

ARTICLES

ACTIVITY BUDGET, FOOD PREFERENCE AND HABITAT USE OF A TROOP OF EX-PET YUCATAN BLACK HOWLER MONKEYS (*ALOUATTA PIGRA*) FOLLOWING RELEASEDavid Feeney¹, Paul Walker² and William O. H. Hughes³¹*Institute of Integrative and Comparative Biology, University of Leeds, Leeds LS2 9JT, UK.*²*Wildtracks, PO Box 278, Belize City, Belize.*³*School of Life Sciences, University of Sussex, Brighton, BN1 9QG, UK. E-mail: william.hughes@sussex.ac.uk***Abstract**

Rehabilitation and reintroduction of endangered species have numerous conservation benefits, including assisting in repopulating local areas depleted of such wild species and encouraging the preservation of the habitat for other species. Recovery and release of ex-pet howler monkeys have the added incentive of increasing public interest and awareness in mammal rehabilitation in a Neotropical context. The activity budget, food preference and spatial movements of a troop of three ex-pet Yucatan black howler monkeys (*Alouatta pigra*) were studied during the six weeks immediately following their release at Fireburn Reserve in northeast Belize. The ex-pet howler monkeys seemed to be more active than wild howler monkeys, with leaves comprising a relatively high proportion of their diet. The troop used a very small number of individual fruiting trees to maintain their frugivorous needs. Fruiting trees seemed to exert a decisive influence on the troop's distribution, resulting in non-random use of habitats. Similar detailed data from other reintroduced ex-pet monkeys are needed to confirm the results. Nevertheless, our data support the preservation of multiple habitat types in a forest environment to benefit howler monkeys' survival and suggest that ex-pet animals can adapt successfully following release.

Keywords: Reintroduction, primate, Belize, activity budget, micro-habitat.

Resumen

La rehabilitación y reintroducción de especies amenazadas tiene numerosos beneficios para la conservación, incluyendo el ayudar a repoblar áreas locales de donde se han extirpado tales especies silvestres y promoviendo la preservación del hábitat donde son liberados para otras especies. La recuperación y liberación de monos aulladores que fueron mascotas tiene el incentivo adicional de incrementar el interés y preocupación del público en la rehabilitación de mamíferos en un contexto Neotropical. El presupuesto de actividades, preferencia de alimentos y movimientos espaciales de un grupo de tres monos aulladores negros de Yucatán (*Alouatta pigra*) que fueron mascotas, fueron estudiados durante seis semanas inmediatamente después de su liberación en la Reserva Fireburn en el nororiente de BÉlize. Estos monos aulladores parecieron ser más activos que los monos aulladores silvestres, y las hojas representaron una proporción relativamente alta de su dieta. El grupo utilizó un muy pequeño número de árboles fructificando para satisfacer sus necesidades frugívoras y los árboles en fruto parecieron ejercer una influencia decisiva sobre la distribución del grupo, resultando en un uso no al azar de los hábitats. Datos detallados similares de otros monos que han sido mascotas reintroducidos, se necesitan para confirmar los resultados, pero estos apoyan la preservación de múltiples tipos de hábitats en el bosque para beneficiar la sobrevivencia de los aulladores y sugieren que animales que han sido mascotas pueden adaptarse exitosamente después de su liberación.

Palabras clave: Reintroducción, primate, BÉlize, presupuesto de actividades, micro-hábitat

Introduction

The howler monkeys (*Alouatta*) have the greatest geographical distribution of any Neotropical primate genus, but include a number of species of conservation concern that are listed as Vulnerable, Endangered or Critically Endangered

by the IUCN (Neville et al., 1988; IUCN, 2015). These include the Yucatan black howler monkey, *A. pigra*, which is listed as endangered having experienced a population decline of as much as 60% over a three generational period due to the effects of deforestation, disease, and the pet trade (Marsh et al., 2008). Yucatan black howler monkeys occur

in Belize, northern Guatemala and Mexico's Yucatan Peninsula, and generally live in relatively small, stable groups of 2-11 individuals, with average troop sizes ranging from 4-7 animals (Crockett and Eisenberg, 1987; Baumgarten and Williamson, 2007; Gavazzi et al., 2008; Dias et al., 2015). Howler monkeys are primarily folivorous, with very variable frugivory levels that can be as high as 95%, and a dietary flexibility that may be enhanced by compensatory shifts in their gut microbiota (Altmann, 1959; Neville et al., 1988; Bravo and Sallenave, 2003; Rodríguez-Luna et al., 2003; Amato and Garber, 2014; Dias et al., 2014; Zárata et al., 2014; Amato et al., 2015). This dietary flexibility is critical to why howlers can occupy a diversity of habitats, including secondary and fragmented forests, and to their ability to adapt to habitat disturbance (Arroyo-Rodríguez and Dias, 2010; Behie and Pavelka, 2012). Howlers can remain feeding in one tree for relatively long time periods compared with other primate species, without even briefly moving from it, and may spend as much as 80% of the daytime resting amid tree branches (Richard, 1970; Anzures-Dadda and Manson, 2007; Palma et al., 2011; Pozo-Montuy et al., 2013; Amato and Garber, 2014). Howlers tend to have a daily routine, with the midday resting, and dawn and dusk feeding that is characteristic of tropical animals, including primates (Altmann, 1959; Bernstein, 1964; Chivers, 1969; Estrada et al., 1999). Howlers can also reduce their physical activity to compensate for low energetic return from leaves when fruit is scarce (Pinto et al., 2003). They show 'foci of activity' associated with their feeding (i.e., specific locations within which most feeding occurs), which usually alter from month to month, coinciding with seasonal availability of preferred foods, with the 'core area' concept describing areas often used for sleeping (Burt, 1943; Palma et al., 2011; Jung et al., 2015).

Food abundance and its distribution can strongly influence how howler monkey troops form and maintain a recognisable territory, thought of as a relatively stable and clearly defined area (Chivers, 1969). Territorial establishment seems to depend on the initial formation of one or more 'home ranges' which, unlike the broader territory, will vary over time (Ostro et al., 1999). Home range is used to express the area of aggregations of day ranges (the linear distances of day travel), thus referring to an area generally traversed by a troop during its daily activities over a specified period. Home range would hence seem to be heavily interlinked to the 'foci of activity' concept, and thus food resource availability is a primary determinant of home range size for Yucatan black howler monkeys, with food availability being in turn affected by factors such as habitat fragmentation and population density (Gavazzi et al., 2008; Arroyo-Rodríguez and Dias, 2010). Indeed, howler monkey troops establish ranges based on experience regarding fruiting cycles, and can move between locations depending on wet or dry seasonal influences on food abundance (Freese, 1976; Napier and Napier, 1985). Originally, it was thought that *A. pigra* preferred extensive, undisturbed and mesic tropical forest (Smith, 1970), but subsequent studies also found *A. pigra*

to inhabit highly disturbed semi-deciduous forests and to be able to supplement their diet in some areas by raiding crops (Horwich and Johnson, 1986; Arroyo-Rodríguez and Dias, 2010; Pozo-Montuy et al., 2013; Zárata et al., 2014). Consequently, howlers are considered a pioneer species that can adapt to diverse habitats (Eisenberg, 1979). However, it is still not completely understood how habitat and food resource variability influences the spatial decision making of howler monkeys, particularly among newly introduced groups, such as translocated troops. Translocated monkeys have been observed still not forming a recognisable territory six months after release into new forest (Silver and Marsh, 2003). Hence, analysing initial development of occupied areas, and later home ranges, seems critical to inform spatial studies of released howlers.

The behavioural and genetic diversity of *A. pigra* needs a combination of conservation approaches to support as many sustainable wild populations as possible. Trade operations in endangered primates, such as howler monkeys, for the pet market continue despite anti-hunting legislation throughout most primate ranges (Peres, 1997; Cheyne, 2010). Rehabilitation and reintroduction projects offer simultaneous solutions to both concerns, as they can recover the pet primate itself, and gather public support to protect wild habitat where reintroductions occur. Yet, while increasingly viewed as a valuable conservation strategy, release of captive individuals can be complex and controversial, particularly as little outcome data exist due to limited monitoring and reporting post-release (Terborgh, 1983; Yeager, 1997; Tutin et al., 2001; Strum, 2005). For example, a review of 87 researched animal reintroductions found that 19 were successful, 22 failed and 46 had unknown outcomes (Fischer and Lindenmayer, 2000). Furthermore, only about 50% of reintroduction projects have attempted release of threatened or endangered species (Beck et al., 1994). Reasons for high failure rates among primate reintroductions include an absence of release site surveying for habitat suitability or food availability (Cheyne, 2010). To facilitate successful primate releases, natural habitats must not host conditions that had caused wild populations to originally become endangered, such as hunting or deforestation. Previous studies of primate reintroductions have focused on translocated monkeys, moved from one part of their range to another (Ostro et al., 1999; Richard-Hansen et al., 2000). There has been no comparable research of released ex-pet black howler monkeys, although they are likely to differ in important ways from translocated animals. For instance, whereas both translocated and ex-pet monkeys require time to adjust to their new habitats, translocated primates would be expected to be already experienced from their previous forest environment. In contrast, released ex-pet monkeys would have most likely little to no previous experience in searching for and locating their own food, or forming and maintaining home ranges and territories, other than that provided as part of a pre-release rehabilitation programme. In this study, we therefore investigated the behaviour and habitat usage of a small troop of

ex-pet Yucatan black howler monkeys during the initial six weeks after release in order to gain insight into their ability to adapt to their new habitat immediately following release.

Methods

The study was conducted over a six-week period from June to July 2011 at the Fireburn Reserve, Corozal District, Belize (18°12'02" N, 88°11'59" W). Fireburn Reserve is an 1,818 acre protected area managed in partnership between the local community and Wildtracks, a conservation nongovernmental organisation. The study site is predominantly tropical, lowland forest, but includes a diversity of habitats including mangrove savannahs. Forest condition (stature and species composition) is variable, and in part reflects the impacts of historical logging, hurricanes and past agriculture. The north and east of the site is dominated by cohune palm, a species that is known to be a successful colonizer on some soil types and to then dominate forest species composition for centuries. Within the "Tropical evergreen seasonal broadleaf lowland forest over calcareous soils: Yucatan variant ecosystem", the six micro-habitats in the area are: 1) medium height lowland moist forest, 2) shorter lowland moist forest, 3) lowland moist forest with cohune, 4) dense cohune, 5) scattered cohune, and 6) secondary growth pioneer species. The region receives rainfall of between 1,200–1,500 mm per annum, with the wet season being June to November, and exhibits a decline in the number of fruiting tree species from the peak month of May. Howler monkeys were once present in the area of Fireburn Reserve, but disappeared from the area in the 1940's/1950's most likely due to the same factors that have caused the declines of other *Alouatta* populations, i.e. hunting, disease, and hurricanes (Pavelka et al., 2007; Marsh et al., 2008). The protected nature of the reserve, strong community support, and provision of diverse, high density potential food resources, now makes Fireburn Reserve suitable to support a howler monkey population. However, natural repopulation of the area is inhibited by the increasing removal by farming of forest corridor linkages with other areas.

The howler monkey troop that was studied consisted of three individuals: a 3 year old female, a 2.5 year old female and a 2.5 year old male. The monkeys had been confiscated from the illegal pet trade by the Belize Forest Department and subsequently transferred to Wildtracks' Primate Rehabilitation Centre for reintroduction into Fireburn Reserve as part of the Belize government's rehabilitation programme for ex-pet monkeys. The monkeys were initially quarantined for 30 days and screened for possible pathogens, before being housed as a group in a forest cage enriched with natural vegetation to enable social bonding, and then housed for several months in a pre-release forest enclosure to encourage the development of foraging skills and group cohesion, following IUCN guidelines for the re-introduction of primates (Baker, 2002). The troop was released on 17th May 2011, and supplementary fruit

and water were provided continuously at the release site in order to assist the initial adaptation of the troop to their new habitat. Observations on the troop were carried out for six weeks as part of the study described here, but were continued after this time by Wildtracks as part of its standard post-release monitoring of reintroduced monkeys.

A total of 31 days of observation were conducted from dawn to dusk (a 13–14 h period) over the six weeks. On each day, the troop was located and its position, activity and movement subsequently tracked until dusk. The position of the troop was recorded with a GPS (accurate to \pm 7 m under the rainforest canopy) when the troop was resting, feeding and every 3–6 min when moving. The GPS records were then integrated with a habitat map for the area to determine habitat usage. Following Rodríguez-Luna *et al.* (2003), the activity of the troop was recorded at 1 min intervals as either: 1) resting (stationary, sitting, standing or lying down without activity, or in activities such as yawning, stretching, or intermittently flicking its tail); 2) feeding (occupied with consuming food, or looking for and holding/reaching for food items); 3) moving (walking, running, climbing or jumping from tree to tree or between branches of a tree, but not including travelling within a tree when foraging); or other behaviour (playing, drinking, vocalizations, mating, physical or vocal aggression, urination and defecation). As observations were recorded at a fine temporal scale of 1 min, consecutive observations of the same activity were assumed to reflect the same activity bout, with the duration of activities then being the time until the monkeys switched to a different activity. Variation in tracking time meant that the calculated percentage durations of each activity often differed considerably between days. In particular, feeding and moving percentages were probably disproportionate on days of short observation times (i.e., under 5 h). In general, on these days the monkeys were followed in their foraging phase, but were lost from view before their likely resting periods. Additionally, as the troop did not have consistent sleeping areas, likely resting time after dawn was often not accounted for. During feeding episodes, it was noted whether the monkeys were eating leaves, fruit, flowers or other material (bark, stems, or fungus). The species of the food plant was recorded where possible, or marked for future identification. To analyse the troop's distribution and microhabitat use, the area was divided into four quadrants with the release site as their centre point. Within each quadrant, the abundance of the five tree species most commonly used as food by the monkeys was surveyed along four 200 m x 6 m transects from this release site. These were: *Ficus* sp. (fig), *Cecropia peltata*, *Brosimum alicastrum* (ramon), *Protium copal* (copal) and *Spondias radlkoferi* (hog plum).

Statistical analysis

Chi-squared or Fisher's Exact tests were used to compare the frequencies of sightings between quadrants and habitats to determine if the use of the site was random. The frequencies of feeding tree species recorded during the

observations and transect surveys were also compared with Chi-squared tests to investigate if plant species were fed on more than expected given their relative abundance in the habitat. The relationship between the arcsine transformed percentage of fruit foraging and the time since release was examined using a Pearson's correlation. In order to check whether the number of observations on the relevant day affected the records of fruit feeding, we also examined this relationship with Pearson's correlation.

Results

Over the initial six weeks following the release of the monkeys, we spent 31 days in the field, with 240 hours of troop tracking time, providing 119 observation/contact hours. Three tracking days contained no troop sightings, but there were no consecutive days of non-sightings. On average 285 ± 31 (mean \pm SE) observations were made per day (minimum 20, maximum 555).

Behavior

The howler monkeys spent the majority of their time engaged in either resting or feeding (Fig. 1). Resting activity was recorded least often of the principal activities (172 separate activity bouts), but unsurprisingly had by far the largest duration, while feeding was recorded more often (284 activity bouts) but lasted for shorter periods of time. Feeding was generally longer when the troop was feeding on fruit (20–60 min) than when they were feeding on leaves (2–15 min). The most common activity in which the troop was observed was movement (334 activity bouts), but this was generally of a much shorter duration than other activities. Compared with published data on wild translocated or established troops of howler monkeys, the troop of ex-pet howler monkeys were observed less frequently resting and more frequently feeding (Fig. 1).

Habitat usage

The furthest distance the troop was observed from their release cage was 277 m in a NW direction (Fig. 2a). The number of sightings per quadrant were 716 (NW), 55 (NE), 69 (SE) and 5 (SW), with the difference in the number of sightings between quadrants being significant ($\chi^2 = 635$, $df = 3$, $P < 0.001$). There was a significant difference between the total number of sightings in each habitat and the extent of that habitat in the study area ($\chi^2 = 179$, $df = 6$, $P < 0.001$). The monkeys were most commonly found in lowland moist forest with cohune (which tended to also contain *Ficus*, *Protium* and *Brosimum* plant species), despite this habitat representing only 6.5% of the study area (Fig. 2b). In contrast, the monkeys were never found in shorter lowland moist forest despite of this occupying a greater proportion of the overall area (Fig. 2b). Most sightings of the monkeys during the first two weeks were in lowland moist forest with cohune or dense cohune (Fig. 2a). Their daily occupied area experienced a pronounced shift westwards in the subsequent two weeks, with the majority of sightings in lowland moist forest with cohune. During

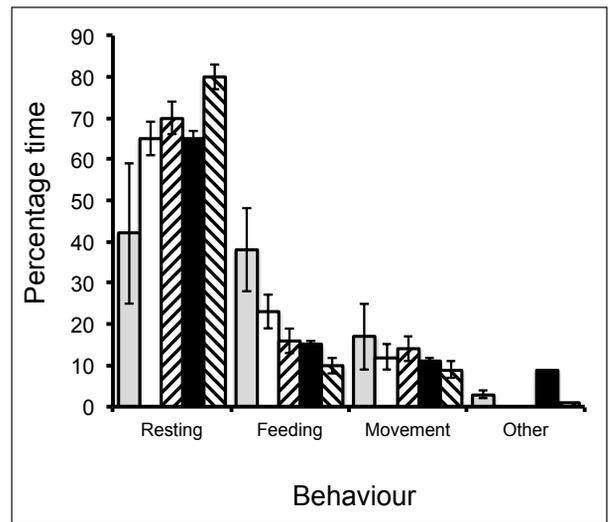


Figure 1. Mean (\pm SE) percentage of time that black howler monkeys were observed engaging in resting, feeding, movement or other behaviours for the troop of ex-pet monkeys (this study; grey), compared with similar data from other studies for translocated wild monkeys (Rodríguez-Luna et al. 2003; white), and wild established monkeys (Richard 1970; Milton 1980; Rodríguez-Luna et al. 2003; right diagonal lines, black, and left diagonal lines, respectively).

the final two weeks of observation, the troop shifted northwards and most sightings were in medium height lowland moist forest.

Foraging

Of the observations of feeding by the howler monkeys, $61.3 \pm 5.3\%$ were on leaves, $38.7 \pm 5.3\%$ on fruit and 0.19% on flowers, with 93.3% of the fruit feeding observations being on only three individual fruiting trees. Overall, there was a significant difference between the frequency at which the howlers were seen eating from a particular tree species and the abundance of that species in the habitat ($\chi^2 = 9.66$, $df = 4$, $P = 0.046$). The monkeys fed on *Ficus* sp., *Cecropia peltata* and *Protium copal* at similar frequencies to their presence in the habitat, but fed more frequently on ramon trees ($\chi^2 = 5.51$, $df = 1$, $P = 0.019$), and less frequently on hog plum ($\chi^2 = 5.31$, $df = 1$, $P = 0.021$), than would have been expected given the relative abundance of these species in the area (Fig. 2c).

There was no significant change in the percentage of observations eating fruit over the six-week period ($r = 0.341$, $P = 0.095$; Fig. 3a). The slight positive trend seemed to be largely due to three data points on days 27, 30 and 31, which showed noticeably high fruit percentages. These were days with less than 5 h observation, thus most likely missing much leaf eating activity. Although there was no significant relationship between the percentage of time eating fruit and number of observation hours on a particular day ($r = -0.340$, $P = 0.097$), it did appear that a lower proportion of time eating fruit was recorded on days when observation time was greater (Fig. 3b). After day 5,

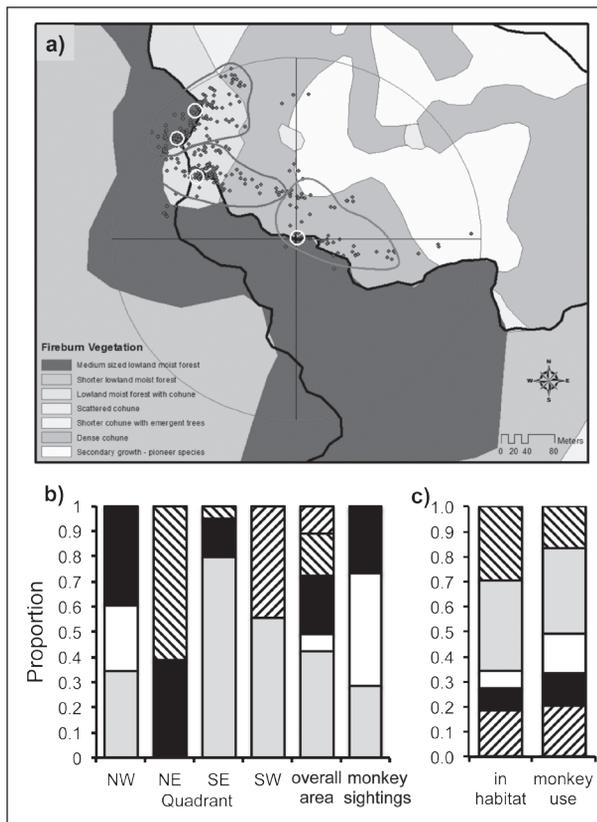


Figure. 2 a) Map of the release area for the troop of ex-pet black howler monkeys, showing the areas of each habitat, locations where the howler monkeys were sighted over the six weeks following their release, and the three principal areas in which the howler monkeys were sighted (outlined in grey) with the foci of activity (white circles; the central circle is the site of release, and the circles to the northwest and then north were occupied subsequently). There were no consecutive days of non-sightings, so it is very unlikely that the troop moved far outside these occupied areas during the study. **b)** Proportion of area of each quadrant and of the overall area that was occupied by each habitat (colour coding as in Fig 2a): medium height lowland moist forest (dark green), lowland moist forest with cohune (light green), scattered cohune (lightest yellow-green, not visible as < 2%), dense cohune (dark brown), secondary growth with pioneer species (light brown), and short lowland moist forest (medium green), and the proportion of sighting of the howler monkey troop in each habitat. **c)** Relative abundance of *Ficus* (right diagonal black lines), *Cecropia* (black), ramon (white), copal (grey) and hog plum (left diagonal grey lines) trees in the area as proportions of total, and the proportion of monkey feeding sightings on each of the tree species.

the troop never returned to avail itself of the supplementary fruit provided at the release site.

Discussion

The troop of ex-pet howler monkeys appeared to adjust rapidly to its new environment, making no use of the supplementary food provided after five days following introduction, and surviving and foraging well for the six-week duration of the study. The troop spent a comparatively higher proportion of its time feeding and moving, and a lower proportion resting, than previous studies suggest is

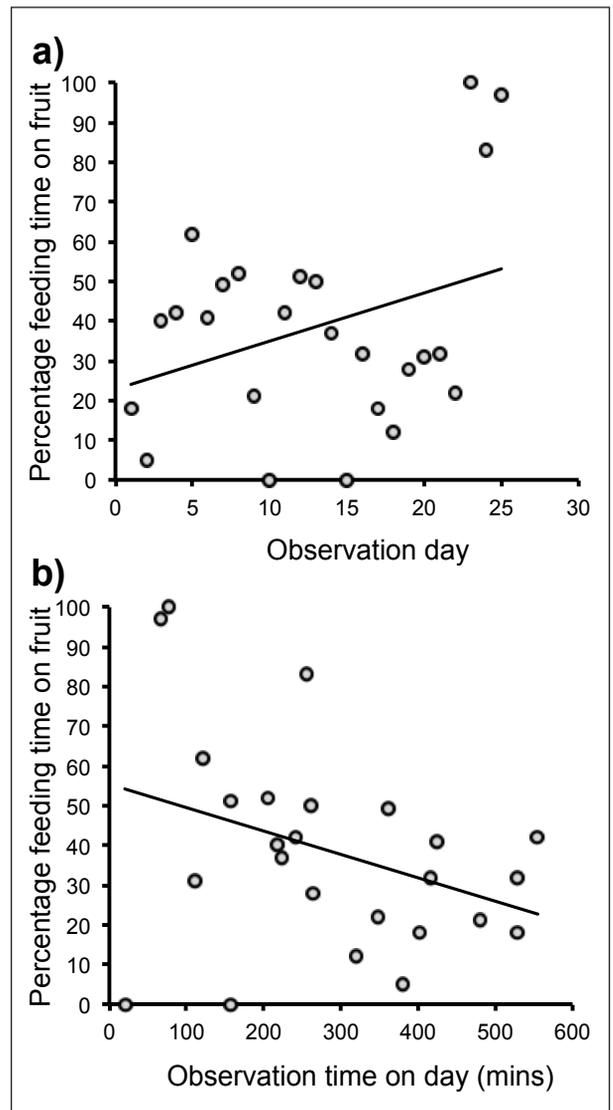


Figure. 3. Relationships between the percentage of total feeding time that a troop of ex-pet black howler monkeys spent feeding on fruit each day and a) the day of observation after release, and b) the total length of time the monkeys were observed on that day. The lines of best fit are respectively $y = 1.22x + 22.8$ ($R^2 = 0.116$), and $y = -0.058x + 55.3$

the case for translocated, established and wild troops of howler monkeys (Richard, 1970; Milton and Milton, 1980; Rodríguez-Luna et al., 2003). The relatively high variation in the data, as well as the high proportion of feeding observations and low proportion of resting observations, were at least in part likely due to variation in tracking time on different days. Habitat use by the troop within the study area was non-random, with the troop spending most time in the NW quadrant and displaying a marked preference for certain habitats. There was spatial evidence of shifts in occupied area between habitats with time.

The howler troop was selective in its choice of trees for foraging. Despite the number of fruiting tree species declining at the site with the commencement of the wet season, there was no significant decline in fruit feeding. This was

primarily due to just three individual fruiting trees, one of which was known locally as the “magic tree” (*Pouteria* sp.), on which the howlers spent 93% of their fruit feeding time. The troop was also selective in its foraging on leaves, with preferred species being fed on more frequently than their abundance in the area would have predicted. Wild howler monkeys have previously been observed to be selective in their use of a small number of species as their principal food sources (Chapman, 1988; Peres, 1997; dos Santos et al., 2013; Pozo-Montuy et al., 2013; Amato and Garber, 2014), and the same seems true of the ex-pet howler monkeys in this study.

The troop had a diurnal activity cycle and movement pattern similar to that of wild and translocated howler monkeys (Altmann, 1959; Bernstein, 1964; Silver and Marsh, 2003; Anzures-Dadda and Manson, 2007; Palma et al., 2011; Amato and Garber, 2014), with long periods with little or no travel being punctuated by occasional periods of long and relatively continuous movement. The periods of travel appeared to often be led by the male. The troop shifted its location over the course of the study, conforming to the concept of howler monkeys having food-associated ‘foci of activity’ to inform spatial movements over time (Chivers, 1969). Two fruiting trees, located 220 m and 255 m northwest of the release point, were particularly focal points of activity. The ripening time of fruits appears to be an important factor in determining the activity of wild, and particularly translocated, howler monkeys too (Richard, 1970; Ostro et al., 2000). It is notable that the attraction of the ex-pet howlers to the fruiting trees resulted in most of their activity being in the northwest quadrant even though this quadrant had a lower abundance of the most favoured tree species for leaf feeding than other quadrants.

Anthropogenic and climate impacts have created a spatial heterogeneity in Fireburn’s habitats and forest canopy. The howler monkey troop clearly utilised some habitats significantly more than others, in keeping with studies of wild howler monkeys at Lamanai Archaeological Reserve, northern Belize (Gavazzi et al., 2008). Monkeys were found most often in lowland moist forest with cohune habitat, despite this making up a relatively small proportion of the area. Although medium height lowland moist forest habitat had the second highest number of howler monkey sightings, these were heavily concentrated in the northwest, with large areas of similar habitat to the south being left unexplored. It is unclear why the troop chose their first occupied range to be east and north of their release site, rather than moving southwards, but it may have been due to the relatively low canopy of forest habitat to the south; a result of past hurricane activity. The similar sighting durations in the three most frequented habitats suggest that where the troop found food in each habitat, they often tended to subsequently rest for long periods on trees close by. Within the observation period, there seemed to be no particular tree species or habitat that influenced where the troop rested. During the troop’s exploratory travel movements, they

were observed moving through dense cohune and onwards into secondary growth with pioneer species. The rapid return (within 1–2 days) to their most frequently occupied areas on each occasion suggested that, despite the occurrence of edible leaf bearing tree species in the areas, a lack of fruiting trees caused the troop to relegate such habitat as a viable extension to their occupied range. These recordings further substantiate observations of *A. pigra* troops seeming to select forest habitat based upon vegetative differences (Ostro et al., 2000), with seasonal fruiting trees being the primary driver of movements within territories. While the troop’s eventual home range would most likely increase in response to seasonal food fluctuations, the observations support food resource availability being more critical to howler monkey survival than actual habitat size (Rodríguez-Luna et al., 2003; Arroyo-Rodríguez et al., 2013). Even small numbers of fruiting trees may be particularly important. Although the activity budget of the ex-pet howler monkeys was somewhat different from that found for translocated and wild howler monkeys, the observations suggest that ex-pet howler monkeys can adjust quickly following release, preferring less recently disturbed forest and possibly benefiting from a mix of habitats. There are of course many considerations which need to be taken into account when considering the release of primates (Baker, 2002), but the results presented here suggest that the release of effectively rehabilitated ex-pet howler monkeys may be viable, providing due regard is given to the habitat structure and food availability at the planned release site.

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