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Finding Balance: The rise of zoo animal nutrition

Das Gleichgewicht finden: Der Aufstieg der Tierernährung in Zoos

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Abstract

Zoo animal nutrition, as an applied scientific field, is roughly a century old and has seen significant development and impact in changing feeding practices within modern zoos. Whilst the history of zoo animal nutrition has been documented within the profession, how and why zoo feeding and zoo nutrition has changed has generally not be addressed. This paper adds to this existing literature by providing an historicised sociological interpretation of the development of zoo animal nutrition. Zoo animal nutrition as an applied science has developed at quite a pace since its establishments in the early 20th century. Modern zoo feeding practices have changed with the knowledge created by zoo animal nutrition but also in line with the zoos' evolution from statements of imperial power to spaces of scientific curiosity and entertainment to conservation-oriented institutions focused on planetary health. The origins of scientifically informed zoo nutrition can be traced back to the work of the Penrose Research Laboratory (est. 1901) at Philadelphia Zoo. Investigations into causes of death of the zoos collection led by Dr Herbert Fox enabled research by Dr Ellen Corson-White who linked dietary deficiencies to disease and mortality. These findings were further developed by Dr Herbert Ratcliffe who developed "zoo cake" – the first manufactured complete feed for zoo animals – which aimed to standardise and optimise nutrition while reducing disease. The adoption of manufactured diets sparked a philosophical and practical debate, exemplified by the 1966 International Zoo Yearbook exchange between Ratcliffe and Heini Hediger. Ratcliffe prioritised internal health metrics and efficiency, whereas Hediger warned against behavioural impoverishment and "domestication" through artificial feeding. This clash crystallised the epistemic divide between pathological science and ethological observation, a tension that persisted through the century. During the final few decades of the 20th century, zoo animal nutrition entered a period which can be characterised as a "nutritional turn." This period would see attempts to institutionalise the field through conferences such as the Dr Scholl Nutrition Conferences and the 1999 European Zoo Nutrition Research Group meeting. Zoo feeding increasingly integrated behavioural ecology with nutritional science. The period also saw the emer-

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gence of the zoo nutritionist as an employed position in zoos, although uptake across institutions remained limited. Present-day zoo nutrition reflects a negotiated balance between evidence-based nutrient provision and the promotion of natural feeding behaviours developed during the nutritional turn with more traditional approaches. The contemporary zoo nutritionists are "ark diplomats", highlighting their mediating role between science, husbandry practice, institutional priorities, and animal welfare. While the field has advanced markedly since its early 20th-century roots, institutional integration remains incomplete. Greater recognition and empowerment of zoo nutrition expertise is essential to meet the intertwined challenges of animal welfare, biodiversity conservation, and planetary health in the 21st century.

Introduction

The modern 21st century zoo is an institution that in many ways is almost unrecognisable from the formative years of modern zoos of the 19th and early 20th centuries.[1] Even those who have been founded since the Hagenbeck revolution of the early 20th century (Rothfels, 2002) have changed greatly in ethos, design, animal welfare, management and organisation of their living collections. The four pillars of the modern zoo: conservation, education, research and recreation, are themselves being reviewed and addressed by the zoo community. Spooner et al. (2023 and 2025), have noted that the four pillars no longer accurately reflect the 'multifaceted roles that zoos/aquariums fulfil in the 21st century' or the connections zoos have with society and their value (Spooner et al., 2023, 2025). In the last 100 years, zoos have progressed from sites of imperial power statements to scientific curiosity mixed with entertainment, and more recently to locations of conservation. A ubiquitous element of the zoo that has changed alongside the outward mission statement, and that can be argued as a marker of change in zoos, is zoo feeding - once an unhindered pastime of zoo visitors alongside the zoos' everyday activities from the princely menageries of the 18th century through to the pre-war zoos of the 20th century. However, the founding of zoo animal nutrition as an applied science at the Penrose Research Laboratory at Philadelphia Zoo in the early 20th century caused a shift in the practice of zoo feeding.

The scientific development on zoo animal nutrition birthed debate, specialists groups, agreement, disagreement, changes in practices and resistance. It pitted great zoo minds against one another, zoo scientists against zookeepers and brought them together. Changes in zoo nutrition and feeding practices can also highlight the differences in approaches across the global zoo industry both historically and today.

This paper provides a historicised sociological interpretation of these changes, drawn primarily from scientific articles and conference presentations throughout the 20th century. The article argues that the zoo animal nutrition developed from a route to solving diseases and death through nutritional deficiencies but that it has evolved over last 100 years to balance the differing perspectives of zoo professionals leading to a best-practice approach of balance between nutritional requirements with natural animal behaviours, ideally promoting an animal-centric approach to care for zoo animals in captivity. The article concludes with a characterisation of zoo nutritionists and zoo nutrition in the 21st century as one of diplomacy and careful attempts to continue to change practices of care through feeding via evidence-based scientific knowledge combined with the *art* of feeding a diverse range of captive exotic animals.

[1]The modern zoo era arguably commenced with the opening of Tiergarten Schöbrunn, Vienna to the public in 1765; this was followed by Zoo Jardin des Plantes in Paris in 1794, and London Zoo in 1828 – widely considered to be the first scientific zoo (Fisher, 1967; Marvin and Mullan, 1987; Baratay & Hardouin-Fugier, 2002).

Ratcliffe's Zoo Cake

Zoo animal nutrition, as an applied science, has been a key element to the care and management of animal welfare and health in zoos for the last century (Crissey, 2001; Fens and Clauss, 2024). Whilst experimentation and research into zoo feeding can be traced back to the late 19th century with work like that of John Bland-Sutton (Woods, 2018), modern zoo animal nutrition traces its roots back to the practices developed at the Penrose Research Laboratory at Philadelphia Zoo in the early 20th century where the aim was to combat diseases and nutritional deficiencies. The approach of nutritional science changed practices of care in zoo feeding by adding the science to the art of feeding diverse and complicated zoo collections (Dierenfeld, 1996).

Whilst zoo feeding in the 21st century modern zoo is not always a universal endeavour, the innovative edge of zoo feeding, mostly in scientific and conservation focused zoos, began through the work of the Penrose Research Laboratory, established in 1901 at Philadelphia Zoo. The impetuous was to gather knowledge for its own sake but it produced, according to Charles B. Penrose (the American surgeon and zoologist), significant practical value that led to improvements in hygiene and the elimination of some diseases in the zoo (Fox, 1923). Penrose, in his forward to *Disease in Captive Wild Mammals and Birds* (1923), notes that in the late 19th century to early 20th century (prior to the laboratory) the autopsies of animal deaths at Philadelphia only took place when an animal of significance had died.

This changed with the opening of the research laboratory, led by Dr Herbert Fox and his team of pathologists. In the early 20th century, the laboratory performed nearly 6,000 autopsies over two decades. Ellen Corson-White, part of this team of pathologists, is significant to the story of zoo animal nutrition as her work focused on dietary and nutrition issues – of which acute gastroenteritis was the most common disease – as discovered through the animal autopsies (Corson-White, 1923, p. 423). For example, in the Diseases in Captive Wild Mammals and Birds publication, Corson-White's chapter on 'The relations of diet to disease' (1923, 415-461) covers the need for a proper diet in zoo animals and how zoo animals must obtain maximum development, maintain a normal weight curve, show minimum susceptibility to disease, live out a full term of life, breed normally, and rear healthy offspring, capable of an independent life after weaning, and must fulfil the calorific needs of the body (Corson-White, 1923).

Furthermore, the diet must take into account the physical and morphological demands of the animals' gastrointestinal tract and the chemical content must be in a useable form inside the animal body (Corson-White, 1923). The awareness of the needs of zoo animals and efforts needed to prevent nutritional deficiencies and diseases are clear outcomes from the laboratories work over the previous two decades. It was not articulated how Philadelphia Zoo made changes to its feeding practices as a result of the findings yet. This would come later in the 1930s, through Dr Herbert Ratcliffe – another pathologist at the laboratory – and his promotion of 'zoo cake'.

Zoo cake was initially designed by Corson-White to combat bone disease in primates at the zoo (Crissey, 2001). It was developed and extended by Ratcliffe in the 1930s and used as a component of the diets for most of the zoos collection. Zoo cake was designed by Corson-White's initial primate recipe and from the results of the twenty-year period of autopsies at Philadelphia where evidence or indications of malnutrition were identified. Ratcliffe's diets are separated into three feeding typologies, omnivorous, herbivorous, and carnivorous. At each point of the introduction of the new diet, the previous diets are noted and instructions for preparing the manufactured feeds and schedule for feeding are provided (Ratcliffe, 1940). Justification for the diet changes are not specifically mentioned although it is clear the main concern was to reduce disease and improve the health of the collection. This is reinforced by the markers for success through positive changes in death rates, birth rates and infant development.

The knowledge and success of these diets were co-produced by dead and living zoo animals, although they themselves were viewed only as objects and their lived experiences are only visible through statistics and records of deaths, births, and disease. Designing these diets was additionally aided by comparison with the known requirements from wild animal diets and closely related species or as Ratcliffe put it, "*whether man or domesticated animal*" (Ratcliffe, 1940, p. 463).

For the omnivorous animals, which included "subhuman primates", the manufactured feed consisted of ground boiled horsemeat, rolled oats, whole wheat meal, soybean oil meal, peanut oil meal, yellow corn meal, dry buttermilk, brewer's yeast (dry), alfalfa leaf meal, oyster shell flour, iodized salt, and cod-liver oil concentrate. The composition was made up of 25% protein, 5% fat, 45% carbohydrate, 1% calcium and phosphorus and iodine under 1% (Ratcliffe, 1940, p. 464). The previous diets are mentioned and included polished rice, boiled sweet potatoes and bananas (with green foods, citrus fruits, milk, and eggs for apes), although nutritional values are not given. For primates, Ratcliffe notes that half of the energy intake came from the manufactured mix, supplemented with uncooked fruits and vegetables (sweet potatoes, carrots, apples, bananas, citrus fruit, and green vegetables). In addition, anthropoid apes were given 1 to 4 litres of fresh whole milk daily. Differences were also noted for gorillas, who were given uncooked ground horsemeat daily and 200 grams of boiled horse liver 3 to 4 times a week. Along with mentioning a variation for some specific taxa, Ratcliffe also outlines an adjusted diet for pregnant or lactating females, showing awareness of the changing needs of the animals at different life stages.

The pattern is repeated for herbivorous and carnivorous zoo cake. Of note is that herbivorous diets were modified versions of manufactured feeds already designed for cattle and sheep from the influential work of F.B. Morrison, highlighting the influence of agricultural nutrition on early zoo nutrition (Ratcliffe 1940). Ratcliffe's diets were designed to be adapted to the requirements of a zoo, whilst knowledge of animal preference, and known wild food habits were considered. They were designed to be easy to be prepared by zookeepers, and saw the reduction of individual food items into one hardened mixture to be divided between the animals as needed. Overall, Ratcliffe viewed the new diets to be acceptable to the animals, adequate for their nutritional needs and, importantly, financially beneficial for the zoo (Ratcliffe, 1940, p. 471).

Zoo cake as a result was the first manufactured, "complete" feed for zoo animals. It was designed under the auspices of uniformity and efficiency, a universal tool to improve the health and well-being of zoo animals in a cost-effective manner that delivered essential minerals and vitamins easily. Historically, this was not an innovation that happened in a vacuum. Complete feeds were explored within human nutrition at this time and can be traced back into the latter half of the 19th century (Haushofer, 2023). Manufactured feeds for domestic pets were also explored around this time with Spratt's Dog Biscuit considered the first manufactured pet feed developed from the 1860s and canned dog food coming to the market in the 1920s (Grier, 2009).

Ratcliffe celebrated zoo cake as a primary reason for the improvement of the health and well-being of zoo animals at Philadelphia Zoo. This served as a key element in a special issue on nutrition within the new zoo journal, the International Year Zoobook. In this issue, Ratcliffe's promotion of zoo cake and manufactured feeds came head-to-head with the opposing philosophy of the father of zoo biology, Heini Hediger – a clash of great zoo minds that would influence the rest of the 20th century and approaches to feeding zoo animals (Lane-Petters, 1966).

Philosophical differences: The 1966 Debate

The 1966 debate is one of clashing epistemic positions and philosophical approaches of zoo scientists from different scientific backgrounds. On the one had there is the promotion of

manufactured feeds by pathologist Herbert Ratcliffe, supported by Hans Wackernagel (Scientific Advisor at Basle Zoo at the time), Heini Hediger, the zoo biologist and director of Zurich Zoo who argues for a more natural approach to feeding, and Ralph Fiennes, pathologist at London Zoo. Whilst Fiennes tries to provide a neutral approach to the competing ideas of natural versus manufactured feeds, he largely supports the need for a manufactured feed due to his view that natural feeding is impossible within a zoo and fresh food items are far too unreliable in nutrient composition. The positions of the pathologists versus the zoo biologist provide a metaphorical and literal difference of standpoint, with the pathologists drawing on knowledge from the internal animal and the zoo biologist using their experience of looking *at* the animal as opposed to in. It is also a debate that still holds significance in the present day: several zoo nutrition experts interviewed for this research highlighted its importance and indeed some slight reservation that zoo animal nutrition no longer entertains such collegiate disagreements.

The debate is staged by Willian Lane-Petter (a former director if the British Laboratory Animals Bureau) as a topic of significant importance, delivered by zoo scientists of global importance. Lane-Petter's attempts to situate the debate neutrally fail, however, as his narrative is one that questions the zoos' ability to provide a natural environment and natural behaviours for zoo animals. Lane-Petter's introduction places the weight of the argument on Hediger to demonstrate how a zoo can care for an animal naturally, challenging the idea that naturalness can exist within the zoo (Lane-Petter, 1966), pointing out that for a zoo to care for an animal naturally would require a deliberate zoo policy of nutritionally deficient diets to mimic wild animal experiences. In support of manufactured feeds, the point is made that more had to be done to alleviate nutritional deficiency in zoo diets and that this can only be achieved through manufactured feeds where the nutritional composition is known and as guaranteed as possible (Lane-Petter, 1966). This is an argument supported by Ralph Fiennes, who whilst attempting a neutral position largely agrees with Ratcliffe's zoo cake. Fiennes argues that the unpredictability of nutritional composition of 'natural' foods means it is difficult to rely on natural feeding regimes to maintain the animals health (Fiennes, 1966). Essentially the debate becomes Heini Hediger's belief that zoo animals should be cared for and fed in a way that is as natural as possible versus the voices of Ratcliffe and Wackernagel arguing for importance of the internal animal health above all else.

Whilst the debate includes several zoo scientists, the essence of this difference of opinion rests on the two main protagonists, Heidger and Ratcliffe, both of whom take different approaches to expressing their opinions on feeding in the modern zoo. Ratcliffe largely repeats his arguments he had made nearly 20 years earlier when he introduced the zoo cake recipe. His 1966 paper introduces two entangled points, the risk of animal disease and that disease can be prevented via proper nutritional provision (Ratcliffe, 1966). The core difference to his previous publications is the citing of data to support the zoo cake approach. For example, Ratcliffe identifies the success by showing that tuberculosis in birds reduced due to improved quality of protein. Furthermore, Ratcliffe notes that resistance to dysentery bacilli by non-human primates increased within 8 weeks of the introduction of the new diets (Ratcliffe, 1966). Additionally, the statistics of mortality rates for mammals and birds at Philadelphia Zoo are included covering a period from 1908 to 1964. These figures identify that two years (1937) after the introduction of new diets rates of death began and continued to decline. The argument is that simply changing diets to include manufactured feeds was integral in reducing the effects of disease and thus death within the zoo collection. Ratcliffe acknowledges the need for feeding to encourage natural behaviours but does not specify how this happens with the zoo cake diet. Furthermore, the imagining of the zoo animal by Ratcliffe is one of a docile, subordinate and cooperative body. Addressing concerns over animal acceptability he merely notes that resistance to the diets was only manifested by the zookeepers (Ratcliffe, 1966). His situating of the zoo animal is as an

object, with knowledge and success informed by death, as opposed to the lived experience and observation of the zoo animal (Moore, 2024).

Hediger uses his paper to systematically pick at the zoo cake approach and Ratcliffe's arguments. Broadly, Hediger presents two key concerns; firstly, the risk of domestication of zoo animals through restrictive feeding practices that do not allow natural behaviours or support their holistic health, including psychological and physiological needs. Secondly, that the improvement in zoo animal health in the early 20th century is not only due to with what or how animals were being fed. For example, Hediger raises the point that during the period of Ratcliffe's results, there had been vast innovation and development in enclosure design, veterinary pathology and husbandry practices (Hediger, 1966). Hediger notes that despite the reduction of some diseases within zoos, there were increases in others, such as arteriosclerosis. He (selectively) uses the commentary and experiences of other zoo professionals (T.H. Gillespie of Edinburgh Zoo and Lee Crandall of the Bronx Zoo) in his attacks on manufactured feeds. However, Hediger's primary concern is not that other zoos achieved similar results as Philadelphia without running a manufactured feed regime or that new diseases were introduced to the zoo, but that the zoo cake approach risked sending zoo animals towards domestication. Hediger expressed his concern for the monotony zoo cake introduced to the animals life, and deep concerns over the influence of agricultural knowledge, such as F. B. Morrisons work, stating that "*in zoos we do not want fast growing protein suppliers, economic food producers or animals for fattening; nor do we want to have anything to do with abstract races of animals reared for domestic or agricultural purposes*" (Hediger, 1966, p. ?). Hediger gives the example of a tiger who arrived at Zurich Zoo from Philadelphia unable to tear meat from the bone, commenting that a tiger who does not know how to tear up meat is no longer a tiger (Hediger, 1966). This aligns with Hediger's deepest fear that zoo animals will become domesticated and caricatures of their wild counterparts through manufactured feeding programmes, and he calls on zoo biologists to avoid this by rejecting manufactured feeds (Hediger, 1966).

Hediger's perspective comes from his work observing zoo animals in captivity and their wild counterparts in their natural habits (de Bont, 2024). Innovation at the zoos Hediger was involved with largely came from his experiences of field studies outside of the zoo, such as the concrete termite mound built at Basel Zoo in the zebra enclosure (de Bont, 2022). Hediger did not necessarily see a demarcation between the zoo animal and the wild animal, instead arguing that each maintained predictable behaviours (de Bont, 2022), meaning the zoo animal was only lacking quantity of space and not freedom as is implied by captivity, and that to ensure their physiological and psychological health this needed to be quality space in a new environment (Chrulew, 2014).

The Nutritional Turn

The Nutritional Turn is a period I have assigned to the late 20th century into the early 21st century that is highlighted by a handful of conferences and events that consolidated the work of Ratcliffe and Hediger. They show the movement of the science and practice of zoo feeding drawing closer together. This section will focus on the Dr Scholl Nutrition Conferences held at Lincoln Park Zoo between 1980 and 1991, and the first European Nutrition Research Group conference held at Rotterdam Zoo in 1999. These conferences were pivotal for two reasons; firstly we can see in the topics discussed a balancing of zoo feeding from the scientific perspective and a focus on the animal both internally *and* externally. Secondly, they hallmark the development of the role of the zoo nutritionist within zoos in Europe and the US. It is in this period that nutritionists are employed by zoos and specific nutrition programmes are launched (Crissey, 2001). Dr Olav Oftedal would be the first, hired by Smithsonian's National Zoological

Park in 1978, with the Philadelphia Zoo hiring its first zoo nutritionist in 1984. Furthermore, nutrition programmes were launched in the US and Europe during the 1980s and 1990s at zoos such as Toronto, Rotterdam, Brookfield Zoo, The Wildlife Conservation Society, Dallas Zoo, Fort Worth Zoo, San Diego, the Durrell Wildlife Conservation Trust, and at the Royal Zoological Society of Scotland (Crissey, 2001). At the turn of the millennia there were 15 full or part-time zoo nutritionists in Europe (van Wees et al., 1999). The pace of zoo nutrition at the time is evident in the conference programmes, and employment of zoo nutritionists. Whilst it is questionable how far the professionalisation of the zoo nutritionist role has since progressed, the nutritional turn of the late 20th century can be identified as a significant era of zoo nutrition as an applied science just 80 years after its establishment.

The nutritional turn began with the first Dr Scholl conference in 1980, bringing together zoo scientists, academics, veterinarians, nutritionists, feed manufacturers, zookeepers, and zoo directors to scientifically explore the diverse and varied problems of feeding and nutrition in the modern zoo. Over its nine years, Dr Scholl Conferences featured 136 papers or discussion groups ranging from detailed analysis of nutrient composition, species-specific research and more general and practical measures and practices of zoo feeding. These conferences provide a historical bridge between the clashing philosophies of the 1966 nutrition debate and the more balanced, science and practice informed approaches of 21st century zoo nutrition science. The inaugural conference started with a justification, arguably a defence of zoo cake and Ratcliffe's work at Philadelphia. Wilbur Amand, senior veterinarian of Philadelphia Zoo, extolled the virtues of the system, mentioning that it was still being used with minimal adjustments from Ratcliffe's design. Although he did acknowledge that some manipulation of the facts had taken place, although Amand defended this by stating; *"I think the facts were manipulated a little bit, not necessarily to sell a product but to sell a concept of philosophy. Still, I think the concept/ philosophy was good"* (Amand, 1980, p. 24).

The first conference kept to the Ratcliffe philosophy, focussing primarily on the animal as a scientific object, the processes inside the body and largely not addressing the lived experience. Out of the 20 papers at this first conference, all provide knowledge gained from the inside of animals. Only in snippets, such as Dennis Meritt's (Assistant Director of Lincoln Zoo) recommendation of *"speaking softly to a new arrival, in its native tongue"* (Merritt, 1980, p. 59) are the lived experience or the human-animal relationship visible. However, the journey to a more balanced approach did not take long to emerge and this is where we see the balancing of Ratcliffe's science objects and Hediger's science subjects combine.

Mary Allen, a research scientist at Michigan State University, delivered a concise overview of manufactured feeds with more "natural" feeding options – described as cafeteria style feeding. The paper does not promote a particular approach but identifies the pros and cons of each approach; manufactured feeds may provide guarantees around nutritional value for the animal, but they also limit natural behaviours. Cafeteria style feeding elicits these natural behaviours allowing visitors and zookeepers to observe the animal eating and enjoying variety. However, using the example of an orange and elephants, Allen cautions against the concept of naturalness of the cafeteria style, noting that just because something is fresh or naturally grown does not mean it is appropriate or connected to the animal's wild diet (Allen, 1982, p.2).

Furthermore, Allen highlights issues related to hierarchies and nutritional wisdom of captive animals and the risks of over or under consumption, albeit acknowledging tha providing medication is easier with fresh food. The key message from Allen is that the approach taken for feeding zoo animals should be centred on the animal as much as possible, rather than the historically human-centred approach of 19th and early 20th century zoos. Along with this paper from Allen, Terry Maple, animal behaviourist, presented on the need to ensure behavioural needs are met as well as nutritional for zoo animals, and Allen again with Bonnie Raphael presented on

implementing and managing nutrition plans in zoos. Ellen Dierenfeld, zoo nutritionist, encapsulated the debate and where zoo nutrition had moved to in the twenty years since the *IYZB* debate at the 7th Dr Scholl conference. Dierenfeld, in hindsight, presented a paper that was largely prophetic in the need for zoos to engage with zoo nutrition science and the changing landscape of the late 20th century zoo. The Dr Scholl conferences were not only important because of the broadening of topics discussed but also because of what they launched: from these conferences, the Comparative Nutrition Society and the Nutritional Advisory Group (NAG) were founded. The conferences also led on to the first European nutrition research group conference at Rotterdam in 1999 (Dierenfeld, personal correspondence, 2022).

The change in content at the Rotterdam conference is evidence of the changing nature of zoo nutrition science, zoo feeding, and indeed the increased levels of knowledge of zoo animals and their wild counterparts. 42 papers were presented across several key areas of zoo feeding, organisms, behaviour/feeding ecology, methods, and application. With an historicised sociological lens, we look at the key presentations of this conference to see how far zoo nutrition had travelled since Ratcliffe's zoo cake and the 1966 debate. Susan Crissey presented on the establishment of NAG and the need to understand not just the science of nutrition but also the practice of nutrition. In Jean-Michel Hatt's paper there is a clear move away from the formative years of zoo nutrition debate, acknowledging the developing importance of conservation issues, the improvement in "substitute diets" and the changing perspectives on the value of domesticated animal nutrition for zoo animals (Hatt, 1999).

A snapshot of zoo nutrition science in Europe is provided by Sofie van Wees who noted that in European zoos, the nutritionist was still a luxury with only 20% of zoos employing one and despite only 28% undertaking nutrition research, 83% believed there was a need for additional nutrition research (van Wees, 1999). A situation that I suspect is still present today, and should be empirically assessed, along with a study looking at the types and depth of nutrition research.

These conferences were pivotal in launching what can be seen as an attempt to institutionalise zoo nutrition, an attempt which arguably has not succeeded. 25 years on from the end of the first nutritional turn and the undoubted increased interest in zoo animal nutrition science – where does the field now stand?

Discussion: The Ark Diplomat and present-day zoo nutrition

The perspective on the history of zoo animal nutrition as an applied science depends on the knowledge backgrounds of individuals, informed by their social, cultural, historical and educational experiences, and roles within the zoo. On the one hand, in less than a century, the knowledge created, the methods trialled, the research completed, the journey taken, has been immense. Zoo animal nutrition in the 21st century is far removed from the Philadelphia Zoo pathologists fighting disease and death. On the other hand, despite evidence-based research, some animals are still being fed incorrectly in managed care, both from a nutritional and behavioural viewpoint. One interviewee for this research was exasperated that a zoo association report found animals as familiar as the giraffe were still being fed incorrectly after nearly two centuries of managed care. My personal experience was one of surprise whenever I came across primates that included fruit. The scientific evidence is clear on the benefits of moving away from cultivated fruit in captive primate diets (Plowman and Cabana, 2019), as supported by the majority of EAZA best practice guidelines for primates which advise against fruit feeding – yet it continues, even within some scientifically focused zoos.

Zoo feeding is an emotive subject, it is a traditional practice and as much as this paper has charted the scientific debate, there is broader discussion not covered in this paper, the 'art of

feeding'. Furthermore, the simple fact is that the zoo world is very diverse, by country, region, qualifications of staff, legal requirements, expectations of visitors, by their living collections. The "silver bullet" of Ratcliffe's zoo cake is clearly not the answer, the idealism of Hediger equally hasn't worked. Whilst towards the end of the 20th century these approaches combined, the advancement of zoo nutrition has not achieved what it hoped for at the turn of the millennium – despite the efforts of brilliant and ingenious nutritionists, veterinarians, and zookeepers.

As the zoo nutritionist has not successfully institutionalised within modern zoos, peaceful diplomacy is a requirement for success zoo nutrition. Zoo nutritionists are broadly "the ark diplomats" of the zoo world, which is a direct outcome of how zoo nutrition science has developed. This characterisation is drawn from the work of philosopher Isabelle Stengers and applied within a historical lens of the Judeo-Christian salvational imagery applied to zoos in the 1960s. This period was notable for its adoption of conservation aims and the saving of endangered species (Moore, 2024; Margodt, 2010; Chrulew, 2017; de Bont, 2024).[2] The ark diplomat is someone who strives to "give peace a chance" through artificial arrangements that slow potential confrontation, rather than practices of flexible negotiations between parties who are ready to adapt (Stengers, 2010; Janicka, 2023). Furthermore, the ark diplomat must be empowered by those that hold the power (Stengers, 2010). For zoo nutritionists, this empowerment comes from zookeepers and from zoo administrators who approve and enact their reviews of diets and changes to diets. The development of zoo nutrition science during the nutritional turn has placed the zoo nutritionist in this diplomatic role where they are seeking, with other zoo colleagues, to improve the health and lived experience of the zoo animal – albeit this is not always a straightforward or peaceful process.

This research project explored the historical journey of zoo nutrition as an applied scientific field and its rise from Ellen Corsen-White's research through to the nutritional turn of the late 20th century. Not featured as strongly here but ultimately relevant to understanding zoo nutrition science today, this research also investigated the experiences and memories of some of those present during the nutrition turn. Through interviews with persons involved in zoo nutrition science, mostly in Europe, some potential reasons as to why the zoo nutritionist has been forced into the role of ark diplomat can be posited.

The reasons for the stalling of the field could fill a paper itself, but broadly, those who participated in the nutritional turn and led the field identified some key issues with the engagement of zoo nutritional science. Andrea Fidgett, formally nutritionist for Chester Zoo in the UK and Director of Wildlife Nutrition at San Diego Zoo, viewed it as an issue of the lack of robust research and lack of investment. '*I think if truth be told where I feel we're at with nutrition is I think both continents have stalled because I don't know that the science that's coming out of Europe is – I think there's a lot of people just trying to get by doing baseline work. Which is, what are we feeding animals and documenting that because there isn't the investment into doing robust science'* (Fidgett, interview, 2022).

Another zoo nutrition expert questioned whether there is too much agreement and that a return to competing debates such as in 1966 is required. "*Maybe one thing we should get more, let's say, controversial discussions also within the zoo field in nutrition. I think we perhaps to agree a bit too much. I think this clashing of this important people and opinions against each other I think is great and I like that and we should maybe have more of that to get then new things happening from it and new ideas"* (Zoo Nutrition Expert, interview, 2022). This perspective arguably aligns with Fidgett's concern on the lack of investment in robust research.

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[2]The modern zoo era arguably commenced with the opening of Tiergarten Schöbrunn, Vienna to the public in 1765; this was followed by Zoo Jardin des Plantes in Paris in 1794, and London Zoo in 1828 - widely considered to be the first scientific zoo (Fisher, 1967; Marvin and Mullan, 1987; Baratay & Hardouin-Fugier, 2002).

Or Cecile Lyon, a zoo nutritionist, who believes that advocacy is what is missing from the field, that knowledge simply isn't being shared sufficiently. '*We have a lot of knowledge available that still currently isn't being used and there are animals that suffer and pass away because they are not fed the correct diet and that's something that's avoidable"* (Lyon, interview, 2022).

The most obvious example of this is the outcome of the work from Amy Plowman at Paignton Zoo in the 2010s, evidence-based knowledge that shows that zoos should not feed captive primates cultivated fruit. Yet, many zoos continue to feed cultivated fruit, despite Plowman's research and recommendations within EAZA best practice guidelines to not feed cultivated fruit to primates (albeit with differing standards from 'not at all', to 'with caution', to 'only in training').

For others, the solution to revitalising zoo nutrition in zoos is for zoos to be smarter about their approaches. Paul Rose, an animal behaviourist with the University of Exeter, took the view that greater collaboration was needed within the zoo world and outside of it with interested parties (Rose, interview, 2022).

Then there is the human condition. Selecting food items, feeding, eating, feeding other animals is part of the human condition. There is a connection to the act itself, it is a shared experience between human and non-human. Fidgett, for example, highlighted that in designing a diet for an animal there needs to be multiple levels of acceptance – the zoo animal and the zookeeper. "*I often talk about acceptance of a diet knowing that I mean two things. I mean, animal acceptance and care professional acceptance. Because without that reciprocity you're not going to achieve what you're both trying to do – which is make sure the animal has what it needs*." (Fidgett, interview, 2022) However, the challenge in creating this acceptance is a large part of the diplomatic work by the zoo nutritionist. Food relationships influence acceptance of zoo animal diets. This is where the role of zoo nutrition scientist is different to other zoo scientists and deserves greater appreciation, understanding, and support from zoo administrators and zoo leaders. Veterinary science, or reproductive science, for example, are not areas most people without PhDs in those areas have experience of. Everyone eats.

Nutrition science as a result must overcome the experience of being human and sharing experiences that human carers can align with. This diplomacy and navigating isn't something other zoo sciences have to overcome to the same degree. It may also shed some light on why there are more zoo nutritionists in North America. Eating manufactured feeds, zoo cake, kibble, is not something humans experience. However, humans globally have been encouraged to ensure they eat 5 fruit and veg a day and the fresh (or natural) food stuffs given to animals in European zoos is known, experienced, understood by zookeepers. Which is why you have situations like zookeepers not giving lion cubs meat on the bone for fear of them choking (Plowman, interview, 2022) or when it was assumed bats had nutritional wisdom and were allowed to choose between fruit and their pellets, resulting in the pellets being left and a calcium deficiency nearly wiping out the bat collection. As Fidgett points out, "*fruit wasn't a source of the vitamins and minerals necessary. You don't eat fruit to get healthy bones"* (Fidgett, interview, 2022).

These issues, conflating shared experiences of eating, the lack of investment in nutrition research, and the lack of debate are examples as to why zoo nutritional science – particularly in Europe – has stalled since its rapid rise in the 20th century.

At the risk of being idealistic, the onus rests with zoo associations, such as EAZA and BIAZA and AZA and zoo administrators themselves. In an age of concern about endangerment of species and the resilience of our planet, the zoo nutritionist is equally endangered and arguably more should be done to integrate the knowledge, practices, and expertise of zoo nutritional science into zoos globally.

Zusammenfassung

Die Tierernährung in Zoos als angewandtes Wissenschaftsgebiet ist etwa ein Jahrhundert alt und hat zu bedeutenden Entwicklungen und Veränderungen in der Fütterungspraxis moderner Zoos geführt. Während die Geschichte der Tierernährung in Zoos innerhalb des Berufsstandes dokumentiert ist, wurde bisher kaum untersucht, wie und warum sich die Fütterung und Ernährung in Zoos verändert hat. Dieser Artikel ergänzt die vorhandene Literatur durch eine historisch-soziologische Interpretation der Entwicklung der Tierernährung in Zoos. Die Tierernährung in Zoos hat sich als angewandte Wissenschaft seit ihren Anfängen im frühen 20. Jahrhundert rasant entwickelt. Die modernen Fütterungspraktiken in Zoos haben sich mit dem Wissen, das durch die Tierernährung in Zoos gewonnen wurde, verändert, aber auch im Einklang mit der Entwicklung der Zoos von Symbolen imperialer Macht zu Orten wissenschaftlicher Neugier und Unterhaltung bis hin zu naturschutzorientierten Einrichtungen, die sich auf die Gesundheit unseres Planeten konzentrieren. Die Ursprünge der wissenschaftlich fundierten Tierernährung in Zoos lassen sich bis zur Arbeit des Penrose Research Laboratory (gegründet 1901) im Zoo von Philadelphia zurückverfolgen. Untersuchungen zu den Todesursachen der Zootiere unter der Leitung von Dr. Herbert Fox ermöglichten die Forschung von Dr. Ellen Corson-White, die einen Zusammenhang zwischen Ernährungsmängeln und Krankheiten sowie Sterblichkeit herstellte. Diese Erkenntnisse wurden von Dr. Herbert Ratcliffe weiterentwickelt, der den „Zoo Cake“ entwickelte – das erste industriell hergestellte Alleinfuttermittel für Zootiere –, mit dem die Ernährung standardisiert und optimiert und gleichzeitig Krankheiten reduziert werden sollten. Die Einführung industriell hergestellter Futtermittel löste eine philosophische und praktische Debatte aus, die durch den Austausch zwischen Ratcliffe und Heini Hediger im International Zoo Yearbook 1966 veranschaulicht wird. Ratcliffe legte den Schwerpunkt auf interne Gesundheitsindikatoren und Effizienz, während Hediger vor Verhaltensverarmung und „Domestizierung” durch künstliche Fütterung warnte. Dieser Konflikt verdeutlichte die epistemologische Kluft zwischen pathologischer Wissenschaft und ethologischer Beobachtung, eine Spannung, die das ganze Jahrhundert über bestehen blieb. In den letzten Jahrzehnten des 20. Jahrhunderts trat die Ernährung von Zootieren in eine Phase ein, die als „Ernährungswende” bezeichnet werden kann. In dieser Zeit gab es Versuche, das Fachgebiet durch Konferenzen wie die Dr. Scholl Nutrition Conferences und das Treffen der European Zoo Nutrition Research Group 1999 zu institutionalisieren. Die Tierfütterung in Zoos integrierte zunehmend Verhaltensökologie und Ernährungswissenschaft. In dieser Zeit entstand auch die Position des Zoofütterers als Angestellter in Zoos, obwohl die Akzeptanz in den Einrichtungen begrenzt blieb. Die heutige Tierernährung in Zoos spiegelt ein ausgewogenes Verhältnis zwischen der evidenzbasierten Nährstoffversorgung und der Förderung natürlicher Fressgewohnheiten wider, das während der Ernährungswende mit traditionelleren Ansätzen entwickelt wurde. Die heutigen Tierernährungswissenschaftler in Zoos sind „Arche-Diplomaten“, die ihre vermittelnde Rolle zwischen Wissenschaft, Tierhaltungspraxis, institutionellen Prioritäten und Tierschutz hervorheben. Obwohl sich das Fachgebiet seit seinen Anfängen im frühen 20. Jahrhundert deutlich weiterentwickelt hat, ist die institutionelle Integration noch unvollständig. Eine größere Anerkennung und Stärkung der Fachkompetenz im Bereich der Zoofütterung ist unerlässlich, um den miteinander verflochtenen Herausforderungen des Tierschutzes, der Erhaltung der biologischen Vielfalt und der Gesundheit unseres Planeten im 21. Jahrhundert zu begegnen.

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