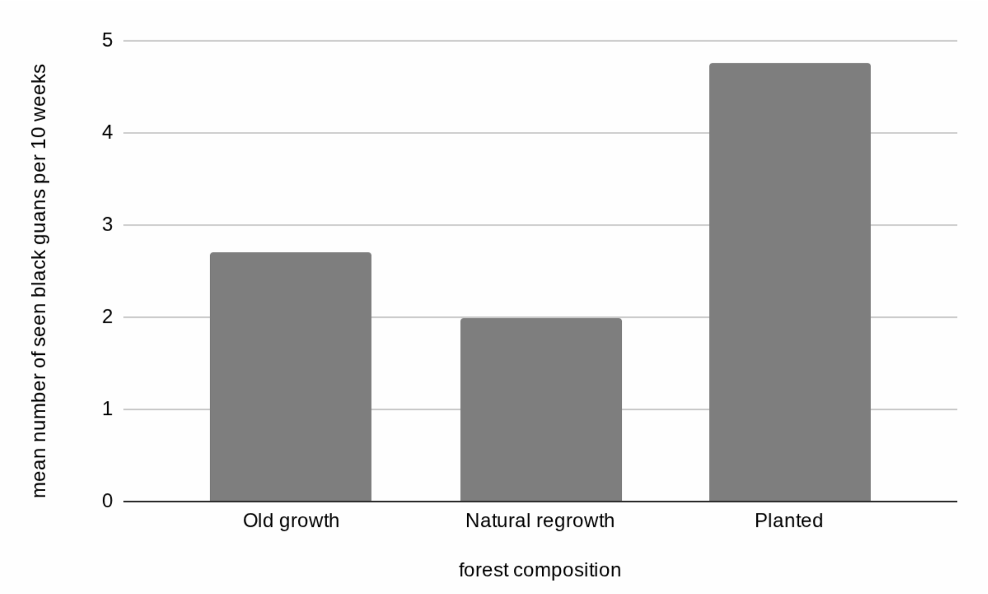

Figure 5: Mean number of seen black guans per camera per 10 weeks divided by forest composition, with a sample size of 116 black guans.

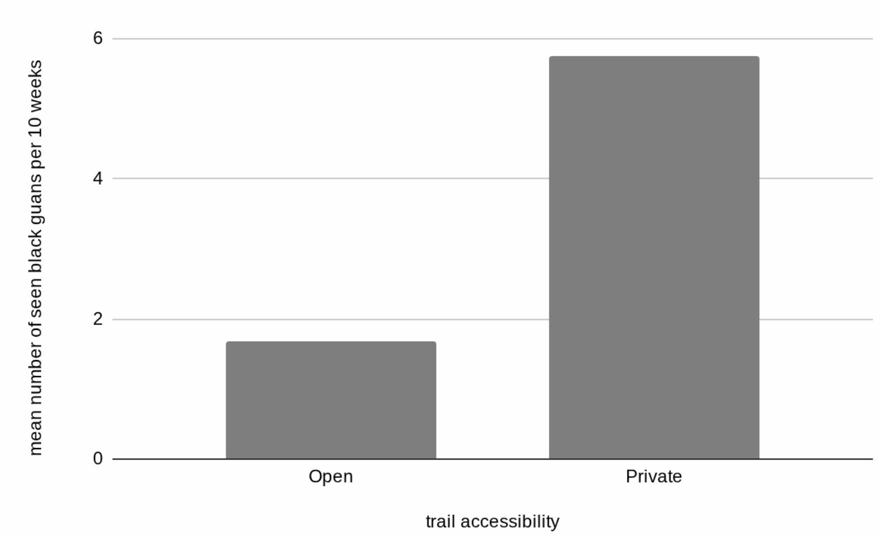

Figure 6: Mean number of seen black guans per camera per 10 weeks divided by trail accessibility, with a sample size of 116 black guans.

To answer the first question: “What is the difference in the number of black guans that are active between different hours of the day?” A negative binomial generalized linear mixed model was made. The results show a significant effect of timeblocks on the ground activity of black guans ($\chi^2 = 11$, df = 117.54, $p < .001$), with timeblock 12 (22:00-24:00), as a reference for the rest.
As shown in Figure 7, the black guans did not show any activity between the hours of 18:00-4:00 at ground level. The black guan only shows ground activity during the hours between sunrise and sunset, with some peaks at the later hours of the day, especially after 12:00.

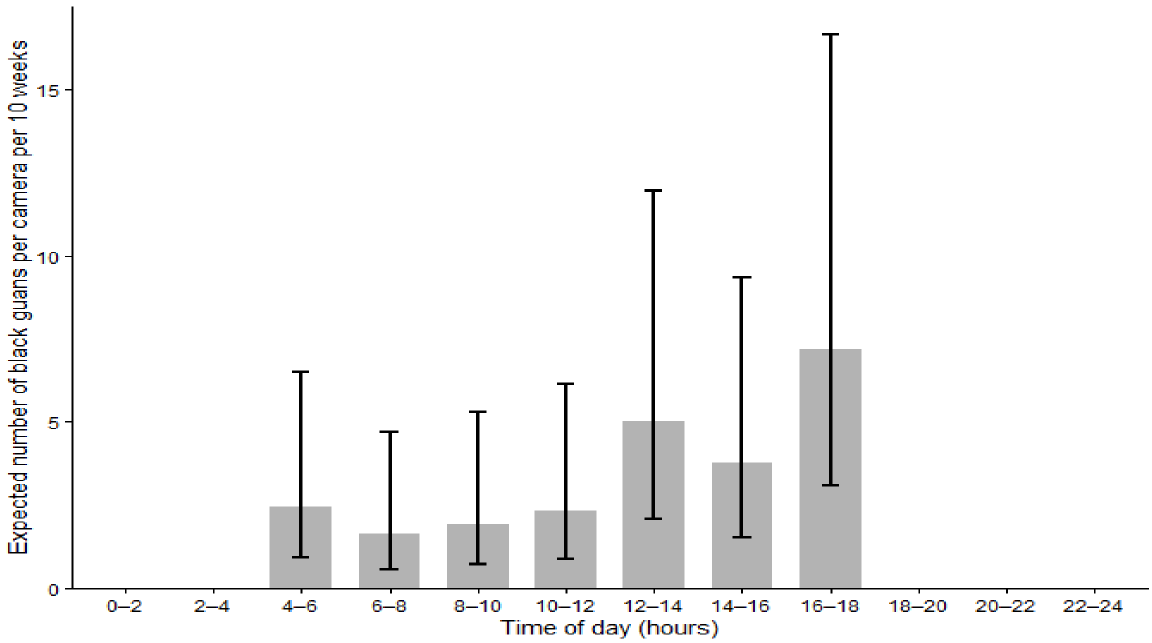

Figure 7: The predicted ground activity of black guans per 10 weeks on one camera across different time blocks of the day. This is based on a negative binomial GLMM. Error bars represent 95% confidence intervals, with a sample size of 116 black guans.

To answer the second question: What is the difference in the number of black guans that are active between different habitats? a negative binomial generalized linear mixed model was made, with camera identity included as a random effect and sampling effort accounted for using an offset.

A significant effect was seen by forest composition ($\chi^2 = 7.35$, df = 2, p = 0.025). The ground activity was lower in old-growth and natural regrowth forest when compared to planted forest. The predicted number of black guans per 10 weeks on one camera is shown for open and private trials in Figure 8. The private trails have a much higher predicted ground activity compared to open trails.

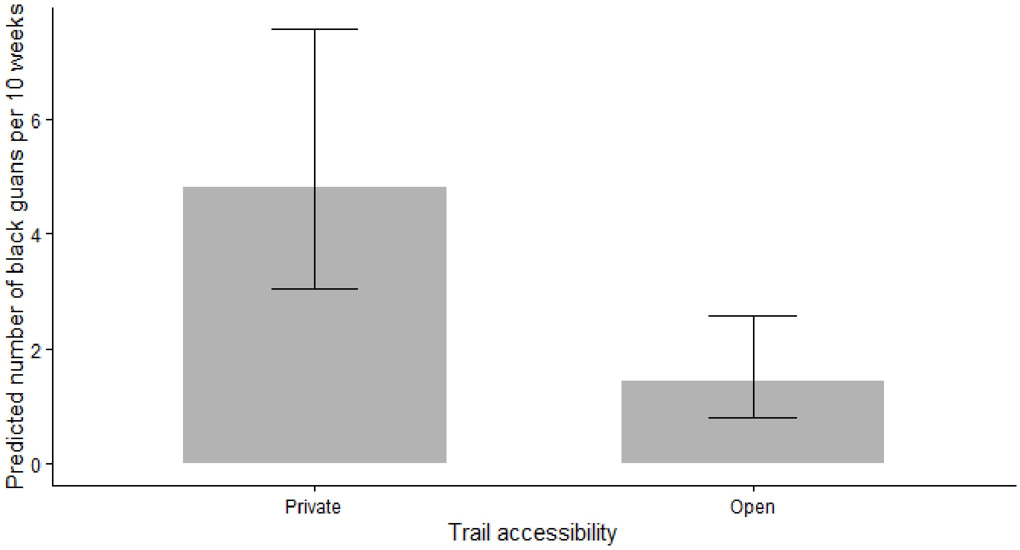

Figure 8: Predicted number of black guans per 10 weeks on one camera on private and open trails. This is based on a negative binomial GLMM, with camera identity as a random effect and sampling effort as an offset. Error bars represent 95% confidence intervals, with a sample size of 116 black guans.

Trail accessibility also showed a significant effect (χ^2 = 10.51, df = 1, p = 0.001), with higher predicted activity on the ground on private trials, compared to open trials.
In Figure 9 the predicted number of black guans per 10 weeks for one camera is shown for planted forest, natural regrowth and old growth. It is shown that planted forests have a higher predicted number of black guans compared to natural regrowth and old growth.

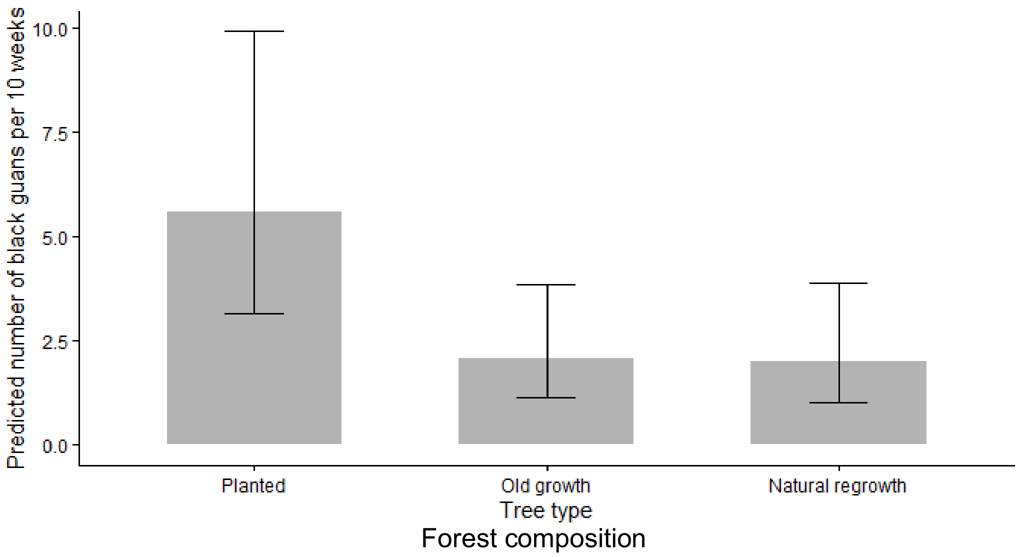

Figure 9: Predicted number of black guans per 10 weeks on one camera across the different forest composition. This is based on a negative binomial GLMM, with camera identity as a random effect and sampling effort as an offset. The error bars represent 95% confidence intervals, with a sample size of 116 black guans.

In contrast to trail accessibility and forest composition, forest type did not explain additional variation in activity, when forest composition was considered. Because of the overlap between these habitat descriptors, forest type was left out of the statistical test.

Discussion

This study shows the differences in ground activity of the black guan in relation to the time of the day, habitat and trail accessibility.
The activity on the ground was only seen during sunrise and sunset, with an increase later in the day, which is in support of the hypotheses, stating they likely remain in the canopy during the night. This aligns with previous research on this bird species, which are described as diurnal bird species, roosting in trees after the dark sets in.
Figure 7 shows that the activity increases later on the day. This may be explained by the reduction in human disturbance as the amount of people visiting the reserve later on the day decreases. Black guans are known to avoid people, which may result in more activity when human disturbance is lower.
Another possible explanation may be the variation in climatic conditions across spatial regions within the reserve. These conditions, such as a lower temperature or rainfall may influence ground foraging. This explanation remains speculative, as human disturbance and microclimate were not directly measured.

Looking at the habitat, the results show that it also played an important role on the ground activity of the black guan. Both the forest composition and the trail accessibility were statistically significant in affecting the ground activity, with a higher predicted activity in planted forest and on the private trails of the reserve.
As said before, the black guan avoids areas with human disturbance, which is supported by the higher ground activity among the private trails. These trails are less disturbed by humans, with foot traffic being limited to researchers only, and could therefore allow the birds to forage on the grounds more often.

Contrary to the hypotheses, the ground activity was higher in planted forest compared to natural regrowth and old growth forest. Where this bird species normally likes dense forest and avoids open places, it was more seen in planted forest in this study. A possible explanation for this is that the planted areas in the reserve are also farther away from the entrance of the reserve, thereby having less human disturbance. Looking at the results, the absence of humans may be more important for the black guans than the habitat type, seeing they still choose the less dense parts of the forest, but do choose the private and less disturbed trails.
Next to that, the planted forest may offer different food sources, as the species of trees differ from the other habitats. This was not taken into account during this study, and remains a speculative conclusion.

Within this study a few limitations should be taken into account when looking at the results. First, the number of camera traps was limited in the first week of year, with a lot of variation in durations in the field for the first half of the year, caused by less

experienced interns, which caused delays in data analysis. The variation of deployment durations in the field may have influenced detection rates, even when sampling effort is accounted for, because periods of camera malfunction occurred during active deployments. These non-functional days were excluded from the analyses.
Besides that, all of the cameras were placed on established trails and none were on game trails; these trails are considered the most private trails in the reserve, without any human disturbance moving across the most remote parts of the reserve, where forest structure remains the most preserved, therefore more likely used by black guans than the trails made for humans. This could influence the sightings of the birds, only seeing the ones that use the main trails and therefore maybe leaving a lot of black guans out of the camera detections.

This study also only focused on ground activity, while these black guans are arboreal to some extent.The results are based solely on detections of black guans at ground level, while the overall habitat or preference for trail accessibility could be different when taking activity in the canopy into account. Getting data of black guans in the trees would allow for a much larger dataset, but is much more difficult to obtain, because it requires cameras up in the trees.

Despite these restrictions, the findings still provide insights into the preference of time, habitat and accessibility for ground activity of black guans in the forest.
When the number of black guans drops, or the IUCN status of this bird species changes negatively, restricting public access to the more sensitive zones could help maintain forage areas for the black guan, seen the results of the strong effect of trail accessibility.

Looking at human disturbance, such as the amount of visitors entering the reserve as well as the climatic variation across the trails influencing the black guan activity can expand the research for the black guan. How much of an influence is the amount of tourism? Does the climatic variation, such as canopy cover or vegetation structure across the different trails have an impact on the ground activity of the black guan? Additionally, taking the seasons into account and looking at the variation of seasonal activity of the black guans could improve further understandings of the black guan. Do they move to different places when the breeding season is coming? Do they use different parts of the reserve in different seasons of the year or do they change in elevation range through the seasons?

Conclusions

This study investigated temporal and habitat related variation in ground activity of the black guan at Cloudbridge nature reserve using camera traps. Looking at the results, the hypothesis is largely supported.
The black guan were exclusively seen during the day, confirming the hypothesis, stating they are only up on the ground during the day. The activity shows some peaks later on in the day, giving the impression that temporal patterns of the black guan could be influenced by human disturbance or environmental conditions.

As well as the temporal patterns are supported by the hypothesis, the habitat characteristics are also supported by the hypothesis. The black guans were predicted to be more frequently seen along the private trials of the reserve compared to the open trials. Suggesting that they avoid human presence.
In addition to the accessibility of the trails, the forest composition also influenced the ground activity. The ground activity was higher in planted forest compared to old growth and natural regrowth forest, which is in contrast with the hypothesis stating they choose old growth forest over planted or natural regrowth. This pattern points to a probable connection between habitat structure and accessibility of humans rather than forest composition alone. A combination of factors but trail accessibility is most influential.

Overall, these findings show the importance of human disturbance and habitat type in the patterns of the black guan ground activity.
While habitat use came out more complex than expected, the hypothesis regarding daytime activity and the avoidance of human presence is supported.
These results contribute to a better understanding of the ecological requirements of the black guan and are contributing to the limited knowledge available on this bird species and its ecology.

Acknowledgements

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