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Investigating Market and Conservation Education Influences on Global Zoo and Aquarium Animal Collections

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Abstract

There is evidence to suggest that visitors to zoological collections prefer to see large, active mammals. To attract visitors, zoos and aquariums might be tempted to select for mammal species in their collection plans to maintain visitor interest. However, collections also play a role in endangered species breeding, many of which are not mammals. Using *International Zoo Yearbook* data, we explored the number of species of mammals, birds, reptiles, amphibians, fish and invertebrates housed in collections across the globe. These data were compared against three hypothetical collection plan strategies: a) marketing, as shown by the prevalence of each taxon in toy retail; b) biodiversity, in which taxa in proportions that reflect their wild abundance, and c) in which all six taxa are represented equally. The global zoological collection plan indicated that on average, collections contain more bird species than other taxonomic groups, followed by fish, mammals, invertebrates, reptiles and amphibians.

Keywords: collection planning, biodiversity, zoos, aquaria, retail

1. Introduction

Given the accelerated loss of biodiversity globally, zoos and aquaria have taken up key roles in both *in situ* and *ex situ* conservation (Buckley, Smith, Crook, Pillans, & Kyne, 2020). According to the "World Zoo and Aquarium Conservation Strategy" (WAZA, 2015), zoological collections now have a duty to engage their visitors in education programmes that enhance their understanding of biodiversity conservation. Many zoos and aquaria use their living collections as ambassadors to help educate the public, in addition to other conservation strategies, such as captive breeding and providing funding for reserves (Hutchins, Roberts, Cox, & Crolly, 1998; Hutchins & Thompson, 2008). To help visitors understand the range of threats that wildlife face, collections should showcase a broad range of species representing many taxonomic groups. The alternative; holding only one taxon, such as primates, might leave visitors with an inadequate understanding of threatened species (Goulart et al., 2009).

Zoological collections clearly have a role to play in terms of conservation education, yet they

must also meet the expectations of their public. Globally, many collections are funded in part or entirely by visitors (WAZA, 2020). This means that any factor that reduces visitor numbers, such as poor reputation or the recent COVID-19 opening restrictions, has the potential to impact a collection's ability to provide conservation and education (WAZA, 2020).

On one hand, zoos and aquaria must provide conservation education and house thriving populations of threatened species (Conway, 2003). On the other, they must ensure they have satisfied the expectations of their public, who may be looking for other species during their zoo and aquarium trips. For example, there is considerable evidence to suggest that many visitors are interested not in seeing the most endangered species, but in the largest, brightest, most active, mammal species (Frynta, Lišková, Bültmann, & Burda, 2010; Courchamp et al., 2018).

1.1 Historic Perspectives on Collection Planning

Some of the earliest evidence of zoos dates back to 2,500 BC, Egypt (Lauer, 1976). Early collections contained a range of birds and mammals, notably hyaenas, felids, baboons, cranes and storks, and royal collections in ancient Egypt and Mesopotamia are known to have housed elephants, giraffes, primates and antelopes. While the exact collection plans for royal menageries remain unknown, it is clear that large mammals have played a dominant role within these zoos.

Some of the oldest extant zoos date back to the late 18th and 19th Century, with The Tiergarten Schönbrunn (Vienna zoo) opening in 1752, and the Zoological Society of London's (ZSL) London zoo opening in 1828 (Lees & Wilcken, 2009). Originally formed as royal menageries, or in the case of The Zoological Society of London's (ZSL) London zoo, for the scientific community, the formation of collection plans was guided by the interests of individuals and the availability of animals.

Animals in early collections, therefore, may have been selected as curios, rather than for their conservation value. There is evidence to suggest that as a result, many collections focused particularly on bringing in mammalian and avian stock (Shora et al., 2018; Brereton & Brereton, 2020; Green et al., 2022). The role of zoos and aquaria in conservation was not realised until the mid-twentieth century, at which point many collections were already well established (Durrell, 1953; Gusset & Dick, 2011). This relatively recent transformation to conservation-oriented establishments may impact the ability of many collections to fully achieve their mission.

Animal collections may only obtain new animals through six strategies: 1) birth or hatching, 2) trade with other collections, 3) donation, 4) confiscation, 5) purchase or 6) collection from the wild (Smith, Hutchins, Allard, & Warmolts, 2002). Collection of animals from the wild is now rare for zoos, and the Convention on the International Trade of Endangered Species of Fauna and Flora (CITES) places further restrictions on the movement of endangered species (Wilkinson, 2000). Ultimately, this limits the speed with which animal collection plans can change; zoos cannot always obtain new species unless they are already housed at other collections.

In the United Kingdom, the British and Irish Association of Zoos & Aquariums (BIAZA) suggest that roles should be designated to each species housed within a collection (Moss & Esson, 2010). These roles may include exhibit or education value, *ex situ* or conservation breeding, or research benefits (Moss & Esson, 2010). In this respect, all species should have a justified purpose within a zoological collection (Stoinski et al., 1998).

1.2 Visitor Interests in Zoo Animals

As zoos and aquaria are funded in part or entirely by their visitors, it is important that they are familiar with the favourite animals of their funders (Moss & Esson, 2010). Courchamp et al., (2018), in a large-scale survey, identified the public's 10 favourite animal species. All ten species identified were mammalian, with the majority featuring in either the Carnivora (big cats, wolves, bears) or primates (gorillas) order. Generally, zoo visitors show greater interest in larger (Ward, Moserberger, Kistler, & Fischer, 2008; Moss & Esson, 2010), brighter coloured (Frynta et al., 2010; Lišková & Frynta, 2013), and more active animals (Carr, 2016). There is also strong evidence to suggest that zoo and aquarium visitors prefer to see mammals above all other animal classes (Margulis, Hoyos & Anderson, 2003; Moss & Esson, 2010).

Unfortunately, this taxonomic bias toward large, active, brightly coloured mammals is not always compatible with zoo and aquarium conservation

output. According to Chapman (2009), approximately 95.6% of all extant animal species are invertebrates: many of these are threatened with extinction. In order to *mirror* biodiversity, mammals, birds, reptiles, fish and amphibians should make up less than 5% of each animal collection. It is unlikely that large collections of molluscs and invertebrates will have attracted power for visitors, however.

There is already considerable research available that suggests there is a taxonomic bias toward mammals in terms of zoo research (Melfi, 2009; Whitham & Wielebnowski, 2013; Stoinski et al., 1998), and in literature (Bajomi, Pullin, Stewart, & Takács-Santa, 2010). Investigations into taxonomic diversity among zoos are valuable to determine whether this bias extends into collection planning.

1.3 Taxa Bias and the Retail Industry

In contrast to zoological collections, retail industries are not required to contribute to conservation or education; the greatest influence of taxa choice is therefore likely to be popularity. Toy manufacturers must produce items that are attractive, and therefore easy to sell to their audience (Sigsgaard, 2009). If a particular product is unpopular, the item may be rapidly discontinued, and new models created. In this sense, toy manufacturers may reflect in part the zoo animal preferences of the general public (Skibins, Dunstan & Pahlow, 2017). Retail organisations could therefore be used as a barometer to compare against existing collections. If zoo collection plans reflect the species composition of toy catalogues, our collections may be considered to be reflective of the preferences of the general public (Rather, 2020).

The aim of the study was to investigate the composition of zoo and aquarium collection plans, to determine which taxa are most commonly housed. The study also aimed to investigate the market and conservation influences on collection plans by comparing them against toy retailer species diversity and wild species numbers.

2. Methods

2.1 Global Collection Plan

Quantitative data was compiled with regards to the number of species housed in zoos & aquaria across the globe. Animals were categorised into one of six taxa: mammals, birds, reptiles, amphibians, fish and invertebrates. Records from individual zoos and aquariums were obtained by using copies of the *International Zoo Yearbook* in the chapter entitled "Zoos and aquariums of the World". We recorded information on all zoos and aquaria recorded in the Yearbook, from volume 39 (published 2005), through to volume 52 (published 2018) to identify how collection plans have changed over time.

Collections were excluded if they did not record the number of animal species housed in their collection. In addition to the numbers of species for each taxon, further variables were recorded including the size of the zoo (in hectares), the annual visitor attendance, membership to regional organisations such as BIAZA or WAZA, continent and country.

All individual collection plans were converted into proportions (%). From these converted data, an 'average' zoo collection plan was calculated, both for each individual continent and globally.

2.2 Comparisons

The possible influences of three different collection planning strategies were tested. These were a) marketing-centric, in which zoos house animals that satisfy the interests of the public, b) biodiversity oriented, in which zoos represent each taxon at the same level which it appears in nature, and c) proportional representation, in which all taxa are equally represented.

For a), the marketing perspective, catalogues of *Schleich*™ animal figurines were analysed to produce toy 'collection plans'. Catalogues from 2005 to 2018 were analysed in terms of the number of species being advertised. Each species was counted only once per year, and where subspecies (e.g dog *Canis lupus familiaris)* or colour morphs (e.g white tiger *Panthera tigris)* were included in the catalogue, these were excluded if the species had already been counted. In cases when multiple models were advertised for a single species, the species was just counted once. Extinct animals, fantasy animals and cartoon characters were excluded from the analysis. In years when catalogues were produced biannually, each species was counted only once, even if it appeared in both booklets. The numbers of each taxon were converted into percentages, and an average representation of each taxon was calculated for the period 2005-2018.

For b) biodiversity representation, the number

of extant species in each of the taxonomic groups was lifted from Chapman's (2009) study of Earth's animal biodiversity. For c) proportional representation, all taxa were assumed to be equally well distributed in zoos, so a proportional representation of 16.66% (100%/6) was calculated per taxa.

2.3 Data Analysis

Data were compiled into a spreadsheet using Microsoft Excel™ 2016, and statistical analysis was undertaken using Minitab 18. First, graphs were produced to show the average number of species of all taxa in the most recent *International Zoo Yearbook* data, and per continent. Next, a line plot was produced to show how species representation in zoological collections had changed over time.

The zoological collection plan information was now converted into percentages, and compared against the representation of the six taxa in Schleich™ catalogues and in nature. As percentages, the collection plan averages per taxa per year were compared against the Schleich™ taxonomic representation using Spearman's rank correlations.

3. Results

3.1 Global Collection Plan

An 'average' collection plan was calculated for all zoos and aquaria combined, and then each continent (Figure 2), and globally (Figure 1). Figure 1 shows that of all taxa in 2018, birds (57.88 spp., 31.37%) have the highest average number of species, followed by fish (55.18 spp., 15.07%), mammals (42.72 spp., 28.24%), invertebrates (32.45 spp., 8.30%), reptiles (29.86 spp., 14.34%), and amphibians (6.70 spp., 2.68%).

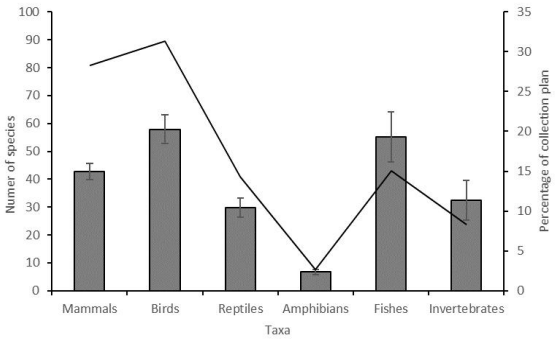

Figure 1. Average number of species of each taxon in the average zoological collection in 2018 (± standard error), plus the percentage each taxa makes up for the average collection plan

Figure 2 illustrates the average number in each taxon, with collections organised according to their continent (± standard error), for all years from 2005 to 2018. The number of mammals appears to be relatively constant across continents. However, there is considerable variance in terms of the average number of species of birds, fish and invertebrates.

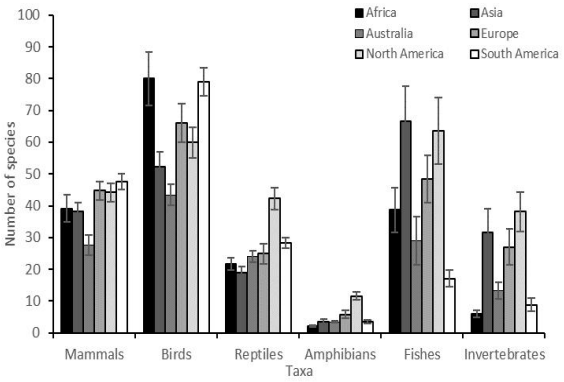

Figure 2. Number of species of each taxon in the average collection plan, categorised by continent

3.2 Comparisons with Toy Retail and Biodiversity Sores

The numbers of species per taxa for Schleich™ figurines were collected across the study period from 2005-2018, and were averaged. Chapman's (2009) recordings of the total number of species per taxa were also used: both sets of values were converted into percentages so that they could be compared against the zoo and aquarium average collection plans (Table 1). From the data, mammals appeared to be over-represented for Schleich™ at over 70% of the advertised species per year. Conversely, mammals were identified as the taxa with the fewest species by Chapman (2009) at only 0.39% of animal species diversity.

Table 1. Number of species, and percentages representation of each taxonomic group according to three different collection planning strategies

	Mammals	Birds	Reptiles	Amphibians	Fish	Invertebrates
a) Schleich™	58.43 spp.	11.64	4.50 spp.	1.07 spp.	5.71 spp.	1.21 spp.

catalogues (average 2005-2018)	(70.76%)	spp. (14.1%)	(5.45%)	(1.3%)	(6.92%)	(1.47%)
b) Biodiversity (Chapman, 2009)	5,487 spp. (0.39%)	9,990 spp. (0.70%)	8,734 spp. (0.61%)	6,515 spp. (0.46%)	31,153 spp. (2.19%)	1,359,365 spp. (95.64%)
c) Proportional representation	16.66%	16.66%	16.66%	16.66%	16.66%	16.66%

Throughout time, mammals remained the most common taxa in terms of number of species in Schleich™ catalogues (Figure 3). Birds were the next most common taxa in terms of number of species, and reptiles, amphibians, fish and reptiles were rare. By contrast, for the average zoological collection plan, birds were consistently the best represented taxonomic group (Figure 4).

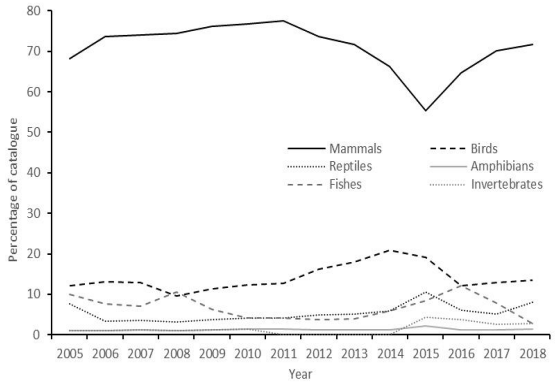

Figure 3. Proportional (%) representation of each taxonomic group in Schleich™ catalogues from 2005-2018. Representation of mammals remains consistently high throughout the study period

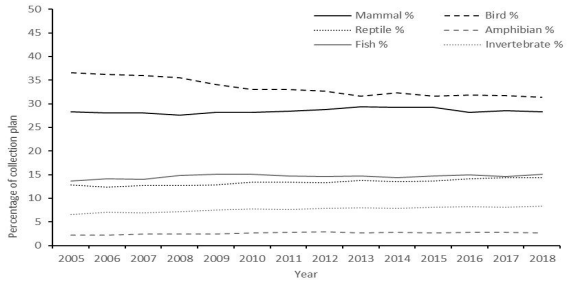

Figure 4. Proportional (%) representation of each taxonomic group in zoo collections from 2005-2018

Spearman's rank correlations were run on the percentage representation of each taxon in the zoological collection plan against their counterpart in the Schleich™ catalogues (for example, mammals in collections versus mammals in catalogues) to determine whether there was any relationship. None of the correlations were significant, apart from birds, where there was a strong, negative correlation (Table 2).

Table 2. Output from Spearman's rank correlations between the percentage representation of each taxonomic group in the average zoological collection plan and Schleich™ catalogues, from 2005 to 2018

Taxa	r	P
Mammals	-0.442	0.144
Birds	0.867	0.039
Reptiles	0.222	0.913
Amphibians	-0.162	0.790
Fish	-0.688	0.341
Invertebrates	-0.15	0.795

3.3 Biodiversity Representation

In contrast to the collection plan and marketing data, Chapman's measures of biodiversity showed a high representation of invertebrates, with 95.64% of all extant animal species being classed as invertebrates. Mammals and birds represented only 0.39% and 0.7% of animal diversity respectively.

3.4 Measuring the Influences on Collection Planning Strategies

The data from the 'average' global zoo collection was compared against the Schleich™ marketing data, biodiversity, and equal proportion data (Figure 5). While none of the collection plan strategies adequately matched the taxa representation from the study, the equal proportions measure was the most similar. However, a chi squared test revealed that the

zoo collection plan data and equal proportions data differed significantly ($X^2(1, N = 6) = 18.65$, $p < 0.001$).

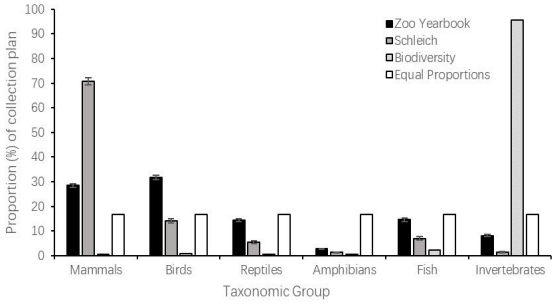

Figure 5. Comparison of the average International Zoo Yearbook collection plan to the average toy collection plan, a proportional representation of biodiversity, and an equal representation of each taxonomic group. The global collection plan data most closely represents the data on equal representation of each taxonomic group

4. Discussion

Zoo collection plans differ considerably from the influences of marketing, biodiversity and equal proportions. This suggests that while market influence may have some influence on the animals that zoos keep, there are other factors which have equal or greater influence on collection plans. The 'average' collection plan was relatively consistent in its proportions, irrespective of continent, though some notable differences were identified. For example, South American collections on average contained more bird species, and Australian collection plans had more reptiles than the average collection plan globally.

4.1 Zoo Collection Plans

Figure 1 showed that on average, animal collections house more species of bird than any other taxonomic group. In terms of number of species, birds are then followed by fish, then mammals, invertebrates, reptiles, and finally amphibians. However, the order is different when considering the proportional representation of species: while birds are still highest in terms of their proportional representation, it is mammals, rather than fish, that have the second-highest proportional representation. The reason for this may be that most animal collections contain mammals, yet many collections house no fish species (Maple, 2003). However, there are a minority of specialist collections, such as aquariums, that house hundreds of species of fish. This might result in relatively high average species numbers for fish (and invertebrates, which are also housed in great numbers in aquariums), whilst their proportional representations are much lower (Thoney, Warmolts, & Andrews, 2003; Brereton et al., 2022).

On average, almost one third of all species housed in zoological collections are birds, according to the current study. With the highest number of species per collection, birds are more common than might be expected from toy marketing data or equal proportions. This is surprising, especially as previous research highlighted birds as the least interesting animal class for zoo visitors (Moss & Esson, 2010). However, birds possess several attributes that may make them attractive to zoo visitors. Some species may grow to a large body size, may be brightly coloured, and many species are active during the day (Frynta et al, 2010).

Birds, and fish, may also be well represented because they can be housed in large, mixed-species aviaries (Smith et al., 2002; Thoney et al., 2003). For example, Klausen (2014) documents an aviary containing eight bird species, including flamingos (*Phoenicopterus roseus)* and pelicans (*Pelecanus rufescens)*. Many species of fish and birds may therefore be housed in relatively compact areas.

One challenge associated with the zoo dataset is that animal species cannot be identified in any more specific detail than Class. This limits the authors' ability to determine whether or not the species being kept are threatened with extinction. Whilst this is a limitation of the current study, previous research (Martin, Lurbiecki, Jay, & Moores, 2014) identified that generally, zoos and aquariums do not always house the most endangered taxa.

One area for development is the representation of amphibians in zoo and aquarium collection plans. On average, zoological collections housed 6.7 species of amphibian; far below the values for all other taxonomic groups. Amphibians were recorded as the least represented taxonomic group in collections across all continents, ranging from 1.12% of African collections, to 4.72% of North American collection plans. The biology of amphibians may have attributed to this relatively poor representation; amphibians often require heated

enclosures with access to clean water (Tapley, Bradfield, Michaels, & Bungard, 2015). Additionally, many amphibian species are of small body size, and are less active than mammals or birds (Hutchins et al., 2008). Historically, amphibians may have been more challenging to keep in zoos and aquaria, when vivaria, filtration systems and heating systems were less advanced (Tapley et al., 2015). Additionally, visitors may show less interest in amphibians in collections, thus reducing the perceived need for zoos to house multiple species (Moss & Esson, 2010).

Conversely, amphibians may represent an opportunity for collections to increase their conservation and education output. Amphibians currently face a range of threats including habitat destruction, climate change, invasive species, and notably, disease (Bowkett, 2009). A fungal disease, known as chytridiomycosis has recently emerged as a disease that may cause extinction of wild amphibian populations (Tapley et al., 2015), and several species, such as the Panama golden frog (*Atelopus zeteki)*, may now only be found in captivity. To safeguard threatened species, zoos can and have set up captive amphibian breeding programmes (Lacy, 2013). Zoos can also use their captive amphibians as ambassadors, helping to promote conservation education and support for conservation of this taxa (Moss & Esson, 2010). However, low representation may limit the ability of zoos and aquaria to raise awareness for this taxa. Further investment into housing a range of amphibians may be valuable for collections across all continents.

4.2 Continental Variation

Zoological collection plan varied considerably with continent: for example, Australian collections tended to house fewer mammalian, avian and fish species than collections on other continents (Figure 2). By contrast, South American collections showed the highest average numbers of mammalian and avian species per collection. Some of the continental variation in average species number may be explained by differences in history and culture. For example, while Australia is host to roughly 386 mammalian species (Chapman, 2009), there are considerable logistic and legislative challenges associated with import of non-indigenous species (Bulbeck, 1999). The reasons for variation in species composition between continents is beyond the scope of this study, but is worthy of further investigation.

4.3 Influence of Retail and Conservation

Of all three collection plan strategies, biodiversity appears to have the least influence on collection plans, as invertebrates, the most common taxa in nature, are relatively poorly represented in collections in terms of number of species (Chapman, 2009). It should be noted that invertebrates are not a Class of animal; rather, they are a Kingdom containing many Classes (Chapman, 2009). For the purpose of simplicity (and as an artefact of the historic records of the *International Zoo Yearbook*, all invertebrate classes have been merged.

There is considerable research to suggest that mammals are the most popular taxa for zoo visitors (Carr, 2016; Moss & Esson, 2010; Ward et al., 1998), and this was clearly reflected in the toy retail data (Sigsgaard, 2009). While mammals represented a greater proportion of the global collection plan than expected by the equal proportions data, it is interesting to note they were not as well represented as toy marketing data would predict, nor were they the best represented taxonomic group in terms of number of species. Mammals play a range of functions in zoos, including conservation breeding, education and as ambassadors (Alroy, 2015). It is likely that flagship mammals such as bears and tigers play a role in attracting visitors to collections (Ward et al., 1998). Indeed, zoo marketing often features large, charismatic mammal species (Feldhamer, Whittaker, Monty, & Weicker, 2002), and a similar trend is seen in the species selected for in zoo breeding programmes (Lees & Wilcken, 2009). However, while selection of large mammals may be favourable in public eyes, this creates problems in terms of sustainability (Skibins et al. 2017). Zoos possess a finite amount of space to house animals, and large animals require greater devotion of time, resources and land (Alroy, 2015; Lacy, 2013). If collections are to focus on housing large, charismatic animals, they may be reducing their housing potential for smaller, yet equally endangered species (Martin et al., 2014).

However, if zoos had fully adopted a marketing perspective on their living collections, we may expect to see mammals representing in excess of 50% of collection plans. However, actual values are considerably lower than this percentage. Zoological collection plans also remained relatively stable in terms of the average number

of animals of each taxon over time (Figure 4). This suggests that even if there is a market influence driving collections toward keeping more mammal species, it does not seem to be driving collection plans in this direction rapidly. There were no correlations between the representation of taxa in Schleich™ catalogues and zoological collection plans, other than a negative correlation between birds in either source, which is challenging to interpret.

Overall, the relationship between visitor interests, market influences and actual zoo collection plans is complex. The number of species per taxa is only one measure of taxonomic representation: other future measures could include the representation of taxa in marketing materials or amount of exhibit space.

4.4 Increasing Exposure

Courchamp et al. (2018) identified what the public consider to be the world's most charismatic animals. All of the ten species identified were mammals. This bias toward mammals may in part be a cultural phenomenon; members of the public are exposed to large mammals regularly through media, yet other taxa may be featured less frequently (Bajomi et al., 2010). Repeated exposure to a subset of large animals may create familiarity and perhaps interest in these animals (Carr, 2016). One point that supports this theory is the case of the clownfish (*Amphiprion percula)* in Moss & Esson's (2010) study. While the large fish surveyed in the study attracted little interest from zoo visitors, clownfish showed high attracting power for visitors. It is possible that prior exposure to the species in media resulted in zoo visitors being more interested in this relatively small fish (Ward et al., 1998; Militz & Foale, 2017)

We encourage zoos and aquaria to view this cultural influence as an opportunity to increase conservation awareness and output. Zoo visitors may not yet be aware of the plight of many amphibian, fish and invertebrate species, but with sufficient exposure they may become interested, and even champion the species (Militz & Foale, 2017). Zoos should aim not only to market large, charismatic animals, but also to showcase smaller, threatened species from speciose taxonomic groups (Maple, 2003). By marketing these animals, zoos may be able to gather greater support for the housing of a more diverse array of species in their living collections.

5. Conclusions

Though mammals are often described as the most popular zoo animal taxon, birds and fish are actually more prevalent in terms of numbers of species in zoological collections. The reasons why greater numbers of species of these taxa are being kept could be related to housing, in that both birds and fish are commonly kept in multi-species exhibits (aviaries and aquariums). In terms of marketing, the prevalence of taxa other than mammals suggests that zoological collections are not simply keeping animals of significant visitor interest, and the reasons for species being selected is likely to be multifactorial. The closest estimate of the average collection plan was the 'equal taxa representation', though it should be noted that some taxa were poorly represented, especially amphibians. It is unrealistic to expect animal collections to showcase all taxa in the proportions that they would appear in nature (i.e., 95.5% invertebrates), but collections should also consider the importance of showcasing key conservation stories. Amphibians, as a particularly threatened taxa, given their susceptibility to environmental change and disease, are taxa that would benefit from greater distribution across zoos and aquaria.

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Highlights

1) Zoo collections are much lower than toy retail collections in mammal bias.

2) Zoo collections do not adequately reflect animal taxa in terms of wild animal species biodiversity.

3) There is scope for both toy manufacturers and zoological collections to increase their representation of amphibian species.

Conflict of Interest

No conflict of interest was reported by the authors.

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