Habitat assessments of reticulated pythons (*Malayopython reticulatus*) along riverbanks in the lower Kinabatangan wildlife sanctuary, Sabah.

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Reflection

I have earned many lessons and skills throughout my year at Danau Girang Field Centre.

It has given me a great inside into to world of scientific research. It has shown me all the steps that need to be taken, and all the planning that goes into designing a research experiment. It gave me a taste of what what working as a field researcher, or doing a masters or PHD degree would be like.

I had so many opportunity to not only work on my own individual project, but all off the other projects running at the centre. This chance to do everything really taught me so much and gave me such a broad range of new skills that I wouldn't have got just doing one single project. Tracking Slow Lorises taught me how Very High Frequency (VHF) worked, working on the python project taught me so much about snakes, gave me the opportunity to handle them. The pig project showed that research does not always go to plan, and constant steps have to be taken to overcome new challenges. This is just to name a few, but working on so many different types of project taught me so much about different study methods and taught me lots about the study species.

The centre also regularly had field courses come to stay. This gave me the opportunity to really develop my people skills. Having to meet new people all the time really improved my confidence in social situations and taught me how to start and maintain conversations. I would regularly give presentations about my project, which really developed my ability to publicly speak and present my work, but also made me scrutinise my own design and help to improve it to a higher standard.

Being responsible for your own research project improved my leadership qualities. It showed me the importance of being a great leader and what it takes to be one. Throughout my year, I had many opportunities at being a leader and I feel very competent in taken a leadership riole in situations. This also improved my organisation and time keeping skills. It taught me that whatever I do, I should always plan ahead to what I will need and what I need to do in order to get it done. It also helped me set goals/ targets. Having a deadline set at the end of the year taught me that I should be setting myself regular targets and my down deadlines throughout the year. There was no external pressure so I become more independent and better at motivating myself to get tasks done.

I had the opportunity to work in the laboratory at the station. I was able to process genetic samples ready for testing, and shown how to collect different genetic samples from a range of species.

Having a year's field experience has been invaluable to me, and taught me so much about research and conservation that I wouldn't have been able to learn otherwise. It has also made me more mature and given me so many new skill that I can use in my final year of my degree and long after.

Abstract

Reticulated Pythons, *Malayoython reticulatus* (Schneider, 1801) are possible keystone predators with a complex ecological function. They predate on a wide variety of prey, many of which are threatened. Understanding of their ecology and behavior is increasingly important, especially in venerable environments like those experiencing high levels of deforestation for palm oil. However, little is currently known. Distribution of pythons spotted along the Kinabatangan River are uneven. Certain riverbanks appear to be hotspots for pythons, whereas on other stretches, very few sighting were recorded. The aims of this experiment are to test whether there is a significant difference between habitat variables where pythons have been found along the river bank, and randomly chosen sites. We will be assessing if does. We will also test whether the size and sex of the pythons effect these variables, and if activity at the river bank is influenced by rainfall. Habbitat assessment were done at sites where a python had been seen, and randomly chosen ones. A grid was set up and habitat variables were measured. Results showed that significantly more sites with pythons has elephant gra on them, compared to random sites. Pythons were found more often on river banks further away from plantations and that size and sex is not effected with the habitat variables. Further reasurch should be done on detectability rate of pythons with the habitat data collected, so that estimates for site occupancy can be made for the area to give greater understanding into the ecology and behavior of reticulated pythons.

Introduction

Expansion of agricultural land is increasingly becoming the largest threat to biodiversity (Fitzherbert et al., 2008). Oil palm (*Elaeis guineensis)* is one of the world's most rapidly expanding crops (Wilcove and Koh, 2010). Global Production of oil palm is increasing by 9% annually, with Malaysia and Indonesia producing more than 80% of the total palm oil (Fitzherbert et al., 2008), while also containing 11% of the world's remaining tropical forests (Iremon- ger et al. 1997). These are biodiversity hotspots for many rare and endemic species (Koh and Wilcove, 2008), therefore understanding the behaviors and ecology of species is vital to observe the responses to the increase in palm oil.

Snakes are an important sub order of organisms to study due to their role as possible keystone predators (ref). They are strictly carnivorous, and as they typically occupy middle to higher levels of the food chain, they are important indicators of trophic complexity (Lind, Welsh and Tallmon, 2005). It is concerning due to their important trophic and ecological roles, they are experiencing population declines, primarily due to habitat loss and degradation (Durso, Willson and Winne, 2011).

Despite their importance, there is a dearth of research done on these animals, and very little is known about their ecology and behavior (Gibbons et al., 2000). This is mainly due to lack of funding, and their difficulty to study due to their cryptic nature, inactive movement patterns, and hard to reach habitats (e.g. dense foliage, arboreal and aquatic environments) (Durso, Willson and Winne, 2011). Most research conducted on snake ecology has been on carpet snakes (*Morelia spilota)* in Australia, and Burmese pythons (*Python bivittatus)* in Florida. Very little however, has been carried out on other snake species in tropical environments.

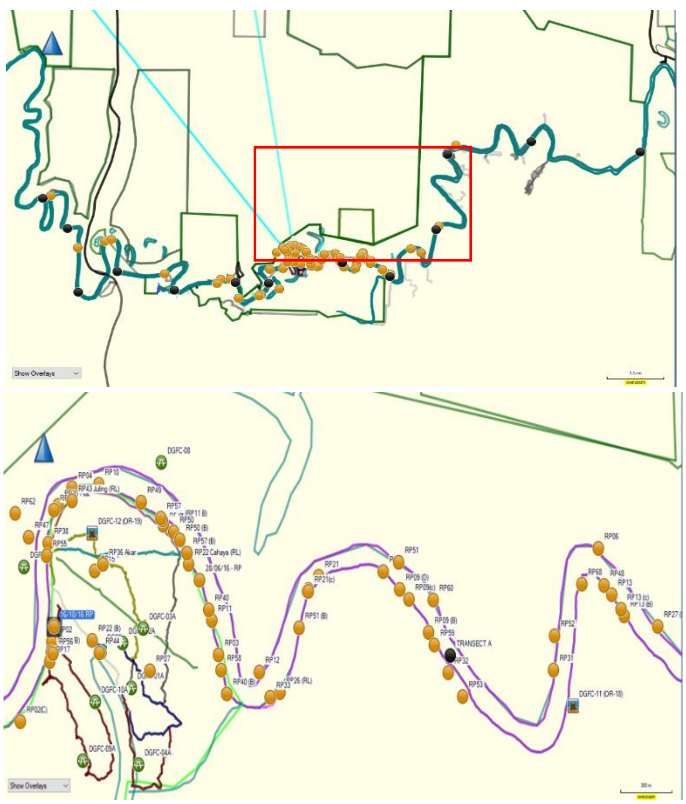
Carpet snake movement patterns and habitat preferences have been shown to change seasonally. They are more dormant and favour more insulated micro-habitats in colder months, whereas they are more active in the warmer months to search for prey (Heard, Black and Robertson, 2004). However temperature in tropical environments do not vary seasonally, and little has been done to understand the behavior of snakes in these climates.

One understudied species exclusive to, and widespread throughout south East Asia is the Reticulated Python (*Malayoython reticulatus*, Schneider, 1801). They are the longest reptiles in the world with sizes commonly ranging from 1.5 – 6 meters, but are capable of becoming larger (Shine et al., 1998). They are nocturnal generalist predators that feed on a wide variety of prey, depending on their size. They commonly feed on small rodents and birds, but as their size increase, they eat bigger prey like civets wild boars and even sun bears (Fredriksson, 2005; Shine et al., 1998; Wiens and Zitzmann, 1999).

They are regulated under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Murray-Dickson et al., 2017). They are heavily exploited for their skin, meat, and use in traditional Chinese medicine (Kasterine, 2012). They are the most heavily traded species in south-East Asia with approximately 140,000 skins exported annually (Kasterine, 2012). Due to their importance they have in there ecosystems as possible keystone predators, and the threats they face themselves, greater understanding of their behavior is needed.

During surveys done by Richard Burger (Phd student at Cardiff University) along the lower Kinabatangan wildlife sanctuary (LKWS), Sabah, Borneo. Pythons can be seen along the riverbank of the Kinabatangan River during evenings, however the reason for their presence there is not known. The Sightings of pythons were unevenly distributed, with certain river banks appearing to be hotspots for pythons, whereas other stretches of river bank recorded few sightings (see figure 1.0)

Figure 1.0



To possibly explain the reasoning for their presence at the river bank, and why certain areas seem to be associated with more sightings, we have conducted the following experiment to test whether there is a significant difference between habitat variables where pythons have been found along the river bank, and randomly chosen sites. We will be answering the following questions: does the vegetation composition, distance to plantation, direction the riverbank faces, incline of riverbank and canopy cover differ significantly at sites where pythons have been spotted, when compared to random sites. We will also test whether the size and sex of the pythons effect these variables, and if activity at the river bank is influenced by rainfall.

Figure 1.0. Mapped distribution of reticulated python's sightings along the riverbank of the Kinabatangan River in the Lower Kinabatangan Wildlife Sanctuary (LKWS). The top image shows all pythons sightings throughout the entire survey area of the river. The bottom is and enhanced image of the red square.

We hypothesis that some habitat variables at sites where pythons have been spotted will differ significantly from sites chosen at random. Different sex and size of pythons will be associated with different habitat variables and, rainfall will effect whether a python is seen at the riverbank

Material and methods

Study site.

The study took place in lots 5-8 of the Lower Kinabatangan wildlife sanctuary (LKWS) in eastern Sabah, Malaysia (5°25'03.9"N 118°02'07.3"E). The entire lower Kinabatangan region was subject to large scale selective logging, and conversion to palm oil plantations (McMorrow & Talip 2001). The (LKWS) consists of 10 lots, selected to increase connectivity with the surrounding forest reserve, and with the goal to create a forest corridor from coastal mangroves to dryland forests upriver (GOOSSENS et al., 2004).

Transects were chosen by (Burger et al., unpublished). The total survey area of 64km was split into 13 sections labeled A to M (see figure 1.0). These sections were further divided into north and south bank, creating a total of 26 transects.

Figure 1.0 shows the total length of the Kinabatangan River surveyed during the study. Transects are shown with block dots. The total survey area of 64km is from section I to M.

Site locations are where a pythons had been spotted along the river, or randomly selected. Each section had 10 random sites, 5 on the north transect, and 5 on the south, each chosen by a random number generator. It produced a number between 0 and the total length of each transect. That number indicated how far along the transect each site was. The software Garmin Basecamp was used.

Survey Method

Python visual encounter surveys (VES) were previously done by (Burger et al., unpublished). These surveys happened from April 2016- present, and occurred between 7pm and 10pm because of their nocturnal lifestyle. A boat was slowly driven along the transect close to the riverbank edge. A group of researchers including, Richard Burger examined the riverbank in search for pythons. If one was spotted, it was collected for samples and returned in the same spot the next day. This location was marked using a GPS device and re visited during the day to complete a habitat assessment of the site

Habitat site assessments were done between February and June 2018. Assessments occurred during the day with approximately 8 sites being done at a time. Every assessment was carried out by the same researcher to maintain consistency, accompanied by a further 1-2 participants. Assessments were only carried out when the river level was low due to danger of crocodiles.

Habitat Assessment. At each site, a five-meter-wide grid was set up from the edge of the vegetation line to the top of the river bank. GPS devises are not 100% accurate and marked points may not be exactly where the device was. In open areas, like the river, accuracy tends to be relatively good and points may only be off by about 3-5 meters. Creating a five meter grid at the site aims to minimise the impact of this error and ensures that the python spotted was definitely within that area. If a single point was chosen, this would likely not be the case. The grid was marked using two sets of poles spaced one meter apart, totalling 5 meters. One was set at the vegetation line, the other at the top of the grid and the distance between them was measured to give the length of the riverbank. (See figure 2.0)

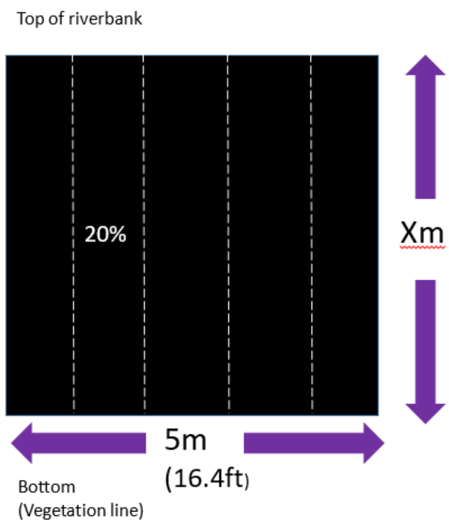


Figure 2.0. Shows one set of markers used at the bottom of the vegetation line to create to assessment grid (right) and a visual representation of the grid set up at each site for the habitat assessments.

Vegetation composition was measured as a percentage occupancy of the grid and divided into categories: bare mud, grass, vines, elephant grass, ground plants (vegetation below a meter that is not grass), log fall and leaf litter. A percentage was estimated for how much of the grid each vegetation type covered (e.g. 60% grass). Poles divided the grid into sections, increasing the accuracy of the estimations. Any vegetation present above 1 meter such as vines or canopy was not counted and total ground cover could exceed 100%. Taking percentage cover was chosen, instead of using a set distance of X meters, due to differences in vegetation lines and slope of bank. This made every site directly comparable.

The vegetation density behind the riverbank was measured using a 180cm tall density stick with 88 (44 white, 44 black) alternating black and white bands approximately 2cm wide. This was taken 8m behind the middle of the top of the grid. The number of white bands that could be seen were counted both standing up (eye level approx. 175cm) and crouched down (approx. 120cm). An average score of the two were recorded. Eight metres was chosen as an appropriate distance to create variation in densities between sites. Further distances resulted in vast numbers of sites with 100% density (zero visibility).

The direction the riverbank was facing was taken with a compass, standing in the middle of the grid. Canopy cover was measured by taking three vertical photos along the top of the grid. One photos was taken at both of the corners, and the other in the middle, between these points. Photos were taken at chest height (approx. 150cm) using a Cannon EOS 1300D, on a zoom of 24mm. The software Image J was used to calculate the area of canopy cover in each photo, and an average score of the three was used. Rainfall was measured with a rain gauge the day before, and day of python surveys by (Burger et al. unpublished).

Data on sex and size of Pythons was provided by (Burger et al., unpublished). Size was categorised into small (0-199 metres), medium (200- 299 metres), and large (300+ metres). Sex was either Male or Female.

The direction of riverbank was recorded standing in the middle of the grid facing the river using a compass. A bearing between 0º-360º was recorded. These numbers were then categorised to eight groups: 347.5º-22.4º =North; 22.5º-67.4º = North East; 67.5º-112.4º = East; 112.5º-157.4º = South East; 157.5º-202.4º = South; 202.5º-247.4º = South West; 247.5º-302.4º = West; 302.5º-347.4º = North West.

Each riverbank was given a score from 0-4 to measure incline. These were done just on visual observations. Each number represents the following: 0 = Flat, 1 = Low incline, 2 = Medium, 3 = High incline, 4 = sheer cliff face.

At all sites, distance to plantation was measured using geographic information system (GIS) of the LKWS and surrounding plantations. Each was recorded how far away they are from the closest plantation, irrespective of what side of the river bank it was behind.

Statistical analysis

All statistical procedures were conducted in R software, version 3.5.1 (R Core Team, 2013). A Kruskal-Wallis rank sum test was done on the following variables: Canopy cover, Distance to plantation, vegetation density, grass%, mud%, vine%, elephant grass%, ground plant%, log%, leaf litter%. For variables showing significant results (shown in table 1.0), the R package "dunn.test" (Dunn, 1964) was used to perform a post hoc Dunn test. This gives the nature and magnitude of deviation and a p=value.

Pearson's Chi-squared tests were carried out on direction of riverbank and slope, comparing how the python sites (observed values), deviated from the expected values acquired from random sites (see table 2.0)

A Principal Component Analysis (PCA) was performed on the following variables: Canopy cover, vegetation density, grass%, mud%, vine%, elephant grass%, ground plant%, log%, leaf litter% to see how these variables interact and effect each other. Sex and size of python was run against this (PCA) with a Simple linear regression.

Binomial Generalised Linear Model (GLM) tested whether a python was seen during a (VES) with rainfall on the day of survey, and one day before survey.

Results

Habitat assessment variables.

A Kruskal-Wallis rank sum test was run on all non-normally distributed variables. Canopy Cover, vegetation density, Mud%, Vine%, Log% and Leaf Litter% showed non-significant p values, (p-value <0.05). Variables: Grass%. Elephant Grass%, Ground Plant% and Distance to Plantation showed significant p values, (p-value >0.05) (see Table 1.0) A post hoc Dunn test carried out on significant results compared the random sites against Python sites. Grass% (z = 3.245480 p = 0.0006*) showed random sites had more grass coverage compared to python sites. Higher elephant grass% (Z =-2.975441 p = 0.0015*) is found more often in python sites than random ones. Higher ground plant% (Z = 1.987033 p = 0.0235*) is shown less often in python sites compared to random sites. distance to plantation Z = 6.078510 p = 0.0000*) showed pythons are found more often on river banks further from plantations than those that were randomly selected. Data is shown in table 1.0.

Table 1.0

Variable	Statistical Test	Kruskal-Wallis Chi-Squared values	Degrees of Freedom	P- value	Z-value (Significant results)	Outcome
Canopy Cover	Kruskal-Wallis rank sum test	0.79719	df = 1	p=0.3719		No significant difference
vegetation density	Kruskal-Wallis rank sum test	3.1101,	df = 1	p=0.07781		No significant difference
Grass %	Kruskal-Wallis rank sum test	10.533,	df = 1	p=0.001173	Z = 3.245480	Random sites have higher grass coverage than python sites
Mud %	Kruskal-Wallis rank sum test	0.85158,	df = 1	p=0.3561		No significant difference
Vine %	Kruskal-Wallis rank sum test	0.89117	df = 1	p=0.3452		No significant difference
Elephant Grass %	Kruskal-Wallis rank sum test	8.8533	df = 1	p=0.002926	Z = -2.975441	Pythons sites have higher elephant grass coverage than random sites
Ground Plant %	Kruskal-Wallis rank sum test	3.9483	df = 1	p=0.04692	Z = 1.987033	Random sites have higher ground plant coverage than python sites
Log %	Kruskal-Wallis rank sum test	0.515	df = 1	p=0.473		No significant difference
Leaf Litter %	Kruskal-Wallis rank sum test	2.9437	df = 1	p=0.08621		No significant difference
Distance to Plantation	Kruskal-Wallis rank sum test	36.948	df = 1	p=1.213e-09	Z = 6.078510	Python sites are found further away plantations than random sites

Table 1.0. Statistical analysis results of variables from randomly selected sites against python sites. Kruskal-Wallis rank sum tests were used for data that was not normally distributed. A post hoc Dunn test was only don't on significant variables (highli ghted grey) and the Z values can be seen.

Pearson's Chi-squared test on incline variable, showed a non-significant p- value of (p=0.2942). However direction of riverbank (N= 63, df = 7, p = 27529e-07) showed a significant result, that python sites (observed values) are significantly different to the random sites (expected values). NE has much higher number of python sites compared to random, whereas S has much fewer python sites than random (see table 2.0).

Table 2.0

Direction	Python (observed)	Random (expected)
N	6	6.0375
NE	21	6.586
E	8	10.395
SE	4	4.93
S	5	14.791
SW	2	7.122
NW	8	7.122
W	9	6.586

Table 2.0. Shows python and random values obtained for each compass direction used in the Pearson's Chi-squared test. NE has much higher number of python sites compared to random, whereas S has much fewer python sites than random.

Size and sex

A Principle Component Analysis (PCA) was run on the variables: canopy cover, vegetation density, grass%, mud%, vine%, elephant grass%, ground plant%, log%, leaf litter% at python sites only. Ten total principal components were produced, but only principal component 1 (PC1) was used for further statistical test. PC1 has a standard deviation of 1.9589961 and explained 38% of variance. For scree plot and loading of each principal component, see appendices (figure 1.0 and 2.0). PC1 and PC2 were plotted against each other in a bi plot showing how the variables interact with one another (see figure 4.0). Figure 4.0 shows that in sites with lots of elephant grass, there is little of the other variables.

Size was run against PC1 using a Simple linear regression (F=1.185, df= 1 and 48, p- value = 0.2817), as was sex (F=1.443, df= 1 and 48, p- value = 0. 2354) (see table 2.0). Both show p-values of non-significant results, therefore showing that neither the sex, nor size of pythons correlate with PC1.

Figure 4.0

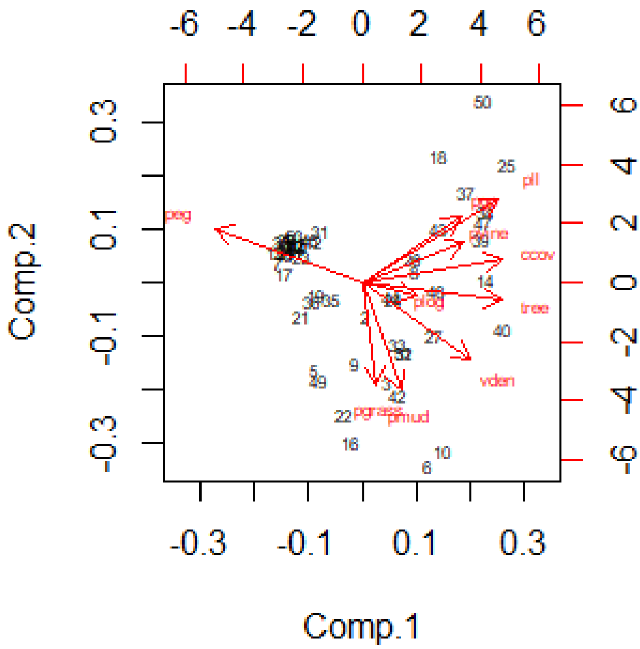


Figure 4.0. Bi plot of Principal component 1 (PC1) against Principal Component 2 (PC2) shows how variables interact with one another. Sites with elephant grass present have less of the other variables measured present.

Rainfall

A Binomial GLM was used to measure if the success of python sightings is effected by rainfall the day of a (VES) survey (Deviance = 132.71 df = 1 p = 0.9994) and the day before a survey (deviance = 132.71 df = 1 p = 0.3167). 1 was given to a survey that witnessed a python, and 0 was given to survey that did not see one. Both results are non-significant, showing that the success rate of finding a python along the river bank, is not effected by rainfall.

Variable	Statistical Test	P- value	Outcome
Day of Rain	Binomial GLM	P=0.9994	No significance
Day Before Rain	Binomial GLM	p=0.3167	No significance
Direction of Riverbank	Pearson's Chi-squared test	p=27529e-07	Riverbank direction of python sites are significantly different to the expected values
Incline	Pearson's Chi-squared test	p=0.2942	No significant difference
Sex	Simple linear regression	p=0.2354	No significant difference
Size	Simple linear regression	p= 0.2817	No significant difference

Table 2.0. Statistical analysis results of variables from randomly selected sites against python sites Binomial Generalised Linear Models (GLM) was used to see how rainfall on the day, and the day before of a python survey effected success rate. Pearson's Chi-squared test was carried out data that was normally distributed. Simple linear regressions were used to compare how sex and size influenced principle component 1.

Discussion

Plantation distance.

distance to plantation result (Z = 6.078510 p = 0.0000*) shown in figure 1.0 show pythons are found more often on river banks further away from plantations, when compared to the random sites sampled. Distance was measured to the nearest plantation, irrespective of if the plantation was on the same side of the river. This is because pythons can swim along the river, and data from (Burger et al., unpublished). Shows movement patters of pythons that they can regularly cross the river and it poses no real boundary to them. The average distance from plantation off all python's sites was 799m, and the average random site was 361m. (obtained from supplementary material figure3.0)

Little is known on how reticulated pythons are interacting with the surrounding oil palm plantations, as very few studies have been. Oil palm plantations produce vast amounts of fruit at rapid rates (Owolarafe, Olabige and Faborode, 2007). This large abundance of food source attracts animals who eat this fruit, this in turn attracts predatory animals, such as the reticulated pythons (Buckle et al., 1997; (MADSEN et al., 2006)).

While plantations provide an abundant food source, it also creates human conflict. Humans have been shown to have an innate fears of snakes (Öhman and Mineka, 2003). When plantation workers encounter a python they will often kill it, so they do not have to work with them nearby. Over the data collecting period, one reticulated was found dead with a large knife wound. Traps looked to be designed for pythons were found around plantation. Pythons are also very prized for their skin (Shine et al., 1999), being the most heavily traded snake species (Kasterine, 2012). Killing pythons therefore provides a financial incentive as the skin can be sold off.

Reasoning for python behavior at the river bank in not known, but it is speculated that they are hunting at the vegetation line along small trails along the riverbank used by mammals. Pythons will then ambush, and consume their prey. As they are possibly already hunting at these sights, there may be little incentive to go into the plantation to feed, instead they are choosing site far away from plantation to avoid human conflict.

Rainfall.

Results for rainfall were non-significant (see table 2.0) showing that the success rate of finding a python along the river bank, is not effected by rainfall the day of a (VES), or the day before. Although insignificant, the sample size for this test was relatively small due to the cryptic nature of snakes being very difficult to spot. Not all snake samples collected by (Burger et al., unpublished) were from surveys. Many were random encounters (pythons found not during a scheduled survey) and therefore could not be counted in this data.

Although data shows detection rate isn't effected by rainfall, spotting a python during a (VES) when wet/raining was more difficult, as they are harder to spot (R.Burger, pers. Comms.). when pythons are spotted, all that can normally be seen is the head poking out of the vegetation line. Snakes have iridescent scales (Mukherjee, Santra and Aditya, 2012) making them look similar to that of a wet stick and stand out from the surrounding habitat. During rain the distinction between snake and habitat is harder to make, making it harder to spot.

Sex and Size

The PCA done on python sites showed that when elephant grass was present, all other measured variables were not (see figure 4.0). The simple linear regression comparing how changes in both sex and size correlate with PC1 Showed non-significant results (seen in table 2.0).

A study by (Shine et al., 1998) showed that a female pythons were found containing prey more often than males. The research concluded larger snakes are more likely to be found with food as feeding rate increases with size, and females are more likely to be found due to the sexual dimorphism that females get much larger than males.

Based on results showed in (Shine et al., 1998), future studies could be done on testing the proportion of female to male encounters Based on feeding behavior alone, you would expect females and larger snakes to be found more often due to higher feeding rates. However if the activity at the riverbank is not for feeding, this may not be the case. There is also certainly other factors that would effect this.

Percentage cover

Variables showing significant results from the Kruskal-Wallis rank sum test were Grass%, Ground plant% and elephant grass% (values shown in table 1.0.). A generalized liner mixed model was initially tried as it would encompass all the variables together in a way that should fit the data much better, however the data was not able to fit into the model.

Results show that grass% and ground plant % was found less common in python sites, when compared to random sites. Not enough research has been done specifically on this area so results cannot definitely be explained, however it is possible to speculate based on general studies of reticulated pythons, as well as years of field experience from (Burger et al., unpublished).

As reticulated pythons are cryptic species, their scale pattern is especially suited for design against leaf litter (Fredriksson, G. M. 2005). One possible reason for significant results is that the bright green colour of the grass and ground plants, contrasts with their brown colour of reticulated pythons. This would cause them to stand out against the background and no longer be as cryptic, which would decrease the ambush success so choose to avoid these areas. This is only speculation and further research should be carried out to test possible causes for this result.

The data shows that pythons are found significantly more in elephant grass ($Z = -2.975441$ $p = 0.0015$*). The z value shows the relationship between python and random sites with the negative value showing elephant grass is found more often in pythons sites, compared to random ones. This significant result does not however, show that pythons are using more elephant grass, just that that are being observed more frequently there. To visualize the data 48%of python sites assessed contain elephant grass, whereas only 26% of random sites contained elephant grass (figures seen in supplementary material figure 4.0) possible bias for random sample may be present based on sample size. To increase accuracy on this test, more random sites should be sampled to get a greater areas of the river bank covered. This study on average had approximately one random point per Km.

During visual encounter surveys done by (Burger et al., unpublished) It was observed over years of surveys that pythons were much easier to spot in elephant grass (R.Burger, pers. Comms.). This is likely because there is very little of other vegetation types at the bank that can help camouflage the python. This can be shown by the PCA done in figure 4.0.

Future studies

Understanding more about cryptic species poses many chananges as detecting the study species is difficult. In snakes detection rate are almost always around 1% (Durso, Willson and Winne, 2011), with wild ones going much lower. Further research should be done in the LKWS on detectability rate for pythons along the Kinabatangan River. If habitat variables obtained from this study were categorised, and further visual encounter studies continued, an experiment to test the detectability rate of pythons in each different habitat types could be done (Guimarães, Doherty and Munguía-Steyer, 2014).

Limitations

A type of study like this has not yet been done. Although other similar habitat studies have have been done, they have generally categorised different habitat types (Walters, Mazzotti and Fitz2016) and not looked at small habitat differences between habitats. Variables were chosen based on practical experience by (Burger et al., Unpublished) Most results (like percentage cover were based on visual estimates) and subject to lots of bias. Everything was done to minimise this by having the same researcher variables for every site to maintain consistency. The study was only conducted over a 5 month period. A longer study time would have allowed for more samples to be collected

Conclusions

Results showed that pythons were found statically more of often in sites containing elephant grass when compared to random, and less likely found in sites containing grass and ground plants, showing that presence of pythons at river banks is effected by vegetation composition. We found that size and sex did not significantly correlate with habitat variables, and, rainfall did not affect whether a python is seen at the riverbank. Future studies should be done on the area on using the data obtained from this experiment to work out detection rates, then to estimate site occupancy in the area.
Greater knowledge of the number of pythons in the LKWS will help to understand more about there behavior which is increasingly important in areas with large scale deforestation. If this is obtained then possible conservation plans may be able to be put in place for the reticulated python.

Acknowledgments

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Supplementary material

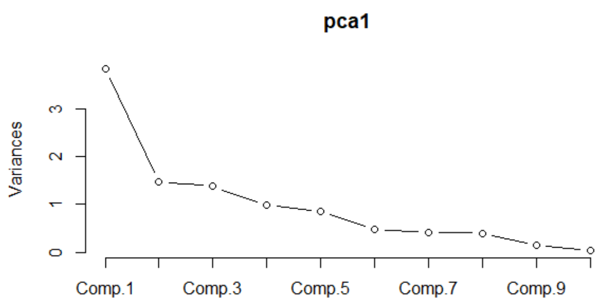

Figure 1.0. Scree plot given for the principal analysis, showing all different components. Component one was the only one that was used

Loadings:

	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Comp.9	Comp.10
ccov	0.413	0.111			0.116		0.574	0.648	0.177	0.134
vden	0.319	-0.361	0.335			0.156	0.526	-0.560	-0.192	
pgrass		-0.483	-0.629	0.193	-0.248					0.513
pmud	0.113	-0.508	0.507	-0.287		-0.371	-0.308	0.207	0.232	0.238
pvine	0.298	0.189	0.126	0.607	0.363	-0.367	-0.236		-0.370	0.167
peg	-0.432	0.257	0.265	-0.141	0.110	0.226	0.130		-0.235	0.722
pgp	0.290	0.310	-0.132	-0.545	-0.333	-0.455			-0.424	
plog	0.159		-0.355	-0.424	0.787			-0.188		
pll	0.400	0.396			-0.179	0.114	-0.200	-0.353	0.605	0.328
tree	0.410				-0.113	0.648	-0.427	0.241	-0.369	

Figure 2.0. Individual loading for each principal component

Site	Average distance from plantation (meters)
Python	799m
Random	361m

Figure 3.0. Average distances from plantation for python sites and random sites

& of python sites containing Elephant grass	& of random sites containing Elephant grass
48%	24%

Figure 4.0. Average number of python sites and random sites that contained elephant grass