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HUSBANDRY REPORTS

A Case Study of Malayan Tapir (*Tapirus indicus*) Husbandry Practice Across 10 Zoological Collections

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The Malayan, or Asian, tapir (*Tapirus indicus*) has a diminishing wild population and is becoming more common in captivity as zoos attempt to manage sustainable ex situ populations. Tapirs can be relatively easy to maintain and breed, but captive animals appear to suffer from reduced activity budgets, obesity, and poor public image. A questionnaire-based survey was designed and sent specifically to 10 collections around the world that exhibit Malayan tapirs, with the aim of assessing husbandry regimes to determine prevalence of standardized practices as well as highlighting any key differences, and to showcase good practice, thus providing information beneficial to those maintaining this species in their zoo. Twenty-five animals were included in the survey from collections across four continents. The research's major conclusions show differing dietary make-up, with a lack of forage provision, contrasting with a diverse array of enrichment protocols used. Significant differences were noted between zoos for total amount of food offered (P = 0.000) as well as ratios of forage to concentrate pellet offered (P = 0.004). Comparing food offered to male and female tapirs with published requirements for an "average" of either gender shows not all zoos providing the amount suggested in husbandry guidelines. Intelligently designed and original enrichment was provided to all animals but differences between zoos were noted in the application and "usefulness" of enrichment for individual tapir. Overall, animals are benefiting from enrichment but welfare could be further improved via consistent feeding of ad libitum forage and regular use of browse as a constituent part of daily rations. Zoo Biol. 32:347–356, 2013.

Keywords: Tapir; *Tapirus indicus*; husbandry survey; diet; enrichment; welfare

INTRODUCTION

The Malayan tapir (*Tapirus indicus*), Order Perissodactyla; Family Tapiridae, is a shy, forest-dwelling herbivore from South East Asia [e.g. Gemita et al., 2007], whose range has been extensively reduced in the recent past [Khan, 1997]. Although generally thought of as a nocturnal solitary species [Williams and Petrides, 1980], recent evidence suggests that the Malayan tapir is more social than first thought [Diz, 2006]. Currently classified as Endangered on the IUCN Red List (due to anthropogenic pressures and disturbance of its natural habitat leading to fragmented populations), Malayan tapir is known to exist in Malaysia, Sumatra (Indonesia), Thailand, and Burma [Lynam et al., 2008]. Malayan tapir is maintained in numerous animal collections around the world generally being termed easy-to-keep [e.g. Barongi, 1999; Shoemaker et al., 2004]. As intermediate feeders, Malayan tapirs select fruits, grasses, and browse trees dependent upon season [Janssen, 2003], an important fact to consider when evaluating captive diets. Previous work on tapir nutrition has noted animals being fed too many domestic fruits and vegetables in place of good quality forage, such as lucerne (alfalfa) hay [Clauss et al., 2008, 2009].

The focus of this research is to evaluate various management practices used for maintaining high standards of welfare in captive Malayan tapir. Previous investigation by the authors has noted published research into captive

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husbandry of this particular tapir species to be lacking; a finding concurrent with other authors [Taylor, 2000; Zenzinger, 2003]. Specifically focusing on enrichment, research into Brazilian tapir (*Tapir terrestris*) enrichment protocols [e.g. Sharpe, 1997; Thompson and Rose, 2008; Zenzinger, 2003] appear common, potentially due to the relative popularity of this species in zoological collections when compared to its Asian relative. Limited scientific assessment of Malayan tapir enrichment practice makes such an evaluative undertaking both informative and useful. Rose et al. [2006] reviewed enrichment practice at the East Midland Zoological Society, Twycross Zoo in an attempt to qualify specific regimes that were of most benefit to improving welfare and promoting natural behavior patterns. Behavioral observations on the same animal noted that enrichment had a significant effect on foraging and locomotory behaviors in this individual [Rose et al., 2008]. Work performed by Zenzinger [2003] has shown that browse is the enrichment artifact most used by tapirs, and the one that alters behavior patterns to the greatest extent; a fact that is to be expected as being browsing ungulates, tapirs spend the greatest proportion of their time foraging [e.g. Henry et al., 2000]. Wild Malayan tapirs occupy large home ranges, from 12 km^2 [Eisenberg, 1997] to over 25 km^2 [Traeholt, 2004] and as such, captive enclosures need to be diverse in furnishing and provide occupational stimulation for the inhabitants. Indeed, Foerster and Vaughan's [2004] research highlights the seasonal nature of tapir habitat use, indicating the complexity of wild tapir activity budgets.

The research presented here is of prime importance as the current census from the IUCN Red List 2011.1 shows that Malayan tapir numbers are decreasing in the wild [Lynam et al., 2008]. As such, the ex situ conservation of this species will require support from specific management guidelines and accurate knowledge on the species' individual captive requirements. The slow reproductive rate of Malayan tapirs plus their low wild population density [Eisenberg, 1997] makes the establishment and future continuation of a sustainable captive population an essential conservation strategy.

METHODS

Data collection was part of a student research project and, after contacts were made at the 2006 International Congress on Zookeeping, questionnaires were posted at the start of 2007 to 10 collections that hold Malayan tapir inside and outside of the European Endangered Species Program (EEP) that expressed an interest in being surveyed and involved in the study. Participating zoos were asked to detail the number of animals held, and to provide details on their housing, feeding practice, and enrichment. Zoos were also asked to provide any information on the behavior patterns of their animals, with a specific emphasis on the performance of abnormal (stereotypic) behavior patterns.

Questionnaire Design

The questionnaire consisted of four sections, (1) demographics of the population housed, enclosure design, and any mixed species arrangements; (2) types of enrichment used (on an individual as well as group basis); (3) daily diet for all animals housed; and (4) if any behavioral observations had occurred on the animals in the collection, specifically concerning noted performance of abnormal/unwanted behavior patterns. Sections contained a mixture of open (please describe any stereotypic behavior observed in your animals) and closed (do you provide any form of enrichment; yes or no) style questions. The authors obtained British and Irish Association of Zoos and Aquariums (BIAZA) Research Group support for the survey, which was posted out to a named individual (curator or similar) at those zoos housing this species. Questions were posed in English, as were responses. Questionnaires were generally filled-in thoroughly with all questions being answered fully. Several zoos provided photocopies of diet sheets, enrichment programs, and other such "in-house" information. Several of the returned surveys included contact information for a named individual should any extra information be required; such detail was used by the authors to clarify specific points during analyses.

Collections Involved

The 10 zoological collections that participated in the survey were East Midland Zoological Society: Twycross Zoo, City of Belfast Zoo, ZSL London Zoo, Port Lympne/Howlett's Wild Animal Park, Royal Zoological Society of Scotland: Edinburgh Zoo, Wilhelma (Stuttgart) Zoo, Royal Zoological Society of Antwerp, Singapore Zoological Gardens, Taronga Zoo, San Diego Zoo. In total, these facilities provided details on 25 individual animals (see Table 1).

TABLE 1. Study population of captive Malayan tapir included in the survey

Zoo	Population at time of survey (including adults and young)	Calf (at time of survey) (animal <12 months)	Age range of all animals kept
1	1.1	0	5–8 years old
2	2.1	1	12 months to 16 years
3	1.1	0	30 months to 11 years
4	2.4	0	12 months to 19 years
5	1.1	0	4 years old
6	1.0	0	24 years old
7	1.2	1	~3 months to 15 years
8	1.1	0	3–9 years old
9	1.1	0	13–23 years old
10	1.1	0	15 months to 18 years

TABLE 2. Differences in tapir housing type between each collection surveyed

Zoo	Total number of animals	Housing type	Extra details on enclosure/management
1	2	Housed together	Pair can be split for breeding.
2	4	Housed together	Pair are split when calves are very young.
3	2	Housed separately	Animals share an outdoor exhibit with adjacent indoor pens.
4	6	Housed together	Animals are split into three pairs.
5	2	Housed together	
6	1	Singularly housed	One elderly animal, housed alone.
7	4	Housed together	Male is split from female when she has young.
8	2	Housed together	
9	2	Housed together	Pair can be split, also a mixed-species exhibit.
10	2	Housed together	

Data Analysis

All analyses were undertaken using Minitab version 16. Individual value plots were created to show the spread of the data around specific confidence intervals for amount of feed given, as well as for fiber content of each zoo's diet. One-sample *t*-tests were used to determine any significant deviation away from the recommended amount of feed provided per animal per day. One-factor chi-squared tests were used to compare differences between fiber values from each collection's diet (after Zootrition analysis). A one proportion sign test was used to compare recommended guidelines for ratios of "pellets: concentrates: other" against information provided in survey responses.

RESULTS

Enclosure type

Table 2 shows that all but one collection keeping more than one tapir regularly house their animals socially, and that the majority of collections provided detail on separation of individuals during breeding. Only one collection (zoo 9) keeps their tapirs in a mixed-species enclosure (hereafter termed "MSE"); animals being housed with koi carp (*Cyprinus carpio*) and ruddy shelduck (*Tadorna ferruginea*). The limited number of MSEs could possibly be explained by the potential temperamental nature of Malayan tapirs and the injury that could be caused to cage-mates.

Nutrition

Each collection provided details of the feeding regime in place for all tapirs housed. Table 3 details trends in (1) concentrate type used, (2) preferred forage, and (3) how often tapirs are fed. It appears that a "meal-based" approach to feeding is apparent in some situations.

Inferential analysis shows a significant difference between the amount of food offered daily to each animal between all collections (χ^2; df = 8; P = 0.000). Consequently, there does not appear to be a standard feeding regime in place that these collections are adhering to. It was not possible to analyze the diet from collection 6 as no specific details on quantities, brands, or types of feed were provided. A one-sample *t*-test was used to compare current recommended total daily food provision (as a percentage of body weight) against that detailed from each zoo listed in Table 4. Assuming guidelines from

TABLE 3. Feeding regime for *Tapirus indicus* across 10 zoological collections

Zoo	Feeds per day	Forage type	Pellet type	Extra detail on diet provision
1	2	None given	Equine-based	100% concentrate pellet
2	2	Lucerne (alfalfa)	Equine-based	Ad libitum hay
3	2	Grass hay	Equine-based	Ad libitum hay
4	2	Lucerne (alfalfa)	Equine-based	Ad libitum hay
5	5	Grass hay	Browser pellet	Ad libitum hay
6	2	Grass hay	Equine-based	Mostly concentrate
7	2	Lucerne (alfalfa) and grass hay	Equine-based Grazer pellet	Measured forage amount[a]
8	2	Grass hay	Herbivore pellet	>70% forage (total ration)
9	3	Lucerne (alfalfa)	Dairy-based	Measured forage amount[a]
10	2	Lucerne (alfalfa)	Herbivore pellet	Measured forage amount[a]

[a]The zoo provides a specific volume of hay for each tapir each day.

TABLE 4. Constituent parts of the overall diet offered to individual tapirs at nine out of ten of the collections surveyed (all weights in grams)

Zoo (if weight given)	Total amount given	Dry matter (DM)	Water content	Total pellet	Total fruits and vegetables	Total grains and bread	Total forage
1	11,700	4,391.88	7,308.12	2,000	5,300	1,600	0
2	11,970	7,751.8	4,218.2	7,000	4,970	0	—
3	10,830	4,957.95	5,872.1	4,000	6,830	0	—
4	6,690	2,471.85	4,218.15	1,500	4,690	500	—
5	15,201	4,730.5	10,463	3,020	11,751	430	—
7	12,680	7,744.7	4,895.3	1,800	4,680	1,200	5,000
8	17,100	7,993.78	9,106.23	2,000	3,100	2,000	10,000
9	12,350	8,074	4,276	700	2,850	800	8,000
10	14,624	8,815.25	5,808.75	5,864	5,760	0	3,000

Shoemaker et al. (2004) and estimating a male tapir to weigh on average 340 kg and a female to weigh on average 386 kg, it can be suggested that a male tapir's daily intake should be 15.3 kg/food and for a female 17.4 kg/food. If each collection housed one male and one female animal, and provided the current total daily amount of food to each, then a significant difference away from recommended guidelines can be seen ($t = –2.76$; $P = 0.025$ for an average male tapir and $t = –4.88$; $P = 0.001$ for an average female tapir); see Figure 1.

Numerous health problems can be associated with poor intake of structural carbohydrate; inferential analysis of each collection's dietary fiber component (Table 5) shows a significant difference between values (for crude fiber (CF), χ^2; df = 8, $P = 0.001$; acid detergent fiber (ADF) and neutral detergent fiber (NDF), $\chi^2 = 8$, $P = 0.000$).

Assuming that zoological collections holding Malayan tapir are following the current and readily accessible husbandry guidelines by Shoemaker et al. [2004], it can be assumed that diets in captivity should be formulated of 33% forage, 33% concentrate pellets, and 33% other (produce, browse, or similar). Comparison of diets (Fig. 2) from this research shows that there is significant deviation away from recommended, published, guidelines (one proportion sign test, $P = 0.004$) with regard to standardized forage/pellet provision. Indeed, weights of feed given and ratios stated do not appear to match (Tables 3 and 4), suggesting that measured amounts are not always provided by keepers. Taking a more radical view and assuming that 70% forage to 30% pellet standard should be followed [as per Lintzenich and Ward, 1997], all diets in this study would fail to provide adequate structural carbohydrate (see ratios for concentrate to pellet per diet, Table 6). However, splitting zoos into "European" and "non-European" shows that zoos in the Southern Hemisphere have a higher forage components to their diets (as fed).

Questionnaire data provided detail on a range of grass and legume forages provided to Malayan tapir in different collections. A range of forage types were detailed as being fed to captive tapirs, specifically: barley straw, wheat straw, oat hay, lucerne (alfalfa) hay, timothy hay, and lucerne-based chaff. There was no standard forage type that appeared favored among collections. Drawing on recommended guidelines for browsers, forage with a medium to high protein and NDF content is preferable; however, several collections noted tapirs consumed straw bedding and therefore this has been included as a forage ration.

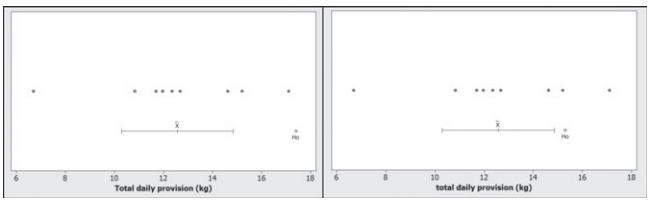

Fig. 1. Individual value plots (with 95% *t*-confidence interval for the mean) showing deviation around the calculated recommended daily provision (represented by H0) for an average female (left) and male (right) Malayan tapir. Each collection's daily provision is indicated by the dots.

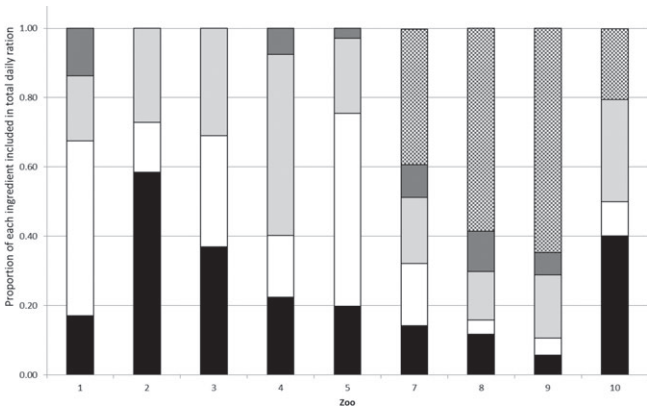

Fig. 2. Ratio of concentrate, fruits, vegetables, "other items"* and forage/browse as a total of the daily ration for captive Malayan tapirs in 9 of the 10 collections (dotted = forage/dark gray = "other"/light gray = vegetables/white = fruit/black = concentrates). *Other including bread, rice, grains.

TABLE 5. Zootrition analysis of total diet for 9 of the 10 collections surveyed

Zoo	Crude fiber (CF) %	Acid detergent fiber (ADF) %	Neutral detergent fiber (NDF) %	Crude protein (CP) %
1	7.58	1.71	1.47	9.49
2	13.74	0.51	0.71	9.91
3	12.60	1.05	1.13	9.32
4	11.17	1.36	1.36	9.92
5	15.93	21.44	29.97	10.71
7	20.39	22.98	31.59	13.50
8	5.66	14.41	8.22	23.51
9	15.50	26.43	37.18	19.63
10	9.63	28.21	15.07	17.31

Enrichment

The majority of collections provide enrichment for their tapirs and details regarding the key forms presented can be seen in Tables 7 and 8. Of the five recognized forms of enrichment (physical, occupational, nutritional, sensory, and social; for more information on categories see Shepherdson, 1998), the results show that enrichment categorized as nutritional, occupational, and sensory types is most often provided. It could be argued that group-housed animals are experiencing social enrichment, and this will be discussed in due course.

The most common browse species reported include willow (*Salix* sp.), ash (*Fraxinus* sp.), sycamore (*Acer pseudoplantanus*), Bambuseae (various species), oak (*Quercus* sp.), lime (*Tilia* sp.), Moraceae (mulberry, fig species), hazel (*Corylus avellana*), sweet chestnut (*Castanea sativa*), poplar (*Populus* sp.), field maple (*Acer campestre*), and beech (*Fagus* sp.). Results appear to suggest that browse is considered more for the purposes of enrichment in European collections, compared to attitudes in non-European zoos.

TABLE 6. Comparison of constituent components of the total diet fed out compared to published guidelines of 30% pellet to 70% forage

		Total ratio of main components		
Ideal ratio	Zoo	Pellet	Forage	Produce
1–2.3 (parts pellet to part forage)	1	1	0	4
	2	1	0	0.7
	3	1	0	2
	4	1	0	3
	5	1	0	4
	7	1	4	4
	8	1	5	1.5
	9	1	11	4
	10	1	0.5	1

DISCUSSION

Using Shoemaker et al.'s [2004] husbandry guide as a baseline, results highlight numerous areas of good practice in the keeping and exhibition of Malayan tapirs in different zoos around the world. It appears that the zoos surveyed meet Hall's [2007] guidelines for tapirs held socially whereby animals need to be separated during calving and calf rearing, potentially due to the chance of dangerous and unpredictable behavior being performed. Wild Malayan tapirs occupy large home ranges, from 12 km^2 [Eisenberg, 1997] to over 25 km^2 [Traeholt, 2004] and as such, captive enclosures need to be diverse in furnishing and provide occupational stimulation for the inhabitants. The results show that collections provided some form of enrichment for their tapirs to increase enclosure utilization and activity in their animals. Current research states that tapirs are generally inactive, due to inappropriate diets causing obesity and altered time budgets [Clauss et al., 2009]; similarly, Green et al. [2007] show that presentation of feed to captive tapirs can affect total activity budgets and behavioral repertoire diversity. Wild tapirs expend the majority of their energy consuming vegetation [Oliveiro-Santos et al., 2010], and calculated times spent foraging range from 8.5 [Novarino, 2005] to 15 hr/day [Holden et al., 2003], depending on habitat type. Therefore, to promote "great welfare" [as per Melfi, 2009], increased opportunities for foraging could be offered. Indeed, Seitz [1998] and Barongi [2000] state that activity of captive tapirs is predominantly influenced by dietary provision and the presence of conspecifics, highlighting links between husbandry and social enrichment.

Encouraging keepers to use low-energy feed items would be highly beneficial as the positive relationship between resting and limited forage opportunity would be reversed. Results suggest that this approach is evident in the survey population and that keepers are attempting to provide rations with some browse content. Collections are using native browse to augment daily rations and at least one zoo stated that they specifically collected types of browse akin to consumed plants in range states to "bulk out" daily diets. Ragone and Cavaletto [2006] demonstrated that fruits from different species of the genus *Artocarpus* contain variable amounts of energy, protein, and fiber, stating that these trees make ideal candidates for sustainable food production.

Field observation suggests that Malayan tapirs are selective browsers and are very specific in terms of ingested vegetation [Williams and Petrides, 1980]. It appears from this research that there are differences between areas of the world in how diets are formulated for this species (Fig. 2); those zoos in the Southern Hemisphere had a greater reliance on forage, browse, and "natural" plant material compared with zoos in the Northern Hemisphere that put a greater reliance on domestic produce and pelleted feeds. Some collections feed locally available browse as a main component of the diet (e.g. *Artocarpus indicus* fruits and leaves fed to

TABLE 7. Enrichment provided for *Tapirus indicus* at the 10 participating collections

Zoo	Enrichment type	Schedule	Time of day	Browse provision
1	N, O, S	Every day	Both AM and PM	Infrequently
2	N, O, S	Twice a week	AM	Yes
3	N, O, S	Every day	Both AM and PM	Yes
4	N, O, S	Every day	Both AM and PM	Yes
5	N, O	Every day	Both AM and PM	Yes
6	N	Twice a week	Both AM and PM	None
7	N, O	Every day	Both AM and PM	Yes
8	N, O, S	Twice a week	PM	Yes
9	N, O, S	Every day	AM	Yes
10	N, O, S	Every day	Both AM and PM	Yes

Type: N = nutritional; O = occupational; S = sensory.

TABLE 8. Array of enrichment provided to Malayan tapirs from the collections included in the survey. Enrichment protocols common to all collections are detailed in the first row

	Enrichment category		
Zoo	Nutritional	Occupational	Sensory
All	Scatter feeding of fruits/vegetables around exhibit. Use of browse to increase roughage intake.		
1	Soaked raisins scattered across grass paddock. Hiding of vegetables within log-piles. Low-sugar jam/honey smeared on enclosure objects.	Forage piles to encourage prolonged feeding. Browse placed in pool. Floating and sinking foods placed in pool. Bark-stripping from cut branches.	Use of compost/peat, different substrates. Heaped chipped bark and piles of old logs. Alternating use of a grass paddock with another ungulate species.
2	Use of whole, not chopped, fruits/vegetables.	Whole feed items placed in pool. Food placed in feed balls for animals to manipulate. Feed/fruit juice frozen in ice blocks.	Use of herbs in specific areas of enclosure. Natural scents spread over logs around exhibit.
3	Use of whole, not chopped, fruits/vegetables. Browse is provided when available.	Target training for grooming and hoof care. Whole apples placed in pool. Whole apples hung on ropes. Squash frozen into ice blocks.	Natural scent marking around paddock.
4	Natural forage growth around expansive grass paddocks enables cut browse provision when animals are kept inside during inclement weather.	Seasonal access to pasture encourages foraging and increases fiber intake. Food placed in feed balls.	Seasonal pasture use to diversify behavioral repertoires.
5	Smearing of peanut butter on logs/tree branches to encourage enclosure exploration.	Target training carried out three times/day to encourage presentation of limbs for examination. Feed placed in feed balls for animals to manipulate. Pool use is encouraged during summer.	
6	Hiding of whole apples around exhibit.		
7	Use of whole fruits/vegetables, specifically melon and squash. Scatter feeding of nuts around enclosures.	Target training and brushing of individual animals. Tapirs are trained for a blood sampling procedure. Heated showers provided in winter.	
8		Fruit of *Lecythis pisonis* is used as a receptacle for enrichments. Tree branches used for de-barking. Hanging of forage and leaves in hay nets.	Hiding of smelly food under logs to increase investigative behavior.
9	Bran mash is used around exhibit.	Feed placed in tubs and feed balls. Fruits are frozen into ice blocks. Animals are brushed, provided with human contact.	Use of essential oils and herbs to encourage investigative behavior. Molasses spread on exhibit furnishings.
10	Smears of sugar-free jelly, peanut butter, applesauce, and banana spread around exhibit. Use of whole pumpkins and melons. Scatter feeding of soaked raisins. Cubes of alfalfa are also fed.	Food placed in a range of feed balls of different sizes. Scratching post made out of yard brush. Pool feeding.	Spices, extracts, and scents spread around enclosure on furnishings. Mulch spread around exhibit to give a variety of substrates. Fresh herbs used to encourage investigation.

animals at the South East Asian zoo). Consequently, work on the components of those plants that occur in the same regions as the wild population of Malayan tapirs could yield interesting results that would be applicable to the formation of a more species-appropriate captive diet.

An explanation centering on the logistics of collecting, growing, and harvesting "native-type" plants/plant material in Northern Hemisphere zoos could account for such discrepancies. Research published by Wilson and Wilson [1973] shows that, historically, fruit and vegetables were a large component of captive tapir diets; the research presented here shows this to be unchanged in some collections. Kawata [2008] refers to the "dire need" for more knowledge on wild diets of even the most commonly housed zoo species. While only an approximation, Figure 1 visibly shows discrepancy between suggested daily amount of food for male and female tapirs, and that actually offered; this deviation being especially pronounced for male animals. Clearly, animals may not consume all that is offered but collections offering up to 3 or 4 kg more than guidelines suggest could think about reducing volume of some dietary items and thus cutting expenditure.

Personal observation, supported by the findings of this study and published work [e.g. Clauss and Dierenfeld, 2008; Hall et al., 2003], identifies the discrepancies between grazer and browser intake. Many zoos provide forage for their tapirs but limited acceptance, high wastage, and an associated reluctance to continue to offer forage seem to be the norm. Veterinary problems associated with other specialized herbivores are linked to poor forage acceptance [e.g. Clauss et al., 2002; Hatt et al., 2005], identifying the importance of a knowledge of evolutionary ecology applied to captive feeding practice. The more specialized the species, the less general the captive management should be. Indeed, comparison between Malayan tapir and black rhinoceros (*Diceros bicornis*) intake highlights, yet again, the issues associated with finding an optimal forage ration for browsing Perissodactyla [e.g. Clauss et al., 2006]. Improvements to the welfare of captive individuals, which have been demonstrated via increases in activity and change to fecal consistency, occur with minor alterations to captive diet [Clauss et al., 2008].

Dietary change not only would benefit welfare but also the public's image of the tapir in the zoo. Seitz [2002] states that the zoo-going public do not find tapirs particularly interesting animals to observe. Similarly, anecdotal evidence collected by the authors of this paper show that the public are generally not very interested in ungulates as a group and find tapirs "boring" due to their inactivity. An objective of an earlier study [Rose et al., 2006] involving Malayan tapir at Twycross Zoo was designed to "make" tapirs more interesting to the public by encouraging the animal to be more active via the use of enrichment. Steiz [1998] supports the idea that tapir can be "made" more interesting to zoo visitors via alterations to exhibit layout and planned use of enrichment, thus directly impacting the conservation/education value of the exhibit.

Only one zoo surveyed attempted an MSE and while the authors know of several collections that mix Brazilian tapir with other species, research suggests that MSE with Malayan tapir to be limited. The large size, shy character, and potential for aggressive behavior in this species may cause zoos to be reluctant to attempt MSE. However, as zoo exhibit design becomes more adventurous and sophisticated, the potential for MSE with difficult species is increased. Added interest in the enclosure, with species from a similar geographic area to the Malayan tapir or inclusion of active or visually attractive animals (as per those included in zoo 9), helps draw in the public and tell a specific conservation and/or educational message [e.g. Hosey et al., 2009]. Interspecific interaction can be used to diversify the behaviors of Malayan tapir in captivity (see zoo 1 in Table 8) and provides another form of enrichment to stimulate and interest captive individuals. It may be that such an exhibit is not feasible in many current collections, due to space and budget demands, and also the potentially volatile nature of the species [e.g. see Janssen, 2003] causing zoo personnel to be wary of multispecies incorporation. What is encouraging is that many of the tapirs in this sample population are housed in enclosures that allow access to a conspecific but that segregation of individuals can be allowed for specific management-related purposes (breeding, parturition, veterinary treatment). Hosey et al. [2009] and Hickey and Rose [2010] detail that interaction with conspecifics can be an important enriching aspect of the captive environment; to be fully enriching for the individual, the animal then must be given the opportunity to remove itself from one situation and enter into another.

Williams and Petrides [1980] state that Malayan tapirs have been observed to congregate in pairs or trios; thus, stating that this species is more social than originally assumed. While tapirs are traditionally considered solitary, if more is known about wild aggregations, this could be factored into captive enclosure design to allow mixing of individuals at particular times or for possible enrichment. The authors know of a case where two Malayan tapirs were maintained in the same enclosure but both had access to individual dens, hence giving the choice of companionship or not. This setup appeared to work well to provide stimulation and chances for social interaction that allow for development of a "full" behavioral repertoire. White et al. [2003] analyzed the effect of rotational exhibition of a range of species, including Malayan tapirs; results showed an increase in important natural behaviors in the tapir, with the conclusion that without the presence of variation in the exhibit, there may not be the chance for some important behaviors to be performed.

Tapirs have been the subject of enrichment studies [e.g. Rose et al., 2006; Sharpe, 1997; Taylor, 2000; Zenziger, 2003] but there is still a relative dearth of available information concerning enrichment methods used for ungulates (when compared to primates or carnivores for example); hence, research into tapir-specific management helps to fill

a gap in knowledge. Indeed, Swaisgood and Shepherdson's [2005] paper on the future "journey" of enrichment studies highlights only one article available on tapir enrichment for the purposes of their research. As a group, ungulates can seem difficult to enrich, but there are guidelines available to act as a starting point [e.g. Burgess/AZA, n.d.; Roddis and Wakefield, 1998; Shepherdson, 1998], and systematic planning for ungulate enrichment can yield interesting results for both animals and keepers alike [Rose et al., 2008; Rose and Roffe, 2008].

It is heartening to note the diverse array of enrichment provided for tapirs at the collections surveyed (Tables 7 and 8) and collections provided some interesting anecdotes alongside of this information. One collection reported poor acceptance of feed balls and specifically that the use of a feed ball depended on the "personality" of the individual tapir, whereas in another collection that employed this form of enrichment, all tapirs used feed balls readily. Contradiction arose between collections as to species of vegetation deemed acceptable to be used for tapir browse; zoos in Europe were particularly divided over the use of white willow (*Salix alba*). Some responses specifically stated that willow was not fed to tapirs as it "is hard to digest," whereas other collections reported willow as being the favorite browse choice of their tapirs with no reported ill-effects. Acceptance of browse can be high, so continued and methodical analysis of browse provision to tapirs is desirable. Melfi [2009] describes a situation where recommended practice for housing and husbandry used for a species is based on empirical evidence of the animal's needs. As befitting this research, more data on wild tapir ecology (specifically concerning diet selection and analysis of wild food choice) fed into captive husbandry practice will further move this species in the direction of excellent welfare overall.

Welfare experienced by tapirs included in this survey appears positive. Stereotypic behaviors were only noticed at two collections and these manifested as locomotory actions normally associated with the presence of a keeper, or the animal anticipating the arrival of an excitatory stimulus (e.g. the arrival of food). All zoos were asked whether or not they conduct nighttime behavioral observations on their tapirs to check "normality" of activity budgets during a period when tapirs are naturally most active. Only two zoos stated that they had ever done this with any form of regularity.

Research by Rose et al. [2008] showed that a singularly housed Malayan tapir portioned different parts of her activity budget to both day and nighttime behaviors, and that increased frequency of activity was observed with the regular provision of a range of enrichment. Interestingly, the effect of enrichment on behavior was more pronounced for daytime activity than during nocturnal observation. The same enrichment provided during the night had no significant impact on behavioral diversity and expected increases in investigative and foraging behavior did not occur. Barongi [2000] states that wild Malayan tapir is more active during daylight than assumed; consequently, it would suggest that more research into the holistic effects of nutritional and sensory enrichment at different times of the day are needed to ensure their relevance to this species overall. Rose et al. [2006] note a similar activity budget in a lone female Malayan tapir when provided with a range of enrichments across different periods of the day. When comparing the findings of Rose et al. with Mahler's [1984] research into captive Brazilian tapir time budgets, similarities do appear; thus, suggesting that well thought-out, evidence-based enrichment [e.g. Rose and Roffe, 2008, 2010] is the optimum way of providing beneficial enrichment to captive ungulates, including tapirs. Kinahan [2001] states that the overall fundamental difference between captive and wild tapir activity budgets concerns time spent actively moving around, or investigating or being able to forage in, the animal's immediate environment. It would appear that certain facets of tapir management impair the species' ability to perform a "wild-type" time budget. It is important to remember that the zoo environment, when compared to a natural habitat, is often controlled and predictable [Kinahan, 2001; Shepherdson, 1998], and not all wild behaviors can be performed exactly for evolutionary purpose. There are key appetitive behavior patterns that fundamentally link to good welfare [e.g. Swaisgood, 2007]; infringement on these behaviors will deprive individuals of the opportunity to best cope with their situation and can lead to stress. The effects of stress on captive tapirs, due to inappropriate housing, husbandry and management are well documented [Janssen, 2003] and hence, stressors should be minimized or removed where possible. The tapir is evidently a difficult animal to exhibit with regard to nutritional requirements and "likeability" with the zoo-going public. Further implementation of species-appropriate husbandry that rectifies or alters provision of care to create positive welfare [as per Yeates and Main, 2008] can benefit behavioral repertoires, activity patterns, and hence public perception.

CONCLUSIONS

1. A summary of the main results show that 70% of the collections surveyed provide some form of enrichment to their tapirs every day and that 70% of collections provide enrichment in the morning and the evening.
2. A total of 90% of collections surveyed provided browse to their animals but only 2 of the 10 collections gave access to ad libitum forage.
3. All Malayan tapirs in these surveyed zoos are managed in enclosures that conform to guidelines based on promoting good welfare in this species.
4. From the results gathered, those European collections contacted appear to not use browse as readily as a main component of tapir diets compared to the non-European collections surveyed.
5. From this research, it appears that there is much good practice evident in the collections surveyed; areas for

improvement identified could be rectified by improved communication between collections, wider dissemination of good practice, and increased inclusion of forage (in whatever form) into daily diets at the expense of fruits, vegetables, and bread.

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Products mentioned in the text

Minitab 16 Statistical Software: statistical analysis program, manufactured by Minitab Inc., State College, PA.

Zootrition V2.6 Dietary and Nutrition Management Software: nutritional analysis program, manufactured by St. Louis Zoo, MO.

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