Faculty of Science & Technology

The influence of poaching on gibbon vocal behaviour in the Sumatran rainforest

A dissertation submitted as part of the requirement for the BSc Ecology and Wildlife Conservation

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Abstract

The influence of anthropogenic activity on animals especially primates has been well researched and is thought to cause adaptations to occur to assist in day-to-day life such as increased call frequencies or a changed sleep pattern to cope with intermittent changing noise levels. Sounds such as gunshots in jungle areas can be heard frequently in countries where illegal logging and deforestation are rampant where poachers often carry firearms for protection and to provide themselves with subsistence food via shooting local wildlife. The species which have been studied, being primarily the White handed gibbon (*Hylobates lar)* is a diurnal arboreal primate using brachiation as its main form of locomotion.

The White handed gibbon therefore is most active during daylight hours when it produces its morning calls designed to ward off other gibbons in the area in protection of its territory. Since most poaching occurs at night to avoid detection by park rangers, this can catch gibbons when they are least aware and so cause them to potentially always be on high alert. This would lead to less sleep and therefore potentially less morning calls to allow the gibbon to compensate for the lack of sleep the night before by 'lying in'.

Different methods were employed to calculate the number of days with a call including using the Arbimon software, as well as SPSS statistics to calculate significance of data and relationships. In field methods were carried out (such as transects being laid down) by other researchers not including myself.

This study aimed to find out if poaching and in particular gunshots affect morning call behaviour of the Hylobates lar, as well as how many days calls were produced further into the forest versus at the forest edge. It was found out that the most days with a call produced were on T1_0m, it was also discovered that gunshots fired the night before had no correlation with calls produced the day after. There were just as many calls the day after a gunshot as there when a gunshot was not present the night before. Vocalisations were heard the most frequently at T1_0m, being the first transect placed down as well as it being close to the forest edge. Gunshots were found to be occurring 8-68 minutes past 19:00. The most frequent shooting day saw 16 shots fired.

This paper concludes that animal behaviour can be very different than to what is previously observed or expected, and so this should be taken into consideration before conservation is applied to sections of forest with endangered species when other areas may require it more.

Acknowledgements

I Would like to thank Amanda Korstjens for her persistent effort in assisting me with my final project as well as collecting the data for me to be able to analyse and use. I would also like to thank Helen Slater and the rest of the team which headed to Sumatra to collect the data, as well as Ellie Vincent for helping with parts of my data analysis. Most of all I would like to thank my family and friends for helping to cheer me on in completing my final piece of the puzzle for university.

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Introduction

Biodiversity globally is on a decline, especially in the tropics with tropical regions supporting two thirds of all known species globally. Forest loss via logging to create room for agriculture as well as to obtain timber is thought to be one of the leading causes of tropical forest destruction and therefore biodiversity decline (Bradshaw, et al., 2008). As much of the tropics are on the equator, high levels of biodiversity are seen due to vast productive areas of land and high levels of rainfall. Photosynthesis is at a high rate in many tropical plant species, particularly species which reside on the forest edge or on an ecotone and therefore bear lots of fruit (Ghiselin, 1977). The added pressure of poaching of exotic species worldwide for the black market and the popular belief behind the medicinal properties of some exotic animals particularly in Africa and Asia is leading to a major decline in biodiversity (Hughes, 2017).

The building of roads through protected areas opens up the opportunity for multiple threats to become present. Construction of roads leads to clearance of forested areas and the promotion of urbanisation in the area. The possibility for fragmentation to occur is also an issue, with Hylobates lar being a primarily arboreal species of primate and so the chance of inbreeding depression amongst communities could increase and genetic diversity decrease within the smaller habitat area (Keyghobadi, 2007). The promotion of urbanisation may encourage the gibbon to become more friendly towards humans in hope of reward of food e.g., fruit or to become more accustomed to humans leading to a higher possibility of capture by poachers (Bhadra & Sarkar, 2022).

There is little written about the influence of poaching on primates in specifically gunshots on primate behaviour and how it affects their quantity of calls especially across Asia. The most obvious response to loud intermittent noises such as gunshots could be fear as seen in different species (Wiseman, 2015). Sometimes it is not the direct impacts which affect animals, but the indirect ones instead, as stated above the noise of the gunshots can create fear amongst animals. Mammals will often react to optical and acoustic stimuli with differing levels of severity, this has been shown in mammals before and gunshots in particular elicited large reactions amongst all the acoustic stimuli provided (Reimoser, 2014). Other animals in the area who may not be the target of the hunter could get used to the sound of the gunshot and therefore not react at all after a while or not be affected by it.

However, if that sound is eventually recognised as a nuisance disturbance by the animal, the sound can still cause stress and increased energy expenditure via increased vigilance with less time to forage for food (Reimoser, 2014). The sound of a gunshot could then indirectly affect an animal by causing it to stress and waste energy regardless of it being hunted or not. This expenditure of energy whilst in a heightened state of awareness means less energy to vocalise potentially as gunshots often happen at night in many poaching scenarios (Geldenhuys, 2016). The noise created by gunshots has the potential to frequently awaken a diurnal animal and therefore interrupt its sleep cycle, this means that the day after more time may be spent sleeping than foraging or vocalising (Grunst, et al., 2021).

1.0 Primate vocal behaviour

Primate vocal behaviour is very varied across different species with multiple species engaging in what is known as ‘morning calls’. Such calls been seen in the Siamang (Symphalangus syndactylus) which marks its territory and communicates with neighbouring groups in this way (Zulamri, et al., 2019). Understanding morning calls is fundamental to working out whether vocal behaviour has changed the day after a gunshot or not.

The morning call of the White handed gibbon (*Hylobates lars*) is what will be primarily focused on in this paper, this is because the morning call (analysed in the software arbimon as a courtship song) happens frequently before 12pm and then calls after that are often considered to be alarm calls to warn of predators etc; this type of call has been seen in the Hoolock Gibbon too (ying, et al., 1999).

The ’great call’ being another way to say morning call which is specific to hylobatids amongst apes. There has been research in how the duetting between females and males occurs during a great call (Terleph, et al., 2017). Individuals have been shown to change their singing in response to their mates change in singing. The coordinated alteration in time to a mates constant vocalisations allows for highly accurate turn taking duets centring around especially the female section of the ‘great call’ phase in specific it's climax notes (Terleph, et al., 2017). Considering this is only specific to hylobatids (in particular females) then it could be important to understand if this behaviour changes with the influence of anthropogenic activity and poaching pressure.

Gibbons have specialised vocal communication which can be akin to human speech and as stated previously the great calls are specific to gibbons. Gibbon mother and daughters are said to co-sing with these interactions leading to song development amongst juveniles (Koda, 2016). The abundant amount of songs created by gibbons is thought to be via a highly unique form of vocalism known as ‘formant tuning’ which can be compared to a human being singing in soprano, with the songs created by gibbons thought to be responses to environmental pressure such as a complicated social structure or their small body size (Koda, 2016).

Gibbons in general are said to have calls which last in duration between ten to thirty minutes with some outliers such as a male white handed gibbon which sang for eighty-six minutes; these songs are preferentially sung around dawn with different species having preferences for different times such as around, before or after dawn (Geissmann, 2000).

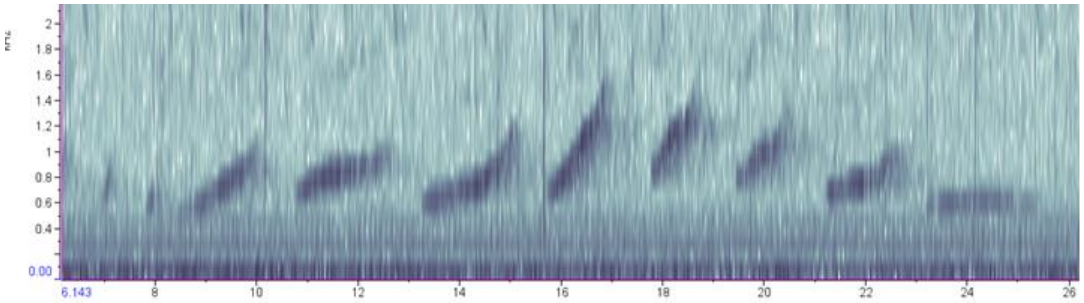

Figure 1- Above is a spectrogram which was used for the pattern matching process in Arbimon with regards to Hylobates lar, credit to Jake Hill.

1.1 how animals respond to gunshots and human influence

Animals in general are likely to respond to gunshots differently dependent on the situation at hand, with few studies having gone into the specifics of the behavioural response. There can be multiple behavioural responses to stimuli (not just including gunshots) such as attraction, avoidance and habituation. Avoidance is said to be the aversion of negative consequences which become associated with a particular stimuli (Knight & Cole, 1991). For example, wolves have learnt to avoid towns or other built up areas in parts of Alaska due to them associating it with human hostility (Thurber, et al., 1994).

Attraction with regards to animal management is defined to be the strengthening of an animal's behaviour due to high positive reinforcement with the implication of the animal moving to the direction of the stimuli (Knight & Cole, 1991). Habituation is the reduction in a response to consistently repeated neutral stimuli (Humphrey, 1930). The combination of these three responses begins to paint a picture of how an animal could respond to gunshots when exposed to them in separate scenarios. As an example, Bears which became habituated to humans were three times more likely to be shot and killed than bears which weren't habituated to humans although habituated bears could have access to more food resources such as human waste which non habituated bears could not get (Shimozuru, et al., 2020).

Habituation as shown before can go wrong, for example shooting cracker shells at bears could lead them to eventually get used to not getting hurt and associate the sound of a gunshot with a neutral stimulus (Shimozuru, et al., 2020). Primate behaviour in response to gunshots could be similar to how the bear above responded and this could lead the primates, in particular gibbons, to become habituated to the gunshots with the mothers of infant babies falling victim to poachers in the future.

Baboons have shown differing behavioural responses with regards to a threat and often it was shown that if a lone male crop-raiding baboon went missing this would not cause concern to other members of the troop or deter that behaviour (crop raiding). This was due to lone males vanishing and migrating to other troops all the time and so only when the killing of a male raider member was witnessed it showed the cost of raiding to other baboons (Strum, 1994).

As mentioned before, there is minimal research into primate behaviour in response to gunshots. This means speculation of how other animals respond must be considered when conducting research.

1.2 Primate hunting

Primate hunting happens globally, with multiple reasons behind it. For example, as mentioned above about pest control this is one of the reasons behind primate hunting, especially in agricultural areas. Primates are also hunted extensively for bushmeat, in particular parts of West Africa where Primates such as the Roloway monkey (Ceropithecus

roloway) have ended up as a Critically Endangered species due to the high value of its skin and meat and it's relatively large body size; the Roloway monkey has also become more cryptic with this increase in poaching changing its behaviour to avoid humans (Koffi, et al., 2022).

As mentioned in the section '1.1 how animals respond to gunshots and human influence' baboons were relatively unreactive if one group member went missing and were more likely to react with a visual display of a dead troop member than otherwise. In Sumatra where *Hylobates lar* lives and other gibbons, these primates could have a similar response and this therefore makes them vulnerable to poachers who can capture baby monkeys or shoot mothers without it changing the gibbons' behaviour vastly to mitigate poaching success (Phoonjampa & Brockelman, 2008).

Trophy hunting is a popular reason for primate and other mammal species hunting worldwide, with a large exporter of primate trophies coming from South Africa with the primary importer being the USA and so within the past 30 years there have been 30,000 primate trophies which can be exported from over 40 countries (Nijman & Healy, 2016). The Convention on International Trade in Endangered Species (CITES) is a global agreement between governments to regulate or put a ban on species which are under threat from hunting pressure via the global species trade (Challender, et al., 2015).

Trophy hunting is not commonly observed in Indonesia, potentially due to much of the primates existing in the forests which would limit the ease of access for hunters. The language barrier is another potential reason trophy hunting is not a large thing there. The main threat to primates in Sumatra is habitat destruction (Marchal & Hill, 2009).

With regards to primate hunting and poaching in Indonesia, poaching for the pet trade remains to be one of the greater survival risks to orangutans and especially Pongo pygmaeus - the Bornean species of Orangutan (Freund, et al., 2016). The Slow loris (Nyctiecbus) is the most commonly (legally protected) traded primate in Indonesia, due to potentially their cute appearance and relaxed nature (Nijman & Healy, 2016). Above shows how primates in Indonesia can be considered for the pet trade and not just for bushmeat with poaching of primates in Indonesia to be common to allow for selling as pets at local markets etc. Indonesia is one of the world's most Islamic countries, hence more of an emphasis on the pet trade than bushmeat as in Islam it is prohibited to eat primates (Radhakrishna, 2017).

Hylobates lar are said to be hunted by poachers or loggers in the forests of Sumatra sometimes for subsistence bushmeat and they are particularly easy to shoot when they are duetting (Nijman, 2009). In other parts of Asia Thai villagers for example do not shoot them (Phoonjampa & Brockelman, 2008). In the study talked about above, there was also evidence of poachers being found in all five major protected areas in Thailand where gibbons were present. Leading for the potential of this occurring in Indonesia via less religious or non-religious groups of poachers.

The study in the previous paragraph shows how some species of gibbon can be used as food, however in general gibbons are poached more so for other purposes (the pet trade).

1.3 Poaching in Indonesia

Wildlife trade globally has become one of the primary reasons for a loss of species as well as extinction (IUCN, 2007). Flagship animals in combination with many exotic species smaller species are at the forefront of wildlife trade, for example poaching for elephant tusks as well as tiger parts for their non-conventional medicinal properties are seriously affecting population numbers (Conrad, 2012). It is confirmed that tiger populations in Indonesia are now completely confined to Sumatra, being the area in which our research took place (O'Brien, et al., 2003). Illegal hunting of tigers, deforestation and the closer proximity of humans to tigers in Indonesia is what is causing a lot of their decline and even with a CITES ban on trade for tiger parts, the trade is a lucrative business when considering selling tiger body parts abroad in particular to China (Hemley, 1994).

The Sumatran elephant (*Elephas maximus sumatrensis*), Sumatran tiger (*Panthera tigris sumatrae*) and Sumatran Rhinoceros (*Dicerorhinus sumatrensis*) are all seriously threatened by poaching in Indonesia with them being endemic to the area of Sumatra (Kinnaird, et al., 2003). These species are considered to be keystone species and are just some of the seriously threatened species in the area. *Hylobates lar* has become endangered due to poaching for the illegal pet trade and habitat loss with the former having become the primary reason for its wild population decline (Bartlett, 2007).

Shown above, much of Indonesia's most recognised species are being hunted to extinction. Gibbons are endangered and even with protected areas, illegal poaching and logging still occur and often go hand in hand with loggers requiring subsistence and therefore end up shooting the Gibbons present for food (Brockleman & Geissmann, 2020). The majority of subsistence hunting of primates in Indonesia is done by villagers who are exploiting *Aquilaria* spp., which are trees valued for their wood as well as the other produce they can create (Rosenbaum, et al., 1999).

1.4 agricultural practices in Indonesia

Indonesia possesses the third largest area of tropical forest in the world, with it's position in relation to the equator creating a high abundance of unique flora and potential opportunities for vegetational produce to be cultivated (Jong, 1997). It is a commonly held belief that swidden agriculture in Indonesia is responsible for up to 50% of Indonesia's yearly deforestation, this slash and burn method clears forests for agricultural areas where palm oil is lucrative with it being in so many products worldwide (Jong, 1997).

Some of the highly important agricultural products produced by Indonesia include palm oil, rubber, cocoa, coffee, tea, cassava, rice and tropical spices (Rahmah, 2017). Orange trees are intertwined with other crops in Indonesia, this is known as intercropping and is one method farmers use to reduce elephant crop damage in Sumatra and Sri Lanka to deter Asian elephants *(Elephas maximus*) and Sumatran elephants; this is thought to be due to the orange being a citrus fruit (Santiapillai, et al., 2010).

1.5 Primate Forest call locations

Studies of primates have been completed to test their preference of call location, for example in Costa Rica calls of the howler monkey (*Alouatta palliata*) were tested to reveal where it vocalised the most out of four different zones with these being interior, riparian, anthropogenic and combined forest edge (Bolt, et al., 2019). It was predicted that vegetation and howling would differ between the different forest zones, with the riparian and interior zones showing the highest values (most calls) and the anthropogenic edge the lowest. The results indicated that vegetation was at it's richest and the howling the longest in interior and riparian zones compared to combined as well as anthropogenic edges.

The resource defence hypothesis was theorised for this study which claims that males call the most in area with rich vegetation in order to protect the food available. The study therefore showed how primates are often more likely to call in areas of high resource value and hence partially why my study predicted that Hylobates lar would call more in the interior zones of the forest versus the anthropogenic edge.

The forest edge, although potentially providing a good view of the surrounding area to scout for predators such as *Neofilis diardi* and *Panthera tigris sumatrae* leads smaller species of primate in particular juveniles as well as infants vulnerable to hunting pressure from humans or predatory birds (Isbell, 1994). This is another reason why the edge may not be a favourable location to produce morning calls at.

2.0 Aims objectives and hypotheses

The aim of this project is to analyse gibbon call behaviour and to discover how this behaviour is affected by human activity, primarily gunshots.

2.1 objectives

1. Work out if Gibbons are less likely to vocalise the day after there have been gunshots the night before.

2. At what time are gunshots most likely to occur

3. To work out where vocalisations are heard the most frequently (which site)

4. Work out if calls are more likely to occur further into the forest or closer to the forest edge.

2.2 Hypotheses

1. The number of calls the day after a gunshot would decrease
2. The number of gunshots would increase further into the night
3. The site with the highest number of calls would be the site with the most fruit
4. Calls would be most likely at transects furthest into the forest

3.0 Methods

3.1 Location

Sumatra is the largest island (164,000 square miles) in the Indonesian Archipelago and is part of the Sundaland Biodiversity Hotspot, this hotspot is made up of Borneo, Sumatra, Java and the Malaysian Peninsula (Myers , et al., 2000). The Sikundur area in the Gunung Leuser national park in Sumatra contains primary and secondary forest which was subject to low to high levels of logging from 1976 to 1988 as well as in the 1990s. On average, 11 vast trees were felled per hectare in this period of time meaning a sizeable amount of habitat was lost leading to a decline in biodiversity and so this hit the forest ecosystem hard (Collins, 2018).

The data were collected in a characteristically disturbed part of lowland forest in Sikundur where the Sikundur monitoring station is located, with much of it being collected by Helen Slater (none was collected by me however I analysed the data) (Slater, 2016). Overall, the area is located in the Langkat District of North Sumatra in the Leuser ecosystem. The vegetation consists of mostly lowland dipterocarp and alluvial tropical rainforest habitat. The Gunung Leuser National Park was established as a UNESCO World Heritage site under the guise of 'The Tropical Rainforest Heritage of Sumatra' and has been this way since 2004. The area is on the edge of the national park boundary meaning it is still at the risk of poaching and illegal logging. (Marsh, 2019).

The Gunung Leuser National Park (GLNP) is rich in biodiversity and is home to one of the last places on earth where wild orangutans (*Pongo abelii*) can be spotted, a large highly arboreal primate native to Indonesia with a unique method of locomotion called quadrumanous scrambling. Other species of primate in the area include Siamangs (*Symphalangus syndactylus*), Thomas leaf monkeys (*Presbytis thomasi*), macaques (*Macaca nemestrina* and *Macaca fasciularis*) as well as multiple species of gibbon including *Hylobates lar* (Harrison, et al., 2020). GLNP is one of the many National Parks located in Indonesia (51 National Parks

total in Indonesia) and is one of the first of five protected areas in the entire country (Rijksen & Griffiths, 1995). GNLP is regarded by many as an area of international conservation interest due to the presence of its highly endangered and distinctive flora and fauna. These include but are not limited to the Sumatran orangutan, the Sumatran rhinoceros, the Sumatran elephant and the Sumatran tiger all native to this one island.

The Sumatran elephant is one of the main seed dispersers in the area as it consumes bananas as well as other types of vegetation, contributing to a healthy ecosystem in the area. The Sumatran elephant is threatened by agricultural practices causing deforestation and human and wildlife conflict is inevitable, elephants wondering onto sugar cane plantations can end up shot and killed. They are also wanted for their ivory which is sold internationally for high prices (Gopala, et al., 2011). Sunda clouded leopards (Neofilis diardi) and the Sumatran tiger are the main large terrestrial predators in Sumatra, with the clouded leopard being one of the primary predators of gibbons in the area (Morino, 2011).

Orange trees draw on elephants' natural aversion to citrus fruits and so are in the vicinity of the forest edge, helping to prevent elephants from consuming and destroying palm oil plantations (Ardiansyah, 2006). One of the main forms of human disturbance in Sumatra is legal and illegal logging, which enables the creation of agricultural areas as well as selling timber for profit. Fruit availability is reduced by logging also, which impacts many species of primates including Hylobates lar and Sumatran orangutans (Husson, et al., 2008).

Figure 2- Above shows the interior of a section of forest inside Gunung Leuser national park- photo credit to AHKorstjens

Figure 3- Above shows *Hylobates lar*, original photo credit to AHKorstjens

3.2 Study sites

ArcGIS Pro software generated randomly ten sampling points at increasing intervals which ranged from 0 to 1500m from the edge of the forest. I studied sites which had increasing intervals of 500m between each other. To allow for data collection accessibility, a location which was within 50m of the sampling point was plotted which created access for bioacoustics data collection. To measure the distance from each site to the forest edge, GPS locations of each site and satellite images were used. This was standardised via using the shortest distance in a straight line, ignoring direction was measured from all the sites to the nearest distinguishable edge of the forest. This was done using google earths satellite images. Helen Slater set up the audio recorders, with myself using recordings from 10 of the 20 sites which were created.

Figure 3- Above shows a transect being placed down by Helen Slater and co, image taken by AHKorstjens.

3.3 Audio devices

10 open field recorders (OFR- OFR-Open Field Recorder-invisible Flock) which were constructed by invisible flock were using in this project. Each OFR is made with a time and location sync via GPS, this enables the meshing of multiple recorders. Each recorder has up to 7 days of battery life, a DPA 4060 microphone, a custom shield which allows for extra robustness in the conditions of the area as well as it being designed to withstand sub-zero temperatures and tropical rainstorms (Flock, 2021). The latter being key in the project undertaken. One of the recorders was attached onto a tree at around head height with the microphone pointing outwards to all the 10 sample sites. All the OFR's were set to record constantly until the battery eventually runs out, with the bit depth being 24bit and the sample rate being 48khz. As sample site access was reduced and the battery life of each recorder varied, data ended up being collected intermittently between August-October of 2019.

3.4 Hylobates lar pattern matching process

The main tool for analyses which was used was a software called Arbimon (Arbimon link- Arbimon) which allows you to be able to pattern match different sounds together. For example, you could create a template out of an audio file of a gunshot and then pattern match that to different recordings by creating a playlist. To create a template, this was done via looking into different recordings, being one minute each. The filter tab was selected and then the range of dates. Morning calls of *Hylobates lar* were focused on and located manually, this was via searching through the time period of 7am to 12pm, the spectrograms produced by Arbimon were then used to provide a template which could be used in the pattern matching process. I had to manually look through false and true matches.

Due to the morning calls of Hylobatidae occurring often between 6am and 10am, the time analysed as mentioned previously was from 7am to 12pm in the afternoon. This is because although it starts an hour later, it in turn allows for more time overall to be analysed. The threshold was set to 0.1 and the matcher was limited to 1 match per 60 second recording. All matches were self-checked manually, to reduce the chance of error in the future. Each spectrogram has a unique pattern however it was very frequent for some patterns to look similar (one containing a call one without) and so I had to take minimal chances and look through all recordings. This was unless they looked extremely similar to the template being used to pattern match, if this was the case then I would write down that there was a call on that morning at that time e.g. 7:46am on the 14th of august.

Very faint vocalisations were discounted as this could lead to potentially false results. *Hylobates lar* vocalisations sounded different at certain points, this was thought to be because of a juvenile vocalising and therefore not in a duet like adults do. Overall, the vocalisations of *Hylobates lar* were highly distinct and were difficult to confuse with other species of primate in the same area.

3.5 Gunshots pattern matching process

First a template was created similarly to how I created it for the *Hylobates lar* (by searching through recordings and then cutting a section of that recording out and using it as a template). After the template was created, the gunshot noise was assigned under homo sapiens and then 'Mechanical Song'. Pattern matching was done in the same was as analysing lar gibbon calls, the threshold was set to 0.1 and the matcher was limited to one match per 60 second recording. Night and day times were calculated using data collected from the field. I had to manually sort through false and true matches.

3.6 Statistical analyses

The software called SPSS Statistics (SPSS link- SPSS) was used to calculate the Pearson Chi square value. The reason this test was run, was to compare observed results with expected results. As one of my hypotheses was that there would be less calls the day after a gunshot, it was logical to use the Pearson Chi-square test which provides observed and expected results. The test determines if the expected data is due to chance or if it is due to a relationship between the variables which are being studied, hence providing me with a value (the p value) which could be statistically significant or not. If the value is below 0.05 then the data is statistically significant.

In order to carry out the Chi-square test, there were a few steps to be carried out. First you must select Analyse, at the top and then Descriptive statistics and then Crosstabs. Then the variables should be moved into columns and rows, for example the site data into columns and the call data into rows (before this you should click on the 'statistics' button that shows up when you go into cross tabs and make sure 'Chi-Square' test is applied before the test is run (Sweet & Martin, 1999). The cells button inside crosstabs should also be clicked on and then observed and expected boxes should both be checked before the test is run.

4.0 Results

4.1 Overview of data

Transect	Potential matches	False matches
T1_0m	357	335
T1_500m	0	0
T1_1500m	7	4
T2_500m	19	9
T2_1500m	3	2
T3_500m	0	0

T3_1500m	34	0
T4_0m	94	86
T4_500m	59	37
T4_1500m	0	0

Table 1- above shows lar call data, potential matches and false matches.

Transects	Potential matches	False matches
T1_0m	700	698
T1_500m	182	179
T1_1500m	653	646
T2_500m	1223	1217
T2_1500m	138	137
T3_500m	135	134
T3_1500m	165	163
T4_0m	1261	1251
T4_500m	458	455
T4_1500m	0	0

Table 2- Above shows gunshot data, potential matches and false matches.

4.2 Gibbon call count and where calls were heard the most

Figure 1 shows the number of Lar Gibbon calls on each day at different sites. There was significant variation in the number of calls recorded per site (Chi-square test, Chi=19.152 , df=9, p=0.024; Table 1).T1_0m in particular had more calls than expected by chance (Table 1). All other sites had a similar expected call count to the expected, predicted by SPSS.

The total number of days observed was 109 and the days with a call present was 10 (9%). Each expected value for the absent section was relatively close to the observed value however in the present section the expected value tended to fluctuate a lot more. T1_0m had the greatest number of calls present with a percentage of 80% of the days having calls. T4_500m had the second most number of calls present with a percentage of 22% of the days having calls.

			Site									
Gibbon call			T1_0m	T1_1500m	T1_500m	T2_1500m	T2_500m	T3_1500m	T3_500m	T4_1500m	T4_500m	T4_0m	Total
	Absent	Observed	5	10	13	6	14	13	11	10	9	8	99
		Expected	8.2	10.0	11.8	6.4	13.6	12.7	10.0	9.1	10.0	7.3	99.0
	Present	Observed	4	1	0	1	1	1	0	0	2	0	10
		Expected	.8	1.0	1.2	.6	1.4	1.3	1.0	.9	1.0	.7	10.0
Total		Observed	9	11	13	7	15	14	11	10	11	8	109
		Expected	9.0	11.0	13.0	7.0	15.0	14.0	11.0	10.0	11.0	8.0	109.0

Table 1- Above shows the number of days where there was a call present and the number of days where a call was absent.

4.3 Number of calls in the morning in relation to gunshots the night before

Figure 2 shows that of the Lar gibbon called the same number of times on days whether there were gunshots the night before or not. There were 61 days without a gunshot and 9 with one making up for 70 total. Of those 9 days with gunshots Hylobates lar called on 5 of the 9 days, with calls therefore being on 55% of those days. On the 61 days gunshots were absent Hylobates lar still called on 5 of those days. The results show Hylobates lar actually called on more days where there was a gunshot the night before than on the days the gunshots were absent. The data ended up being highly statistically significant at 0.004.

The expected number of calls was far less at 1.8 when gunshots were present on those 9 days.

LarGibbon (nr days when a call was present) * Gun Shot occured (nr shots heard between 19:00 till 7:00 before this time) Crosstabulation

			Gun Shot occured (nr shots heard between 19:00 till 7:00 before this time)		
			Absent	Present	Total
Lar gibbon number of days when a call was present or absent	0	Observed	61	9	70
		Expected	57.8	12.3	70.0
	Present	Observed	5	5	10
		Expected	8.3	1.8	10.0
Total		Observed	66	14	80
		Expected	66.0	14.0	80.0

Table 2- Above shows the number of calls in relation to the gunshots present the night before

4.4 Number of vocalisations deeper into the forest versus at the forest edge

As stated in the results analysis above the highest number of days with a call was 4, and this was at a transect closest to the forest edge (T1_0m). The expected values fluctuated across the board and so there was no particular trend when observing the volume (amount) of calls from the forest edge vs the inner forest. It was hypothesised however that the number of calls would increase the further into the forest you go, due to it being less disturbed than the forest edge.

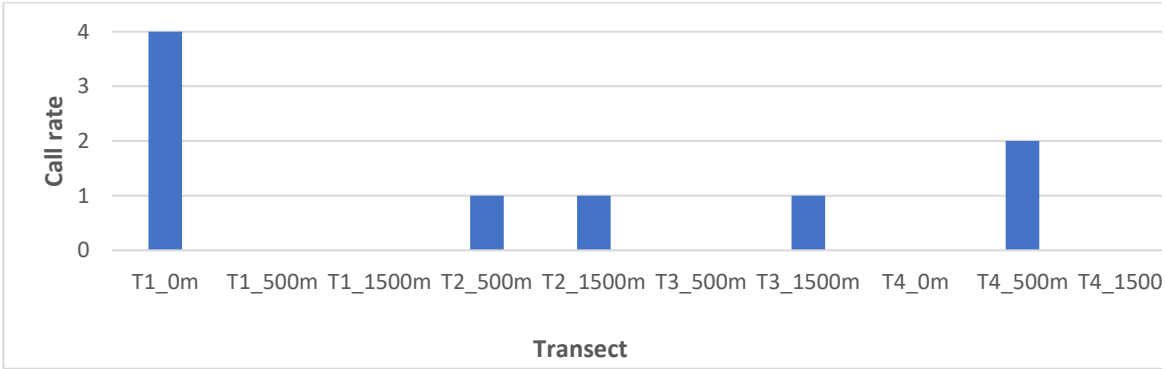

Figure 4- Above shows the different call rates at each transect, in relation to the forest edge.

4.5 What time gunshots are most likely to occur at

Each minute past 19:00 was calculated for each time there was a gunshot leading to results such as 428 minutes past 19:00 in T1_0m and 62 minutes past 19:00 for T1_500m. The median of the results came out as 85 minutes past 19:00 or 20:25. This in conjunction with the different times seems to have come out accurately for what time the average gunshot occurred at. Figure 3 below shows that the highest number of gunshots occurred 8-68 minutes after 19:00, with next highest being 68-128 and then 488-548. There is a large leap between each of these histogram bins, especially 128-488. However apart from the highest number of occurrences happening at 8-68 minutes after 19:00, the rest of the data shows how sometimes no gunshots occur like at 188-248 and so on. From analysing the graph, it is clear that most of the gunshots occur from 8-68 and 68-128 minutes past 19:00 with this being 22 occurrences total for these two bins.

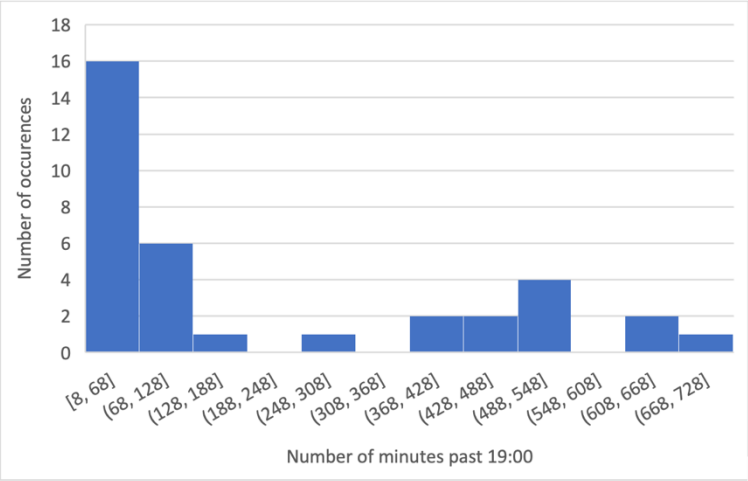

Figure 5- Above shows number of gunshots (occurrences) which occur a certain number of minutes past 19:00.

5.0 Discussion

The main aim of this research project was to determine whether anthropogenic noise influences primate vocal behaviour (in specific gunshots) the morning after the noise has been heard or not. What was found was that overall, the results proved to be statistically significant, and that Gibbons called regardless of whether a gunshot was present or absent the night before.

5.1 Number of calls in the morning in relation to gunshots heard the night before

The number of calls in the morning with no gunshots the night before was similar to days with gunshots the night before. I had hypothesised that nights with no gunshot would lead to a higher chance of gibbons singing the morning after compared to nights with a gunshot. This hypothesis turned out to be false, however desensitisation to gunshots overtime could play a role in why there was very little difference. Typically, many species of gibbon are involved in the pet trade and so are captured rather than shot, meaning the gibbon would potentially be less likely to associate the gunshot with danger (Cheyne, 2009).

However, when considering the pet trade, it is often the infants of the gibbons which are taken rather than the adults present, and so therefore the adults would have to be shot to get at the infants (Cheyne, 2009). It is evident from my results that potentially in this instance adults are not being actively hunted due to the lack of notable difference in morning call timings on days with and without gunshots. Gibbons live in small family units, and so when a family is hunted the babies are taken and the adults who would pass on the information are killed (Cheyne, 2009). This means that the information about fearing gunshots would potentially not spread through the population.

Gunshots occurred in the very much majority at night, Hylobates lar are diurnal gibbons (Laska, et al., 2008). Over time it is understandable that the gibbons would end up associating that noise as occurring at night and therefore the threat involved to occur at night instead of the morning or day after. If the gibbons were in distress at night, there would likely be more social interactions in the form of increased vocalisation which were not heard when gunshots were present unless the gibbons learned to stay quiet to avoid further detection from poachers/hunters (Deng, et al., 2016).

Typically, loggers who are in the Gunung Leuser national park make up much of the gibbon hunting that occurs for subsistence food (IUCN, 2007). Typically, it would make more sense for this logging to occur in the day as it is easier to see what is being sawn down and less dangerous, although higher chance of being caught. Then hunting would occur after 19:00 to find food for the night as the hunters settle down, potentially opportunistic hunting of gibbons as they sleep and are potentially less aware of their surroundings (if hunting hasn't occurred in that particular area of the forest before.

5.2 At what time are gunshots most likely to occur

Gunshots most often occurred between 8-68 minutes past 19:00, at this time (19:00) is when sunset occurred when the results were collected. Gunshot occurrence was studied to work out whether they influence the vocal behaviour of gibbons the morning after there was a shot, and from what my results showed is that overall gunshots did not impact on behaviour. I also hypothesised that the number of gunshots would increase further into the night for good reason, and this was because potentially due to a lesser rate of human

activity in the area enticing poachers to take more risks with it being darker instead of dusk (Wiafe, 2018).

Typically, poachers in parts of Africa can be more brazen when hunting and will often hunt in the daytime when searching for big game such as elephants or rhino. This is partially due to the preys' lack of ability to escape being so large and so less of a reason to surprise it by. Hunting at night, whereas with regards to gibbons and primates which are thought to be nimbler the ease of capturing an infant at night when it has less energy could be thought of as a tactic used by poachers to hunt more agile primates (Bitetti, et al., 2000). As sometimes primates were hunted for subsistence in Sumatra, poachers and illegal loggers could have killed the adults and used them for meat whilst keeping the infants for the pet trade. Potentially having that subsistence meat to help them through a night of logging, with it being said before that trucks take the logs out during the night-time to avoid detection (McCarthy, 2002).

Poachers don't just hunt gibbons however, they also hunt tigers, rhinos and elephants in the area even though it is a protected area (Plowden & Bowles, 2009). This could explain the reason behind the gunshots starting at earlier times, with different animals being hunted at different times of day in order to make the hunt as easy and as effective as possible. Tigers often hunt at night time and the Sumatran rhino is most active at dawn and dusk, as it started getting dark at 19:00 in Gunung Leuser national park then this could potentially be a time poachers pick to avoid tigers however still have the cover of darkness to their advantage with it being a midground between night and day (Qureshi, et al., 2012).

The Sumatran rhino being cathermal due to their need acquire more food and have more time to forage puts them at risk of poachers hunting at dusk as mentioned in the previous paragraph (Schaik, 1996). Poachers could understand this fact and therefore hunt at dusk when rhinos are more visible as they are active in the area, with this time of day being the twilight zone with the atmosphere being partially light up by the sun, and so the area is not completely dark or light (Tetens, 1961).

5.3 Where vocalisations are heard the most frequently

In my study, vocalisations were heard the most frequently at T1_0m right at the forest edge. There could be many reasons for this, including potentially better sound quality in that area with less background noise to drown out gibbon morning calls or simply that recorder was better than others at picking up higher pitched frequencies that the gibbons make. Typically, gibbons have a tree that is taller than the rest which they call from, allowing sound to travel further (Mitani, 1985). When gibbons vocalise for example in a tree emitting territorial calls or alarm calls they are particularly vulnerable to predation, including clouded leopards which can climb trees to hunt prey and so once again trees in this area may provide a structural advantage against predation including height or better vegetation coverage for the gibbons to hide (Sunarto, et al., 2015)

Vocalisations on average were similar to the expected number calculated by SPSS, with the only major outlier being T1_0m. This area had twice the number of calls as the highest other site, leading to the theory that in the time recording was occurring at this transect, there may have potentially been more human activity also in the interior of the forest and so this could drive the gibbons further to the forest edge to escape possible hunting or to avoid loud noise caused by chainsaws cutting down trees (Bitetti, 2019). Forest fragmentation in the area, would lead to a lack of optimal biological corridors for gibbons to use as they are primarily highly arboreal (Vanhoof, et al., 2020). Areas with more days with calls may have had better access to taller trees or better biological corridors allowing for ease of access to the forest edge in that area hence why more calls were picked up than other forest edge locations.

5.4 Number of vocalisations deeper into the forest versus at the forest edge

Contrary to what was hypothesised, the number of calls did not increase the deeper into the forest was studied. The highest number was on a transect at the forest edge, this forest edge is considered to be an 'anthropogenic edge' (AE) because the cut off from forest and monoculture is man made (Harper, et al., 2015). The forest edge provides a view for miles with it consisting of cleared land for agriculture, one of the reasons why Hylobates lar chooses to call in this location could be to give it a better field of view of approaching predators such as predatory birds like the Black eagle (Isbell, 1994). As mentioned before about how although the forest edge can be more dangerous due to the amount of exposure, this increased field of vision of aerial predators could explain the most common call location being T1_0m.

Calls are directed at other communities of *Hylobates lar* to forests beyond the monoculture plantations. Forest fragmentation via the agricultural practices can cause sound to travel father with less obstructions as well as less interference from other species calls and less trees, which could be the reason behind the morning call location. Lack of physical obstructions could also be the reason behind recorders at the forest edge capturing more emitted calls, hence why call capture could have been better at the forest edge. If the forest is more open at this section of the edge, then it could be easier to spot poachers (granted the gibbons perceive these humans as a threat, loud sharp noises could be interpreted as a threat by the gibbons) and trappers (Brockelman, et al., 1998).

A global study completed on quantifying edge determined abundance changes in 1673 species showed that 85% of species were affected either positively or negatively by this change, with 46% being positively affected and 39% negatively affected (Pfeifer, et al., 2017). This potential for a positive effect could be the reason for the Gibbon calling close to the forest edge. The study above showed that animals could be attracted to forest edges, including primates and so this could be because of the higher productivity of the vegetation at the forest edge, with trees having more sunlight, as well as potentially fewer natural predators at forest edge due to human influence. Clouded leopards and tigers hunt *Hylobates lar*, both these species of predator are not frequently seen at the forest edge with a study done in the Gunung Leuser forest showing how predators were seen deeper into the forest (Slater, 2021).

Gibbons habituated with human activity whilst benefitting from the potential advantages the forest edge brings over the forest core, could prove to be another reason why calls were most present at T1_0m. Habituation as discussed in the introduction leads to behaviours unexpected of the animal in question (Williamson & Feistner, 2003). Although at T4_0m also being the forest edge there were 0 days with a call present, this can be explained by a lack of food in the area compared to at T1_0m or lower productivity. The edge effect can have a profound effect on the plant diversity and plant species richness at the edge of the forest, and in multiple cases there has been instances where plant species richness and diversity were higher at the edge than in the centre of the forest such as a study completed in China where abiotic factors differed including light density, temperature and moisture (Li, et al., 2018). These differing factors provide a fruit rich forest edge for a frugivorous primate like *Hylobates lar.*

6.0 Limitations and recommendations

Due to my lack of expertise in primate species identification via audio playback, it was sometimes difficult to differentiate between the Lar gibbon and other species in the area such as species of bird which could sound similar to Hylobates lar especially if audio distortion comes into play. As well as this, some audio files had a limited number of recording time potentially meaning I had to discount a day which had a call on it due to the recording having less than 30 minutes of data on it. As I was also not in the field when the data were collected, it is much harder to imagine what the area from the interior of the forest looks like regardless of the photos taken and so I have to predict for example that one area has less biological corridors than another or that fruit was more readily available at one transect without being provided with extra data to back this claim up or even better being able to observe it in person.

In the future, I would recommend that different statistics software's are to be trialled as well as SPSS due to how confusing SPSS can be for someone who has not had a significant period of time to learn how it works. This would allow for higher accuracy in statistical analysis. As well as this, I would also recommend that more photos of the exterior and interior of the forest are taken, to give someone who is potentially doing their dissertation on analysing previously collected data a chance to imagine properly what they are looking at with regards to the forest.

7.0 Conclusions

I have concluded that anthropogenic noise can potentially have a profound effect on primates, however not all. From my research, I have concluded that gunshots heard the night before do not have a significant impact on primate behaviour the morning after and that this was potentially due to many factors coming into play which were examined in the paper. The quality of audio recorder and the background noise of the area has the potential

also to skew results sending them in different directions than to be what is expected based on previous research carried out by other scientists. Overall, the study has been successful in showing how species react to anthropogenic noise and shows how much or little the species is affected by said noise. (Harris, n.d.)

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9.0 Appendices

9.1 Interim review form

Independent Research Project
Interim Interview - Agreed Comments Form

Student Name: Archie Bedford	Programme: Ecology and Wildlife Conservation
Date: 5/4/2023	IRP Title: The influence of poaching on gibbon vocal behaviour in the Sumatran rainforest
Supervisor Name: Amanda Korstjens	

Agreed comments – to include progress and plans for completion:
There needs to be a section about data analysis.
Talk more about animal behaviour in the discussion section and how it can differ to other animals.
Add more to the methods.

Student Signature: Archie Bedford	Supervisor Signature: Amanda Korstjens

9.2 Learning contract

Bournemouth University

LEARNING CONTRACT: INDEPENDENT RESEARCH PROJECT

Change file name by adding your name to it.
Email to akorstjens@Bournemouth.ac.uk!

The learning contract is an agreement between student and supervisor: it should clearly indicate what is expected from both sides. The text in Sections 2 and 3 provides guidance and can be modified to give more details reflecting what has been agreed, such as deadlines for submission of drafts and provision of feedback, word count limits/exclusions and number/timing of meetings. **Importantly, the document checklist helps students to follow the required procedures (e.g. ethical approval and risk assessment) and communicate what has been done to the supervisor.** **The student should submit a draft of the completed form to the supervisor (by the May deadline in the year preceding the final IRP submission) and request a meeting to discuss and finalise the content. Both the student and the supervisor are responsible for keeping a signed copy of this document and following what has been mutually agreed.**
1. YOUR DETAILS
Student name: Archie Bedford
Degree Programme: Ecology and Wildlife Conservation
Proposed IRP Title: Influence of poaching (gun shots) on gibbon vocal behaviour in the Sumatran rainforest.
Supervisor name: Amanda Korstjens
Excellent dissertations are made available for future students to refer to. Please tick this box to indicate that you agree to your dissertation being added to this collection, should it be selected. ☒ **YES**
2. As the student undertaking the above project I agree to:
• E-mail my supervisor on a fortnightly basis with a progress report • Meet with my supervisor at least once a month to discuss progress and I understand that it is my responsibility to organise these meetings • Comply with the terms of this learning contract and the guidance set out in the Guide to Independent Research Projects

- I understand that this is an *independent* project and that I am solely responsible for its completion
- I agree to comply with all ethical, laboratory and fieldwork protocols established by the Faculty.
- Attend the interim interview in October
- Hand in the first full draft of the thesis in January 2023

3. As the supervisor of this project I agree to:

- Meet with the student undertaking this project on at least a monthly basis and to respond to the progress e-mails as appropriate
- To meet formally with the student in October 2022 to undertake the interim interview
- To provide guidance and support to the student undertaking this project bearing in mind that it is an *independent* research project. This is inclusive of commenting on drafts of the final report in a timely fashion.

3. DOCUMENT CHECKLIST

All information (including examples and links) on risk assessments, ethics, proposals & interim interviews: see the handbook!

Research Proposal Attached? ☐ **YES** ☐ **NO** **absolute deadline for Amanda's students: 1st July 2022 and includes:**

☐ **YES**	☐ **NO**	**Risk Assessment for fieldwork and evidence of COSSH assessment for all laboratory procedures (online risk assessment completed)**
☐ **YES**	☐ **NO**	**Completed booking for all field equipment**
☐ **YES**	☐ **NO**	**Letters of permission where appropriate providing evidence of access to such things as field sites and/or museum archives**
☐ **YES**	☐ **NO**	**Completed Ethics Checklist**

4. INTERIM INTERVIEW – Progress evaluation

The interim interview will consist of a short presentation by the students regarding their progress to by the 'date' of the interview the student will discuss:

- **Clear well-argued aim and objectives**
- **Preliminary review of the relevant literature for introduction**
- **Data collection status.**
- **Plans for subsequent months**

Interim Review Date: second week of October

5. Variance from the Independent Research Project Guide

The IRP assessment is normally governed by the guidance provided in the Independent Research Project Guide. Any variance in terms of format (e.g. technical report, scientific paper) and word limit should be agreed and specified here. Submission date cannot be changed unless evidence of mitigating circumstances is provided in accordance with the standard BU Guidelines.

Any changes? ☐ **YES** ☒ **NO** If YES please provide details below:

Both of the undersigned parties agree to be bound by this learning contract:	
Student Signature:	Archie Bedford
PRINT NAME:	ARCHIE BEDFORD
Date:	3/10/2022

Supervisor Signature:	AHKorstjens
PRINT NAME:	Amanda Korstjens
Date:	06/06/2022