Nature without Suffering: Herbivorisation of Predator Species for the Compassionate Stewardship of Earth's Ecosystems

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Abstract

Predation causes suffering and the premature deaths of prey animals. With innovative technologies on the horizon, humanity could phase it out. We argue that herbivorisation, i.e., turning carnivorous species into herbivorous ones with biotechnologies, is better than other strategies for ending predation, because it is the one most likely to preserve environmental values such as biodiversity and receive democratic support. Pressure on vegetation in herbivorised ecosystems would increase, but fertility control could relieve this pressure. We respond to other objections and conclude that the process should be considered as a future megaproject to reduce naturogenic harms.

Keywords

wild animal suffering – predation problem – trophic levels – paradise engineering – gene editing

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Y: Tell me how carnivorous animals could live without destroying other animals?

Z: Tell me how the animals they prey on can live, if they be killed? (Gompertz, 1824)

...is it not your duty, if not to keep me happy and contented within this kingdom of yours, at least to forbid that I should be tormented and molested, and to see that my dwelling there should do me no harm? And I say this, not only for myself, but on behalf of the whole human race, and of all other animals and living creatures. (Leopardi, 1827)

1 Introduction

Predation is the primary cause of death in nature, killing 55 per cent of terrestrial vertebrates (Hill, DeVault, & Belant, 2019). That makes predation probably the most challenging and important problem in wild animal ethics (Sapontzis, 1984, 1987; Cohen & Regan, 2001; Everett, 2001; Cowen, 2003; Fink, 2005; Simmons, 2009; Palmer, 2010; Horta, 2010; Ebert & Machan, 2012; Moen, 2016; Kapembwa, 2018; Bramble, 2020; Faria, 2023; Nussbaum, 2023). One predator causes serious harm (e.g., early and painful death, injuries, anxiety, and stress) to many prey animals, but eradicating predation would have profound effects on ecosystems. This dilemma calls for thoughtful proposals. This essay argues for herbivorising predators (HP) and phasing out predation through directed rapid evolution. In other words, we argue for the genetic reprogramming of predators, i.e., non-human animals that hunt other animals to kill and eat them, into herbivores, i.e., animals who neither need nor want to kill other animals for survival (Pearce, 2009; McMahan, 2010, 2015; Mosquera, 2015; Johannsen, 2021).

Herbivorising predators is possible because natural evolution has already led to the herbivorisation of some formerly carnivorous and omnivorous species. We find the evolution of carnivory to herbivory in fishes (Vermeij & Lindberg, 2000), early synapsids (Hotton III et al., 1997), non-avian dinosaurs (Weishampel & Norman, 1989; King, 1996; Barrett et al., 2010), birds (Storer, 1971), lizards (King, 1996, pp. 29–46; Espinoza et al., 2004), crocodyliforms (Melstrom & Irmis, 2019), frogs (da Silva & de Britto-Pereira, 2006)[7], jumping spiders (Meehan et al., 2009), and other taxa. Herbivorous dinosaurs, such as the triceratops and the long-necked diplodocus, had omnivorous and carnivorous ancestors (Ballell et al., 2022). Several existing herbivorous and plant-dominant omnivorous species of the mammalian order Carnivora such as the giant panda (Wei et al., 2015), red panda (Hu et al., 2017), brown palm civet (Mudappa et al., 2010), kinkajou (Kays, 1999), binturong (Lambert et al., 2014), and spectacled bear (Peyton, 1980; Figueirido & Soibelzon, 2010) demonstrate the evolution of herbivory from carnivorous ancestors. Indeed, all species of herbivorous tetrapods are herbivorised predators, as they all evolved from predatory lobe-finned fishes (Wainwright et al., 2015, see the descriptions of suction feeding; Van Wassenbergh, 2019; Lemberg et al., 2021, p. 7).

The above examples of natural evolution suggest that HP is possible, and current developments within biotechnology could make HP through human-directed evolution feasible. One reason for the timing of this paper is the recent expansion in our capacity to genetically modify organisms with new tools in synthetic biology. Increasingly powerful techniques present new options to re-engineer genetics and produce welfare-improving phenotypic properties in wild animals[8]. There is no sign of this progress slowing down. We could introduce heritable traits into predators that shift them away from carnivorousness and towards herbivorousness. HP may involve genetic modifications, for instance, with a technique known as clustered regularly interspaced short palindromic repeats (CRISPR), tuneable gene drives (Noble et al., 2019), artificial selection, and other tools and techniques

[7] In addition, regarding amphibians, salamanders of the genus *Siren* have been shown to deliberately consume significant amounts of plant material as part of their omnivorous diets (Schwarz et al., 2021).
[8] See Macfarlane et al. (2022) for a review and examination of the potential applications of synthetic biology in conservation.

that may be invented soon, such as novel artificial intelligence systems. Scientists have already utilised artificial selection in research on the reverse process: predatorising omnivores by making voles more carnivorous (Hämäläinen et al., 2022). The increased feasibility makes the discussion about herbivorisation more pertinent; as technological progress makes it more practical to herbivorise predators, the ethical debate will become more relevant.

This paper presents a moral argument, with considerations of feasibility, to start a discussion among ethicists and scientists about the desirability of HP as a vehicle for the compassionate stewardship of non-human nature. If the argument for HP is sound, it entails that individuals are permitted to apply safe, animal-friendly, and effective technologies to herbivorise predators, that society should do so, and that we should at least begin conducting scientific research to find and develop the necessary technology.

It should be uncontroversial that a fundamental condition in an idyllic biosphere is that sentient beings are not forced to inflict suffering on each other to survive. Suppose we discovered an alien civilisation that evolved in a naturally predator-free ecosystem and successfully genetically engineered some animals on their planet to become predators.[9] Wouldn't we be horrified? Or the reverse: suppose another alien civilisation on another planet had, for animal welfare reasons, successfully developed predator-free ecosystems. Would we admire that civilisation, or instead lament what they had done?

Some may view improving nature as counterintuitive, utopian, and a product of human hubris. Nevertheless, technological advancements will likely give us increasing powers over nature. If that is the case, the welfare of current and especially future wild animals will depend on whether we choose to intervene. We begin here with the premise that we should responsibly abolish predation (if possible) so that the biosphere has just two trophic levels: primary producers and herbivores (including detritivores). The critical

[9] We thank an anonymous reviewer for this example.

question then becomes, '*How* should we reduce predation?' This paper argues that herbivorisation is the best way to end predation, mainly because doing so preserves instrumentally valuable biodiversity and some environmentalist values that people consider important. As herbivorisation is a long-term project that primarily benefits wild animals in the far future, it fits in the longtermist tradition in welfare ethics (MacAskill, 2022; O'Brien, 2024).

2 Defining herbivorisation

Herbivorisation is the human-directed process of turning carnivorous species into herbivorous ones. In other words, HP *reprograms* predator species into strictly herbivorous ones. The offspring of predators are born with specific psychological preferences and physiological properties that are closer to those of herbivores. Each new generation becomes more herbivorous until the post-predator is fully adapted as a herbivorous species.

Herbivorising predator *individuals* would involve changing the qualitative identities (i.e., what many people call the 'essential properties' or 'nature' (Katzav, 2002)) of individual predators through interventions in their bodies and minds. Existing predator individuals become more herbivorous because of changes in their preferences and physiological properties that occur during their lives; the changes occur within a generation of predators. Animal A transforms into an animal with different properties and preferences, as when a meat-eating maggot metamorphoses into a nectar-eating, adult-stage blowfly. In contrast, the herbivorisation of predator *populations* involves changing the physiology and preferences of the predators' offspring. The changes occur at the moment of reproduction (i.e., in the germline), so the qualitative identity of an existing individual animal remains unchanged. Rather than animal A being born with its properties and preferences, animal B is born with different properties and preferences. The changes that occur in herbivorising predator populations are like changes that occur through evolution or selective breeding. In summary, with HP, the changes in physiology and preference occur between generations of animals, not within generations.

In this paper, we argue for herbivorising predator populations, not for herbivorising predator individuals. Specifically, we define HP as deliberately influencing the physiological properties and preferences of predatory animals' offspring through interventions in reproduction, such that the offspring can live healthy lives without needing to harm prey animals.

We focus on herbivorising populations because that is less controversial. Artificially changing an individual's qualitative identity is controversial, because it could be more invasive or painful for the individual or it could be considered as a violation of that individual's essential nature. Changing a population over generations is less controversial, although it may face the non-identity problem in population ethics (Parfit, 1984, part 4; Johannsen, 2021, chapter 3; O'Brien, 2022), especially if herbivorised post-predators would have a lower welfare than their nonherbivorised predator counterparts. As we do not see a reason why the welfare of herbivores would be lower, we do not discuss this non-identity problem here.[10]

In addition to physiological and associated anatomical modifications (e.g., to teeth, jaw joints, muscles of mastication, and gastrointestinal tracts), HP might require modifying animals' cognitive (Rohwer, 2018) and moral characteristics (e.g., genetically enhancing cross-species empathy and pro-sociality in post-predator species). We could even uplift predators' capacities for moral agency and political participation (Paez & Magaña, 2023). HP

[10] An anonymous reviewer noted that, as O'Brien (2022) argued, changing which animals come into existence might generate greater moral responsibilities (secondary moral duties of justice) towards those animals. But such responsibility also occurs when we change individual's qualitative identities: due to their change, these individuals will give birth to other offspring, so other animals will come into existence. Furthermore, many common human activities indirectly affect the reproduction of wild animals and hence entail such secondary moral duties. We will leave the issue of such duties that arise due to herbivorisation for future research.

aims to bring about the harmonious coexistence between all kinds of wild animals, so that, as Martha Nussbaum (2006) says, 'all species will enjoy cooperative and mutually supportive relations with one another', which sometimes requires the 'supplanting of the natural by the just'. A critical pathway for this supplantation might be biotechnologies that reshape predatory animals' personality traits and other mental properties.

Herbivorisation may also involve modifying plants to make them more palatable, nutritious (e.g., higher in protein), and digestible by post-predators (Johannsen, 2017, p. 341). In addition, we might learn how to genetically engineer different plants that herbivores eat to grow faster and be less vulnerable to overconsumption.

3 Alternatives to herbivorisation

One alternative to herbivorisation is to do nothing: humans abstain from intentionally interfering with predation in the wild. Doing nothing about the predation problem has the benefit of avoiding unintended negative consequences. It seems implausible, however, that there is *nothing* we can do, now or in the foreseeable future, to alleviate the harms of predation in ways that would, on balance, better animals' lives. Considering our current and increasing ability to improve the situations of prey animals, doing nothing is an inexcusable dereliction (Cochrane, 2019). Doing nothing means continued animal suffering.

The following five alternative options to HP involve intentional, active interference in nature.

3.1 Painlessly killing predators (PKP)

Predator species can be driven to extinction by PKP before they can reproduce. However, we prefer HP over PKP first because HP would be less invasive and harmful to existing predatory animals if we assume that predators have net-positive welfare. With HP, these animals could survive, procreate, and bond with their offspring, while PKP would deprive them of all valuable pleasures. With PKP, predators might see their offspring being killed, which could negatively affect their psychological well-being. Thus, we are sceptical of Ben Bramble's (2020) argument favouring PKP. Bramble argues that HP deprives predators of many valuable pleasures, such as those related to their relationships with their offspring, which might cause them to become depressed. We believe it is unlikely that, for instance, seeing one's offspring eating more plants than usual would be more depressing than seeing one's offspring being killed.

A second advantage of HP over PKP is that the latter deprives some humans of the pleasure of watching (herbivorised) predators in the wild. After HP, people could still enjoy watching bears, although those bears would behave more like giant pandas than naturally omnivorous grizzly bears.

Third, undoing HP is more manageable than undoing PKP. It might be easier to recarnivorise herbivorised predators than to de-extinct predator species. If we do not know how to bring back extinct species, PKP is irreversible; this means option value is lost (Arrow & Fisher, 1974): when after eliminating predators, if we learn that predation has some overriding value after all, or that the new ecosystems without predation have lower animal welfare, we can no longer return to the state with predation (especially if we have not learned how to carnivorise herbivores or how to de-extinct predator species). On the other hand, HP is more reversible: if we can turn predator species into herbivores, we may also have learned how to turn those herbivores back into predators. Scientists can make some omnivorous species more carnivorous (Hämäläinen et al., 2022). Therefore, if we learn that eliminating predation has too many negative consequences, HP offers more options for returning species to their predatory states.

Fourth, HP is preferable to killing predators because ecosystems would retain biodiversity among their animal species. Evolutionary lineages persist because predator species survive in the form of herbivorised post-predators. Biodiversity is valuable to the welfare of sentient beings by enhancing ecosystems' productivity (Isbell et al., 2015; Duffy et al., 2017) and resilience or stability (Xu et al., 2021) and by supplying potentially beneficial options for the future (Faith, 2021). One may counter this point by maintaining that, in the absence of predators, herbivores might multiply into new species and reclaim any losses in biodiversity. However, this herbivorous diversification would not be as rapid as herbivorisation (unless one uses genome editing on existing herbivores and thereby experiments on the victims of predation).

Humans will probably always prefer that species not become extinct. As herbivorisation preserves evolutionary lineages, it might have more democratic support than PKP.

The major disadvantage of HP compared with PKP is that HP is a slower process (Bramble, 2020). PKP protects prey from predators more immediately, while HP is protracted. Even if relatively sudden dietary modifications to species were physically possible, they likely would not be conducive to animals' well-being and fitness. We acknowledge this disadvantage but also believe that the advantages, as mentioned earlier, make HP better than PKP. Moreover, we would offset the gradual nature of HP with predation mitigation strategies (see section 3.4) during the herbivorisation process.

3.2 Sterilising predators (SP)

The wildlife anti-natalist view (Vinding, 2016) advocates that we drive predator species to extinction by making individuals infertile (e.g., with immunocontraceptive vaccines, oral contraceptives or fertility-targeting gene drives). Although SP is less invasive than PKP, it offers similar drawbacks to HP. Most significantly, as with PKP, ecosystems would become more vulnerable given massive biodiversity losses, and we would lose beneficial future options otherwise derivable from those extinguished species, given that SP is probably more difficult to undo.

3.3 Separating predators (SPP)

Another possibility is to separate predators from prey animals in separate habitats and feed them animal-free meat alternatives. However, Nussbaum (2023) has criticised this approach as presenting 'the separate enclosures problem'. First, SPP may be less workable than HP if it requires immense costs to maintain habitat borders and to produce and distribute meat alternatives. In contrast, HP aims at permanent (intrinsic and genetic) changes that likely require less upkeep. Second, separation involves restricting animals' freedom of movement: natural habitats would become confined areas in which animals' free migration and dispersal would be hindered. Third, segregation does not truly solve the conflict but merely sidesteps it. Nevertheless, because we do not believe that society would accept relegating predator species to extinction (i.e., society would not choose PKP or SP), the most viable alternative to HP, which also *stops* predation, is SPP with massive, shrewdly designed enclosure systems that ideally, if possible, are on the scale of today's largest nature reserves and wildlife refuges (or larger, especially if connected by corridors). Still, a more desirable solution would be redesigning nature's trophic structure so that its inhabitants can peacefully coexist and interact.

3.4 Mitigating predation (MP) with cultured meat robots

Other, more modest options for intervening in the predator-prey dynamic seek to reduce predation rather than abolish it. The advantage of MP over the options for ending predation is that the milder interventions would have less risk of being more harmful than good.

Strategies for MP might include allowing predators to continue to exercise their predatory instincts and feed without hunting and killing animals. Predators could hunt insentient robots that mimic prey animals (Fukuhara et al., 2022) and dispense cultured meat as a reward when captured; this would reduce pressure on sentient prey. Free-roaming, biomimetic robotic prey loaded with morsels of cruelty-free nourishment would make plausible what Nussbaum (2023) considers infeasible: a substitution for prey animals that does not require the 'zooification' of nature within highly managed enclosures.

The problem with this intervention is that it must be monitored constantly. The robots must be checked to ensure they work correctly, be repaired, and sometimes be replaced; moreover, cultured meat must also be provided to carnivores all the time. Considering the broad geographical distribution of carnivorous wild animals, this option would demand many human resources and much energy, and such a predation mitigation programme could be jeopardised in times of economic crisis, for instance. MP is a less persistent solution: if human civilisation collapses or humanity goes extinct, predation mitigation stops. In contrast, HP would presumably endure much longer without any human oversight before carnivory re-evolves.[11]

Nevertheless, creative strategies for MP may be complementary to HP in the short run and offer stopgap measures that could quickly reduce predation harms and allow predators to slowly herbivorise. In other words, the combination of HP and MP offers more advantages and fewer disadvantages than PKP, SP, or SPP.

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[11] We thank an anonymous reviewer for this consideration.

3.5 Desensitising prey animals

Rather than target the attackers (i.e., the predators), one might intervene in the lives of the victims (i.e., the prey animals). Desensitising prey animals with (genetic) painkillers, for example, would decrease their suffering by making them less susceptible to the pain that predators cause (Johannsen, 2021). More generally, desensitisation might involve changing the preferences of prey animals (i.e., removing fear and anxiety) so they no longer prefer not to be attacked by predators. Alternatively, one might shift the hedonic scale of prey animals upwards such that they only experience gradients of positive states and no more suffering. The current Darwinian mix of pleasure and pain could be genetically superseded by a new motivational architecture: "a world filled with varying sizes of carrots, and no sticks." (Pearce, 2024).

One powerful argument against desensitising prey is the infeasibility objection. Pain is a helpful tool for moderating potentially damaging behaviour. In those who experience rare genetic disorders that block pain, a lack of pain awareness often leads to accumulated wounds, bruises, burns, broken bones, and other undetected health issues (Drissi et al., 2020). Pain is an indicator for the purpose of self-preservation.[12] There might also be a moral objection against desensitising prey. For example, applied to humans, we find it perverse to alter humans so that they no longer mind being slaves.[13]

In summary, of all the conceivable, concrete ways to end the harms of predation, HP (in combination with MP in the short run) is the strategy most likely to be embraced by humanity because it offers the best solution for reconciling wildlife conservation with animal

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[12] Research should nevertheless aim to discover how painlessness might be activated *only when desperately needed* so as to not interfere with normal functioning. Rather than an alternative to HP, genetic analgesics could be used as suffering-reducing stopgap measures while predators are still being herbivorised.
[13] We thank an anonymous reviewer for this point.

ethics.

4 Objections to herbivorisation

This section discusses the strongest anticipated and actual objections against reducing predation through HP. We distinguish four categories of objections based on the following concerns: hubris, unnaturalness, harm, and futility.

4.1 Hubris and human arrogance

4.1.1 We should not play God.

Hubris-based objections are often raised in response to human interference with predation. Among all the different kinds of hubris, one of the most profound is the idea of 'playing God' (Kirkham, 2006). However, what does 'playing God' mean? Do humans play God when using agriculture or building infrastructures that massively interfere with nature? Moreover, is 'playing God' always wrong? After all, if God creates and allows suffering to exist (or is unable to prevent it), then our aspirations to abolish suffering and become liberators of those who do suffer are beyond what God is able or willing to do. Therefore, we are not merely 'playing God', but are instead aspiring to something better, something with appropriate seriousness; we could not say that such an aspiration is just 'playing'.

According to three interpretations of 'playing God', predators already play God in either a bad way or a heedless way. In one interpretation, 'playing God' involves determining the lives of others. Predators determine who they hunt and kill. By killing their victims, predators determine the fates of prey animals.

A second interpretation is that God influences the qualitative identities, essential properties or natures of others. Similarly, predation influences the evolution of prey animals. Through selection, prey animals' genes, bodies, and minds change because prey animals evolve stronger limbs to run away from predators, better senses to spot predators, greater anxiety responses to hide from predators, and other adaptations. Prey animals would not look or behave like they do if not for predators.

Third, ‘playing God’ might consist of influencing how ecosystems function on large scales. The theory of trophic cascades and keystone predators (Beschta & Ripple, 2009) demonstrates that predators can significantly influence ecosystems. Removing or reintroducing predators can have significant knock-on effects lower down the food chain. Humans have the advantage of being able to first think about the consequences of their interventions with nature; we can perform environmental impact assessments, do scientific research, and effectively communicate our concerns for possible adverse effects. Non-human predators in the wild do not. They play God heedlessly. Thus, predators play God in such a way and to such an extent that when humans play God through HP, it is morally necessary as it is a less harmful intervention of power.[14]

4.1.2 HP changes ecosystems unpredictably and involves unforeseen risks and perverse effects.

A common claim is that we lack the knowledge to safely conduct large-scale nature interventions such as HP, considering the complexities of ecological dynamics (Delon & Purves, 2018). For instance, Aaron Simmons (2009) maintains, ‘it seems dangerously naive to assume that humans are knowledgeable enough to be able to simply take over the job of nature in the wild without causing serious ecological problems’. However, research on HP is in its infancy, so an epistemological argument based on nature’s complexity warrants exercising caution but not abandoning the idea altogether. Not only do we need to conduct the

[14] An anonymous reviewer remarked that human interventions such as HP could be applied in short time periods, whereas predators change ecosystems slowly, on long timescales (according to natural evolutionary standards). It is the rapid pace of change that could make HP potentially dangerous.

necessary research, but we anticipate dramatic advancements in biological understanding and the technological means for redesigning organisms and ecosystems that might make HP practical. As Johannsen (2021) notes, our fallibility, which constrains how we can justifiably intervene in nature, shrinks as we gain more knowledge through research.

Pessimistic views of HP underestimate our ability to learn how to re-engineer life. Through scientific research, we can continually learn how to intervene more effectively, to the point that HP is fine-tuned and its effects are sufficiently predictable. More research should be done to improve our predictions about how ecosystems would be affected by introducing novel herbivores, such as post-predators. Herbivorisation would not be a sudden, rash action but an incremental process guided by science; post-predators would only be released into the wild once we are confident about how they might affect ecosystems.

We must also consider that, just as there might be unforeseen adverse effects of HP, there also might be unforeseen *positive* effects. Specific post-predators could help members of other animal species and entire ecosystems in surprising ways.

The argument that we should not change ecosystems out of caution for the risks may involve a status quo bias (Faria, 2022, p93). We can apply the reversal test to evaluate such a bias (Bostrom & Ord, 2006). This test employs the logic that if one direction brings us down and we are not at the top, the opposite direction must bring us up. Suppose that HP would result in a worse functioning ecosystem involving even more animal suffering than what occurs now. What about the opposite, namely predatorising herbivores? Just as the herbivorisation of predators is a natural process of evolution, the predatorisation of herbivores also occurs naturally. We could accelerate this process by turning more herbivorous species into predators. Consider repredatorising herbivorised predators (i.e., turning herbivores who were once carnivores back into carnivores). Is that process good if the reverse (i.e., turning species into herbivores) is bad? If, because of complexity or other reasons, one believes that turning herbivores into predators would also make things worse for ecosystems, then the current state of predation and herbivory would be optimal (measured in terms of, e.g., maximum animal welfare or minimum suffering). However, no natural mechanism directs the level of predation in nature towards an optimal state. Natural evolution does not optimise the number of predator species to maximise animal welfare. Nature is involved with predatorising herbivores, but nature is ignorant about potential causal chains. Nature neither cares about complexity nor is sufficiently knowledgeable to avoid the perverse side effects of changing the predation rate. Predatorising herbivores could worsen things, given that nature cannot foresee anything. Hence, it would be a coincidence that the current state of nature is optimal and enables the least amount of animal suffering.

Taken to its extreme, the reasoning that neither herbivorising nor predatorising is good because both interventions have uncertain consequences, such that the risks outweigh the benefits, implies that all interventions in complicated systems are wrongheaded. From the human body to the national economy, there are many extraordinarily complex systems in which prediction is fallible. However, numerous interventions (e.g., medical or government regulations) in such systems are considered appropriate and standard practice. Status quo bias also applies to doctors' decisions to begin, continue, or end medical treatments or central banks' decisions to increase or decrease interest rates. Such interventions could worsen things, but scientific research can enable us to gather enough knowledge to make reliable predictions about the results. It remains to be convincingly argued why ecosystems are and always will be too complex for intervention, unlike human bodies and national economies.

4.2 Unnaturalness

4.2.1 HP is unnatural and, therefore, bad.

Herbivorisation is natural because it also occurs in nature, through evolution, and without human interference, as the examples in the introduction demonstrate. Even if HP is unnatural, this does not imply that it is morally impermissible. The argument assumes that a property of naturalness has intrinsic value. However, nature does not value naturalness because nature does not have the mental capacity for valuation. This fact contrasts with the intrinsic value of animal welfare: animals value their welfare.[15] The pervasiveness of natural suffering suggests that naturalness is not a property associated with animals living happy, flourishing lives (Johannsen, 2021). Mainstream society's judgement that naturalness is more valuable than animal welfare is anthropocentric. Humans are the source of that valuation, but non-human animals do not share it.

4.2.2 HP eliminates a natural, normal, and necessary process, and that elimination is bad.

Bruers (2015) argues for a 3-N principle in which a process or behaviour is good if it is natural (i.e., evolved in nature), normal (i.e., happens frequently), and necessary (i.e., required for the survival of the entities that perform that process). Predation is one such process and is, therefore, permissible. A stronger version of this principle maintains that a natural, normal, and necessary process should not be eliminated.

However, how HP violates this 3-N principle requires clarification. HP makes predation unnecessary: animals would survive without eating other animals. Furthermore, Eze Paez (2015) criticises the 3-N principle because it quickly results in speciesism: humans are not willing to apply the principle when humans are the victims of predation.

[15] Note that this argument depends on a specific interpretation of intrinsic value of a property (such as naturalness or welfare), namely as a value that is valued by the entity (e.g. ecosystem or sentient being) itself. According to another interpretation, a property can have intrinsic value even if the entity that can possess the property does not value that property. However, we believe that an entity's property that is valued by the entity itself is more important than an entity's property that is not valued by that entity. Consider a burning-museum dilemma where you can save either the authentic Mona Lisa painting or a baby. The Mona Lisa does not value beauty, authenticity or aesthetic integrity. The baby values physical comfort and bodily integrity. The flames violate those values, but as the baby itself values physical comfort, we should prioritise saving the baby.

4.2.3 HP changes an animal's nature or qualitative identity, which is bad.

There are three responses to the concern that HP impermissibly changes an animal's nature or qualitative identity. First, herbivorising predator populations does not involve changing the natures of individuals. As previously stated, as with evolution, change in any HP programme occurs between generations, not within generations. Hence, HP involves as much change to animal identities as does natural evolution[16].

Second, if one interprets herbivorisation as influencing qualitative identities, it is unlikely that humans have not already drastically influenced those identities of animals. In fact, humans not only have affected the qualitative identities but even the total or numerical identities of animals (Noonan & Curtis, 2022). A numerical identity is the relation that the animal bears only to itself (an animal is numerically identical with itself and with nothing else). For millennia, the presence of humans has influenced the behaviour of predators, and these behavioural changes have affected the offspring of predators. The many populations of predators alive today are, at least partially, the product of human interference throughout our history. Now, let us consider a counterfactual world in which humans did not exist. In that counterfactual world, on this same day, it is unlikely that many predators would be numerically identical to those in our actual world. The counterfactual world contains other predators with other numerical (and hence other qualitative) identities. The predators in our actual world do not exist in that counterfactual world. In other words, the predators alive today owe their existence to humans. Nevertheless, we do not see how this makes a human presence or our past activities immoral.

[16] As for changing the natures or qualitative identities of *species or other taxa*, we do not believe there is anything wrong in principle about such a change.

Third, in a sense, predators drastically change the qualitative identities of their prey victims as far as the prey animals go from being alive to being dead, from being living organisms to being excrement that has passed through another organism's digestive tract. A living animal has very different properties than a digested animal. Herbivorisation aims to enable predators to show respect for other animals by not changing the qualitative identities of other animals in a harmful way.

4.3 Harms to sentient beings

4.3.1 HP violates the rights of predators.

To transform animal diets by a trophic level or more, HP would require many years of laboratory experimentation on predators, which could result in their suffering and potential deaths. However, from a consequentialist or welfarist perspective, the suffering of prey animals that current and future predators cause is much more than the suffering of predators that humans would cause during herbivorisation and animal experimentation. Once the predators are herbivorised, there would be no suffering from either predation or experimentation.

Kyle Johannsen (2021) defends genetically experimenting on animals within a deontological framework. In Johannsen's moderate deontology, positive duties (of assistance to wild animals) can trump negative duties (e.g., not using animals in experiments) when the stakes are very high.

From a rights-based perspective, we must consider whether predators can violate the rights of prey or unjustifiably harm prey. Predators are not considered moral agents; hence, many believe they do not have moral duties to respect the rights of others (Regan, 1983). However, Dale Jamieson (1990), Michael Fox (1999), and Simmons (2009) criticise this moral agency account. First, prey animals do not care whether it is either moral or amoral agents trying to kill them; they do not want to be killed by *anyone* or *anything*. If we say moral agency matters such that being killed by an amoral agent is less harmful or permissible, then we impose our moral preferences onto prey animals. Second, the moral agency account is unfair because it grants amoral agents the privilege to harm others. What if the cognitive abilities of predators increased? What if lions became sufficiently clever enough to be capable of moral reflection and moral agency? Would they then lose their privilege to kill others and not be herbivorised? Third, there is no sharp distinction between moral and amoral agency. Consider a human child: When do they become a moral agent? How clever must a lion be to lose its right not to be herbivorised? Fourth, prey animals could have a positive right to be protected from deadly dangers such as predation, even if predators are amoral agents.

For these reasons, we assume that predators effectively violate the rights of prey.[17] Herbivorisation minimises the quantity and quality (i.e., seriousness) of such effective rights violations. First, regarding quantity, one predator effectively violates the rights of many prey animals. None of those prey animals gave consent to be killed. Herbivorisation, on the other hand, would involve the violation of the rights of a predator while also preventing more predators from being born.

Regarding quality, predation involves a large-scale violation of the right not to be attacked, captured, and killed. In contrast, at most, HP involves a much smaller-scale violation of the right not to be captured. Accidental deaths may occur, but these would be fewer than the deaths caused by predators. More research is needed on minimising the

[17] The qualifier 'effectively' means that if the agent (i.e. the predator) would behave in the exact same way (i.e. kill the prey) but would be a moral agent, it will be a clear case of a rights violation. We assume that effective rights violations (done by amoral agents) are as impermissible as real rights violations (by moral agents). Hence, with this assumption, the presented argument remains valid even if one believes that predators cannot really violate rights because they are not moral agents.

negative experiences of the predators who will be used as experimental subjects for herbivorisation.

4.3.2 HP increases competition, which harms herbivores.

Turning carnivores into herbivores within ecosystems might cause intense competition. Dropping the carnivorous trophic level and adding new herbivores (i.e., post-predators) to ecosystems could result in fierce competition over resources, leading to starvation and mass casualties.

However, HP might have specific compensatory effects that alleviate competition for food and the associated animal welfare risks of the overconsumption of plants. These effects, associated with increased herbivory, include beneficial increases in light availability (Huisman & Olff, 1998; Eskelinen et al., 2022), fire prevention (Rouet-Leduc et al., 2021), nutrient redistribution from urine and faeces (Wolf et al., 2013), and seed dispersal (Aurélie et al., 2015). In addition, as herbivores increase in abundance, they may self-regulate their reproductive output in response to higher population density and its effects; this regulation has been observed in rodents (Chitty, 1960; Edwards et al., 2021) and ray-finned fishes (Reznick et al., 2019).

Plants are more independent of predators for their protection from herbivores than is commonly supposed. Experiments show that the relationship between trophic structure and primary productivity is complex (Wegener & Odasz-Albrigtsen, 1998; Cuny et al., 2021). This complexity occurs because, aside from top-down control by predators, a host of other factors that influence plant diversity and productivity contribute to preventing herbivores from overexploiting plants (Polis, 1999; Vuorinen et al., 2021). Some of these factors are directionally bottom-up, such as evolving plant chemical and physical defences (Strauss & Agrawal, 1999; Agrawal, 2007), mutualism and competition among plants, interdependence between plants and herbivores (Ehrlich & Raven, 1964), and dynamic and spatially heterogeneous environments. For example, there are mechanisms by which plants compensate (or even over-compensate) for tissue damage and biomass loss from herbivory (Lehtilä, 1999; Garcia & Eubanks, 2019). While such bottom-up processes would not wholly obviate a need for management like fertility control, they might soften HP's ecological concerns.

Even if HP results in more competition within the trophic level of herbivores, several options are available to mitigate this competition. First, as mentioned earlier, we have access to wildlife fertility control: contraceptive methods that decrease the population sizes of herbivores (Asa & Moresco, 2019; Massei, 2023).

Second, we could engineer post-predators to consume certain vegetation types or plant parts so they would not compete intensely with existing herbivores for food. We could direct post-predators to recolonise formerly occupied but empty herbivorous niches or create new niches that nature has not yet 'discovered'. Less than 20 per cent of plant biomass in land environments and about 50 per cent in aquatic environments is eaten (Polis, 1999), which suggests that there are opportunities for new herbivorous niches and greater herbivore abundance.

Third, a strategy could involve engineering many post-predators to be large-bodied generalists.[18] Larger and less specialised herbivores tend to increase plant diversity by consuming mostly dominant, weed-like plants, so rarer and more vulnerable plants can thrive (Olff & Ritchie, 1998; Bakker et al., 2006). Promoting plant diversity might strengthen ecosystem stability and productivity (Isbell et al., 2015), compensating for herbivores' greater abundance and diversity (more diverse herbivore assemblages might in certain contexts

[18] There are good prospects for strategically modifying animal body sizes since these changes occur naturally. In numerous clades, body size has varied widely. Compare, for example, modern armadillos to compact car-sized extinct glyptodonts. The domestication of dogs shows that it is possible to breed animals that have very different body sizes yet belong to the same species.

present more threats to total plant biomass). Engineering post-predator generalists rather than specialists would also make post-predators more adaptable to different environments.

More research on the effects of herbivorisation on competition is needed. But even if intra-level competition increases, HP does not necessarily increase overall competition. First, HP decreases competition between predators. Second, we can consider predators to be herbivores who compete with other herbivores for resources, as both herbivores and predators seize and use scarce resources (e.g., energy and nutrients). The difference is that predators use an inherently violent way of seizing resources by killing herbivores. Consider two animals that compete for plant nutrients. This competition occurs in one of two ways. One animal may try to eat the plant first. Alternatively, if the first animal has already eaten the plant, the second animal can still get the plant's nutrients and energy by killing and eating the first animal. The latter form is called predation, but it is competition between animals for plant nutrients.

4.4. Harms to ecosystems

4.4.1 HP results in overpopulation.

Without predation pressure, herbivores might overpopulate and overexploit ecosystems. Is predation necessary to control herbivore populations and avoid ecosystem degradation?
The case of large herbivores, such as elephants, rhinoceroses, and hippopotamuses, shows that predation is unnecessary. These herbivores face low predation pressure and yet generally do not overpopulate and overexploit ecosystems. A good example is the giant panda, a recently herbivorised post-predator whose adults have few natural predators. Nevertheless, they do not easily overpopulate because they evolved to have low birth rates. Furthermore, in ecosystems with a single top predator population, that apex predator has no predation pressure. There are no predator species higher in the food chain. However, such apex

predators are generally not believed to overpopulate and overexploit the ecosystem automatically. More research is needed, but currently no known law in ecology prohibits the existence of resilient ecosystems with two trophic levels. There is no reason to believe that ecosystems with three or more trophic levels can be stable, whereas ecosystems with two levels cannot. Theoretical models show that ecosystems with omnivores or with intraguild predation (killing and eating animals from a competing species) could lead to unstable population dynamics, where the omnivore can drive a prey species to extinction (Holt & Polis, 1997; Mylius et al., 2001).

4.4.2 HP has destructive ecological implications and might result in ecosystem collapse.

The considerations presented in the previous two objections indicate that HP does not necessarily cause ecosystems to collapse. It is unclear that the loss of *trophic* diversity would cause disastrous ecological consequences, primarily because HP would conserve *phylogenetic* diversity, which is more directly connected to biodiversity's instrumental value (Faith, 1992; Flynn et al., 2011). Moreover, we posit that herbivorised ecosystems will be highly diverse (and hence resilient), given that herbivorous groups of terrestrial organisms tend to be more diverse than carnivorous ones (Barrett et al., 2010).

The blanket generalisation that an absence of predators would *invariably* cause disastrous trophic cascades is logically and empirically unsupported, especially in terrestrial systems (Polis & Strong, 1996; Polis, 1999). Trophic cascades spatially vary in their strengths (Borer et al., 2005), and strong ones frequently are short-lived (Piovia-Scott et al., 2017). Furthermore, it is essential to remember that HP would, in ecological timescales, be cautious and slow, reducing its likelihood of causing disastrous trophic cascades.[19] The ecological

[19] In evolutionary timescales however, HP would be very sudden. We may not be able to predict long-term evolutionary consequences. For instance, how might former preys' predator defenses evolve following herbivorisation, given they will no longer be functional for that purpose?

complexity that allegedly makes us ignorant and thus incapable of responsible herbivorisation ironically supports the feasibility of predation abolition; nature's complexity casts doubt on the contention that predatory animals are ecological necessities preventing the world from becoming bereft of vegetation (cf. the 'green world hypothesis' of Hairston et al., (1960) and ensuing work by Robert T. Paine, John Terborgh, and James Estes). Predation is a *single* and *indirect* factor influencing plant biomass and diversity. While HP would, in all likelihood, *alter the compositions of* plant communities to some extent, it is a speculative leap to assume it would devastate them.

A greater diversity of herbivores under HP is more likely to support a greater diversity of plants ('diversity begets diversity'), thus bolstering biodiversity's instrumental value. Increases in herbivore diversity can, depending on habitat and herbivore body sizes (Bakker et al., 2006), positively affect plant diversity by, for instance, restricting the dominance of a broader range of plant species (Duffy, 2002) and reducing plant competition for light (Ritchie & Olff, 1999). Increasing ruminant diversity has been shown to encourage plant diversity in grassland ecosystems (Wang et al., 2019). Moreover, post-predators could be deliberately engineered and integrated into communities to maintain or enhance ecosystem-stabilising plant diversity.

Finally, some theoretical and empirical evidence suggests that herbivorising predators could have a double stabilizing effect on ecosystems. Ecosystems with lower vertical diversity (i.e. shorter food chains) and with more horizontal diversity (i.e. more herbivore diversity) tend to be more stable (Zhao et al., 2019). Metaphorically speaking: a wider and lower food pyramid is more stable. Herbivorising predators both decreases vertical and increases horizontal diversity.

We want to stress again that more research on the ecological effects of HP is needed. The above cited scientific literature offers signs of hope that HP can be done ecologically sustainably, but it is too preliminary to draw strong conclusions.

4.5 Futility

4.5.1 Carnivorousness could re-evolve.

Carnivorousness could re-evolve, whether in populations of herbivorised former predators or pre-existing herbivores. Theory and numerical modelling suggest that shifting from being a competitor to eating your competitor can, in some circumstances, be a secure, advantageous strategy (Cropp & Norbury, 2020). To mitigate this, we could monitor for any potential reversion to predation and intervene when necessary to support post-predator herbivorousness and troubleshoot the issues of ecological imbalance that would cause this re-evolution.

4.5.2 Herbivorisation would be too costly.

The economic costs of HP would be significant. HP would be more expensive than eliminating predators in the short term. However, HP may be an inexpensive route compared to the other means of ending predation. For instance, it may be less expensive than perpetually separating predator from prey with the need to feed predators. Even if, in the end, HP is infeasible, it is unlikely that such an ambitious undertaking, one that would immensely deepen our understanding of the biosphere, genetics, dynamics of complex systems, etc., would be fruitless and a waste of resources[20]. Moreover, re-engineering Earth's ecosystems to be blissful could become a unifying mission for humanity.

[20] Herbivorising or partially herbivorising even just a few flexible species might significantly prevent suffering.

5 Conclusions and future directions

Considering the multitude of extreme harms that predation inflicts on wild animals, humanity should carefully phase out the carnivorous trophic level. There are a handful of ways, each with advantages and disadvantages, in which we might reduce and end predation. Our most preferred way is herbivorising predators because of the ecological benefits of maintaining greater diversity; moreover, we are hopeful that it is the method that future society will most likely accept for abolishing predation, considering how deep-seated human preferences are for preserving the evolutionary lineages of animals. Given that trophic position is an evolvable trait (Moosmann et al., 2021) and genetic engineering breakthroughs will continue, HP's technological feasibility is promising.

Rather than remain an arcane subject discussed among a handful of philosophers interested in wild animal suffering, large-scale genetic interventions into nature, such as HP, should (in the normative sense) become accepted subjects of study at the vanguard of science in the coming decades. There is a need to research how ecosystem engineering could reduce and eliminate extreme suffering in nature and even maximally enhance animals' lives. Insights into the potential of HP to improve the lives of prey animals should come primarily from the disciplines of biology, including bioengineering, ecology, zoology, botany, evolutionary biology, paleobiology, physiology, morphology, ethology, and genetics. However, while science can tell us *how* we might successfully herbivorise the biosphere, *implementation*, as with any significant international human endeavour, requires democratic support and investment from states. Only our collective actions can meet the challenges of wild animal suffering.

Predation of presumably sentient prey has been a dietary strategy on Earth for over half a billion years since around the end of the Precambrian (Stanley, 1973), which amounts to a tremendous totality of suffering. No genuinely civilised society would allow this distressing state of nature to persist if it could help it.

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The authors declare there are no competing interests.

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