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Pygmy slow loris *Nycticebus pygmaeus* — natural diet replication in captivity

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ABSTRACT: In captivity, the pygmy slow loris *Nycticebus pygmaeus* population worldwide suffers from poor reproduction, dental diseases, facial abscesses and various other health problems which, cumulatively, mean that the population is far from self-sustaining. The diet recommendations are anecdotal at best, and improvements are urgently needed for this vulnerable species. New evidence suggests that wild *N. pygmaeus* are primarily exudativores, and consume nectar and gum daily from a variety of tropical plant species, along with a large variety of insects. The typical diet in captivity contains fruit, a concentrated pellet, some insects and occasionally gum as enrichment. Our aims were to compare the behavioural activity budget of 1 male *N. pygmaeus* at Paignton Zoo on his original diet, on the same diet with added nectar and on an evidence-based naturalistic diet of mainly gum and nectar. We also investigated the nutrient intake of 2 males when given these diets. Behavioural observations were made overnight using night-vision cameras for 15, 10 and 11 d for each diet, respectively. Abnormal (generalised linear mixed model, GLMM $\chi^2_{(1,2)}$ = 8.673, p = 0.013), travelling (GLMM $\chi^2_{(1,2)}$ = 6.107, p = 0.047) and feeding (GLMM $\chi^2_{(1,2)}$ = 79.679, p = 0.0001) behaviours all varied significantly between diets. In the behavioural study, the addition of gum, nectar and insects and the removal of fruit expanded and diversified the loris' activity budget and reduced the extent to which abnormal behaviour patterns were displayed. The intake study showed that both lorises consumed more when fed the naturalistic diet, suggesting they found it more palatable. Evidence of diet change suggests that a naturalistic approach to feeding *N. pygmaeus* enhances its welfare.

KEY WORDS: Loris · Diets · Evidence-based husbandry · Gum · Nectar · Exudativore

INTRODUCTION

Evidence-based husbandry, particularly nutrition, is beginning to gain momentum within the traditionally anecdotal sphere of zoo practice. Increasing numbers of studies clearly show that husbandry can be improved through research and the answers that it provides (Kaemanns et al. 2000). The pygmy slow loris *Nycticebus pygmaeus* has long been treated as a frugivore in zoological collections. Early literature on the subject (e.g. Charles-Dominique 1977) lumps *N. pygmaeus* into the same ecological niche as the frugivorous potto *Perodicticus potto.* Slow lorises were described to feed on fruits, insects and small vertebrates (Stevens & Hume 1995). Zoos feeding dead mice, dead 1 d old chickens, mealworms and fruits to *N. pygmaeus* became common practice. Recent studies by Wiens (2002), Nekaris et al. (2010) and Streicher et al. (2013) suggest that this lorisid species is actually an exudativore. Their wild diet has been reported to reflect the following proportions: gum (30%), other exudates such as sap and nectar (30%) and insects (40%) (Streicher 2009, Nekaris & Bearder 2011).

These small primates are endemic to Vietnam, Laos, southern China and eastern Cambodia (Starr et al. 2011). They inhabit various environments, all containing abundant amounts of leaf cover such as bam-

boo forests, mixed deciduous hardwood forests and dense scrubland (Nekaris & Bearder 2011). *Nyctice-bus pygmaeus* exhibits a gouging behaviour (method-ical biting of tree lignin and cambium) to harvest exudates from trees such as gum trees (Starr & Nekaris 2013). Unrefined gum from wild species of trees is said to contain an important amount of cal-cium, which may be important to balance out the high phosphorous concentration found within the invertebrates that they ingest (Charles-Dominique 1977, Power 2010). Lorises have been recorded feed-ing from a variety of tree species nightly, specifically Sapindaceae, Euphorbiaceae, Fabaceae, Anarcdi-aceae and Burseraceae (Tan & Drake 2001, Nekaris et al. 2010, Streicher et al. 2013). Their lower canines and incisors (tooth comb) are specialized and used in conjunction with their tusks (specialized procumbent caniniform premolars), which are used to gouge holes in tree bark (Kubota & Iwamoto 1967, Nekaris et al. 2010). The gum pools up within the tree's wound and eventually hardens; *N. pygmaeus* can then col-lect the exudate using their long narrow tongue or simply bite it off (Coimbra-Filho & Mittermeier 1978). The intestinal tracts of slow loris species have been shown to have a longer cecum and a wider large intestine than many of the frugivorous species of bush babies (Galaginae) (Stevens & Hume 1995). This would suggest some amount of hind gut fermen-tation is possible. All of these morphological adapta-tions: lower gouging tusks, a long thin tongue and a relatively short intestine with a larger colon and ce-cum fit the morphological descriptions of an exuda-tivorous primate (Kubota & Iwamoto 1967).

There is a European Endangered Species Plan (EEP) for *Nycticebus pygmaeus* that includes 40 zoo-logical institutions in Europe. A typical zoo diet can include any mixture of the following: vegetables, in-sects, monkey pellets, a source of animal protein (hard-boiled eggs, mice, chicks, etc.), dairy products, gum and, more often than not, fruit (Müller et al. 1985, Fitch-Snyder et al. 2001). The captive population suf-fers from various illnesses, many of which are be-lieved to be linked to diet. Commonly reported health problems include obesity, kidney problems, bone dis-orders and dental diseases (Müller et al. 1985, Ras-mussen 1986, Ratajszczak 1998, Fitch-Snyder et al. 2001, Fuller et al. 2014). It has been hypothesised that diets high in sugar and with minimal gouging oppor-tunities promote dental problems and obesity (Stre-icher et al. 2013). There is strong support that the cap-tive diet is linked to health problems and diminished longevity in captive *N. pygmaeus* (Fuller et al. 2014). Lorises are also known to exhibit poor reproductive

success in captivity (Debyser 1995, Fitch-Snyder et al. 2001). There is clearly a need to review captive feed-ing practices and identify possible diets that reflect the animal's physiological, morphological and behav-ioural adaptations, in order to reduce the health prob-lems afflicting the captive population (Kaemanns et al. 2000). Our aim was to put a naturalistic evidence-based diet on trial and analyse the behavioural differ-ences, if any, of a captive *N. pygmaeus* when fed a typical zoo diet versus this new diet. We also investi-gated the effects of diets on the weight of *N. pyg-maeus* and the differences in nutritional content.

MATERIALS AND METHODS

Study animals

We had access to 2 adult male lorises (L1 and L2) at Paignton Zoo Environmental Park (Paignton, Eng-land) for a dietary intake study between March and May of 2013. Both were housed singly in off-show mesh enclosures (1.3 × 1.3 × 2 m) filled with branches and 2 side shelves halfway up. One of the males (L1) was observed in order to investigate the effect of diet on behaviour. Due to limited time and availability of suitable cameras, behavioural data could only be col-lected for 1 animal (L1). Both L1 and L2 were fed the same diet, to determine how a naturalistic diet change affects weight and food intake. Each loris was only weighed at the start of the study and again at its end because of keeper schedules and availabilities. All food and specimens were weighed using a Ranger Count Advanced Scale (Ohaus).

Behavioural data collection

We collected behavioural data by using 2 SG560D digital scouting cameras. One camera was always placed in the same top corner of the enclosure, aimed into the middle bulk of the branches, while the other camera was always placed at the end of a shelf, facing the location where the food bowl was always placed. An estimated 30% of the enclosure was not visible by either camera. There is no reason to believe that be-haviours relevant to the outcome of our study were engaged in in these spaces, since there is minimal or no branching, very little mesh and no food resources located in these areas. The nocturnal animals were in diurnal enclosures; therefore, the motion-activated cameras were switched on between 19:00 and 06:00 h. When activated, they took a 10 s video clip in

night vision; this was followed by a 2 min resting period before the cameras were ready to be triggered again by motion. The field of vision of both cameras did not overlap. The video clips were watched the next day, and behaviours were recorded continuously using an ethogram determined during preliminary observations (Table 1). Feeding behaviours observed were: ingestion of gum, gouging of branches used as part of the enclosure furniture (branch gouging), ingesting feed from provided food bowl using mouth only (feeding orally), feeding from provided food bowl using hands to bring to oral cavity (feeding with hands), drinking nectar and catching and consuming insects. Afterwards, all behaviours were added together to form 4 main behaviour groups: travelling, feeding, and 'other', including abnormal behaviour patterns (ABPs) (Table 1). We define ABP as any behaviour not known to be performed in the wild, which could potentially be harmful to the animal and is discouraged by the keepers. L1 had been reported to perform a behaviour that was classified as an ABP, which was intense scratching of the wooden wall near the feeding surface. When L1 moved out of the camera's field of vision, the data recording stopped; therefore, activity budgets only include observed behaviours, and contain no out of sight data. Data were recorded for 3 wk, 2 wk and 18 d when being fed Diets 1, 2 and 3, respectively (Table 2).

Diets

Diets 1 and 3 are shown in Table 2. Diet 2 was exactly the same as Diet 1, but with the addition of 1 g nectar each day. The gum used was Mazuri Zoo Foods Marmoset Gum; the nectar was Mazuri Zoo Foods Sunbird Nectar. The diet was presented once a day for all 3 diets at about 17:00 h by a keeper. The keepers had control of the diets within the constraints of Table 2. Both lorises received the same diet on the same day; however, variation was present within the choice of fruits and vegetables offered. The fruits, vegetables and mealworms were given in the same sized metal bowls, which were always placed in the same location on a flat surface. The nectar was given in the same bird feeder attached to the same branch throughout the study. Gum was placed in holes that were drilled in two 25 cm logs. These logs were placed at random

Table 1. *Nycticebus pygmaeus*. Ethogram used to record the behaviour of pygmy slow loris at Paignton Zoo Environmental Park when fed 3 different diets. **Bold**: behaviours focused on and analysed in this paper; ABP: abnormal behaviour patterns

Travelling	Feeding	Other
On surface	**Ingestion of gum**	ABP
On the ground	**Branch gouging**	Investigation
On a branch	**Feeding orally**	Hanging
	Feeding with hands	Inactive
	Drinking nectar	Self-scratching
	Catching and consuming insects	Self-grooming

within the enclosure, but always within the view of the top corner camera. The locusts were placed in a mesh cylinder, which only had 2 holes large enough for them to actually escape, creating a trickle feeder. This feeder was always attached to the same branch. Because the locusts were given while the lorises were still asleep, they would have had ample time to escape the large mesh doors if not placed in a trickle feeder. There was an acclimatization period of 1 wk between each diet when ingredients were gradually changed over the course of the week. No data collection took place during this period. The diets were given in chronological order, rather than being assigned randomly.

We weighed the amount of food ingested when fed each diet by weighing the feed given and again weighing the residual feed for the last 5 consecutive days of both Diet 1 and Diet 3 as part of the intake study. Diet 2 was not included in the intake study because its main goal was to observe the palatability of nectar to captive *Nycticebus pygmaeus*. The

Table 2. *Nycticebus pygmaeus*. Diets 1 and 3 fed to pygmy slow lorises at Paignton Zoo Environmental Park. Diet 1: on fruit and vegetable (veg) days, three-quarters fruit and one-quarter vegetables (leafy and/or root vegetables depending on availability) were given. Diet 2 was the same as Diet 1, but with the addition of 1 g nectar every day. Diet 3: vegetables were dependent upon availability, but always included 1 root vegetable and 1 watery vegetable that were not leafy, such as cucumber, pepper, celery stalk, etc; fruit variation included apples, pears, bananas, melon, grapes and berries

Weekday	Diet 1	Diet 3
Mon.	Chick and 2 g gum	2 g locusts, 40 g veg, 3 g gum, 1 g nectar
Tues.	42 g fruit and veg	25 g mealworms, 3 g gum, 1 g nectar
Wed.	35 g mealworms	2 g locusts, 40 g veg, 3 g gum, 1 g nectar
Thurs.	42 g fruit and veg	2 g locusts, 30 g veg, 3 g gum, 1 g nectar
Fri.	Chick and 2 g gum	2 g locusts, 40 g veg, 3 g gum, 1 g nectar
Sat.	42 g fruit and veg	25 g mealworms, 3 g gum, 1 g nectar
Sun.	42 g fruit and veg	2 g locusts, 40 g veg, 3 g gum, 1 g nectar

results of the 5 respective days were then averaged. The nutritional contents of the consumed diets were analysed using the Zootrition Software (Version 2.6, St. Louis Zoo), and results were displayed on a standard dry matter basis (no moisture content).

Analysis

We created activity budgets for each of the 3 diets using the periods of time during which each individual behaviour was observed (in seconds) over the entire diet phase and, subsequently, divided by the total observed time. The effect of diet on the proportion of observed time performing behaviours of interest was analysed using a Generalized Linear Mixed Model (GLMM), SPSS Version 20 (IBM) with pairwise post hoc tests. Behavioural data is rarely normally distributed, and GLMMs are more powerful than a non-parametric Mann-Whitney U-test. If the pairwise comparisons were then not significant, a Cohen's D effect size was calculated. We only analysed the behaviours that were deemed important to the research question (Table 1). These included all feeding and travelling behaviours. ABPs were also distinguished due to their possible welfare implications.

RESULTS

Nutritional content of diets and intake study

We provided the lorises *Nycticebus pygmaeus* with similar amounts of food (as dry matter) when fed Diet 1 and Diet 3 (Table 3). There was more food consumed when fed the naturalistic diet (Diet 3). Both individuals lost weight during the 3 mo of the study. L1 began at a body weight of 474 g and ended at 464 g; L2 started at 460 g and ended at 454 g. These are descriptive statistics and were not analysed for statistical significance. Nutritional analysis of the diets as consumed indicated that Diet 3 was very different nutritionally than Diet 1, as shown in Table 4.

Behavioural differences

Unpredictable and uncontrollable events (staff miscommunication, L1 altering the camera, etc.) reduced the number of days of useable videos to 15, 10 and 11 for Diets 1, 2 and 3, respectively. We recorded, on average, 306, 228 and 221 videos for Diets 1, 2 and 3,

Table 3. *Nycticebus pygmaeus*. Intake study results showing the amounts of feed presented and consumed by the captive pygmy slow lorises on a dry matter basis, and consequently, the amount of energy consumed. Amounts consumed are the means of the intake study of Loris 1 and Loris 2, which lasted 5 d for each specimen

	Diet 1	Diet 3
Food presented (g)	25.28	26.23
Food consumed (g)	16.54	25.42
Energy consumed (MJ)	140	179.6

respectively, each night (number of total observations for Diet 1 is 4590, Diet 2 is 2280 and Diet 3 is 2431). The proportions of observed feeding behaviours are shown in Fig. 1. Gouging behaviour was the only feeding behaviour to vary significantly between diets (GLMM $\chi^2_{(1, 2)}$ = 16.32, p = 0.0001) (insect feeding was not analysed as it was only possible in Diet 3). Fig. 2 shows the entire activity budget, with all behaviours combined into the 4 main behaviour groups. Diet had a significant effect on travelling ($\chi^2_{(1, 2)}$ = 6.117, p = 0.047), feeding ($\chi^2_{(1, 2)}$ = 79.68, p = 0.0001) and ABP ($\chi^2_{(1, 2)}$ = 8.67, p = 0.013). Pairwise comparisons showed that Diets 2 and 3 differed significantly for travelling (p = 0.050); Diets 1 and 2 (p = 0.001) and Diets 1 and 3 (p = 0.0001) differed significantly for feeding. The post hoc pairwise test was not significant for the ABP behaviour. However, the dif-

Table 4. *Nycticebus pygmaeus*. Nutrient comparisons of Diet 1 and Diet 3 as consumed by captive pygmy slow lorises (dry matter basis). Diet 2 was not included in this table because the diet's sole purpose was to detect the palatability of nectar to captive pygmy slow lorises. All nutrients included in this table were represented by at least 75% of the ingredients in both diets, except for vitamin D_3, which was still included due to its importance in a nutritional analysis for primates. ADF: acid detergent fibre; NDF: nitrogen detergent fibre; NFE: nitrogen-free extract

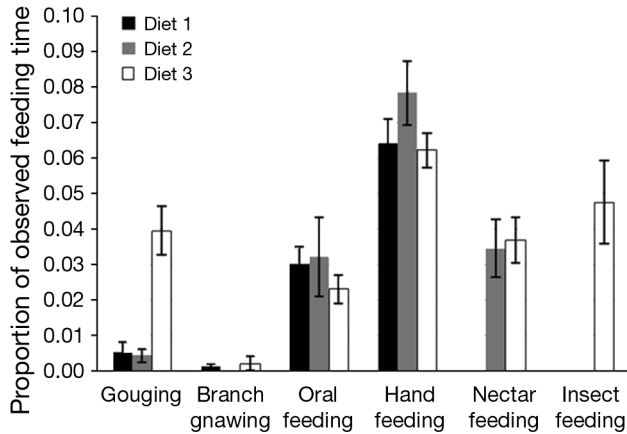| Nutrient	Diet 1	Diet 3
Crude fat (%)	23.15	9.24
Crude protein (%)	42.76	23.77
ADF (%)	4.83	6.86
NDF (%)	7.35	9.17
NFE (%)	1.96	17.90
Fe (mg kg^{-1})	56.37	36.35
Ca (%)	0.55	1.25
P (%)	0.70	0.42
Vitamin A (IU A kg^{-1})	28.64	154.57
Vitamin C (mg kg^{-1})	302.44	1427.00
Vitamin D_3 (IU D kg^{-1})	0.49	10.40
Vitamin E (mg kg^{-1})	27.51	743.00

Fig. 1. *Nycticebus pygmaeus*. Proportion of observation time spent engaged in various feeding behaviours by a captive adult male pygmy slow loris when fed 3 different diets. Error bars are SE
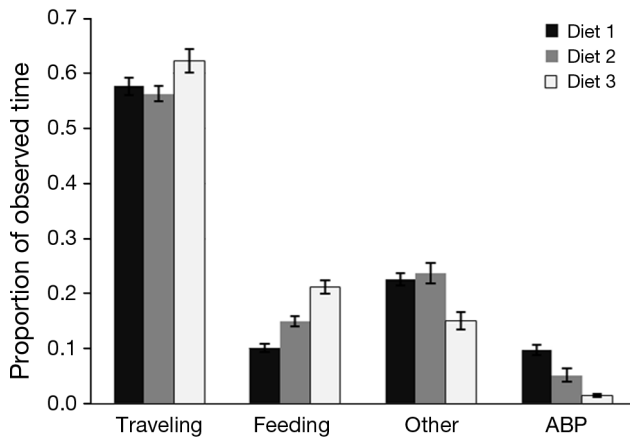

Fig. 2. *Nycticebus pygmaeus*. Proportion of observation time spent engaged in various behaviours by a captive adult male pygmy slow loris when fed 3 different diets. ABP: abnormal behaviour patterns. Error bars are SE

ference between Diets 1 and 3 had a large effect size ($n_1 = 15$, $n_2 = 11$, Cohen's $D = 2.000$).

Although not analysed, the 'other' behaviour decreased as shown in Fig. 2. All behaviours were observed less often, most notably inactivity decreased by 77.76% and licking decreased by 59.79% when comparing the behaviours during the administration of Diet 3 to those during Diet 1.

DISCUSSION

Nutrition

The low population size used for the nutrition part of this study (N = 2) and for the behavioural part of

this study (N = 1) implies that the results obtained are particular to these individuals and do not necessarily reflect the entire captive population. However, the specimens were not atypical for captive *Nycticebus pygmaeus*, which suggests that there is no reason why results should be different for any other *N. pygmaeus*. The naturalistic diet proved to be more palatable than the sweeter, original diet. On Diet 3, L1 and L2 each ingested on average 8.88 g more dry matter than on Diet 1, and consumed 39.6 MJ more. However, L1 lost 14 g and L2 lost 10 g of weight overall. There was a large increase in gum, nectar and insects in the new diet. Nectar, while energetically dense, was only given at a 1 g dry matter quantity per day, and is made up of soluble sugars. Gum is mainly made up of structural carbohydrates, starch and proteins, which are all digestible to some extent within the *N. pygmaeus* digestive system (Stevens & Hume 1995). With their widened intestine and functional caeca, they are believed to ferment compounds that cannot be digested by a simple stomach. The increased intake of insects such as locusts created an influx of chitin that the *N. pygmaeus* were not accustomed to in captivity. It has been shown that they possess some chitinase and cellobiase activity within their gastric mucosa; although it has never been quantified exactly how much their digestive system can hydrolyse into energy (Stevens & Hume 1995, Fleagle 2013).

Chitinase activity is the presence of an enzyme that catalyses the hydrolysis of chitin into multimers of poly-B-1,4-N-acetylglucosamine (GlcNAc) (Cohen-Kupiec & Chet 1998). These multimers are then further hydrolysed by cellobiase activity into monomers of GlcNAc, which are accessible to some organisms as a source of energy (Cohen-Kupiec & Chet 1998). A large influx of indigestible matter would typically act as a fibrous bolus and stimulate peristalsis, decreasing food transit time and therefore decreasing the amount of energy that is actually absorbed. The Zootrition software is limited in some respects. Because it is dependent upon nutritional data provided by an outside source, metabolizable energy data is sometimes unavailable and data derived from a proximate analysis must be used instead. While all energetic contents of the diets were reported to be metabolizable by primates, those actually metabolizable by *Nycticebus pygmaeus* remain an educated guess. We will continue to weigh individuals in order to monitor the effect the diet is having on them. If their weights continue to decrease and fall below what is considered ideal (418 g for wild males), then the quantity of the diet or its components will be re-assessed (Nekaris

& Bearder 2011). Neither specimen was considered to be overweight by the zoo's veterinarians; however, they were both still above the wild average. A small amount of weight loss was considered to be a positive effect of the change of diet.

The calcium to phosphorous ratio was 0.78 in Diet 1, but drastically increased to 2.97 in Diet 3. A Ca:P ratio of 3 is ideal for the formation and maintenance of bones, and is believed to reduce the chances of metabolic bone disease (Stevens & Hume 1995). The crude fat content was reduced by 13.91 g of dry matter, and crude protein decreased by 18.99 g of dry matter in Diet 3. It has previously been observed that captive *Nycticebus pygmaeus* suffer from renal impairments such as chronic interstitial nephritis (Fitch-Snyder et al. 2001). A very high protein load may be at the root of this problem. The metabolites of protein are filtered out through the kidney tubules, and, at high concentrations, these metabolites have been reported to cause many renal illnesses in humans (Friedman 2004). A lower protein intake may help to reduce or avoid these problems in a captive situation and save some of the veterinary costs incurred by zoos. If such health issues are reduced the loris' longevity and breeding could also be improved. The naturalistic diet (Diet 3) contained higher fibre fractions, with an increase of 2.03 g of ADF and 1.82 g of NDF over Diet 1. The digestive system of *N. pygmaeus* is believed to be able to digest hemi-cellulose, as well as to ferment a small portion of cellulose; therefore, a higher amount of fibre fractions would be appropriate for the gut flora and extend possible benefits to the health of the animal. All vitamins in Diet 3 were present in larger amounts than in Diet 1, due to the larger amounts of gum and nectar, both of which are fortified with vitamins.

Behaviour

Feeding

There was no precedent to judge L1's activity budget during Diet 1 as being 'abnormal', when compared to the same animal's behaviour while feeding on the naturalistic diet (Diet 2). However, it is an interesting way of assessing how the current captive diets have perhaps affected *Nycticebus pygmaeus* (L1). The only feeding behaviour that was shown to be significantly different depending on the diet fed was gouging. This was expected since Diet 1 originally provided gum on only 2 d wk^{-1}; this averaged

out to 0.53% (±0.31) of the observed behaviours being the collection of gum every day on Diet 3. This increased the observed gouging behaviour to 3.96% (±0.68) per day. Even if this result is not a surprise, gouging is the main natural behaviour that is performed by exudate feeders in the wild and is actually relied on as the staple food item of their diet (Starr & Nekaris 2013). Providing opportunities for *N. pygmaeus* to gouge may also help decrease the dental problems that have been observed at many zoological institutions (Fuller et al. 2013, Streicher et al. 2013). Biting through the lignin and having teeth in contact with the structural carbohydrates that occur naturally within gum may be favourable for the condition of their teeth, analogous to flossing for humans. For institutions that rely on free deliveries from supermarkets to feed their animals and have no choice but to feed fruit, providing treegum every day could help to offset the diets high in soft, sugary foods (Streicher et al. 2013). Gum can be provided occasionally and has been shown to act as a source of enrichment, providing physiological benefits by increasing health, as well as reducing stereotypic behaviours (Huber & Lewis 2011).

Other natural feeding behaviours include grabbing a prey item or plant part with 1 or 2 hands while hanging or standing bipedally, followed by bringing the food item to the mouth for consumption (Streicher et al. 2013). Because the bulk of the diet was provided in a bowl, it was common to see *Nycticebus pygmaeus* lean into the food bowl and ingest the diet using his tongue and teeth directly, bypassing the handling. The items found in the bowl included fruit, mealworms, chicks and vegetables, which, in a natural setting, would always be handled before ingestion. At present, there is no evidence to suggest that such 'oral feeding' behaviour is abnormal or harmful. There were no significant differences in either of these feeding behaviours when fruit was removed during Diet 3, but the activity budget did show a slight increase in 'hand feeding'. Feeding on a naturalistic diet could increase naturalistic behaviours, which would include a decrease in oral feeding and an increase in hand feeding; however, this was not the case. The amount of time spent hunting, lunging, grabbing and consuming the locusts in Diet 3 averaged 4.76% (±1.16%), which is slightly higher than the amount of time engaged in gouging behaviour. Naturally *N. pygmaeus* would ingest more gum than insects; however, in the same situation they would also receive most of their energy from gum, in the form of structural carbohydrates (Fleagle 2013). In a captive setting, most of their energy comes from food

items such as fruits, mealworms, or whole vertebrate prey, which do not require or act as a stimulus for gouging. If a richer and nutritionally complete gum were available, then it could become the main source of energy in a captive setting, and, if provided in adequate amounts, should increase the percent of gouging behaviour to levels higher than that of food handling. With this logic in mind, the comparatively greater number of hand feeding observations are not a concern to the animal's welfare as long as a reasonable amount of gouging is also represented.

Overall behavioural expression

All analysed behaviour groups were significantly affected by diet. Travelling behaviours were slightly, yet significantly, higher during the administration of Diet 3 than of Diet 1. The data show that feeding behaviours procured a larger part of L1's activity budget during Diet 3 than during Diet 1. Gouging and nectar feeding are stationary because of the cryptic stance, which includes no movement, to not betray their vulnerable position while feeding (Streicher et al. 2013). Gouging and nectar feeding are behaviours which occur for relatively short periods of time within an interval, but occur often (Streicher et al. 2013). A *Nyctice-bus pygmaeus* can gouge on 1 location for up to 20 min at a time, but constantly be moving between gouging sources and nectar sources (Streicher et al. 2013). They are known to revisit the same site on different occasions nightly as well (Streicher et al. 2013). This behaviour was reflected in captivity, with L1 consuming small quantities of gum and nectar at a time, necessitating higher amounts of locomotion, and it could help to explain why travelling behaviours increased while Diet 3 was given.

The ABP we observed was not a classic case. There is a hatch near the L1 feeding area that links one enclosure to the next, which houses pygmy marmosets *Cebuella cebuella*. The hatch is locked from the outside and cannot be opened from inside the enclosure. L1 spent, on average, 9.64 % (±0.92) of his time clawing at the hatch during the administration of Diet 1. This behaviour is potentially harmful, because of the repeated stress to claws of being forcefully dug into, and dragged through the wood. There is no evidence that *Nycticebus pygmaeus* performs this behaviour in nature. We were not concerned with the causation of this behaviour pattern, but instead aimed to outcompete the time spent performing this behaviour pattern by providing opportunities to perform functional and natural behaviours.

In this study, this behaviour has been shown to be statistically significantly affected by diet, yet the post hoc test did not yield a significant result between diets. The very high effect size between Diets 1 and 3, however, suggests that there is a trend towards a decrease in ABPs on the more naturalistic Diet 3. There is potential for a well-presented, naturalistic diet to decrease ABPs, although, due to the smaller sample size, the results must be interpreted conservatively.

CONCLUSIONS

Our evidence-based diet for *Nycticebus pygmaeus* has proven successful in altering the expression of natural behaviours in 1 male *N. pygmaeus*. By including gum, nectar and insects every day and removing fruit, natural behaviours such as feeding and travelling increased, and ABPs appeared to decrease. The naturalistic diet used was believed to be nutritionally more favourable, which may reduce the occurrence of obesity, and dental and kidney illnesses that are linked to typical captive diets. The 2 individuals used in this study hardly represent the species as a whole; however, they can be used as a starting point for further research of a larger population. A nutritional survey of the zoological institutions currently caring for *N. pygmaeus* should be undertaken to identify its status and needs with regards to the EEP, and naturalistic, evidence-based diets should be recommended to the institutions that would benefit from such knowledge.

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