Activity Patterns of Terrestrial Mammals at Springhill, Arima Valley, Trinidad

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ABSTRACT

Camera-traps were used to record terrestrial mammals over a period of 19 months at the Springhill Estate, Arima Valley, Trinidad. Eleven species or taxonomic groups were recorded during 925 trap nights. We describe the activity patterns with respect to time of day and lunar cycle for several of these species. Although these patterns mostly reflect current knowledge of the behaviour of these species based on existing literature, we found some minor differences.

Key words: Camera-trapping, mammals, Trinidad, activity patterns, tropical forests.

INTRODUCTION

The terrestrial mammals of Trinidad are well known and are a subset of those mammals occurring on the South American mainland (Allen and Chapman 1893) (Alkins 1979). However, knowledge of the behaviour of many of these species is still limited. Camera trapping provides a relatively simple way of discovering more about many of these often nocturnal and elusive species.

The use of camera-traps to monitor mammals has become widespread over the last few decades and as the technology has become cheaper and more reliable, the techniques used have been refined and the information gained has expanded (M. Tobler, Carrillo Percastegui, Leite Pitman, Mares and Powell 2008) (Ahumada *et al.* 2011). As well as being a technique to survey diversity, many other aspects of an animal's life can be studied, including daily activity patterns, breeding seasons, feeding behaviours, and territorial behaviour. The influence of factors such as temperature, season and moonlight has also been more closely examined. Some nocturnal animals exhibit changes in behaviour due to the phase of the moon, with either more or less activity on full moon nights; others show no change (Michalski and Norris 2011). Obtaining data to examine these changes in behaviour would be difficult and time consuming if individual animals had to be tracked and monitored. The use of camera traps is one manner in which the data can be gathered more efficiently.

In September 2013, three camera traps were initially placed on trails surrounding the Asa Wright Nature Centre (AWNC) on the Springhill Estate, Arima Valley, Trinidad, as part of a "Bioblitz" event (Rutherford 2014). After the three nights of this event, preliminary results were limited to a single agouti record. Following the event, we decided to continue monitoring the area to ascertain the other mammal species that could be recorded. The Arima Valley has been well surveyed in the past with William Beebe recording 19 small to medium mammals (Beebe 1952) but there had been no recent general surveys. This study aims to give an update on the diversity and activity patterns of small to medium mammals.

MATERIALS AND METHODS

Study Site

The study occurred on the Springhill Estate in the Arima Valley on the southern slopes of the Northern Range in Trinidad. The forest is originally classified as tropical premontane moist forest (Nelson and Nelson 2008), but is actually a mix of lower montane forest, young secondary forest, and abandoned or semi-active woody agriculture (Helmer *et al.* 2012).

Camera Placement

On 18 October 2013, we placed five cameras at various locations around the AWNC, including both on and off trail sites, and retrieved them on 3 November 2013 to review the results and evaluate our overall success. The four cameras that were placed at off-trail sites had very low detection rates, but the one camera placed on a trail performed comparably better, recording six species. Based on this, we decided to place cameras at two locations along one section of trail for continued functioning.

Two sites on the Bamboo Valley Trail were almost continuously monitored from October 2013 to May 2015; for short periods, cameras were reserviced or temporarily reassigned to other projects. At Site 1 (UTM 20P, 686314, 1185231; elevation 326 metres), the camera was mounted on a small tree at approximately 60cm above the ground. The tree was at a bend in the path on a steep uphill section of the trail surrounded by cocoa trees and prickly palms. The start date for Site 1 was 18 October 2013 and the stop date was 29 May 2015. The Site 2 (UTM 20P, 686320, 1185302; elevation 337 metres) camera was also mounted on a small tree at a height of 60cm pointing slightly uphill

and surrounded by clumps of invasive giant bamboo *Bambusa vulgaris* in the immediate vicinity and secondary forest (Fig. 1). The start date for Site 2 was 22 November 2013 and the stop date was 20 March 2015. We used Bushnell 6MP Trophy Cams for the duration of the project. This model has a passive infrared sensor with a night vision infrared LED flash. They were set up to take three shots, approximately once per second, per triggering event, and were set at the highest level of sensitivity.

In addition to the cameras mentioned, we set up two extra cameras operating from 22 November 2013 to 22 December 2013, and from 16 January 2014 to 20 March 2014. These were placed at the same sites and facing the same direction, but set to record 20s video clips.

Data Processing and Analysis

We used an automated, open source camera-trap data processing software to assist with organising and analysing our records (Sanderson and Harris 2013). A period of sixty minutes was used to assume independent pictures of a species at a location. Microsoft Excel was used for graphs and analysis. The frequency of a species' activity during each hour of a 24 hour period was examined to ascertain whether they were chiefly nocturnal, diurnal or crepuscular. We also investigated each species activity during full moon and new moon periods (full moon activity was measured as the number of records five days before and five days after a full moon, likewise for new moon activity). Two-sample t-tests, assuming unequal variances, were conducted to determine whether there were significant difference between these periods.

Video clips were also sorted to species and the behavioural activity of the animal was noted: the categories were: moving (animal travelled through the site with no significant pause); foraging (animal actively moved leaf litter or vegetation); feeding (animal eating); social interaction (animal interacting directly with another conspecific); territorial (scent marking/sniffing). Photo subjects were identified to species whenever possible using suitable field guides (Eisenberg 1989; Emmons and Feer 1997); small rodents could not be positively identified beyond the family level, and so were grouped together for analysis.

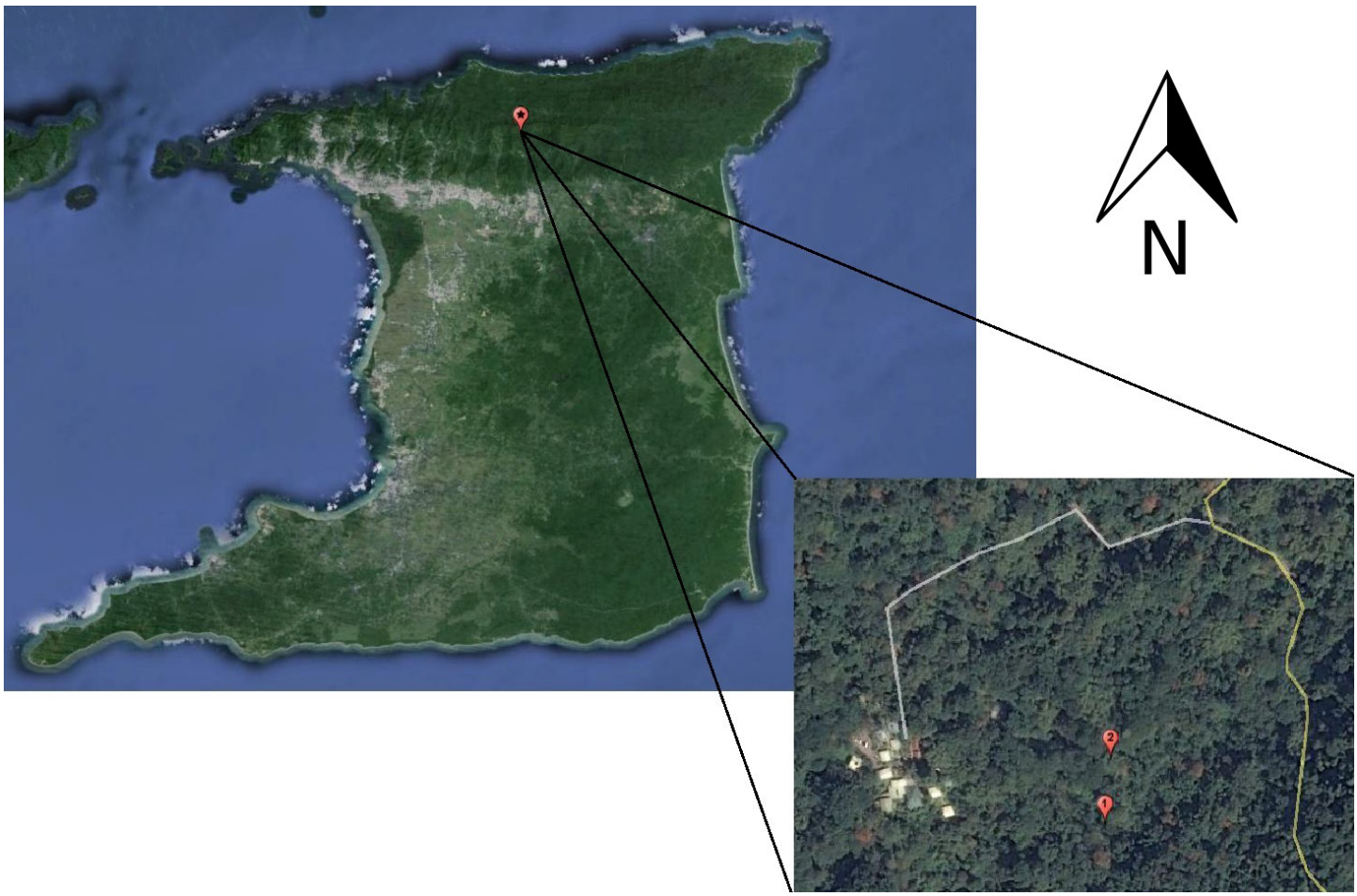

Fig. 1. Map showing location of Springhill Estate in the Northern Range, Trinidad and (inset) Sites 1 and 2 along the Bamboo Valley Trail east of the Asa Wright Nature Centre (Google Earth)

RESULTS

Overall, 506 camera trap nights were logged for Site 1 and 419 for Site 2. Discrepancies in total number of nights were due to battery failures, camera malfunctioning, and the temporary reassignment of the cameras to other projects. Overall 1696 images were used for analysis. Eleven different mammal species/taxonomic groups were identified from the images (Plates 1 and 2). During our survey, sunrise ranged from 0542 to 0629h, whilst sunset ranged from 1739 to 1832h.

Red-rumped agouti *Dasyprocta leporina* (Plate 1a) was the species most recorded, (n =1014 independent detection events), and comprised 59.8% of the total records. They were exclusively diurnal. Their activity occurred over a 14 hour span (0534 - 1843 h; Fig.2a), and there was no significant difference (t_{46}=0.21, p =0.415) in activity between full moon and new moon periods (Fig.3a). The majority of photo events were of a single agouti but there were 18 instances where two individuals were recorded together in the same photo; of these, 11 appeared to be of an adult female and a juvenile based on the size difference between the animals. There were 70 video clips of agouti which showed a range of behaviours: moving (51%), territorial (32%), foraging (10%), feeding (6%), and social interaction (1%).

The second most numerous taxa recorded included all small rodents combined (Plate 1b) (n = 373), which together comprised 21.9% of the total independent records. It was impossible to confirm which species of rat or mouse was recorded, as the image resolution was often too low and/or the animals too small. In addition, defining species-specific features were not generally visible. As there was a wide range in the sizes of individuals we recorded, it is quite likely they represented several different species. They were active during a 14 hour span (1754 - 0615h; Fig.2b) making them almost entirely nocturnal.There was no significant difference (t_{45}=0.39, p =0.347) in the activity of small rodents between full moon and new moon periods (Fig.3b). The majority of the photos were of a single rodent, but there were eight photos when two individuals were recorded together. Some of these photos could have included two different species, as the rodents were sometimes a sufficient distance apart as to be not aware of or interacting with each other. One video clip showed an adult foraging with two small juveniles following behind; other video clips showed foraging and feeding behaviour.

Common opossum *Didelphis marsupialis* (Plate 1c) records comprised 8.8% of the total number of records (n = 150) and were active during a 12 hour period (1804 - 0540h; Fig.2c) making them nocturnal. There was no significant difference (t_{39}=0.97, p =0.169) in the activity of opossums between full moon and new moon periods (Fig.3c). The majority of sightings were of single adult individuals, but there were four photos of an adult carrying a single juvenile on her back, and one occasion of an adult with three juveniles on her back. These occurred in April, May and July. One photo showed two adult or subadult opossums walking together. The video clips showed foraging behaviour (with several individuals observed searching through the leaf litter), feeding behaviour, and movement through the site.

Lowland paca *Cuniculus paca* (Plate 1d) constituted 6% of the total records (n =102); they were entirely nocturnal and only active during 12 of 24 hours (1819 - 0529h; Fig.2d). There was no significant difference (t_{42}=0.77, p=0.222) in the activity of paca between full moon and new moon periods (Fig.3d). There were three events where two paca were in the same image and the difference in size indicated that it was a mother and juvenile pairing. The video clips just showed paca moving through the site with no other activity, although one mother and juvenile pairing did seem to notice the infrared flash of the camera as they both turned to look directly towards the camera before continuing on.

Nine-banded armadillo *Dasypus novemcinctus* (Plate 1e) represented 1.8% of the total (n = 31) and were always nocturnal being active in 11 of 24 hours (1817 - 0505h; Fig.2e). There was a significant difference in the activity of armadillo during different phases of the moon with more activity during a new moon than a full moon (Fig.3e) using the two-sample t-test for unequal variances (t_{29}=2.17, p<0.05). Most armadillo records were of individual animals but there was one record of two moving together and one of four animals together. Three video clips showed armadillos foraging in the leaf litter and moving through the site.

Ocelot *Leopardus pardalis* (Plate 1f) were recorded only 11 times, constituting 0.6% of the total records. They were recorded during 8 of 24 hours, with a range through the night from 2020 to 0528h and a single sighting at 1310h (Fig.2f) making them mostly nocturnal. There were not enough samples to examine any differences in the activity of ocelot between full moon and new moon periods (Fig.3f). An adult female and a juvenile, about half the size of the adult, were seen together in late May 2014.

Several species were seen in such low numbers that they were not included in the statistical analysis. Southern tamandua *Tamandua tetradactyla* (Plate 2g) were recorded at both sites on nine occasions through the night between 1927h and 0857h. Red-tailed squirrel *Sciurus granatensis* (Plate 2h) were recorded at both sites on four separate occasions all in the morning. A lone red brocket deer *Mazama americana* (Plate 2i) was recorded once at Site

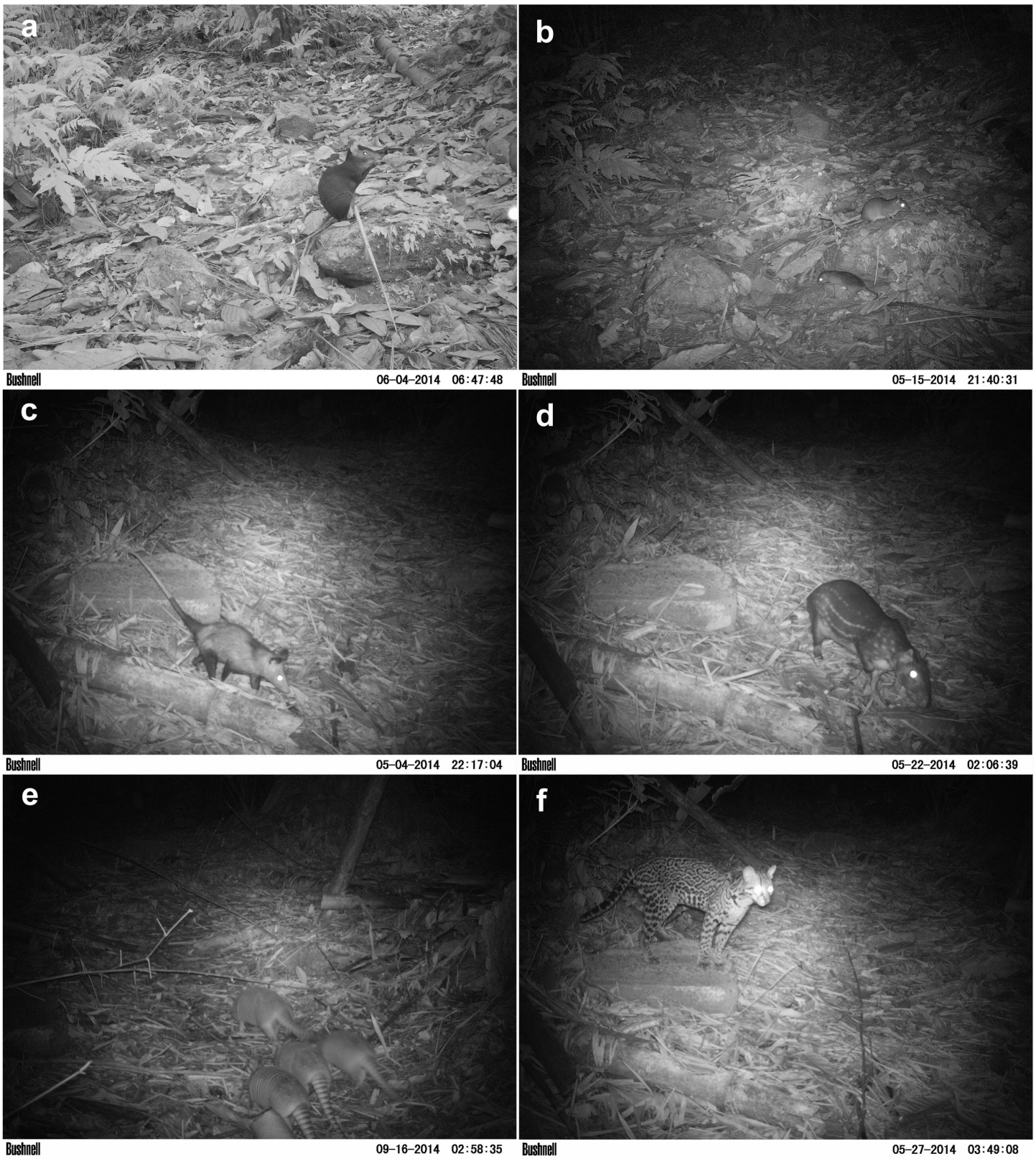

Plate 1. Species detected in camera traps at Spring Hill: a. Agouti, *Dasyprocta leporina*; b. small rodents, c. Black-eared Opossum, *Didelphis marsupialis*; d. Lowland Paca, *Cuniculus paca*; e.Nine-banded Armadillo, *Dasypus novemcinctus*; f. Ocelot, *Leopardus pardalis.* Spring Hill.

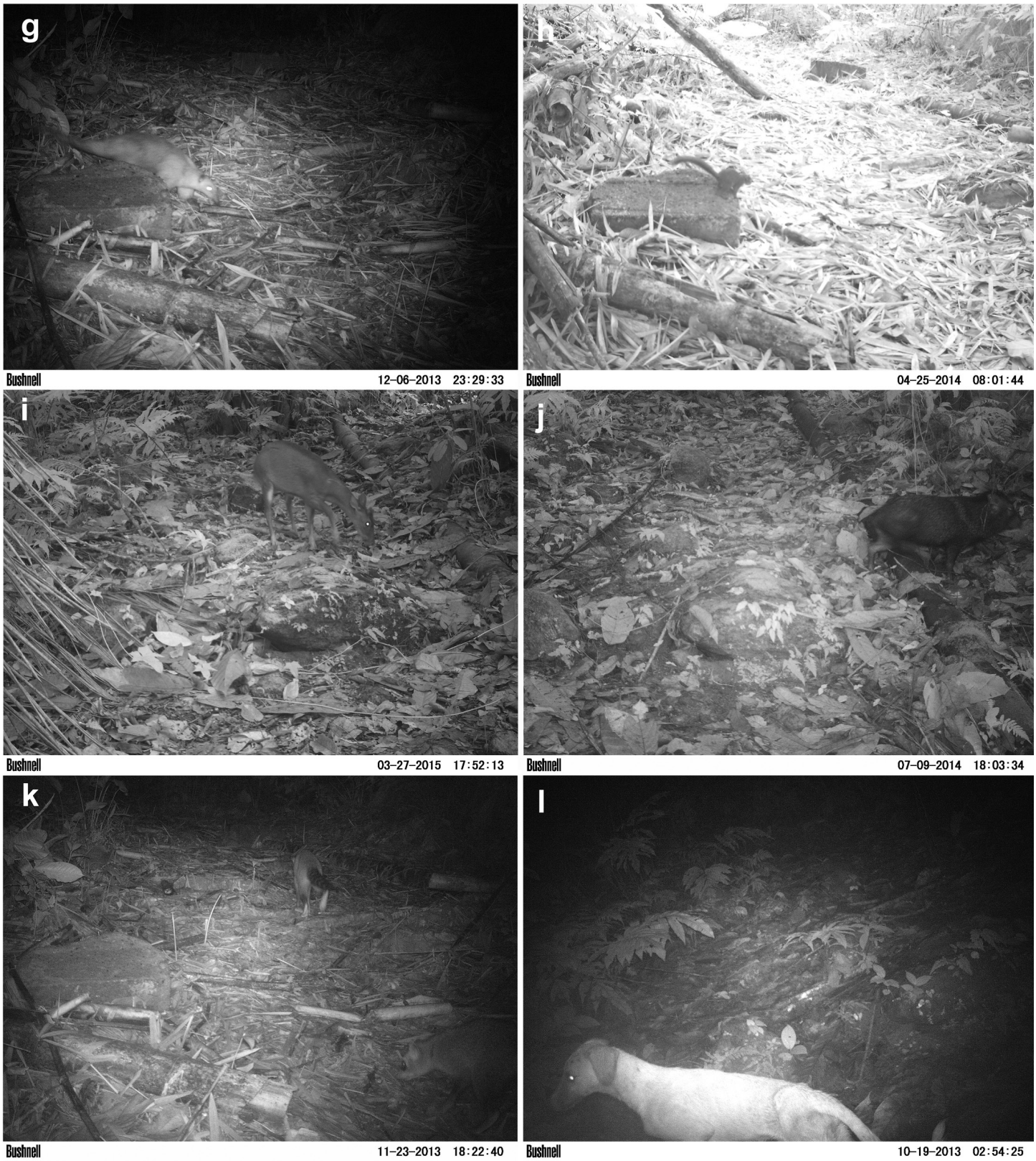

Plate 2. Species detected in camera traps at Spring Hill: g. Southern Tamandua,*Tamandua tetradactyla*; h. Red-tailed Squirrel, *Sciurus granatensis;* i. Red Brocket Deer, *Mazama americana*; j. Collared Peccary, *Pecari tajacu;* k. Crab-eating Raccoon, *Procyon cancrivorus*; l. Domestic Dog. Spring Hill.

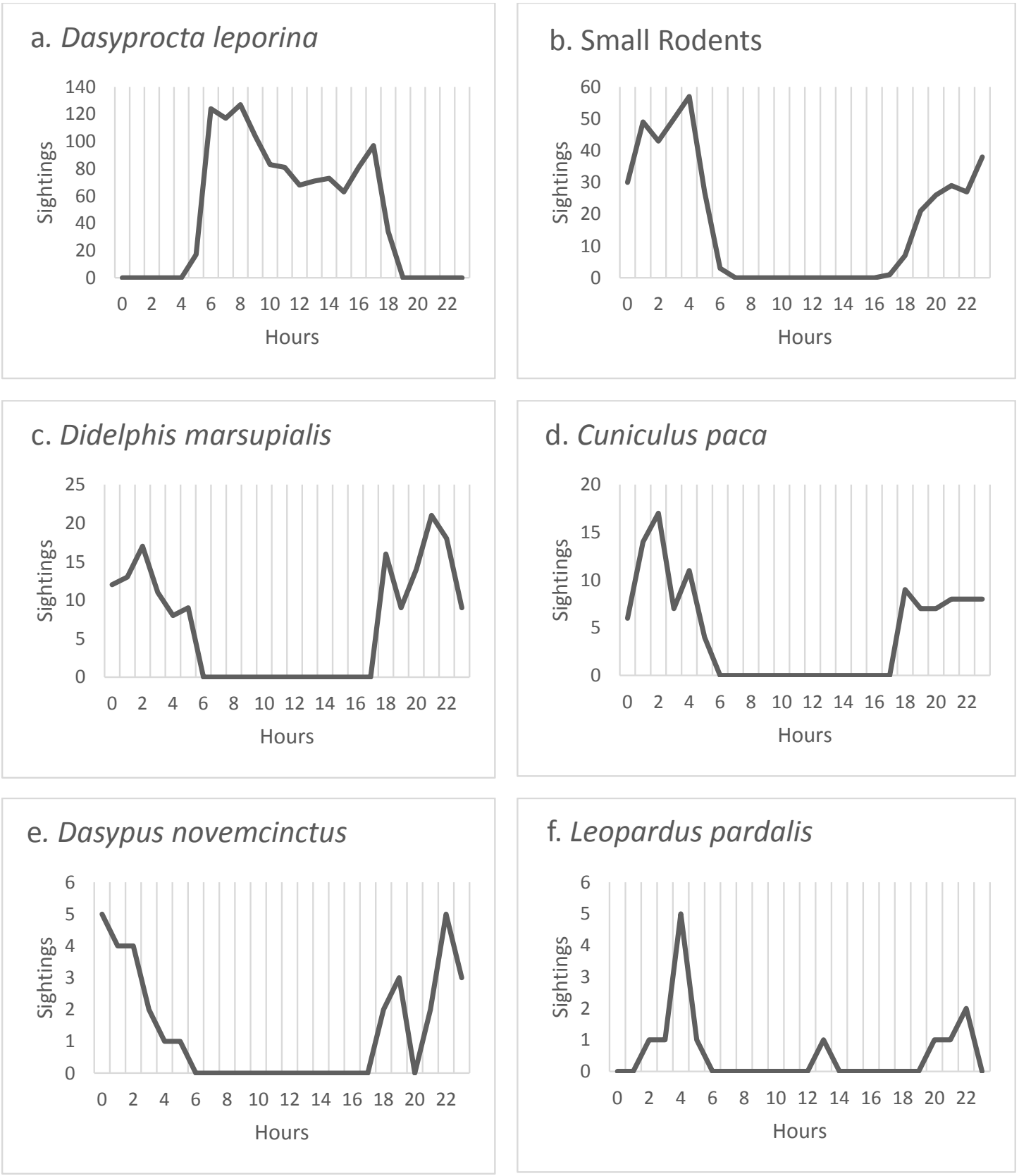

Fig. 2. Activity over a 24 hour period for 6 mammal species/groups based on camera trapping data from October 2013 to May 2015 at Springhill Estate, Trinidad.

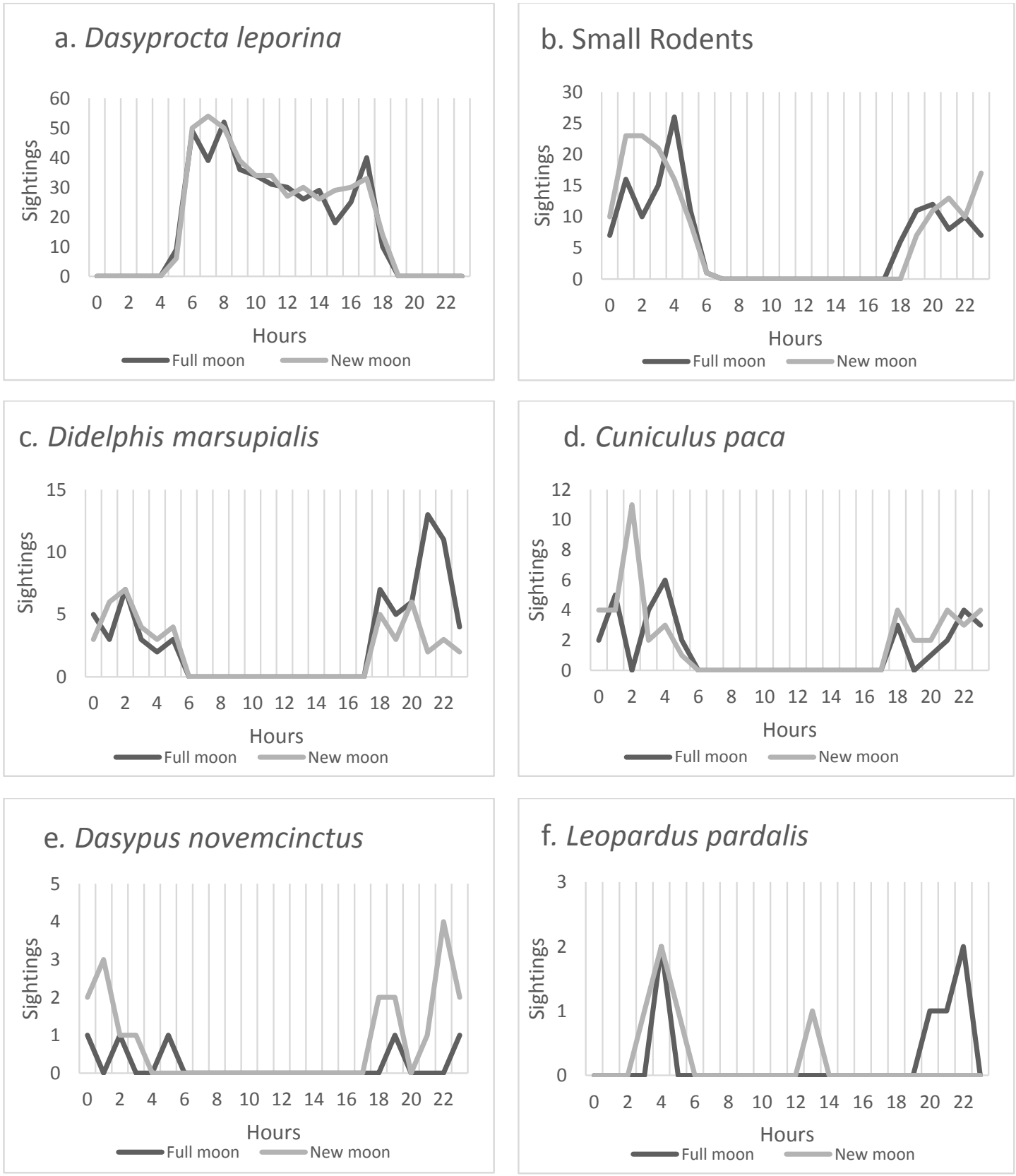

Fig. 3. Activity over 24 hour period for 6 mammal species/groups during full and new moons based on camera trapping data from October 2013 to May 2015 at Springhill Estate, Trinidad.

1 in March 2015 around dusk 1752h. Collared peccary *Pecari tajacu* (Plate 2j) were recorded once at Site 1 in July 2014 around dusk 1803h; one individual was photographed clearly, and a partial photo of a second animal was also taken. Three crab-eating raccoons *Procyon cancrivorus* (Plate 2k) were recorded once at Site 2 in November 2013 just after dusk at 1822h.

In addition to mammals, we recorded other animals on camera. The most common of these was the large terrestrial tegu lizard *Tupinambis cryptus,* a common resident around Springhill and often encountered during the day. A single photo was also taken of a green iguana *Iguana iguana*, and several birds were recorded as well, including great antshrike *Taraba major*, grey-fronted dove *Leptotila rufaxilla* and cocoa thrush *Turdus fumigatus*. Domestic dogs, consisting of several different individuals, were seen on 11 occasions (Plate 2 l).

DISCUSSION

Previous surveys recorded 19 different medium-large mammals in the Arima Valley (i.e., not including bats, rats, and mice) (Beebe 1952). Of these 19, Beebe classified nine as terrestrial and ten as arboreal. During this survey, we recorded all of the terrestrial mammals with the exception of the small Asian mongoose *Herpestes javanicus* and otter *Lontra longicaudis*, whereas we also recorded three of the arboreal mammals.

The diurnal pattern of activity of the agouti corresponds with previous reports in that we observed a peak of early morning and late afternoon activity (Dubost 1988). However, reports that agouti may be active on bright moonlit nights (Emmons and Feer, 1997) were not supported by our study, as not a single agouti photo occurred at night regardless of moon phase. The majority of the behavioural activities caught on the video clips showed individual agouti moving through the sites and occasionally stopping to scent mark or sniff at certain rocks, this territorial behaviour is well known in agouti

We believed that combining small rodent records into one group was necessary, as positive identification of all individuals to species level would not only be very time consuming, but also likely impossible. From previous studies however we can at least suggest which species are most likely to be present at these sites. During a live-trapping study at Springhill (2005), several large-headed rice rats (*Hylaeamys megacephalus* - named as *Oryzomys capito* in the paper) were captured very near these camera-trapping sites (Nelson and Nelson 2008). In addition, during night walks on the estate, MGR took colour photographs of a rat on trails near the camera trapping sites which were later identified as *Proechimys trinitatis* (Fiona Reid, per.com.). In an older trapping study in Turure Forest (in the Guiaco-Valencia Reserve near Sangre Grande, north-east Trinidad) 40.9% of the rodents trapped were *P. trinitatis* and 28.6% were *H. megacephalus* (Everard and Tikasingh, 1973), the authors also mentioned that *H. megacephalus* were the most abundant of the small ground dwelling rodents in the forests of northeastern Trinidad. However they then went on to state that *P. trinitatis* were only abundant in the seasonal marsh-forest typified by Turure Forest. It is therefore possible that these two nocturnal species (Eisenberg 1989) accounted for many of the sightings in this study although the majority are perhaps more likely to be *H. megacephalus*.

Common opossum were strictly nocturnal, with activity high in the early part of the night and then tailing off towards dawn. This is consistent with the results of a study in Venezuela which used radio-tracking to follow common opossums (Sunquist, Austad, and Sunquist 1987).

Paca are known to be nocturnal (Eisenberg 1989) (Emmons and Feer 1997), which is consistent with our study, with no records at all during the day. Although there were more sightings of paca during new moon periods, the difference in frequency compared to full moon periods was not found to be significant, similar to the findings of a study in southern Brazil which found only a slight difference (Michalski and Norris 2011). The images consisting of two paca together were most likely a female adult and a juvenile based on the size difference between the individuals. These sightings were spread throughout the year with one each in May, July and November, consistent with the year round breeding habits of the species (Dubost, Henry, and Comizzoli 2005).

Armadillos showed strictly nocturnal activity, which largely corresponds with their known behaviour (McBee and Baker 1982). The decrease in activity shown by armadillos during periods of the full moon supports other studies (Harmsen, Foster, Silver, Ostro and Doncaster 2011).

Ocelot records were mainly at night, although a single sighting at 1310h suggested that they can be active during the day; similar results were found by other studies (Gómez, Wallace, Ayala and Tejada 2005) (Di Bitetti, Paviolo and De Angelo 2006). The presence of a juvenile in May is not unexpected, as ocelots are thought to lack a distinct breeding season (Haines, Tewes, Laack and Morrison 2005) and a juvenile could be present any time of year, however further research is required to see if this is true of ocelots throughout their range. Camera trapping projects that focus on spotted cats tend to have a pair of cameras set up on each side of a trail; using this approach, images of both flanks of an animal can be captured to allow identification of individuals (Di Bitetti *et al.* 2006). As we were only using single cameras at each site, we did not get photos of each flank, so it was not possible to confirm repeat

records of the same ocelot. However, an examination of the photos taken depicting enough of the flank for comparison seemed to suggest that there were three different individuals present.

Historically tamandua were reported as rare in the valley, and generally only observed foraging high in trees (Beebe 1952); therefore, getting photos of them on the ground was fortunate. Surveys in southeastern Brazil reported that although they could be active at all hours, they tend to travel on the ground only under cover of darkness (Trolle 2003). This was mostly the case in our survey, but one individual was seen at 0857h.

The red brocket deer is generally a solitary, secretive animal which forages from evening through early morning (Eisenberg 1989); our single sighting at 1752h was relatively early in the evening. Another camera-trapping activity in the Arima Valley has detected deer both further down the valley nearer human habitation, and at the top of the valley in pristine forest (Luke Rostant pers. com.). Although there is no hunting allowed on the Springhill Estate, poaching is still a problem throughout the Arima Valley, and in areas where there is hunting pressure red brocket deer tend to be more nocturnal (Di Bitetti, Paviolo, Ferrari, De Angelo and Di Blanco, 2008).

Collared peccary have also been recorded at higher elevations in the Arima Valley (Luke Rostant, pers. com.). Beebe mentioned them as being generally rare and occurring more towards the head of the valley (1952). A study in Peru reported that collared peccaries are mostly diurnal (Tobler, Carrillo-Percastegui and Powell, 2009), consistent with our sighting before dusk.

Crab-eating raccoons are generally nocturnal, solitary and most often found near water sources (Emmons and Feer 1997). It was therefore unusual to record three animals together around dusk. The passing of the three raccoons was also caught on video and this allowed a more accurate study of the group, the raccoon in the lead was larger than the two animals following behind. It is most likely that the record was of a female–offspring unit (Eisenberg 1989) moving from one water feature to the next as there are several streams as well as the head waters of the Arima River within 60 metres of the trail. In December 2014, a camera trap, in place for one week, overlooking the stream running into Dunstan's Cave, Springhill Estate recorded several photos of a raccoon foraging in the water.

The presence of domestic dogs can be a problem due to their potential negative impact on wildlife (Bergman, Breck and Bender 2009). Camera trapping results from another group working at AWNC recorded a dog with what looked like a red-tailed squirrel in its mouth giving further evidence of the problem of feral dogs.

The use of video clips provided interesting information that would not have been collected if only stills were taken; however, processing time is longer and more computer memory is required for video footage (Glen, Cockburn, Nichols, Ekanayake and Warburton 2013), so we opted for still photos for the majority of the project. From the clips recorded only the agouti was seen in sufficient enough numbers to allow further analysis.

In order to gain a fuller picture of the status of the mammal species present in Springhill further methods should be employed including, trapping, transects and spotlighting. For future camera trapping projects at Springhill, an interesting avenue of investigation would be to place cameras in the canopy to see if detection of arboreal mammals is effective, although the cameras may have to be set on fruiting trees to increase the likelihood of detection of species. Potential target species include silky anteater *Cyclopes didactylus*, Brazilian porcupine *Coendou prehensilis*, mouse opossum *Marmosa robinsoni* and the bare-tailed woolly opossum *Caluromys philander*. These species have all been recorded in the Arima Valley before (Beebe 1952) but sightings recently are rare. Trinidad's two native species of monkey, the red howler monkey *Alouatta macconnelli*, and the white-fronted capuchin *Cebus albifrons,* were both present in the valley back in the 1950s (Beebe 1952) but there have been hardly any sightings until very, recently when two capuchins were spotted by staff at AWNC on 12 February 2016 (KCF, pers com.).

Future studies could also examine the difference in activity patterns of these common species in relation to forest size, type, and level of disturbance. In a study on Amazonian forest fragments it was found that the size of a patch had a significant effect on the activity of small terrestrial mammals (Norris, Michalski and Peres, 2010). Although the Springhill Estate is mixed secondary forest that is protected from hunting and poaching, there are many other areas in Trinidad and Tobago with differing levels of protection and forest types that would provide for interesting comparisons. Currently, collaborative efforts are being made to bring together the results of camera trapping projects from all over Trinidad and Tobago. This will hopefully lead to a better understanding of the state of the nation's terrestrial mammals, which face heavy pressure from hunting and poaching (The Cropper Foundation, 2010).

For further results from camera trapping in Trinidad and Tobago see www.inaturalist.org/projects/trail-cameras-of-trinidad-tobago.

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