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Deflighting zoo birds and its welfare considerations

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Abstract

*For over a century the practice of deflighting has taken place in zoological collections in order to ensure birds remain in open-topped enclosures. Over time, efforts have been made to improve or develop new (surgical) techniques, reduce risk of complications during deflighting and minimise stress and pain during the procedure. However, increased public interest in issues of animal welfare has coincided with a questioning of the practice of removing a bird's ability to fly. The ensuing debate, which continues to progress among a variety of differing stakeholders, has led to various legislative adjustments across a number of countries. Despite significant legislation, the dialogue has been both subjective and highly emotive. A plethora of opinions exist as to why deflighting should be outlawed, why it is necessary, or how it has the potential to improve a bird's living conditions. However, most are based on assumption or issues unrelated to welfare. To the authors' knowledge, to date, no scientific data have been published on the welfare implications of deflighting for the commonly deflighted bird species, such as waterfowl, flamingos (*Phoenicopteridae*), pelicans (*Pelecanidae*), storks (*Ciconiidae*), cranes (*Gruidae*) and herons (*Ardeidae*). The aim of this study is to present an overview of the relevance of deflighting to zoo husbandry, the species primarily affected, the techniques currently in use, the legality in differing countries and the extent of scientific knowledge as regards potential ethological and welfare concerns. An urgent need for evidence-based studies is highlighted, to further inform this practice at a species-specific level.*

Keywords: *animal welfare, birds, deflighting, pinioning, wing-clipping, zoo*

Introduction

In zoological institutions, most of the commonly displayed bird species are kept in aviaries that allow behaviour primarily associated with the avian class to be performed, notably flight (J Dekker, EAZA, personal communication 2016). Notwithstanding those species naturally unable to fly, only a small minority of bird species are commonly in open display under flight restraint (Dollinger *et al* 2014). Flamingos (*Phoenicopteridae*), pelicans (*Pelecanidae*), geese (*Anseriformes*), cranes (*Gruidae*) and other species regularly undergo deflighting throughout the world (Hesterman *et al* 2001; Bennett & Baumgartner 2015; J Dekker, EAZA, personal communication 2016), leading many to question whether or not deflighting is compatible with the animals' welfare and, if so, under which circumstances.

According to the Zoos Directive of the European Union (Council Directive 1999/22/EC), zoological institutions are obliged to accommodate "their animals under conditions which aim to satisfy the biological and conservation requirements of the individual species" as well as to prevent "the escape of animals in order to avoid possible ecological threats to indigenous species". A number of zoo representatives are of the opinion that in certain instances and for certain bird species, both goals can best be achieved through the use of deflighting procedures (Hesterman *et al* 2001; Dollinger *et al* 2014). As a contrast some authors are critical of surgical alterations (Tyson 2014), considering deflighting to be a relic from a bygone era (Bračko & King 2014) that, indeed, should even be made illegal (Schmidt & Jäger 2015).

Furthermore, this debate extends beyond zoological institutions to include each individual country's individual legal regulations which show wide variation, ranging from prohibition of any deflighting procedure to their unequivocal permission (see Table 1). Additionally, flight restraint — pertaining in particular to the practice of pinioning — is subject to increasing criticism from animal rights organisations declaring it to be a violation of animal welfare (CAPS 2013; PeTA Deutschland eV 2017).

Table 1 Legislation towards flight restraint in selected countries.

Country	Irreversible methods	Reversible methods	Explanation	Legislation/source
Europe				
Germany	Forbidden, exemptions on the municipal level no longer exist	Forbidden, exemptions on the municipal level exist	In zoos, deflighting methods have been tolerated/not punished by the authorities over the last 20 years, no uniformity among the local communities, continued toleration unlikely	Tierschutzgesetz 2006; Dollinger *et al* 2014; Schmidt & Jäger 2015; Maisack & Schmidt 2017; Beckmann & Thal 2017
Austria	Forbidden	Allowed	Allowance for animal welfare-related or species conservational purposes	Tierhaltungs-verordnung 2 2004
Switzerland	Forbidden for private individuals, allowed for zoos	Allowed	General exception from prohibition for zoological institutions due to their status of being of superordinate interest	Tierschutzverord-nung 2008
The Netherlands	Forbidden	Allowed		Wet Dieren 2019
England and Wales	Allowed (exception: farmed birds)	Allowed (including farmed birds)	Pinioning needs to be carried out by a veterinarian	Mutilations Regulations 2007; Animal Welfare Act 2006; Welfare of Livestock Regulations 1982
Belgium	Allowed	Allowed	Allowance for ornamental birds and fowl that are usually not kept in fully closed exhibits to preclude the risk of escaping	Ministry of Social Affairs 2001
France	Allowed	Allowed	Allowance for ornamental birds and fowl that are usually not kept in fully closed exhibits to preclude the risk of escaping	Ministry of the Environment 2004
Sweden	Allowed only for listed birds	Allowed only for listed birds		Djurskyddsmyndighetens föreskrifter om djurhållning i djurparker 2004
North America				
USA	Allowed	Allowed	Birds in exhibitions are excluded from the Animal Welfare Act In some cases, pinioning is even officially and explicitly prescribed	Animal Welfare Act 1966
Oceania				
Australia	Mostly allowed	Allowed	Individual Territory legislations, eg in New South Wales unreservedly allowed, in South Australia only allowed for quail, pheasants, plovers and water birds	Animal Welfare Regulations 2012; South Australian Code of Practice for the Husbandry of Captive Birds (undated); NSW Guidelines for the pinioning of birds 1996

The purpose of this article is to provide an account of the occurrence of deflighting in zoos, the species affected, techniques currently in use, different legal stances adopted in various countries and the extent of scientific knowledge on the subject. Additionally, there will be discussion of ethological and welfare concerns. Welfare implications are framed within the context of their compatibility with flight restraint.

Overview of deflighting techniques

Although a number of deflighting techniques have been developed and described, very few are in regular usage (Bennett & Baumgartner 2015; J Dekker, EAZA, personal communication 2016). Most of the procedures have experimental or historical merit and have been discussed extensively (Hesterman *et al* 2001; Bennett & Baumgartner 2015). The majority are typically performed on only one wing in order to create a functional asymmetry to prevent birds from gaining balance mid-air (Hesterman *et al* 2001). Attempts to inhibit the physiological, flight-enabling movement of the wing by tenectomy (Demirkan *et al* 2010), tenotomy (Degernes & Feduccia 2001), arthrodesis of wing joints (Bennett & Baumgartner 2015), patagiectomy (Bennett & Baumgartner 2015) or neurotomy

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Table 2 Deflighting techniques regularly used.

Method	Implementation (Utilisation)	Timing/Frequency	Potential complications	Welfare implications
Reversible				
Wing clipping/Wing feather trimming[1,2,3,11]	Cutting the primaries of one side (very common)	Repeatedly, after/during every molt	Feathers need to be fully molted, otherwise heavy bleeding and pain might occur	Repetetive capture (at least annually). Feather stumps irritating the skin can provoke excessive grooming and even automutilation behaviour
Brailing[1,2,4]	A brail secures the carpal joint in flexion (uncommon)	Permanently	Brail needs to be switched between both sides every 2 to 4 weeks to avoid irreversible arthrodesis or soft tissue changes	Repetetive capture in short time interval. Potential discomfort due to foreign body
Irreversible				
Pinioning[1,2,5,6]	Amputation of the wing tip	Once, irreversible	High vulnerability of the stump (depending on the technique used)	
Hatchlings	One clean cut with scissors through the metacarpal bone (very common)	Between the third and tenth day	Very low risk of complication	Usually carried out without anaesthesia/analgesia, believed to produce little pain (empirically)
Adults/juveniles	Surgical removal under anaesthesia and analgesia, various techniques described (occasionally)	As soon as the first remiges are molted	Increased risk of haemorrhage, re-injury and infection	Surgical intervention; afterwards repeated capture is necessary as bandaging and post-operative analgesia is advised; hospitalisation problematic (especially in group-living species)
Feather follice extirpation[2,7,8]	Surgical excision of the primaries' feather follicles (occasionally – especially in Germany over the last decades)	Once, irreversible, feathers should not be in growth during procedure	Increased risk of haemorrhage and infection, repeated capture is necessary as bandaging and post-operative analgesia is advised	Surgical intervention; afterwards repeated capture is necessary as bandaging and post-operative analgesia is advised; hospitalisation problematic (especially in group-living species)
Feather follicle destruction[2,9,10]	Destruction of germinal tissue via the hollow shaft of the cut feather with diode laser or cryoprobe (occasionally)	Once, irreversible, feathers must not be in growth during procedure	Relatively new technique, equipment settings are still in evaluation	Minimally invasive surgical intervention; no post-operative care needed

[1] Hesterman *et al* 2001; [2] Bennett & Baumgartner 2015; [3] Lin Zhang *et al* 2010; [4] Curton 2001; [5] Joint response from the EAZA and BIAZA to the release of the Born Free Foundation's *Beyond the Bars* report on wild animal welfare in the United Kingdom 2017; [6] Flinchum 2006; [7] Krawinkel 2011; [8] Vollmerhaus & Sinowatz 2004; [9] D'Agostino *et al* 2006; [10] Shaw *et al* 2012; [11] Vinke *et al* 2016.

(Hesterman *et al* 2001) turned out not only surgically challenging and with high complication rates, but also capable of leading to unsatisfactory results in terms of preventing flight (Bennett & Baumgartner 2015). As a result they tend not to have been used on a large scale in displayed birds despite failing to have an obvious effect on birds' appearance. More reliable results have been recorded with techniques that involve the loss of flight feathers or their germinal tissues, therefore it's these that are used as a matter of routine in most zoological facilities (Dollinger *et al* 2014; J Dekker, EAZA, personal communication 2016) and are described in Table 2.

Legal issues

Often, decisions regarding deflighting are not made solely on an institutional basis. Legal regulations, recommendations from umbrella organisations and public pressure through animal protection or animal rights organisations can all have an impact on a zoo's deflighting management. Whether deflighting itself is allowed and, if so, by which of the methods mentioned, is stipulated each country's own laws and regulations and these vary considerably from country to country. This is described in Table 1.

Present state of affairs

In principle, in terms of welfare, deflighting only affects individual species considered less dependent on or even independent of the ability to fly (Dollinger *et al* 2014). Commonly deflighted species tend to be those strongly bound to the ground or water and that use their ability to fly to mainly escape predators, reach elevated sleeping places or migrate (Dollinger *et al* 2014). Neither predator avoidance nor food shortage/unsuitable climatic conditions are supposed to occur under human care. It is assumed therefore that species belonging to this group do not experience a loss in their urge to carry out this natural behaviour when deflighted in captivity.

Overall, general consensus exists amongst zoo personnel as to which species are deemed suitable for deflighting or not (TVT 2015). The most commonly deflighted zoo birds are flamingos, pelicans, most species of Anseriformes, storks (*Ciconiidae*), cranes, some grebes (Podicipediformes), some bustards (*Otitidae*), seriemas (*Cariamidae*) and ground hornbills (*Bucorvidae*) (Dollinger *et al* 2014; TVT 2015; J Dekker, EAZA, personal communication 2016). Less often, deflighting is seen in vultures (*Aegypiinae, Gypaetinae*, and *Cathartidae*), other Pelecaniformes such as herons (*Ardeidae*) and *Threskiornithidae*, cormorants (*Phalacrocoracidae*), screamers (*Anhimidae*) and the secretary bird (*Sagittarius serpentarius*) (Dollinger *et al* 2014; TVT 2015; J Dekker, EAZA, personal communication 2016). An exception to the general consensus that exists concerns the case of deflighting parrots. In US zoos, in particular, it is common practice to present deflighted parrots on perching structures or 'parrot islands' (Association of Zoos and Aquaria, AZA, Parrot Taxon Advisory Group, TAG, personal communication 2015). According to the chair of the European Association of Zoos and Aquaria (EAZA) Parrot TAG, this form of exhibit is rarely seen in European zoos. Parrots' popularity as companion birds has meant that the question of deflighting has extended to the pet sector, becoming a controversial and widely discussed topic amongst specialists (Antinoff 2002; Engebretson 2006; Vinke *et al* 2016).

In June 2016, a survey conducted for EAZA (available only on personal request) provided information on current deflighting management as well as the future prospects of 78 Full-Member EAZA Zoos from 23 European countries (J Dekker, EAZA, personal communication 2016). According to the report, 72 of all the participating zoos (92.3%) were keeping pinioned birds in their collections. However, only 29 (37.2%) stated that they still carried out the procedure, indicating that the remaining 43 zoos either still have birds in their collection that were previously pinioned or were pinioned upon procurement. The surveyed zoos were asked to list all the flamingo, cormorant, stork, pelican, swan, goose and duck species in their collections and divide them into numerical groups, ie 'pinioned' and 'fully winged' (including birds that are wing-clipped). Additionally, a statement concerning 'future plans (5–10 years)' for the mentioned species was requested.

The survey revealed that 80.5% of geese, 62.8% of flamingos, 62.6% of ducks, 61.1% of pelicans, 44.9% of cranes and 24% of storks were kept pinioned. However, no mention was made of the flight status of the non-pinioned birds of these species — whether they were irreversibly deflighted via methods other than pinioning, whether they are wing-clipped or live in aviaries. Therefore, no definitive conclusions can be drawn regarding birds' flight status in these institutions, since the mere presence of pinioned birds — especially in long-lived species — does not reveal the status of the rest of the group. That said, despite the incomplete nature of the information provided, a decrease in the use of pinioning is detectable (J Dekker, EAZA, personal communication 2016; Van Lint 2017).

Even though no exact figures are available on numbers of birds held under flight restraint, it is clear that deflighted zoo birds still commonly exist in European and North American zoos.

Perception among different stakeholders

Zoo governing and accrediting bodies

The World Association of Zoos and Aquaria (WAZA) is the umbrella organisation for zoos around the world and unites, *inter alia*, local associations as well as national zoo organisations. All members agree to comply with WAZA's Code of Ethics and Animal Welfare adopted in 2003 in San José, Costa Rica. The only reference to deflighting noted: "Pinioning of birds for educational or management purposes should only be undertaken when no other form of restraint is feasible."

EAZA went a little further in their 2014 Standards for the Accommodation and Care of Animals in Zoos and Aquaria, with "there should be a net welfare benefit to the individual animal and/or its conspecifics before accepting […] pinioning of birds". And, further, that "closed aviaries of appropriate size are thus preferred to open enclosures where pinioning is the only efficient method of restraint."

The British and Irish Association of Zoos and Aquaria (BIAZA) released a Position Statement on Bird Flight Restraint in 2012, which recommended that "wherever possible […] birds are maintained in large, complex, but fully enclosed aviaries that allow expression of a wide range of natural behaviours, including flight" but also "that in some cases a form of flight restraint may be more appropriate." All members are obliged to carry out a cost/benefit analysis addressing the welfare concerns of each affected species, which should also take into account its conservation status. To serve as a guideline and assist BIAZA members perform an appropriate assessment, a table comparing potential costs and benefits in relation to flight status is provided. However, BIAZA points out that "there is little published evidence for the welfare effects, positive or negative, of most forms of flight restraint."

This stance on flight restraint in zoos has recently been further emphasised by EAZA and BIAZA which repeatedly asserted their overall preference for aviaries over pinioning as well as their recognition that, in some cases, "pinioning

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may represent a more favourable long-term welfare outcome, if […] a decision […] is made on the strength of scientific evidence" (joint response from EAZA and BIAZA to the release of the Born Free Foundation's *Beyond the Bars* report on wild animal welfare in the United Kingdom in 2017). In addition, they both announced the continuation of their own research as well as their intention to follow recommendations of impartial welfare scientists.

Likewise, the Avian Scientific Advisory Group (ASAG) of AZA released *Recommendations for Developing an Institutional Flight Restriction Policy* in 2013. Although less specific about preference, ASAG strongly recommends that its members establish a "written policy on if, when, and how flight restriction is employed" as well as to "collect data that could be relevant to the choice of flight restriction methodologies on individual animals." The group also underlined the need for scientific investigation into this matter. The Parrot TAG of AZA even states that the "beauty of flight" should be promoted wherever possible and asked "all facilities to evaluate this practice in their own collections" (AZA Parrot TAG, personal communication 2015).

The Association of Zoological Gardens (Verband Zoologischer Gärten, VdZ) in Germany recommended the adoption of a regulation that allows zoological institutions to deflight a specified group of bird species (VdZ 2016) — as is the case in Sweden (see Table 1). The Association also points out that enforcing prohibition in Germany might lead to a decrease of those endangered species that are commonly kept deflighted under human care. This would affect not only German zoos but also others throughout Europe, since reducing numbers of individuals in a species lowers its genetic variability and thus the chance to maintain a genetically stable *ex situ* population — especially in less commonly kept species.

Veterinary associations

As many of the deflighting techniques described in Table 2 are associated with surgery, the discussions also extend into the veterinary sector where they become the subject of lively, international debate between zoo veterinarians at conferences (eg Baumgartner *et al* 2012 [in Bussolengo]; Vinke *et al* 2015 [in Bristol]).

A number of veterinary associations have even released official statements: The Veterinary Association for Animal Welfare (TVT) in Germany released a statement in 2015 (Stellungnahme der TVT Arbeitskreis 7 zum Flugunfähigmachen von Vögeln 2015) in which they express their categorical disapproval of deflighting. However, for 2.15% of avian species they concede that under certain conditions deflighting could, theoretically, offer a greater degree of welfare compared to housing in aviaries. The species in question are listed in the statement's appendix and again consist of those with a strong attachment to the ground or water (eg flamingos, pelicans, cranes). Although, at present and in light of current knowledge, the TVT considers wing-clipping of these species justifiable, they are also keen for further research.

In 2012, the New Zealand Veterinary Association (NZVA) stated that permanent flight restriction is not approved and "that in the future, enclosures are designed or modified in such a way as to incorporate broad welfare considerations including the ability for a bird to display flight" (NZVA 2012).

The Association of Avian Veterinarians (AAV) considered pinioning as "an acceptable practice in […] flighted species that are routinely kept in open enclosures" (AAV undated) without elaborating any further.

In peer-reviewed and scientific literature

The majority of peer-reviewed articles dealing with deflighting concentrate on the assessment of surgical techniques (see Table 2) rather than whether the practice itself should come into question. However, a number of authors have either justified or criticised particular aspects of the different practices. A very precise evaluation of the issue was offered by Dollinger *et al* (2014) in *Flugunfähigmachen von Vögeln – Für und Wider* (published in German). Against an increasingly complicated backdrop the authors set out an exhaustive evaluation of the pros and cons of deflighting and the range of techniques deployed.

An argument against prohibiting the keeping of deflighted birds is the resultant interference with zoos' social function, in terms of education, research and conservation (Council Directive 1999/22/EC). Few would have sufficient funds in place to support relocating all species of bird under flight restraint in open display to larger aviaries. Expense, not to mention restrictions due to preservation orders, often make it impossible to build new exhibits or turn such exhibits, which are commonly dominated by large water areas, into aviaries (Dollinger *et al* 2014). This predicament is further exacerbated by the fact that birds "do not have the star attraction appeal" of large mammals, such as elephants or gorillas (Carr 2016), meaning zoos might be reluctant to invest large sums of money in the creation of large aviaries (Bračko & King 2014). This led Dollinger *et al* (2014) to express concerns that prohibition of deflighting might lead zoos to give up keeping, breeding and exhibiting affected species, thereby endangering the role of zoo-kept birds as ambassadors for their relatives in the wild. It would also jeopardise the security of a genetically stable *ex situ* back-up population as well as limiting the possibility of gaining scientific knowledge about these species. Klausen (2014) and Bračko and King (2014) argue, on the other hand, that presenting deflighted birds interferes with zoos' mission to educate its visitors, since it not only reflects false reality but also brings into question the zoos' ethical sincerity.

An advantage of keeping birds either irreversibly deflighted or in fully closed aviaries is the prevention of escape (Dollinger *et al* 2014). This should be seen not only as protection for the escapee, which might suffer predation, food shortage or climatic discomfort, but also for local biodiversity and protection from potentially invasive species. An advantage that may be lost with wing-clipping since the need for newly grown feathers to be cut in the narrow time slot between finished growth and full flight capacity comes with a high risk of escape (Dollinger *et al* 2014).

In terms of breeding, Bračko and King (2014) note that fully flighted birds — especially large and long-legged species — are generally considered to have better copulation results. The wing asymmetry created by deflighting is presumed to impact negatively on copulation success in those species that copulate standing, as it may interfere with the male's attempt to maintain balance on the female's back while cloacal contact is made. This has been studied extensively in flamingos where low rates of copulation success, especially in pinioned birds, have been reported and even quantified in various publications (Pickering 1992; King 1994; Farrell *et al* 2000; King & Bračko 2014). Bračko and King (2014) also posited the notion that the prospective attractiveness of deflighted males from species that wing flap as part of their courtship display might be reduced. On the other hand, self-sustaining flamingo populations kept under flight restraint (including pinioned groups) commonly occur (Rose *et al* 2014), eg the three largest flocks of greater flamingos in Germany all show continuous breeding success despite being deflighted, ie Weltvogelpark Walsrode (dpa 2018), Wilhelma Zoologisch-Botanischer Garten Stuttgart (data obtained via Zoological Information Management System, ZIMS) and Tierpark Hellabrunn Munich (Tierpark Hellabrunn 2018). Moreover, Rose *et al* (2013) were not able to find a difference in overall behaviour between airworthy and pinioned greater flamingos within a flock — neither in breeding nor in other behaviours.

A commonly held opinion is that in some cases and species, deflighting can be "a practice that delivers benefits to the captive bird by, ironically, increasing its freedom within captivity" (Hesterman *et al* 2001). This opinion is also supported by Dollinger *et al* (2014) and the TVT (2015). They state, that for some bird species under human care, flight restraint might actually offer a higher state of welfare than can be provided without, for example, those with a strong binding to the ground and/or water and the presumed insignificance of flight under human care. Therefore, Dollinger *et al* (2014) focused their attention on discussing the significance and biological function of flight in general for different bird species and its use in their daily behavioural repertoire. The use of flight varies greatly among different bird species, with some even evolving to give up their capacity to fly. It follows that in species that only make use of their wings in situations not occurring under human care, eg searching for new feeding grounds or predator avoidance, or in situations physically impossible to recreate, eg migration, it might be appropriate for emphasis to be placed on ensuring birds are able to carry out their more relevant behavioural repertoire in the best way possible.

Considering species' biology as well as the potential need for a species to fly, Dollinger *et al* (2014) proposed a list whereby bird species commonly kept in zoos were assigned to one of four categories: i) suitable to be kept free-ranging and flight capable (eg Indian peafowl [*Pavo cristatus*]); ii) preferentially kept deflighted in open display (eg flamingos, pelicans); iii) equally suitable to be kept deflighted or in an aviary (eg shoebill [*Balaeniceps rex*]); and iv) only to be kept in aviaries (eg herons, parrots [Psittaciformes]). This classification system is largely analogous to the proposed list of the TVT (2015). Vinke *et al* (2016) suggested that every decision on whether or not to deflight should be made not only at a species level but also taking into account the given circumstances of the animal or group in question. Therefore, they presented a three-step decision tree encouraging establishments to first collect data on the species' biology (ie the role wing use plays in the species' life), the individual's previous life experience (including the habituation to contact with humans) and the given housing and management situation (ie social group structure, potential hazards). The second step is a critical evaluation of whether the purpose of the intervention is merely to simplify management procedures or whether it genuinely promotes welfare. Provided the latter applies, the third step is to help choose between permanent and reversible deflighting techniques. Again, special attention is paid to the question of whether a bird is socialised to humans. The authors provide advice regarding birds unaccustomed to human contact, emphasising the need to not underestimate the stress animals experience during capture and restraint.

Although they concede that an ideal exhibit would allow expression of the full behavioural repertoire, including proper flight, Dollinger *et al* (2014) doubt the feasibility of this for most zoological institutions for the reasons mentioned earlier. This point is emphasised by the fact that many, if not most, of the species in categories (ii) and (iii) are relatively large birds that need a long runway to take off and demonstrate low manoeuvrability in flight. An aviary providing not only an opportunity for safe take-off and landing but also a choice between directions in mid-air would require to cover a very large area. Therefore, the display of birds in aviaries only to avoid deflighting procedures but without enabling actual flight needs to be evaluated critically, especially when large well-structured areas for keeping deflighted birds would be available. Moreover, some authors report an increased risk of bird injury upon collision with the boundaries of unsuitable aviaries (Krawinkel 2011; Dollinger *et al* 2014), while others point out that an inability to fly can lead to traumatic injuries in deflighted birds (Hesterman *et al* 2001; Bračko & King 2014).

Another advantage of fully closed aviaries is that of improved control of predators. Foxes (*Vulpes* spp), racoons (*Procyon* spp), rats (*Rattus* spp), crows (*Corvus* spp), martens (Mustelidae) and other indigenous predators (Bračko & King 2014; Schmidt & Jäger 2015) threaten not only nests, eggs and chicks but also adult birds. Exhibits closed on all sides facilitate establishment of successful predator control (Bračko & King 2014). However, trials with hidden cameras at Nuremberg Zoo revealed mustelids readily entered exhibits thought to be predator-proof (K Baumgartner, personal communication 2018).

Odense Zoo in Denmark, which opened in 2009, has a large aviary for African water birds which has been cited as a positive example of the successful realisation of an alterna-

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tive to deflighting (Klausen 2014; Schmidt & Jäger 2015). Built mainly to "move away from the pinioning of birds" (Klausen 2014), the aviary accommodates commonly deflighted species such as greater flamingos, pink-backed pelicans (*Pelecanus rufescenes*) and hottentot teals (*Spatula hottentota*), among others. The former vice director of Odense Zoo, Bjarne Klausen (2014), stated that "in the new aviary the birds appear to fly for no other reason than just to fly." This was confirmed by the chief zoologist of Odense Zoo, Nina Collatz Christensen, who stated that all bird species with the exception of flamingos and helmeted guinea fowl (*Numida melagridis*) can indeed be observed to fly on a regular basis, without any visible stimulus.

Finally, it has to be noted that although opinions are strongly divergent, attempts to actually measure the effects of deflighting procedures on avian welfare using animal-based measures have not yet been made, a fact that most authors — regardless of their position — agree upon (Dollinger *et al* 2014; Rose *et al* 2014).

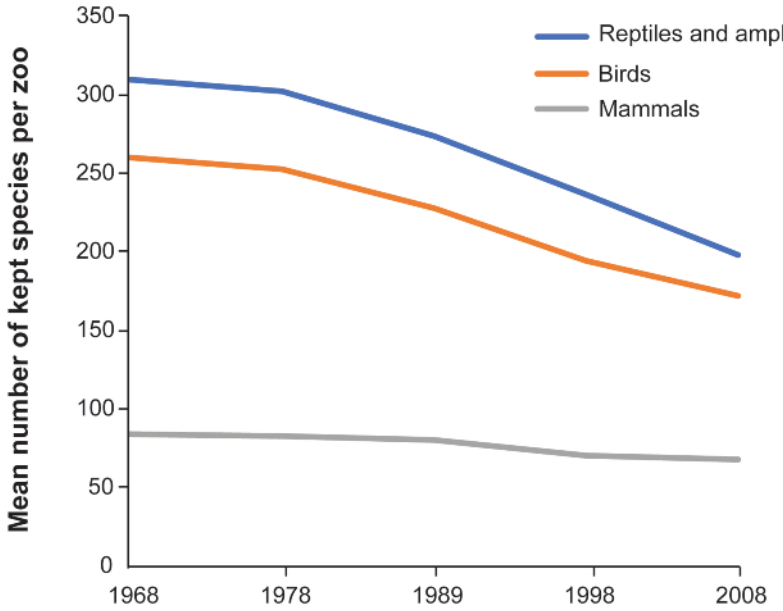
Discussion

The present overview shows the relatively small extent to which the effects of deflighting have been discussed in peer-reviewed literature. Almost all arguments are based on assumptions, observations, institutional or financial interests or even basic empathy. Although welfare implications are mentioned occasionally, they appear as an aside to other questions and therefore seldom advance to the level of a technical discussion. Elevation of this discussion away from mere speculation to evidence-based arguments demands not only reliable research but also a precise and scientifically sound approach.

For evaluation, one must be aware that the concept of displaying animals inevitably includes the restraint of movement of all species presented, irrespective of their mode of locomotion. Therefore, every zoo animal has its freedom abridged in some form or another. Moreover, a zoo will never be able to provide conditions that exactly match a species' habitat. Nevertheless — or even because of it — every zoo is responsible for ensuring its inhabitants have the best standards of welfare possible within the limitations that exist. This balancing act between curtailing and providing animals with the possibility to express species-specific behaviours describes the challenge of every modern animal husbandry unit and demands a precise assessment of welfare (eg Botreau *et al* 2007; Mellor 2016). This, again, requires extensive knowledge of a species' behavioural repertoire and specific needs. Taking all this into consideration, one may be tempted to deny the necessity for any bird to fly under human care — no predators, no food shortage, no external migratory pressure. This leads us to ask: is the ability to fly inextricably linked to a bird species' need to express 'appropriate behaviour' (Botreau *et al* 2007)? For most members of the avian class, this can be answered easily: yes, their daily routine is so obviously dictated by the use of their wings (eg for all passerines [Passeriformes], Charadriiformes, Piciformes and more) that keeping them in aviaries is mandatory. For other species, however, evaluation of this question is far more complex. Greater flamingos (*Phoenicopterus roseus*), for example, seem to be bound very strongly to the ground, and although able to fly long distances, these flights seem associated only with migration and foraging (Bouaguel *et al* 2013; Rose *et al* 2014). Therefore, the question of the significance of flight is justifiable, and efforts to attain extensive knowledge not only for greater flamingos but for every single species in doubt are desirable. Although assumed by some authors, it is simply not known whether for certain species a large and well-structured exhibit — allowing the full remaining behavioural repertoire to be expressed — can balance out this inability to fly. Nor is it known whether offering life in a relatively small aviary that allows intact wings but no proper flight (as is often the case for larger species that have low manoeuvrability and require a lot of space for take-off, eg flamingos, cranes) is a valid compromise. In general, it has to be conceded that the behavioural need for flight apart from being directly connected to another purpose (eg moving from A to B, hunting, flight etc) is barely understood. Large aviaries that permit flight can help by collecting data from their resident species and their need to fly under human care. Observations such as those from Odense Zoo might indicate the diversity of how species make use of this opportunity, although it is important to point out that the behaviours shown (Klausen 2014) only rely on anecdotal observations that have not yet stood up to peer-reviewed scientific scrutiny.

The lists of birds mentioned that seem appropriate for being deflighted are valuable compilations indicating the species for which research is needed. All single taxa demand their own unbiased approach and collected data should be transferred to other species very meticulously, especially to those distantly related to the species studied. Phylogenetic comparative methods (Mellor *et al* 2018) are useful tools to include the varying relationships between species in the statistical analysis and should be used once sufficient data are available. These indicate that factors influencing a species' welfare are more likely to be transferable to a closely related species than to one more distantly related. In practice, this means that, for example, findings pertaining to the greater flamingo are more likely to also be applicable to the American flamingo (*Phoenicopterus ruber*) than to the Dalmatian pelican (*Pelecanus crispus*). Therefore, concentrating on one or two popular representatives of every order or family in doubt first and transferring data on less commonly kept species rather than trying to exhaustively evaluate one order after the other would appear reasonable. However, even between closely related species major differences may occur. The brown pelican (*Pelecanus occidentalis*), for example, uses its wings for several behaviours. It partly nests and roosts in trees (Nelson 2005) and its foraging strategy relies on plunge-diving for fish from a height of several meters (Schreiber *et al* 1975). This feeding behaviour shows a strong similarity with the distantly related gannets and boobies (*Sulidae*) (Nelson 2005). The close relative, on the other hand (Kennedy *et al* 2013), the American white pelican (*Pelecanus erythrorhynchos*), hunts

Figure 1



Trends of the mean number of animal species kept in 37 VdZ-Zoos from 1968 to 2008. Figure redrawn with permission from P Dollinger.

whilst swimming and nests aground; thereby showing a resemblance with more distantly related pelican species from the Old World (Nelson 2005). This example shows the importance of considering both the biobehavioural knowledge and the phylogeny.

The effect of increased awareness of animal welfare by the general public as well as growing knowledge about zoo animals and their behavioural needs as a result of research can be observed in zoos worldwide. Species' exhibits are growing as well, as are attempts to address animals' needs through structure and management. This development is most gratifying but needs also to extend to bird-keeping. Yet consideration must be given to the fact that this development is occurring in conjunction with the ongoing depletion of species in most zoos, especially birds, reptiles and amphibians (see Figure 1). This evolution, however, has limited compatibility with what zoos are supposed to stand for, ie 'preservation', 'education' and 'research' (Council Directive 1999/22/EC). To ensure a genetically stable *ex situ* population of a species, several independently existing zoo populations that exchange individuals are required. Therefore, the reduction of species in zoos endangers biodiversity; either through keeping populations that falter due to the lack of genetically valuable exchange partners or by establishing a common agreement on which few species are to be kept to guarantee a genetic variability (VdZ 2016). The diversity of bird species in zoos is already decreasing dramatically (Dollinger 2014); possibly due to their reduced popularity compared to mammals (Moss & Esson 2010; Carr 2016). The fact that few zoos are willing or even able to hold on to species that are of low visitor interest is troubling. Many are in dire need of fundamental management and housing changes and afflicted by high financial and/or spacial expenses. A decrease in the keeping and subsequent preservation of affected species seems unavoidable. However, the role of zoos in wildlife conservation consists not only of breeding but also showing species, education and fundraising — all of which being linked inextricably (Swanagan 2000; Conway 2003; Tribe & Booth 2003). Therefore, especially in the case of (critically) endangered species, conservation needs must be met in accordance with animal welfare standards. Moreover, it is crucial for these two goals not to be seen to be competing, but as different aspects of the same common aim: the welfare of the species and the individual (Fraser 2010).

As far as Europe is concerned, there is movement away from pinioning and more towards wing-clipping (J Dekker, EAZA, personal communication 2016). This would appear a generalised reaction to the banning of pinioning (and other irreversible methods of deflighting) as opposed to a revised outlook based on concerns for welfare. And it is worth noting that these prohibitions lack any scientific basis. Basic empathy leads to the over-riding notion of pinioning and other surgical interventions as being nothing more than 'mutilations'. Nevertheless, it remains highly questionable whether such a stark outlook is necessarily accurate and whether wing-clipping represents a better alternative, simply as a result of being less invasive. Wing-clipping necessitates repeated capture; for most species once or even twice a year. The impact of these potentially stressful and harmful intrusions remains unknown — and the risk of injury connected with repeated capture and restraint, especially in species with a greater risk of capture-induced myopathy, such as flamingos (Brown & King 2005), should also come into consideration. Moreover, the increased risk of escape in wing-clipped birds is undeniable. Not only does this contravene the EU Zoos Directive, which demands prevention of "the escape of animals in order to avoid possible ecological threats to indigenous species" (Council Directive

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1999/22/EC), there is also the potential for preventable suffering or harm to escaped individuals to be considered. Obviously, an escaped bird is much more likely to experience stress, hunger or harm due to disorientation, isolation, predators, lack of food, inappropriate climate, etc. Various incidents of bird escape have shown that not all individuals are recoverable and, as a result, pose a potential threat to themselves or to the unfamiliar ecological habitat they enter.

Another aspect requiring further clarification is the extent to which the lowered copulation rate (Pickering 1992; King 1994; Farrell *et al* 2000; King & Bračko 2014) in some deflighted bird species enters the realm of diminishing welfare. In species commonly kept in pairs (such as cranes and most storks) the process of deflighting may directly affect conservation efforts, since a non-reproducing pair is of limited or even non-existant value to the conservation of a threatened species. In well-reproducing flocks (eg flamingos, pelicans) this is less of an issue, although the observation that wing-clipped birds struggle less to mount the female, compared to pinioned ones remains noteworthy (Farrell *et al* 2000). Repeated failed attempts to mount has the potential to be deeply stressful, thereby impinging on the birds' welfare. Similarly there is also the suggestion that deflighted males may appear less attractive to females than their intact conspecifics. Limited data availability fail to corroborate these hypotheses (Rose *et al* 2013), however both considerations are worthy of scientific examination.

Animal welfare implications and conclusion

It is possible that further investigation will reveal that for some of the bird species in question, flight is an essential component of their ability to carry out appropriate behaviour. In such cases, the only suitable exhibit for these animals will be large aviaries, and the associated high costs and management difficulties might lead to certain species becoming a rarity in zoos of the future. In the face of such a scenario the only reasonable approach is science-based animal welfare assessment. Increasing public concern about animal welfare, however heartening, must act as the catalyst for a scientific endeavour and not be the platform for fundamental changes. From the "outdated" (Mellor 2016) 'Five Freedoms' (Farm Animal Welfare Council 1992) to the "12 subcriteria" (Botreau *et al* 2007) up to the differentiated concept of "a life worth living" (Mellor 2016) various concepts and improvements to animal welfare evaluation have been proposed as tools to facilitate exhaustive assessment. These should also be applied here and adjusted to take into account species of bird in question to attain credible scientific results that justify far-reaching decisions, be it at a legislative or institutional level.

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References

Animal Welfare Act 1966 *United States Department of Agriculture L: United States of America*. https://www.gpo.gov/fdsys/pkg/USCODE-2015-title7/html/USCODE-2015-title7-chap54.htm

Animal Welfare Act 2006 *(c45) Parliament of the United Kingdom L: United Kingdom*. https://www.legislation. gov.uk/ukpga/2006/45/pdfs/ukpga_20060045_en.pdf

Animal Welfare Regulations 2012 *Department for Environment and Water L: South Australia*. https://www.legislation.sa.gov.au/LZ/C/R/ANIMAL%20WELFARE%20REGULATIONS%202012/CURRENT/2012.187.AUTH.PDF

Antinoff N 2002 Anatomic alteration in birds. *Journal of Avian Medicine and Surgery 16*: 57-64. https://doi.org/10.1647/1082-6742(2002)016[0057:AAIB]2.0.CO;2

Association of Avian Veterinarians undated *Position Statement of the AAV On Permanent Anatomic Alterations of Avian Species*. https://www.aav.org/general/custom.asp?page=surgicalalter

Baumgartner K, Kempf H, Will H and Lendl C 2012 Feather follicle atrophying by laser: an improvement of extirpation for animal welfare reasons. *Proceedings of the International Conference on Diseases of Zoo and Wild Animals* pp 22-25. 16-19 May 2012, Bussolengo, Italy

Beckmann M and Thal D 2017 Flugunfähigkeitsbewirkende Behandlungen von Zoovögeln. Rechtliche Rahmenbedingungen des Tier- und Naturschutzrechts. *Natur und Recht 39*: 154-163. [Title translation: Deflighting procedures in zoo birds. Legal framework of Animal Welfare Law and Conservation Law]. https://doi.org/10.1007/s10357-017-3151-y

Bennett RA and Baumgartner K 2015 Avian deflighting techniques. In: Miller RE and Fowler ME (eds) *Fowler's Zoo and Wild Animal Medicine* pp 650-660. Elsevier/Saunders: St Louis, Missouri, USA. https://doi.org/10.1016/B978-1-4557-7397-8.00065-7

Botreau R, Veissier I, Butterworth A, Bracke MBM and Keeling L 2007 Definition of criteria for overall assessment of animal welfare. *Animal Welfare 16*: 225-228

Bouaguel L, Saheb M, Bensaci E, Bougoudjil S, Bouslama Z and Houhamdi M 2013 Status and diurnal behavior of the greater flamingo (*Phoenicopterus roseus*) in Algerian eastern high plains. *Annals of Biological Research 4*: 232-237

Bračko A and King CE 2014 Advantages of aviaries and the Aviary Database Project: a new approach to an old housing option for birds. *International Zoo Yearbook 48*: 166-183. https://doi.org/10.1111/izy.12035

Brown C and King C 2005 *Flamingo husbandry guidelines: a joint effort of the AZA and EAZA in cooperation with WWT*. https://docplayer.net/20893564-Flamingo-husbandry-guidelines.html

Captive Animals' Protection Society (CAPS) 2013 *Mutilated for your viewing pleasure - Pinioning birds in English zoos*. https://forms.freedomforanimals.org.uk/wp-content/uploads/2013/03/CAPS_Birds_in_Zoos_Summary_0313_FINAL_v2.pdf

Carr N 2016 Ideal animals and animal traits for zoos: General public perspectives. *Tourism Management 57*: 37-44. https://doi.org/10.1016/j.tourman.2016.05.013

Conway W 2003 The role of zoos in the 21st century. *International Zoo Yearbook 38*: 7-13. https://doi.org/10.1111/j.1748-1090.2003.tb02059.x

Council Directive 1999/22/EC 1999 *Council of the European Union*. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=uriserv:OJ.L_.1999.094.01.0024.01.ENG

Curton JM 2001 Brailing... a flight restraint technique. *AFA Watchbird 28*: 34-35

D'Agostino JJ, Snider T, Hoover J and West G 2006 Use of laser ablation and cryosurgery to prevent primary feather growth in a pigeon (*Columba livia*) Model. *Journal of Avian Medicine and Surgery 20*: 219–224. https://doi.org/10.1647/1082-6742(2006)20[219:UOLAAC]2.0.CO;2

Degernes LA and Feduccia A 2001 Tenectomy of the supracoracoideus muscle to deflight pigeons (*Columba livia*) and cockatiels (*Nymphicus hollandicus*). *Journal of Avian Medicine and Surgery 15*: 10-16. https://doi.org/10.1647/1082-6742(2001)015[0010:TOTSMT]2.0.CO;2

Demirkan I, Altin S, Demirkan A and Korkmaz M 2010 Comparison of the effects of flight restraint in the partridge (*Alectoris chukar*) by tenectomy, capsulectomy or tenectomy plus capsulectomy techniques. *Kafkas Universitesi Veteriner Fakultesi Dergisi 16*: 1017-1024. https://doi.org/10.9775/kvfd.2010.2296

Djurskyddsmyndighetens föreskrifter om djurhållning i djurparker 2004 *Djurskyddsmyndigheten L: Sweden*. https://www.jordbruksverket.se/download/18.26424bf71212ecc74b08000877/1370040445226/DFS_2004-19.pdf. [Title translation: Animal welfare Regulations on Animal Husbandry in Zoos]

Dollinger P, Pagel T, Baumgartner K, Encke D, Engel H and Filz A 2014 Flugunfähigmachen von Vögeln – Für und Wider. *Der Zoologische Garten 82*: 293-339. https://doi.org/10.1016/j.zoolgart.2014.01.004. [Title translation: Deflighting birds – pros and cons]

dpa 2018 *July 10 Babyboom bei den Flamingos im Vogelpark Walsrode*. http://www.neuepresse.de/Nachrichten/Niedersachsen/Uebersicht/Babyboom-bei-den-Flamingos-im-Vogelpark-Walsrode

EAZA/BIAZA 2017 *Joint response from the European Association of Zoos and Aquaria and the British and Irish Association of Zoos and Aquariums to the release of the Born Free Foundation's 'Beyond the Bars' report on wild animal welfare in the United Kingdom*. https://www.eaza.net/assets/Uploads/EAZA-Documents-Other/2017-03-EAZA-and-BIAZA-response-to-the-release-of-the-Born-Free-Foundation-report-on-wild-animal-welfare-in-the-United-Kingdom-FINAL.pdf

Engebretson M 2006 The welfare and suitability of parrots as companion animals: a review. *Animal Welfare 15*: 263-276

European Association of Zoos and Aquariums (EAZA) 2014 *Standards for the Accommodation and Care of Animals in Zoos and Aquaria*. https://www.eaza.net/assets/Uploads/Standards-and-policies/Standards-for-the-Accommodation-and-Care-of-Animals-2014.pdf

Farm Animal Welfare Council 1992 FAWC updates the Five Freedoms. *Veterinary Record 17*: 357

Farrell MA, Barry E and Marples N 2000 Breeding behavior in a flock of Chilean flamingos (*Phoenicopterus chilensis*) at Dublin zoo. *Zoo Biology 19*: 227-237. https://doi.org/10.1002/1098-2361(2000)19:4<227::AID-ZOO1>3.0.CO;2-H

Flinchum GB 2006 Management of waterfowl. In: Harrison GJ and Lightfoot TL (eds) *Clinical Avian Medicine* pp 831-848. Spix Publishing, Inc: Palm Beach, FL, USA

Fraser D 2010 Toward a synthesis of conservation and animal welfare science. *Animal Welfare 19*: 121-124

Hesterman H, Gregory NG and Boardman WSJ 2001 Deflighting procedures and their welfare implications in captive birds. *Animal Welfare 10*: 405-419

Kennedy M, Taylor SA, Nádvorník P and Spencer HG 2013 The phylogenetic relationships of the extant pelicans inferred from DNA sequence data. *Molecular Phylogenetics and Evolution 66*: 215-222. https://doi.org/10.1016/j.ympev.2012.09.034

King CE 1994 Management and research implications of selected behaviours in a mixed colony of flamingos at Rotterdam Zoo. *International Zoo Yearbook 33*: 103-113. https://doi.org/10.1111/j.1748-1090.1993.tb00612.x

King CE and Bračko A 2014 Nineteen years of management for Phoenicopteriformes in European Association of Zoos and Aquaria institutions: The Fabulous Flamingo Surveys and strategies to increase reproduction in captivity. *International Zoo Yearbook 48*: 184-198. https://doi.org/10.1111/izy.12041

Klausen B 2014 A mixed-species exhibit for African water birds (including pelicans, flamingos, spoonbills and storks) at Odense Zoo, Denmark: breeding success, animal welfare and education. *International Zoo Yearbook 48*: 61-68. https://doi.org/10.1111/izy.12043

Krawinkel P 2011 Feather follicle extirpation: Operative techniques to prevent zoo birds from flying. In: Miller RE and Fowler ME (eds) *Fowler's Zoo and Wild Animal Medicine* pp 275-280. Elsevier Health Sciences: St Louis, Missouri, USA. https://doi.org/10.1016/B978-1-4377-1986-4.00036-6

Lin Zhang S, Hui Yang S, Li B, Xu YC, Hua Ma J, Feng Xu J and Guang Zhang X 2011 An alternate and reversible method for flight restraint of cranes. *Zoo Biology 30*: 342-348. https://doi.org/10.1002/zoo.20326

Maisack C and Schmidt T 2017 Zum Flugunfähigmachen von Vögeln in Zoos und privaten Geflügelhaltungen. *Natur und Recht 39*: 734-741. https://doi.org/10.1007/s10357-017-3250-9. [Title translation: About the deflighting of birds in zoos and private bird collections]

Mellor DJ 2016 Updating animal welfare thinking: Moving beyond the Five Freedoms towards 'a life worth living'. *Animals 6*: 21. https://doi.org/10.3390/ani6030021

https://doi.org/10.7120/09627286.29.1.069 Published online by Cambridge University Press

Mellor E, Kinkaid HM and Mason G 2018 Phylogenetic comparative methods: Harnessing the power of species diversity to investigate welfare issues in captive wild animals. *Zoo Biology 37*: 369-388. https://doi.org/10.1002/zoo.21427

Ministry of the Environment 2004 *Arrêté du 25 mars 2004 fixant les règles générales de fonctionnement et les caractéristiques générales des installations des établissements zoologiques à caractère fixe et permanent, présentant au public des spécimens vivants de la faune locale ou étrangère. (JORF n°78) Ministère de l'Environnement L: France.* https://www.legifrance.gouv.fr/eli/arrete/2004/3/25/DEVN0430016A/jo/texte. [Title translation: Order of March 25 2004, laying down the general operating rules and general characteristics of installations of fixed and permanent zoos, presenting to the public live specimens of local or foreign fauna]

Ministry of Social Affairs 2001 *Arrêté royal relatif aux interventions autorisées sur les vertébrés pour l'exploitation utilitaire de l'animal ou pour limiter la reproduction de l'espèce. (2001016198) ministère des affaires sociales, de la sante publique et de l'environnement et ministère des classes moyennes et de l'agriculture L: Belgium*. http://www.etaamb.be/fr/arrete-royal-du-17-mai-2001_n2001016198.html. [Title translation: Royal Decree on authorised interventions on vertebrates for the utilitarian use of the animal or to limit the reproduction of the species]

Moss A and Esson M 2010 Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology 29*: 715-731. https://doi.org/10.1002/zoo.20316

Nelson JB 2005 *Pelicans, Cormorants and their Relatives: The Pelecaniformes, First Edition.* Oxford University Press: Oxford, UK

New Zealand Veterinary Association 2012 *Flight restriction in birds*. http://www.nzva.org.nz/?page=policyflightres

NSW Guidelines for the pinioning of birds 1996 *Department of Primary Industries L: New South Wales.* https://www.dpi.nsw.gov.au/animals-and-livestock/animal-welfare/general/bird-pinioning

PeTA Deutschland eV 2017 *Systematische Verstümmelung von Vögeln – PETA erstattet Strafanzeige gegen Tierpark Cottbus sowie 19 weitere Zoos und Tierparks.* https://www.peta.de/systematische-verstuemmelung-von-voegeln-peta-erstattet-strafanzeige-gegen-6. [Title translation: Systematic mutilation of birds – PETA brings charges against Zoo Cottbus and 19 other zoos]

Pickering SPC 1992 The comparative breeding biology of flamingos (*Phoenicopteridae*) at The Wildfowl and Wetlands Trust Centre, Slimbridge. *International Zoo Yearbook 31*: 139-146. https://doi.org/10.1111/j.1748-1090.1991.tb02377.x

Rose P, Croft D, Dow S and George A 2013 Investigating the behaviour and welfare of captive flamingos. *Conference paper.* Bristol Zoo Gardens, Bristol, UK. https://www.researchgate.net/profile/Paul_Rose4/publication/282287727_Investigating_the_behaviour_and_welfare_of_captive_flamingos/links/560a854208ae576ce63fe31d.pdf

Rose PE, Croft DP and Lee R 2014 A review of captive flamingo (*Phoenicopteridae*) welfare: a synthesis of current knowledge and future directions. *International Zoo Yearbook 48*: 139-155. https://doi.org/10.1111/izy.12051

Schmidt T and Jäger C 2015 Das Flugunfähigmachen von Vögeln in zoologischen Einrichtungen unter Tierschutzgesichtspunkten. *Amtstierärztlicher Dienst (BbT) 3/15*: 163-167. [Title translation: Deflighting birds in zoological institutions in the light of animal welfare]

Schreiber RW, Woolfenden GE and Curtsinger WE 1975 Prey capture by the brown pelican. *The Auk 92*: 649-654. https://doi.org/10.2307/4084778

Shaw SN, D'Agostino JJ, Davis MR and McCrae EA 2012 Primary feather follicle ablation in common pintails (*Anas acuta acuta*) and a white-faced whistling duck (*Dendrocygna viduata*). *Journal of Zoo and Wildlife Medicine 43*: 342-346. https://doi.org/10.1638/2010-0114.1

South Australian Code of Practice for the Husbandry of Captive Birds undated *Department for Environment and Water L: South Australia*. https://ablis.business.gov.au/service/sa/south-australian-code-of-practice-for-the-husbandry-of-captive-birds/492

Swanagan JS 2000 Factors influencing zoo visitors' conservation attitudes and behavior. *The Journal of Environmental Education 31*: 26-31. https://doi.org/10.1080/00958960009598648

The Mutilations (Permitted Procedures) (England) Regulations 2007 *The Mutilations (Permitted Procedures) (England) Regulations.* Defra: London, UK. https://www.legislation.gov.uk/ukdsi/2007/9780110757797

The Welfare of Livestock Regulations 1982 *The Welfare of Livestock Regulations: UK.* Defra: London, UK. https://www.legislation.gov.uk/uksi/1982/1884/pdfs/uksi_19821884_en.pdf

Tierärztliche Vereinigung für Tierschutz eV 2015 *Stellungnahme der TVT Arbeitskreis 7 (Zoo und Zirkus) zum Flugunfähigmachen von Vögeln*. https://www.tierschutz-tvt.de/index.php?id=50&no_cache=1&download=TVT-Stellungn._Flugunf%C3%A4higmachen_von_V%C3%B6geln__Mai_2015_.pdf&did=175. [Title translation: Statement of the Veterinary Association for Animal Welfare, work group 7 (zoo and circus) regarding the deflighting of birds]

Tierhaltungsverordnung 2 2004 *(BGBl. II Nr 486/2004) Bundesministerium für Gesundheit L: Austria*. https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20003860. [Title translation: Second Ordinance on Animal Husbandry]

Tierpark Hellabrunn 2018 *Die ersten Sommer-Vorboten sind geschlüpft – Flamingo-Küken in Hellabrunn*. https://www.hellabrunn.de/uploads/media/32_Pressemitteilung_Sommer-Vorboten_Flamingo-Kueken.zip. [Title translation: The first harbingers of summer are hatched – flamingo chicks in Hellabrunn]

Tierschutzgesetz 2006 *Bundesministerium der Justiz und für Verbraucherschutz L: Germany*. https://www.gesetze-im-internet.de/tierschg/BJNR012770972.html. [Title translation: Animal Welfare Law]

Tierschutzverordnung 2008 *Der Schweizerische Bundesrat L: Switzerland*. https://www.admin.ch/opc/de/classified-compilation/20080796/index.html. [Title translation: Ordinance on animal protection]

Tribe A and Booth R 2003 Assessing the role of zoos in wildlife Conservation. *Human Dimensions of Wildlife 8*: 65-74. https://doi.org/10.1080/10871200390180163

Tyson E 2014 For an end to pinioning: The case against the legal mutilation of birds in captivity. *Journal of Animal Ethics 4*: 1-4. https://doi.org/10.5406/janimalethics.4.1.0001

Verband der Zoologischen Gärten (VdZ) eV 2016 *Hintergrundinformation des Verbands der Zoologischen Gärten (VdZ) zur Einschränkung des Fliegens einiger weniger Vogelarten in Zoos*. https://www.vdz-zoos.org/fileadmin/user_upload/08112016_-_zur_Flugeinschraenkung_von_Voegeln.pdf. [Title translation: Background information of the Association of Zoological Gardens, Germany towards deflighting of few bird species in zoos]

Vinke CM, Schoemaker NJ, Meijboom FLB and van Zeeland YRA 2015 Some welfare and ethical considerations on flight restraint methods in birds. *Conference Proceedings AWSELVA-ECAWBM-ESVCE Congress* pp 19-20. 30 September-4 October 2015, Bristol, UK

Vinke CM, van Zeeland YRA, Schoemaker NJ and Meijboom FLB 2016 As free as a bird on a wing: some welfare and ethical considerations on flight restraint methods in birds. In: Speer BL (ed) *Current Therapy in Avian Medicine and Surgery* pp 683-709 First Edition: St Louis, Missouri, USA

Vollmerhaus B and Sinowatz F 2004 Haut und hautgebilde. In: Nickel R, Schummer A and Eugen Seiferle E (eds) *Lehrbuch der Anatomie der Haustiere. Band 5. Anatomie der Vögel.* Parey im MVS: Stuttgart, Germany. https://doi.org/10.1055/b-0037-148467. [Title translation: Skin and integumentary appendages]

Wet Dieren (Animal Law) 2019 *Ministerie van Economische Zaken en Klimaat L: The Netherlands*. https://maxius.nl/wet-dieren/artikel2.8/?fbclid=IwAR39MbTKcM-GN_Lfylr293rj31lswliTqZKwtrTqVEc4ujeNvLTi1i7L7HA

William van Lint 2017 Pinioning: here to stay? *Zooquaria 96*: 12-14

World Association of Zoos and Aquariums (WAZA) 2003 *Code of Ethics and Animal Welfare*. http://www.waza.org/en/site/conservation/code-of-ethics-and-animal-welfare

https://doi.org/10.7120/09627286.29.1.069 Published online by Cambridge University Press