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Survey of the feeding management of giant anteaters (*Myrmecophaga tridactyla*) and tamanduas (*Tamandua tetradactyla*) in the EAZA ex-situ programme

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Abstract

Feeding giant anteaters and tamanduas as insectivorous species provides a lot of challenges for zoological institutions. In the last decades an in-house mixture, called 'Dortmund mixture', was the most common feed used in giant anteaters and tamanduas in many countries within the European Association of Zoos and Aquaria ex-situ Programme (EEP). Some nutritional problems occurred due to imbalances in the diets. The more recent nutritional recommendations for both species advise an adapted and balanced complete feed formulated for insectivorous species due to different problems arising with an in-house mixed feed as Dortmund mixture. To objectify the present situation a questionnaire was designed and sent out to 78 institutions of the EEPs for giant anteater(s) and tamandua(s). The questionnaire was divided into different sections and asked for data on husbandry, health status, feeding, especially feed composition, feed supplementation and faecal consistency. It was completed by 45 institutions with data for 130 animals, 89 giant anteaters and 41 tamanduas. The data thus represent 54% and 59% of the EEP populations. For both species, a complete feed is mainly utilised. Especially institutions that have integrated anteaters and tamanduas into their facilities during the last 10 and 20 years, use a complete feed. Regarding the in-house mixtures, there are distinct differences, both in composition and amount of each ingredient used. The evaluation of the feeds used for enrichment, for example, shows a clear species difference. While in tamanduas mainly insects are used for this purpose, in giant anteaters it is mainly fruits and avocado. In contrast to the past, many anteaters today are fed an adapted complete feed. Surprisingly, concerning feeding supplements the use of fat-soluble vitamins and combined vitamin–mineral preparations is still common in both species. More effort needs to be put into enforcing current feeding recommendations, especially for the giant anteaters.

KEYWORDS

anteater, feeding management, Myrmecophagidae, nutrition, tamandua

1 | INTRODUCTION

The family Myrmecophagidae includes the genera *Myrmecophaga* Linnaeus, 1758 with only one recent species, the giant anteater (*Myrmecophaga tridactyla:* Linnaeus, 1758), as well as the tamandua, which includes two species, the northern tamandua (*Tamandua mexicana:* Saussure, 1860) and the southern tamandua (*Tamandua tetradactyla:* Gray, 1825) (Gaudin et al., 2018; Hayssen, 2011; Navarrete & Ortega, 2011). In the following, 'tamandua' refers to the southern species, that is, *T. tetradactyla*.

Feeding giant anteaters and tamanduas as insectivorous species provides a lot of challenges for zoological institutions. In the field, giant anteaters consume approximately 30–40,000 ants and termites per day (Möller, 1990), the majority of which are ants (Jiménez et al., 2018; Montgomery, 1985; Redford, 1985). Tamanduas also feed on both ants and termites, although arboreal insects are preferred, mainly depending on the availability in habitats (Gallo et al., 2017). This species has also been described to consume fruits, unlike the giant anteaters (Brown, 2011). In the past, animals kept under human care were often fed with a mixed unbalanced diet composed of meat, dry dog or cat food, dairy products, oatmeal and other ingredients (Puschmann, 2004), also known as the 'Dortmund mixture'. The adaption from this mixed diet to a complete balanced diet has often been accompanied by an impairment of the faecal consistency as well as weight loss up to complete refusal of the new diet (Clauss et al., 2010; Osmann, personal communication, 2021; Wyss et al., 2013). In contrast, in another study on the basal metabolic rate of giant anteaters it was described that these animals have significantly lower maintenance requirements compared to dogs, leading to a higher susceptibility for overfeeding and obesity (Stahl et al., 2012). For this reason, the challenge in keeping anteaters is to provide a diet that is as species-appropriate as possible and does not lead neither to obesity nor emaciation of the animals.

In the last decades, there have been several scientific publications on the feeding of anteaters in captivity in the United Kingdom (Clark et al., 2016) and from North and South America (Jimeno & González, 2004; Morford & Meyers, 2003a; Trusk et al., 1992; Ward et al., 1995). nevertheless, the ex-situ programme of the European Association of Zoos and Aquaria (EAZA) in Europe has not yet collected data on the feeding management of giant anteaters and tamanduas. The hypothesis was, that the feeding regimes within the EAZA still differ extremely and that complete diets are preferred nowadays. Another hypothesis was that different opinions on the species specificity of the ration exist. The objective of the present study was to gather information on the feeding management of giant anteaters and tamanduas in EAZA facilities as well as to have a closer look at the composition of the in-house mixes. The results will be incorporated as current recommendations into the eep husbandry guidelines for giant anteaters and tamanduas and, therefore, will be trend-setting for the feeding of these insectivorous species in the future.

2 | METHODS

A questionnaire was designed and sent to 78 institutions of the EAZA ex-situ programme (EEP) for giant anteaters and tamanduas in spring 2021. Feedbacks received within 3 months were considered. The questionnaire was divided into different sections and asked for data on husbandry and health status, like actually clinical condition. The majority of the questionnaire dealt with feeding management aspects, especially feed composition, feed supplementation, number of feedings, time of the last feed transition and feed used for enrichment. The WALTHAM® Faeces Scoring system (Moxham, 2001) was used to assess the most common faecal consistency. Grade 1 in this score is the driest one, described as 'bullet-like' and Grade 5 is used for watery diarrhoea. The first section of the questionnaire dealt with data on the individuals, such as age, sex and weight. The mean weight was 48.8 ± 8 kg for giant anteaters and 7.2 ± 1.8 kg for tamanduas. At the time of data collection, giant anteaters were on average 11 ± 6 years old and tamanduas 8 ± 5. The questionnaire was completed by 45 institutions with data for 130 animals. The majority of these were giant anteaters with 89 individuals, furthermore, data for 41 tamanduas were collected. Among the 89 giant anteaters, 49 were female and 40 male, and of the 41 tamanduas, 23 were female and 18 male. Ninety-seven percent of the giant anteaters and 85% of the

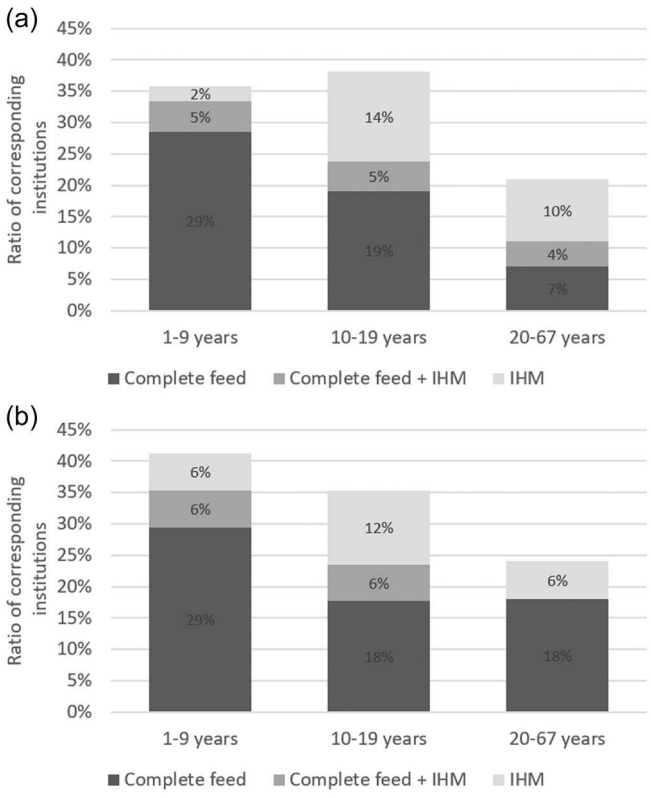
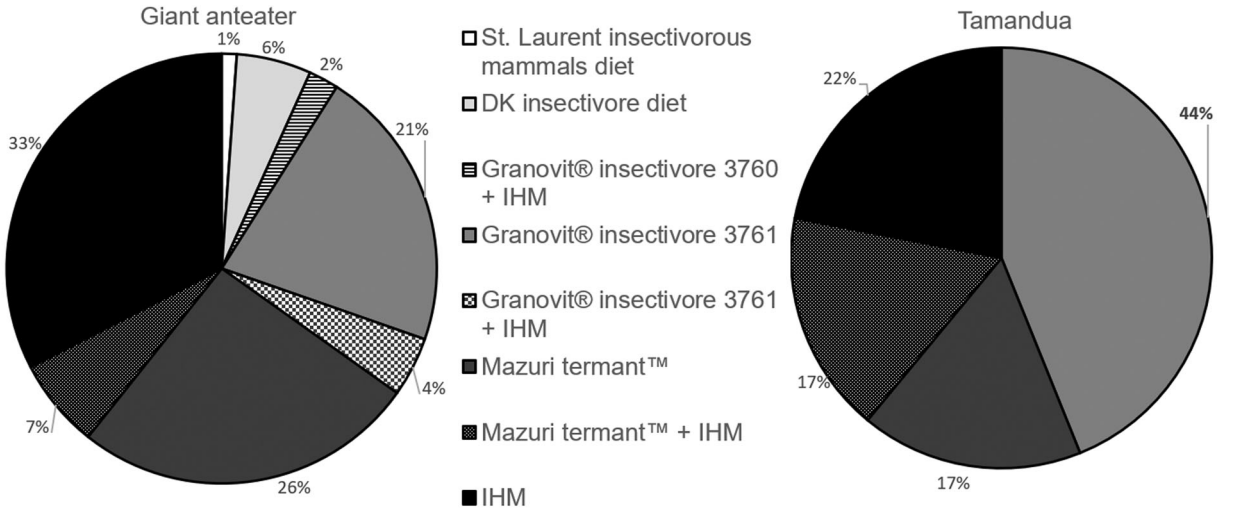


FIGURE 1 Different basic diets, divided into three categories and specified depending on the years of animal husbandry of the species (a) giant anteater (*Myrmecophaga tridactyla*) and (b) tamandua (*Tamandua tetradactyla*) at the individual institution, in-house mixture (IHM).



Basic diet	Giant anteater [N]	Tamandua [N]
St. Laurent insectivorous mammals diet*	1% [1]	0% [0]
DK insectivore diet †	6% [5]	0% [0]
Granovit® insectivore 3760 + in-house mixture (IHM) ‡	2% [2]	0% [0]
Granovit® insectivore 3761 §	21% [19]	44% [18]
Granovit® insectivore 3761 + in-house mixture (IHM) **	4% [4]	0% [0]
Mazuri termant™ ††	26% [23]	17% [7]
Mazuri termant™ ‡‡ + in-house mixture (IHM)	7% [6]	17% [7]
In-house mixture (IHM)	33% [29]	22% [9]

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† Kiezebrink International B.V., Putten, Netherlands
‡ GRANOVIT AG, Kaiseraugst, Switzerland
§ GRANOVIT AG, Kaiseraugst, Switzerland
** GRANOVIT AG, Kaiseraugst, Switzerland
†† Mazuri Zoo Foods, Witham, United Kingdom
‡‡ Mazuri Zoo Foods, Witham, United Kingdom

FIGURE 2 Basic diets and used frequency in giant anteater (*Myrmecophaga tridactyla*) and tamandua (*Tamandua tetradactyla*) in this study, in-house mixture (IHM).

tamanduas were born in captivity. Only 3% of giant anteaters and 10% of tamanduas were stillborn in the wild. Of the 45 zoological institutions that took part in this project, 29 exclusively keep giant anteaters and three exclusively keep tamanduas. The remaining 13 institutions have integrated both species into their animal husbandry. The number of animals listed in the EEP as of 31 March 2021 was 164 individuals for giant anteaters and 69 for tamanduas (Schappert & Bernhard, personal communication, 2021), the data thus represent 54% and 59% of the EEP population. Data analysis was performed by Microsoft Excel©, statistical analysis by SPSS Statistics© Version 22, 2013 (IBM Corporation). The results are provided as average ± standard deviation, total number and percentage. Normality was tested by χ^2 test when possible. Proximate analysis of two different in-house mixtures, sampled by two different corresponding institutions, was performed using standardised methods. Main ingredients of the complete feeds were taken from the respective manufacturers' specification as stated in 2021.

3 | RESULTS

In terms of husbandry, it can be noted that 74% of institutions have added anteaters to their husbandries within the last 20 years. A very small proportion, around 11%, have had experience with anteater husbandry for 40–67 years. In comparison, especially institutions that have integrated giant anteaters and tamanduas into their facilities in the last 10, respectively, 20 years use a complete feed. An overview of the different diets fed in relation to the respective animal species is shown in Figure 1.

The most frequently fed diets were two commercial complete feeds and an in-house mixture. Both species are mainly fed with different complete feeds. But the in-house mixture is used for about a quarter to a third of the animals. Some zoos mix a complete feed with their in-house mixture (Figure 2). Between 2010 and 2021, the diet of 70 animals, giant anteaters and tamanduas, was changed. The largest proportion of these animals, around 37%, were fed Mazuri Termant™ (Mazuri Zoo Foods) prior to the feed change. Other relevant former diets are the in-house mixture and granovit® insectivore 3760 (GRANOVIT AG). This complete diet was fed to 29% and 27% of the anteaters respectively. All animals that received granovit® insectivore 3760 (GRANOVIT AG) before the feed changeover were fed with granovit® insectivore 3761 (GRANOVIT AG) after the changeover. The feeding of Mazuri Termant™ (Mazuri Zoo Foods) was changed to granovit® Insectivore 3761 (GRANOVIT AG) in 9 of 27 animals and to an in-house mixture in eight animals. There are distinct differences between the facilities in the composition of their own food mixes, which are more or less based on the

TABLE 1 Presence of the individual food items in the in-house mixtures (IHM) of giant anteater *(Myrmecophaga tridactyla)* and tamandua *(Tamandua tetradactyla)*, [*N*] number of institutions.

Food item	IHM giant anteater	IHM tamandua
Dry feed		
Dry cat food	33% [6]	38% [3]
Dry dog food	56% [10]	63% [5]
Dried insects	17% [3]	13% [1]
Complete feed		
Leaf-Eater	22% [4]	0% [0]
granovit® 3761[a]	17% [3]	0% [0]
Mazuri Termant™[b]	17% [3]	38% [3]
Meat		
Beef	78% [14]	50% [4]
Horse mince	6% [1]	0% [0]
Poultry meat	0% [0]	25% [2]
Dairy products		
Yoghurt/curd/cottage cheese	50% [9]	63% [5]
Actimel®[c]	0% [0]	13% [1]
Egg		
Egg	78% [14]	75% [6]
Quail egg	0% [0]	13% [1]
Cereals		
Muesli	6% [1]	0% [0]
Oatmeal/oatflakes	44% [8]	13% [1]
Fruits		
Banana	78% [14]	88% [7]
Apple	61% [11]	25% [2]
Melon	17% [3]	0% [0]
Grapes	11% [2]	0% [0]
Kiwi	17% [3]	13% [1]
Orange	11% [2]	25% [2]
Pear	28% [5]	25% [2]
Vegetables		
Tomato	50% [9]	88% [7]
Cucumber	11% [2]	0% [0]
Carrot	6% [1]	0% [0]
Other		
Honey	61% [11]	38% [3]
Shrimp shells	22% [4]	0% [0]
Potting soil	6% [1]	0% [0]
Wheat bran	6% [1]	0% [0]
Sunflower seed	11% [2]	0% [0]
Babybrei	6% [1]	0% [0]
Olive oil	0% [0]	25% [2]

[a]GRANOVIT AG.
[b]Mazuri Zoo Foods.
[c]Danone Deutschland GmbH.

Dortmund mixture, for giant anteaters and tamanduas. Products such as different commercial dry dog or cat food, beef, eggs, bananas and tomatoes are found in almost every feed mix (see Table 1). However, other ingredients such as minced horse meat, grapes, carrots or olive oil are used only sporadically in the in-house mixtures. None of the corresponding institutions stated that they had currently or in the past analysed their own in-house mixtures for nutritional composition. The main ingredients of the different complete feeds named in this survey were 31.6 ± 4.3% for crude protein, 11.0 ± 1.7% for crude fat, 10.9 ± 1.4% for crude fibre, 6.9 ± 1.3% for crude ash and 28.6 ± 3.6% for nitrogen free extracts (NFE). Two in-house mixtures from two different corresponding institutions were analysed using proximate analysis. The main ingredients of this in-house mixtures were 23.2 ± 1.8% for crude protein, 9.5 ± 2.7% for crude fat, 5.0 ± 0.5% for crude fibre, 10.6 ± 4.7% for crude ash and 51.7 ± 0.3% for NFE (Table 5).

Probiotics are used in 3% of the animals and taurine in 13%, with daily amounts ranging from 0.006 to 1.7 g original substance. Vitamin K is the most frequently used vitamin as a feed supplemented. It is daily given in 15 (16%) giant anteaters and 21 (51%) tamanduas. An overview of the use of feed supplements can be found in Table 2. Few institutions reported using a combined vitamin–mineral supplement. Mainly, Supradyn® energy (Bayer AG), a vitamin–mineral concentrate, is used. This vitamin–mineral supplements where mainly used in animals getting an in-house mixture. Peat is used as a feed supplement or as part of the in-house mixture in 35 (39%) giant anteaters and in 5 (12%) tamanduas. Other feed supplements mentioned randomly were healing clay/earth, oak bark and formic acid.

The evaluation of the diseases occurring in the gastrointestinal tract to date revealed 'diarrhoea of unknown origin' was reported most frequently in both giant anteaters and tamanduas. Endoparasitosis and bacterial enteritis were the second and third most frequently mentioned disorders. Other diseases mentioned and their frequency are listed in Figure 3. In total, 86 giant anteaters and 38 tamanduas were reported to receive enrichment foods or rewards and treats on a regular basis. For both giant anteaters and tamanduas, various insects as well as yogurt or avocado are primarily used for these purposes (Table 3). Proportionally, however, more insects are used in tamanduas. In both species,

TABLE 2 Frequency of the mentioned feed supplements in accordance to the basic diet complete feed (CF), complete feed + in-house mixture (CF + IHM) and in-house mixture (IHM) in giant anteater (*Myrmecophaga tridactyla*) and tamandua (*Tamandua tetradactyla*).

	Giant anteater			Tamandua		
	CF [N]	CF + IHM [N]	IHM [N]	CF [N]	CF + IHM [N]	IHM [N]
Vitamin C	0% [0]	0% [0]	7% [2]	4% [1]	0% [0]	0% [0]
Vitamin K	4% [2]	0% [0]	45% [13]	36% [9]	100% [7]	56% [5]
Vitamin E	0% [0]	0% [0]	0% [0]	0% [0]	0% [0]	33% [3]
Biotin	0% [0]	0% [0]	3% [1]	0% [0]	0% [0]	0% [0]
Nekton® MSA[a]	0% [0]	0% [0]	0% [0]	0% [0]	0% [0]	22% [2]
Supradyn® Protovit[b]	0% [0]	0% [0]	0% [0]	0% [0]	0% [0]	22% [2]
Vibowit®[c]	0% [0]	0% [0]	0% [0]	0% [0]	0% [0]	11% [1]
Supradyn® energy[d]	0% [0]	0% [0]	7% [2]	0% [0]	0% [0]	33% [3]
Supradyn® forte[e]	0% [0]	0% [0]	7% [2]	0% [0]	0% [0]	0% [0]
olivitasol®[f]	4% [2]	0% [0]	7% [2]	0% [0]	0% [0]	0% [0]
Taurin	13% [6]	17% [2]	28% [8]	4% [1]	0% [0]	22% [2]
Peat	21% [10]	75% [9]	55% [16]	12% [3]	29% [2]	0% [0]

[a]NEKTON GmbH.
[b]Bayer Portugal LDA.
[c]Teva Operations Poland Sp. Z o.o.
[d]Bayer Vital GmbH.
[e]Bayer Austria Ges.m.b.H.
[f]Vetoquinol S.A.

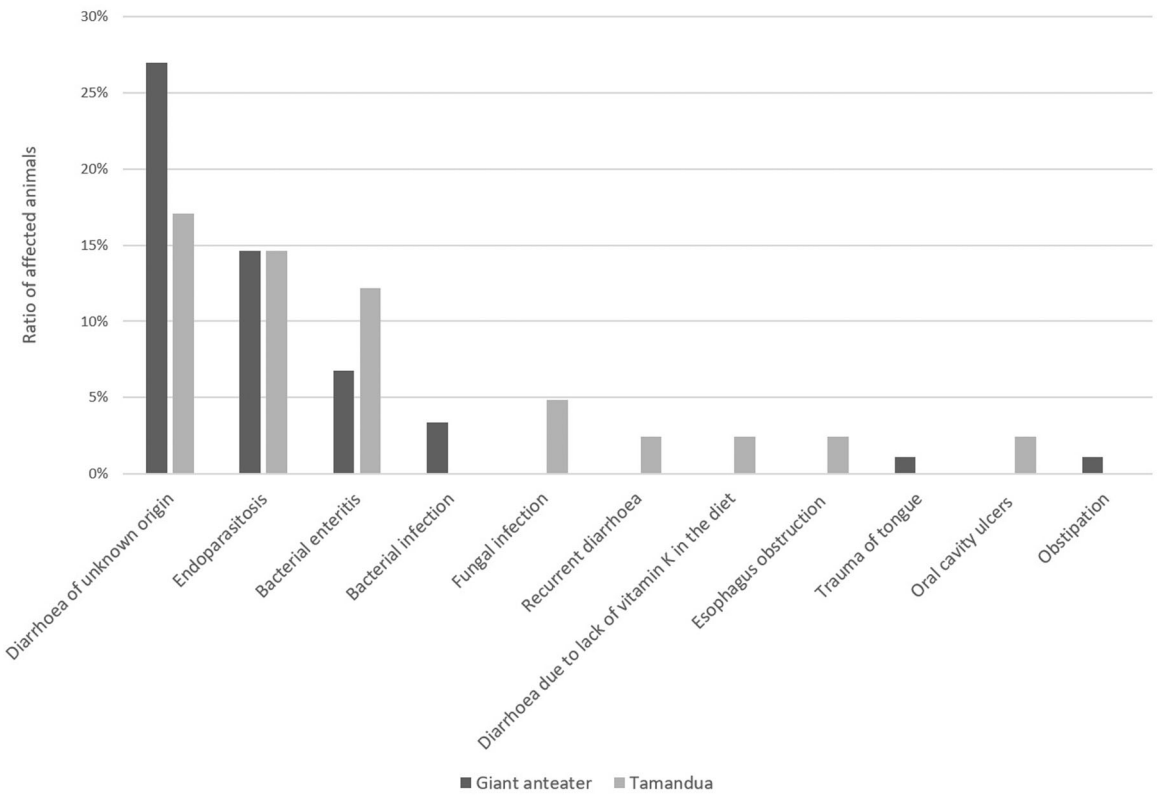

FIGURE 3 Ratio of all giant anteaters (*Myrmecophaga tridactyla*) and tamanduas (*Tamandua tetradactyla*) in the study affected by the resptective disease/clinical sign.

TABLE 3 Ratio of feed items used for enrichment purpose in giant anteater (*Myrmecophaga tridactyla*) and tamandua (*Myrmecophaga tridactyla*) as a percentage of all food enrichments mentioned, [*N*] sample size.

	Tamandua [*N*]	Giant anteater [*N*]
Insects		
Mealworm	20% [23]	7% [16]
Rose chafer larvae	4% [5]	0% [0]
Grasshoppers/locusts	4% [5]	2% [4]
Cricket	9% [10]	8% [20]
Zophobas	4% [5]	2% [5]
Wax worms	7% [8]	1% [2]
Morio worms	1% [1]	1% [2]
Termites	0% [0]	0% [1]
Cockroach	1% [1]	0% [0]
Mold beetles	3% [3]	0% [0]
Feed of animal origin		
Yoghurt	8% [9]	21% [49]
(Juvenile) Mice/rat	1% [1]	7% [16]
Blood	0% [0]	1% [2]
Rabbit	0% [0]	1% [2]
Chicken	4% [5]	2% [5]
Egg	6% [7]	5% [12]
Fruits/vegetables		
Tomato	2% [2]	0% [1]
Avocado	15% [17]	27% [64]
Fruits (banana, orange, melon)	6% [7]	10% [24]
Other	3% [3]	6% [14]
Honey/honeycomb		
Dog pellet	2% [2]	0% [0]

whole prey (mice, rat, chicken or rabbit) is fed. A further difference is the use of fruits, which are fed more frequently to giant anteaters than to tamanduas.

The WALTHAM® faeces scoring system (Moxham, 2001) was used to assess the most common faecal consistency. In cases where several scores were marked for one animal, only the lowest score was included in the evaluation. As can be seen in Table 4, the median consistency score is lower when peat is added to the basic diet. Overall, faecal consistency is better in tamanduas (2.8 ± 0.6) than in giant anteaters (3.3 ± 0.7). The faecal consistency, scored by the WALTHAM® faeces scoring system, was divided into two groups, score 1–3 was considered physiological and scores 3.5–5 was considered nonphysiological. There was no correlation between the use of a complete feed and an in-house mixture ($p = 0.140$, $n = 75$) regarding the faecal consistency in giant anteater. Due to data availability, the same evaluation for tamandua was not possible.

4 | DISCUSSION

Feeding of giant anteaters and tamanduas appears to vary widely by continent or country. The hypothesis, that complete feeds nowadays are used predominantly within the institutions of the EEP was confirmed. Clark et al. (2016) reported similar results for the United Kingdom were mainly Mazuri Insectivore™, Mazuri Zoo Foods, a commercially available complete feed, is used. In contrast, Morford and Meyers (2003a) reported that a mixture of Leaf-Eater pellets and dry cat food is primarily used in the United States. Thus, the completeness as well as the balancing is not guaranteed due to the lacking appropriateness for anteaters. Also in this study, some institutions reported using Leaf-Eater pellets in their in-house mixture for giant anteater. This mixture is attributed to Mark Edwards, Society Nutritionist for the San Diego Zoological Society (Morford & Meyers, 2003a). However, it is important to keep in mind that Leaf-Eater pellets contain high levels of vitamins A- and D, and thus there is a high risk for hypervitaminosis caused by these two fat-soluble vitamins. Cases of hypervitaminosis A and D have each been described for giant anteaters and tamanduas (Cole et al., 2020; Osmann, personal communication, 2021; Crawshaw & Oyarzun, 1996). Clinical signs in a giant anteater associated with hypervitaminosis D included lethargy, occasional vomiting, variable faecal consistency and pruritus in addition to weight loss and anorexia (Cole et al., 2020). A high vitamins A and D content in the diet of tamanduas kept in North and South America was already found by Trusk et al. (1992). In this study, a relationship between skeletal abnormalities and tissue mineralisation and hypervitaminosis A and D was also suspected. In comparison, skeletal changes such as vertebral hyperostosis due to hypervitaminosis A have been described for the domestic cat (Corbee et al., 2014). For other Carnivora such as the red panda, periarticular exostoses due to presumed hypervitaminosis A have also been published (Lynch & Slocombe, 2002). Any basic feed for giant anteaters and tamanduas should, therefore, be evaluated very critically for vitamins A and D content. Despite the known sensitivity to hypervitaminosis A and D, the use of vitamin–mineral supplements containing very high levels of these vitamins was reported by some institutions. It seems that this issue should be better communicated through the EAZA's respective ex-situ programmes and the fact that fat-soluble vitamin levels in the basic diet for anteaters should be kept as low as possible should be included as essential into the husbandry guidelines.

The current evaluation demonstrates that the Giant Anteaters within the EEP are predominantly fed with complete feeds. However, 33% of the animals are still fed with an in-house mixture which is quite a large percentage. The 'Dortmund mixture', on which the in-house mixtures are based, was developed in the 1980s at Dortmund Zoo (Bartmann, 1983) and was recommended to other institutions over many years,

TABLE 4 Reported faecal consistencies depending on the basic diet using the WALTHAM® Faeces Scoring System (median, sample size) and in-house mixtures (IHM).

	Giant anteater			Tamandua		
	$\bar{x}$ faecal score all animals [*N*]	$\bar{x}$ faecal score in animals with peat added to the basic diet [*N*]	$\bar{x}$ faecal score without peat added to the basic diet [*N*]	$\bar{x}$ faecal score all animals [*N*]	$\bar{x}$ faecal score in animals with peat added to the basic diet [*N*]	$\bar{x}$ faecal score without peat added to the basic diet [*N*]
St. Laurent insectivorous mammals diet[a]	4 [1]	NA [0]	4 [1]	NA [0]	NA [0]	NA [0]
DK insectivore diet[b]	3.5 [5]	3.5 [2]	4 [3]	NA [0]	NA [0]	NA [0]
Granovit® 3760[c] + IHM	3 [2]	3 [2]	NA [0]	NA [0]	NA [0]	NA [0]
Granovit® 3761[c]	3.5 [19]	3 [2]	3.5 [17]	3 [18]	2 [3]	3 [15]
Granovit® 3761[c] + IHM	4 [4]	4 [3]	4 [1]	NA [0]	NA [0]	NA [0]
Mazuri termant™[d]	3.5 [23]	2.75 [6]	3.5 [17]	2.5 [7]	NA [0]	2.5 [7]
Mazuri termant™[d] + IHM	4 [6]	3.5 [4]	4 [2]	2.5 [7]	3.25 [2]	2.5 [5]
IHM	3 [29]	2.75 [16]	3.5 [13]	3 [9]	NA [0]	3 [9]

[a]SAINT LAURENT SAS.

[b]Kiezebrink International B.V.

[c]GRANOVIT AG.

[d]Mazuri Zoo Foods.

TABLE 5 Mean of the main nutritional values of different complete feeds and in-house mixtures for giant anteater (*Myrmecophaga tridactyla*) and tamandua (*Tamandua tetradactyla*) in comparison to stomach content of tamandua published by Oyarzun et al. (1996) [*N*].

	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Crude ash (%)	NFE (%)
Complete feed for insectivore [5]	31.6 ± 4.3	11.0 ± 1.7	10.9 ± 1.4	6.9 ± 1.3	28.6 ± 3.6
In-house mixture for insectivore [2]	23.2 ± 1.8	9.5 ± 2.7	5.0 ± 0.5	10.6 ± 4.7	51.7 ± 0.3
Stomach content of tamandua (Oyarzun et al., 1996)	50.9 ± 1.6	11.2 ± 2.9	NA	13.9 ± 2.7	NA

especially within the EEP. Therefore, the currently still practised feeding regimes of an in-house mixture for giant anteaters could, on the one hand, be based on purely historical aspects. On the other hand, it can also be attributed to the fact that with this mixture, it was demonstrably possible to keep the animals until middle, and in some cases, old age, as well as to record good breeding successes. For consequences of changing the feeding regime of giant anteaters from an in-house mixture to a commercial complete feed often range from weight loss to feed refusal (Clauss et al., 2010; Osmann, personal communication, 2021; Wyss et al., 2013), some animals keepers tend to stick to the 'proven feed'.

Likewise, most of the tamanduas in the EEP are fed with a complete feed. Our observations show that the change of feed for this species is less difficult than the change of feed for giant anteaters. The keeping of this species expanded within the last 10 years, so it can be assumed that the respective institutions have only recently become more intensively involved in the feeding of tamanduas. The more current recommendations for feeding tamanduas prefer a complete feed specifically for insectivores instead of a 'Dortmund mixture' (Jimeno & González, 2004; Valdes & Brenes Soto, 2012). Table 1 shows how different the individual in-house mixtures can be. Because not only the respective components but also their amounts in the total mixture differ, the variability of the mixtures is very high. Consequently, animals that were used to an in-house mixture before being transferred to another zoological facility may receive a completely different in-house mixture in the recipient facility and, therefore, first significantly reduce or stop their feed intake. This is a common problem in the shipment of giant anteaters (Clauss et al., 2010; Osmann, personal communication, 2021). The more animals are fed with a similarly composed complete feed, the more convenient a feed transition could be for the individuals after animal transport in the future.

An essential ingredient of all in-house feed mixtures is raw meat, especially beef but also horse or chicken. However, the use of raw horse meat in particular is critical, as lethal meningitis has already occurred in the Southern Tamandua due to transmission of *Streptococcus equi* ssp. *zooepidemicus* (Yuschenkoff et al., 2021). In the present study, it was noticeable that an in-house mixture was fed to all animals in which bacterial enteritis was reported as having occurred to date. In contrast to a processed finished feed, raw meat provides a good breeding ground for microbial growth and could,

therefore, lead to foodborn illness in animals (Strohmeyer et al., 2006). Thus, the use of raw meat may have a greater impact on anteater health than previously thought. In addition, it leads to an unbalanced ration, if not calculated accurately.

The evaluation of the feeds used for enrichment, shows a clear species difference. While in tamanduas mainly insects are used for this purpose, in giant anteaters it is mainly fruits and avocado. In the wild, however, only the tamandua has been described to consume fruits (Brown, 2011).

In their original habits, anteaters have a diet consisting mainly of ants, termites and, in the individual cases of tamanduas, fruits (Brown, 2011; Gallo et al., 2017; Lubin et al., 1977; Oyarzun et al., 1996). The natural diet thus mainly consists of protein and fat as it is described for tamandua stomach content by Oyarzun et al. (1996). They found values of 50.85 ± 1.64% for crude protein. In contrast the mean value for crude protein in the complete feed in this study was 31.6 ± 4.3% and for the in-house mixes even only 23.2 ± 1.8%. For the crude fat content, the mean value of the complete feeds corresponds to the value found by Oyarzun (11%). The in-house mixes are slightly lower at 9%. Thus, the modern complete feeds seem to be closer to a natural diet in terms of crude protein and crude fat content than the traditional in-house mixes (see Table 5). The previously frequently fed 'Dortmund mixture', however, consists to a high degree of carbohydrates (Stahl et al., 2012). There are recent studies in other species, examining the role of diet and the gut microbiome in several chronic diseases (Singh et al., 2017). Nutrition-related diseases play a major role in giant anteaters. Chronic diarrhoea and poor faecal consistency are the most common clinical manifestations (Morford & Meyers, 2003b). Further research is needed on the influence of differently composed diets on the gut microbiome, and related diseases like diarrhoea in giant anteaters and tamanduas. In literature, faeces of wild anteaters are described as big and cylindrical-like bars (Chame, 2003). In the present study, the median scores of faecal consistencies in giant anteaters for the different diets were between scores 3 and 4. This means that faecal consistency is mainly described between 'moist, beginning to lose form' and 'the majority of form is lost, poor consistency'. A too-soft faecal consistency has often been described for giant anteater under human care (Gull et al., 2015; Morford & Meyers, 2003b; Stahl et al., 2012; Valdes & Brenes Soto, 2012; Wyss et al., 2013). This was also confirmed in the present study. But the average faecal score was in most cases 1 score better (drier) when peat was added to the basic diet. In one experiment, only the influence of chitin on faecal consistency has been tested so far. Leuchner et al. (2017) could not demonstrate any modification of the faecal consistency when adding different amounts of chitin to two different basic diets. Further studies on the influence of peat on faecal consistency are needed.

Overall, the trend in feeding giant anteaters and tamanduas seems to be towards an adapted complete diet. As there is limited variance in the natural diet, a complete diet consisting primarily of insect protein is most likely to meet the needs of these dietary specialists. Whether the switch to a complete feed will lead to fewer alimentary and metabolic diseases in the future should be investigated.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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