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Bad animals, techno-fixes, and the environmental narratives of alternative protein

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In the last decade animal agriculture has received significant scrutiny for its many negative environmental consequences. In response to these myriad concerns a wide range of voices have advocated for diets that include less animal products (meat, dairy, eggs), often arguing that animal-based diets are inherently more resource intensive than those based on plants. Prominent in this discourse is a narratives formation developed by a slew of venture capital-backed food technology startups known as alternative protein that I refer to as the bad animal narrative. This narrative argues that livestock are fundamentally bad technology, and the solution to the many environmental problems of animal agriculture is to replace livestock with novel technologies to produce animal product alternatives that will satisfy consumer demand while also solving one of the fundamental environmental challenges of modern agriculture. In this paper I use discourse analysis frameworks from political ecology and science and technology studies to examine a large corpus of publicly available text that includes alternative protein company websites, mission statements, blogs, and connected media pieces, as well as life cycle assessment reports documenting the environmental impacts of alternative protein products as well as conventionally and alternatively produced livestock. This analysis finds that the bad animal narrative places blame on livestock without clearly providing evidence, and it rests on a set of problematic assumptions about the current food system and its possible futures. Analysis of life cycle assessment statistics finds that the industrial system, rather than livestock themselves, is the chief driver of the environmental problems of animal agriculture. The paper concludes with a consideration of the future food system envisioned by the bad animal narrative and its implications for sustainability.

KEYWORDS

alternative protein, animal agriculture, cellular agriculture, discourse, future of food, life cycle assessment

Introduction

> "Livestock are the most environmentally destructive technology ever created by humans. My goal is to make that technology obsolete." – Dr. Patrick Brown, founder and CEO of Impossible Foods

The first decades of the Twenty-First Century brought with them significant public attention to the environmental problems associated with industrial food systems (e.g., Pollan, 2006; Kenner, 2008; Vermeulen et al., 2012; Campbell et al., 2017; Hawken, 2017). Animal agriculture and the consumption of animal source foods (ASF) like meat, milk, and eggs are commonly cited as the chief drivers of food-system-driven environmental degradation, particularly as discussions of

climate change have become more common in the media. To be sure, these problems are well documented, with animal agriculture fairing particularly poorly. On climate change alone, animal agriculture is, by some accounts, directly responsible for around 5% of anthropogenic greenhouse gas (GHG) emissions and indirectly responsible for another 10–15% (Mottet and Steinfeld, 2018; IPCC, 2019). As public concern has increased, so too has public discourse focused on potential solutions to these issues. Interestingly—and I would argue, problematically—much of this discourse focuses on the nature of livestock species rather than the social/political/economic systems that use livestock to produce food.

The primary way the environmental problems of animal agriculture maniest as established knowledge, and thus shape public discourse, is in the form of life cycle assessment (LCA) statistics. LCA are computational models that quantify the various environmental costs of consumer goods and other economic activities across their production, distribution, use, and disposal. Importantly, LCA models are constructed such that they can proportionately attribute environmental impacts such as GHG emissions to particular stages of the life cycle. Likewise, models can be scaled to quantify the impacts of units as large as an entire industrial sector or as small (and tangible) as a gallon of milk. These features make LCA well suited for comparative analysis, and in recent decades LCA have been widely used in many contexts, including academic analysis, corporate accounting, and by environmental organizations like the Intergovernmental Panel on Climate Change (IPCC) and the Food and Agriculture Organization of the United Nations (FAO).

LCA can be a highly useful too, and model results have understandably shaped public discourse on the environmental problems of animal agriculture and their possible solutions. Perhaps unsurprisingly, a significant stream of discourse takes a decidedly neoliberal tack, arguing that individual consumers should solve these problems by shifting their diets away from ASF and toward foods with comparatively lower LCA scores (Tilman and Clark, 2014; Vergunst and Savulescu, 2017; Wang, 2017; Montague, 2019; Willett et al., 2019). The logic of this argument is that decreased consumer demand will lead to decreased production of ASF, thus alleviating the environmental problems.

Recently, the proponents of a food technology sector often called *alternative protein* (AP) have introduced a new narrative formation, also heavily reliant on LCA, into this public discourse that I refer to as the *bad animal narrative.* This narrative still focuses on consumer choice, but rather than reducing ASF consumption, the bad animal narrative argues that we should stop using livestock to produce ASF and instead use a raft of new biotechnologies to produce versions of these foods that look, feel, and taste the same while still performing better on LCA. In other words, as the quote that begins this paper so clearly states, animals are a bad technology for producing food. If we upgrade our technology, we will solve the environmental problems of animal agriculture.

The AP sector, which encompasses a broad range of food products and manufacturing techniques, functions in many ways like a other technology sectors (Chiles et al., 2021; Fairbairn et al., 2022), and as such, the bad animal narrative is a specifically technological discourse. It is also a narrative that is well suited to LCA assessment and comparison. If livestock are understood to be a technological component of a manufacturing system, then an LCA of that particular system can attribute environmental impacts directly to that technology and comparing that LCA with an LCA of an AP system that removes the animal as a technology can demonstrate the savings. There may well be environmental benefits to AP products, just as there surely are environmental benefits to diets that include fewer ASF. There are broader concerns with AP and the bad animal narrative, however, that deserve greater scrutiny from academics, journalists, policy makers, and the general public engaged in this discourse. First, this narrative offers a bold vision for a future food system reoriented around myriad novel industrial technologies and with little to no livestock—a vision that has far greater implications than the simple swapping of technologies would suggest. Secondly, AP is a major player in the new agriculture and food tech sector that attracted more than $100 billion in capital investment from 2015–2020 (AgFunder, 2021), and that level of economic power confers the ability to profoundly shape discourse. Given that much of this investment is either from venture capital or corporate investment from major multinational players in the current ASF industry (Howard et al., 2021), attention should be given to the extent to which this discourse is in service of investor profit instead of (or in addition to) environmental concerns. Lastly, the bad animal narrative further pushes discourse toward technofixes that can work to obscure questions about structural problems in our food system and the role livestock could play in sustainable food futures.

In this paper I pursue a critique of the environmental claims of AP through analysis of the bad animal narrative using discourse analysis methods common to the fields of political ecology and science and technology studies. After situating my analysis in the broader literature on AP and a brief discussion of methods, I present three lines of inquiry. First, I examine the language used by AP to construct this narrative, including the key assumptions embedded in the narrative. I then consider the role of LCA in this narrative formation with two goals in mind: to give additional scrutiny to the environmental claims of AP, and to consider whether LCA models do condemn livestock as a technology or instead offer other possible interpretations. Lastly, I consider the environmental and sustainability implications for the food future envisioned by the bad animal narrative that are obscured by this discourse.

Defining alternative protein

AP is an umbrella term used to refer to food products (and the companies producing them) that use plant-based ingredients, fungi, or lab produced tissues to produce or simulate ASF like meat, dairy, and eggs. It should be noted at the outset that AP does not attempt to offer a substitute, like tofu, but rather an alternative means of producing foods that are functionally and esthetically equivalent to animal-derived products. There is some evidence to suggest that many consumers would be willing to try AP products in the future (Bryant et al., 2019), yet relatively little is known of who is currently consuming AP products or how they fit into their diets. It may well be that in practice currently available AP products are consumed mostly by vegetarians and flexitarians that would otherwise eat tofu to decrease ASF consumption. This possibility, however, is not in keeping with the promotional efforts of the AP sector. Following the discourse deployed by advocates, AP *are* meat, dairy, and eggs produced by alternative means, and consumers should change their purchasing rather than the structure of their diets (e.g., see Broad, 2020).

Abbreviations: AP, alternative protein; ASF, animal source food; LCA, life cycle assessment.

Under the umbrella of AP, the sector can be segmented based on the primary technologies used to produce food products: cultivated alternative protein (often called *cellular agriculture* or *clean meat*), plant-based alternative protein, and fermented alternative protein (Good Food Institute, 2022).[1] There are important convergences and divergences among these subcategories, and a full accounting of the diversity of forms and technologies in AP is beyond the scope of this paper. For the purposes of the arguments presented here, the key distinction among these technologies is *how* they aim to remove livestock from the food system.

Plant-based AP replaces proteins and other nutrients and flavor compounds derived animals with those from plants and uses new processing technologies to produce food products that simulate ASF. Similarly, fermented AP replaces animal-sourced proteins and nutrients with those produced through fermentation—either whole biomass such as fungi, or through genetically modified yeasts that produce things like whey protein as a biproduct of their metabolism.[2] The approach among these two sub-categories for removing animals from the food system is similar to that of veganism: eat plants and fungi, not animals. Yet unlike veganism, plant-based and fermented AP do not advocate that consumers change the types of foods they eat (e.g. beans instead of burgers), but simply buy different versions of their current diets that are not sourced from animals.

Cultivated AP employs technologies from the biomedical sciences to replicate animal tissue cells in bioreactors and aggregate them into familiar forms like chicken tenders, burger patties, or steaks. This approach seeks to remove animals from the *process* of producing foods rather than as a source of ingredients. Indeed, cultivated AP would require that some quantity of livestock remain in the food system as a source of donor cells. Since virtually all extant food products in this sub-category of AP are still in development (and not commercially available), it is not yet clear how many animals would be needed to support large scale production.

The bad animal narrative examined here is common across the AP sector, and for much of the paper I will use the term AP to discuss environmental narratives and discursive tactics that are broadly deployed. When it is relevant, I will also use the terms noted above to differentiate between the subcategories of AP. My primary goal in making these distinctions is to add nuance to the analysis below.

Alternative protein futures

The AP sector emerged relatively recently, but there is already a diverse academic literature on the subject, and an exhaustive review is beyond the scope of the analysis presented here. Indeed, a recent review article by Lonkila and Kaljonen (2021) included 123 articles from the social sciences alone. Here I briefly review three important themes in AP scholarship to better situate the analysis that follows among those examining the world-making ambition of AP, the phenomenon of green capitalism in AP, and broader discussions of the environmental impacts of ASF and AP.

The promissory discourse of AP

One of the most prominent themes in the emerging AP literature is the analysis of promissory narratives and other discursive practices deployed by AP companies and their advocates (Lonkila and Kaljonen, 2021). In particular, scholars have focused on the ways in which language is used build a base of public support (i.e., consumers) for AP and to attract financial investment. Several scholars have explored the metaphors and other discursive tools used by AP to project their products as edible, wholesome, and variously equivalent or superior to traditional ASF (Jönsson, 2016; Sexton, 2018; Jönsson et al., 2019; Sexton et al., 2019; Broad, 2020; Clay et al., 2020). This research has noted consistent narrative devices employed by AP to molecularize ASF (Sexton, 2018) into common sets of nutrients and flavor compounds that can be combined to "make" meat, milk, and eggs through processes that do not require animals (Broad, 2020), including from mundane resources with scant environmental impact (Guthman and Biltekoff, 2021). Others have observed that AP discourses, as well as some techno-futurist narratives of the livestock sector, produce a biopolitics of food system responsibility (Sexton, 2018; McGregor et al., 2021) whereby the solution to the negative impacts of animal agriculture is the disciplining of bodies, whether it be cattle or human consumers of ASF. At the same time, scholars have also observed that these AP narratives divert attention away from structural problems and over-consumption of ASF and toward questions of brand loyalty (Ormond, 2020; Clay et al., 2020), arguing that the problems of the food system can be solved through consumption rather than social, economic, or political reforms.

The arguments in this paper contribute to this literature in two ways. First, this analysis focuses on environmental narratives in AP, which have received far less attention in the literature. This paper also extends the discursive analysis to consider how statistics are folded into AP narratives to validate and mobilize the AP framing of food system problems and solutions. Secondly, this paper moves beyond the present narrative to consider the future ramifications of the AP environmental narrative. As other scholars have noted, AP not only offers new food products but a clear vision for remaking the food system that may or may not be the best path forward (Metcalf, 2013; McGregor and Houston, 2018; Jönsson et al., 2019; Guthman and Biltekoff, 2021).

Green capitalism

The academic literature has also offered significant consideration to the ways in which AP—both the technologies and the incumbent discourses—fit within broader developments often referred to as green capitalism (Goldstein, 2018). Research in this area has argued convincingly that despite paradigm shifting narratives, AP largely offers incremental market reforms tailored to corporate-dominated food systems (Broad, 2019; Clay et al., 2020; Fairbairn et al., 2022). Likewise, scholars have noted that AP generally reinforces the neoliberal subjectivity of individual responsibility that fits well within current capitalist framings of market-based sustainability (Sexton

1 Some framings of AP include insect-based proteins, but I have excluded such products from my analysis for two reasons. First, the narrative framings used by insect-based AP differ to some extent since they tend not to style their products as analogs of ASF. Secondly, since insects are animals, these companies are not arguing for the de-animalization of the food system, which is a core tenet of the bad animal narrative.

2 Some AP products use multiple methods to produce ingredients, perhaps most well-known is the heme compound in the plant-based *Impossible Burger* that is produced using fermentation.

et al., 2019; Ormond, 2020; Clay et al., 2020). Others have noted that the AP sector is best understood as part of the venture capital driven technology sector that is the hallmark of the 4th industrial revolution (Chiles et al., 2021; Guthman and Biltekoff, 2021; Fairbairn et al., 2022). Fairbairn et al. (2022), for instance, observes that narratives used by AP and other food technology start-ups frequently simplify the problems of the food system to both create a sense of urgency and cast their products as ideal investments that will remake the food system and provide significant financial returns. Furthermore, Guthman and Biltekoff (2021) note that many of the environmental claims made by AP companies are cloaked in secrecy to protect intellectual property and ensure return on venture capital investments. I contribute to this research here by assessing the ways in which the environmental futures proposed by the bad animal narrative may entrench existing power structures in the food system and thus offer little ecological benefit.

Environmental impacts of livestock and AP

Given that much of the narrative work of AP focuses on environmental sustainability, I find it useful to consider AP in the context of the broader academic literature on the ecological impacts of animal agriculture, particularly cattle. There are relatively few peer-reviewed publications directly considering the environmental impacts of AP, particularly in comparison with the streams of scholarship reviewed above. Several scholars have used modeling approaches to compare various AP technologies with conventional and vegan diets (Alexander et al., 2017; Lynch and Pierrehumbert, 2019; Van der Weele et al., 2019; Santo et al., 2020). These analyses find that while AP products do reduce certain environmental impacts, the magnitude of improvement is highly dependent on the comparisons being modeled. For instance, Alexander et al. (2017) found that AP-based diets have significantly lower environmental impacts than industrial beef, but they are roughly equivalent to diets based on chicken and eggs and may offer less benefit than diets that focus on reducing food waste and overall consumption of ASF. Numerous scholars have also been critical of the ways in which LCA are used in the assessment of animal agriculture. These scholars have noted that LCA frequently offer incomplete (and potentially misleading) assessments of environmental impacts (Freidberg, 2015; Sevenster et al., 2020), and that they are highly dependent on production practices to the extent that meaningful comparisons can be difficult (Head et al., 2014; Mottet et al., 2017; Stanley et al., 2018; Lynch and Pierrehumbert, 2019; Rowntree et al., 2020).

The analysis that follows contributes to this literature in two ways. First, I offer needed scrutiny to the environmental claims made by AP with particular attention to the ways in which LCA statistics are used to validate and propel the bad animal narrative. Secondly, I place the social scientific literature on AP discourse in dialog with the potential environmental consequences of the food future envisioned by AP.

Methods

The focus of this analysis is on discursive practices used by AP to shape public debate on the environmental problems and solutions of animal agriculture, particularly in wealthy countries. To that end, the data used here is drawn from publicly available sources published in English, namely the mission statements, websites (including official blogs, news releases, etc.), and promotional materials of AP companies and boosters. Many AP companies included in this data set provide direct links to news articles, podcasts, and interviews from outlets across English language media, and these articles were also included in the corpus of material for this discourse analysis.

Companies were initially identified for inclusion in this study from the investment portfolios of venture capital funds devoted to new food technologies and food tech incubators investing in AP start-ups. Additional sources were identified from a thorough review of the academic literature on AP, as well as references from media reporting on the AP sector. I developed a database of AP companies from these various sources to support this discourse analysis based on two criteria. First, all included sources use novel technologies to produce analogs of traditional ASF as outlined earlier in the paper, and second, all included sources must be producing or developing consumer products. Thus companies that produce traditional vegan food products are not included in this analysis despite significant overlap in vegan and AP environmental narratives (Mouat and Prince, 2018). Similarly, food tech companies that are developing processing equipment and systems for AP production or producing wholesale ingredients for other AP companies are not included in this database, even though many of these companies are rightly considered part of the broader AP sector. This sorting resulted in a database of 55 AP companies, including 16 producing cultivated AP, 24 plant-based AP companies, nine fermented AP operations, and seven AP producers that combine plant-based AP with either cultivated or fermented approaches.

The examination of LCA draws on a set of publicly available LCA reports commissioned by AP companies included in the compiled database. While other AP companies report that they have conducted LCA for their products, or publish comparative statistics consistent with LCA, relatively few actually make these reports freely available. For instance, Zero Egg, an Israeli plant-based AP company, notes in their sustainability statement that their environmental claims are based on a comparative LCA conducted by the consulting company Sher, but the report itself is not available. Given these limitations, the analysis of LCA conducted here is limited to six publicly available LCA commissioned by AP companies representing four plant-based products and two fermented products (Table 1). Also included is an aggregate LCA of cultivated AP conducted by the Dutch consulting firm CE-Delft and commissioned jointly by the European animal rights group GAIA and the AP thinktank and incubator The Good Food Institute (Sinke and Odegard, 2021). This report provides the only available LCA on cellular agriculture that includes data provided (and anonymized) by companies developing cultivated AP products.

The discourse analysis employed here utilizes methods common to the fields of political ecology and science and technology studies. These methods pay particular attention to how language and is used to identify the drivers of environmental degradation and propose solutions, as well as the political and institutional context in which particular narratives come to be seen as true and to what ends (Hajer, 1995; Forsyth, 2003; Goldman et al., 2011). Source material is read with particular attention to the language used by AP to frame the environmental problems of AP and how scientific knowledge in the form of LCA statistics is used to present these problems as true, urgent, and only solvable through the adoption of an AP-based food system. Narrative practices and themes were identified and assessed iteratively through the practice of qualitative memoing. I provide

TABLE 1 Life cycle assessment statistics for a range of AP and ASF products.

Product	Product category	Functional unit	GHG emissions	Water use	Land use	Geographic location	Source
Impossible burger	PBAP	1 kg ground product	3.5 kg CO_2e	106.8 L	2.5 m^2/y	USA	Quantis
Beyond burger	PBAP	1 kg ground product	3.53 kg CO_2e	28.84 L	3.97 m^2	USA	University of Michigan
Oatly oat mylk beverage	Plant-Based AP	1 kg packaged product	0.27 kg CO_2e	NA	NA	Sweden	CarbonCloud
Ripple mylk beverage	Plant-Based AP	kg protein/l mylk product	24.467 kg CO_2e	4,855 gal	NA	North America	Life Cycle Associates, LLC.
Quorn mycoprotein	Fermented AP	1 kg mycoprotein	1.137 kg CO_2e	35 L	1.8 m^2	UK/EU	Carbon Trust Advisory
Perfect day whey protein	Fermented AP	1 kg whey protein powder	2.71 kg CO_2e	73.9 L	NA	NA	WPS
Cultivated AP aggregate[b]	Cultivated AP	1 kg ground type product	13.6/2.5 kg CO_2e	42/56 L	1.8/1.7 m^2	EU	CE-Delft
Diversified regenerative beef[a]	ASF	1 kg beef	−3.5 kg CO_2e	NA	NA	Georgia, USA	Quantis
Multispecies regenerative composite	ASF	1 kg carcass weight	4.2 kg CO_2e	NA	NA	Georgia USA	Rowntree et al. (2020)
Adaptive rotational grazing beef	ASF	1 kg carcass weight	−6.55 kg CO_2e	NA	NA	USA Midwest	Stanley et al. (2018)
Conventional chicken	ASF	1 kg ground meat	3.025 kg CO_2e	40 L	6 m^2	EU	CE-Delft
Conventional pork	ASF	1 kg ground meat	5.225 kg CO_2e	46 L	4.6 m^2	EU	CE-Delft
Conventional beef	ASF	1 kg beef	48.5 kg CO_2e	2558.24 L	47.4 m^2	USA	Thoma et al. (2017)
Conventional dairy beef	ASF	1 kg ground beef	18.51 kg CO_2e	165.79 L	24.69 m^2	Northeastern USA	University of Michigan
Conventional cow milk	ASF	1 kg protein in fluid milk	30.9–79.4 kg CO_2e	1970–5620 L	NA	NA	WPS
Tofu	Vegan	1 kg product	0.95 kg CO_2e	27 L	1.8 m^2	EU	CE-Delft
Wheat-based meat substitute	Vegan	1 kg product	0.425 kg CO_2e	2 L	0.2 m^2	EU	CE-Delft

Where necessary, statistics were converted to reflect a common functional unit of 1 kg of product. Comparisons made between products are useful but should be considered reasonable approximations in cases where they are derived from different LCA models.
[a]The farm case study used for this study is the same case used for the multispecies LCA of Rowntree et al. (2020).
[b]This LCA calculated the impacts of cultivated AP with a modeled electricity supply based on conventional and 50% renewable energy, with both statistics shown.

quotes that exemplify the development of the bad animal narrative. These are representative quotes of a discourse common to the corpus of sources used in this analysis, and I endeavor to use diversity of sources in quotations.

Bad animals, good technologies

The bad animal narrative can be subtle at times, and it exists as one of several streams of discourse deployed by the AP sector to argue the urgent need for their products. Here I document the main narrative beats of this particular discourse as well as the unspoken assumptions on which the bad animal narrative depends.

AP companies begin their discursive formation with an established fact. As Giuseppe Scionti, founder and CEO of the plant-based AP company Nova Meat, states in video on the company YouTube channel, "The current livestock system is unsustainable for the environment, and it's important to find a solution to this urgent problem (Novameat, 2019)." Understanding that the "current livestock system" referenced here is the industrial livestock system, this statement is demonstrably true. AP companies commonly support this by providing headline statistics on the water use, land use, and carbon emissions associated with animal agriculture taken either from IPCC reports or the United Nations Food and Agriculture Organization (FAO) report *Livestock's Long Shadow* (Steinfeld et al., 2006). However, on this foundation AP frames the environmental problems of (industrial) animal agriculture systems on one particular aspect of the livestock system, the animal itself. In some cases this framing is quite explicit, as in the case of the plant-based AP company Impossible Foods in a 2018 blog post,

> "Unless we act quickly to reduce or eliminate the use of *animals as technology in the food system*, we are racing toward ecological disaster (Brown, 2018, emphasis added)."

However, this discursive framing is often more subtle, with AP companies proposing a singular solution that implies a particular driver of the environmental problems of animal agriculture. Consider the following declaration by Just Food on their website in reference to their plant-based egg:

> We separated the egg from the bird to end the unsustainable mass production of one of the world's most common foods. Because the industrialized egg system sucks for our bodies, for the earth and, let's be honest, it's not a party for the birds either.

This framing posits that the solution to the ills of industrial egg production is to remove chickens from the system, which implies (perhaps subtly) that the chief problem of the industrial egg system is that eggs come from chickens. This narrative tactic relies on implicit logic: livestock must be the source of these established environmental problems or removing the animal from the system would not be a credible solution.

Thus framed, the AP sector identifies two particular problems with livestock as a technology. First, AP argues that livestock are inherently destructive. As Mosa Meat, a cultivated AP company based in the Netherlands, argues on their website:

> [O]ur burger, [doesn't] need to draw as much water from the rivers; cut down rainforests to create pasture and animal feed; use as much energy; or work with chemicals which can run-off into our oceans."

Keeping with this narrative, as demand for ASF increases, we must destroy more land and release more greenhouse gases. Animal technology requires it. Even companies developing AP seafood products contribute to this narrative of destruction in their own way, despite the fact that they endeavor to address a very different set of environmental concerns, such as over-fishing, by-catch, and plastic pollution. The plant-based seafood company Oceanhugger Foods documents the central question that motivated their founding after visiting a Tokyo, Japan, fish market:

> [We] saw two football-field sized warehouses full of tuna sold in one morning. [We]… saw the incredible volume of tuna sold every single day, and asked [ourselves]: "How can the oceans ever keep up?" The answer is "they can't."

And shortly following this, they offer their solution:

> to create a plant-based alternative that would offer people the experience of eating their seafood favorites, without adding pressure on the oceans.

Here Oceanhugger follows the discursive pattern of demonstrable degradation and tidy AP solution that implies a particular source of environmental destruction: so long as seafood is sourced from the bodies of ocean animals, issues like over-fishing will persist.

Secondly, this narrative argues that livestock are inefficient. Pat Brown, for instance, explicitly states that "cows, pigs, chicken and fish did not evolve to be eaten. They're terribly inefficient at turning plants into meat (Brown, 2018)." While the environmental destruction narrative is fairly consistent across different forms of AP, there are subtle differences in the efficiency argument between plant-based and cultivated AP that are worth noting. The plant-based AP argument for efficiency is essentially the same environmental argument that vegans and vegetarians have been making for decades: livestock consume more feed (generally expressed in kilograms) than the quantity of ASF they produce. The fundamental metric used here is referred to as the feed-conversion-ratio (Mottet et al., 2017), and so long as the ratio is greater than one, it is more efficient for humans to simply eat the plants. Plant-based AP modifies the vegan narrative by arguing instead that people eat their AP products, which use more efficient technologies to convert plants into meat, milk, and eggs. Cultivated AP tends to focus less on feed conversion and more on the efficiencies gained by removing the messiness and biological needs of animal bodies. Tissue cells, the argument goes, can be fed more efficiently in a bioreactor than in the body of a cow. As the Israeli firm Aleph Farms notes on their website, "we are skipping the cow part, not the steak part." Plant-based and cultivated AP firms often express this efficiency similarly in terms of land use, water withdrawals, and the like, even if the basis for efficiency claims is different. The plant-based company Just Food and the cultivated AP company Mewery, for instance, both offer engaging interactive web pages that combine dynamic visuals and statistics to demonstrate the increased efficiency of their products. Additionally, cultivated AP argues that culturing cells streamlines the supply chain. For example, SuperMeat—an Israeli firm producing chicken via cellular agriculture—argues that with their process "[n]o [disassembly] or cleaning of birds is needed, decreasing expensive labor and risk for zoonotic diseases. Target tissues are grown and harvested directly, resulting in 100% edible chicken meat." Despite these divergences, both cultivated and plant-based AP narratives converge in their conclusions: AP technologies solve the efficiency problems of livestock.

The bad animal narrative favored by AP is straightforward and compelling, yet it is also notable for its numerous unacknowledged assumptions. This style of simplistic problem framing is common in the technology sector (Fairbairn et al., 2022), and as Jönsson (2016) argues, these silences are an equally important part of discourse. I find it useful to acknowledge several critical assumptions in the bad animal narrative here as they create openings for analysis and discussion of both the LCA statistics used by AP and the future food system this narrative envisions.

First, the AP narrative assumes a particular type of industrial livestock production that favors confined animal feed operations (CAFO), which is the most resource intensive and environmentally damaging livestock system. This assumption manifests in many ways in the data analyzed for this research, ranging from frequent mentions of industrial agriculture and factory farms to imagery depicting cattle in feed lots or caged chickens. This assumption is also seen in the comparative LCA provided by some AP companies, which always use an industrial livestock system based in a developed country for comparison. Given the numerous well-documented harms associated with industrial livestock operations, there is clear utility for the bad animal narrative in making this assumption, yet the reality is that livestock production systems are quite diverse (Mottet et al., 2017). Globally, the vast majority of ASF derived from poultry is produced in industrial systems, but for other types of ASF, assuming industrial production can be quite misleading. The majority of pork produced in OECD countries follows the industrial model, but globally industrial pork only represents around 56% of production. For ASF

such as beef that are sourced from large ruminants, only 7–13% of global supply derives from feedlot systems—a trend that holds true for OECD and non-OECD countries like (Mottet et al., 2017).

Assuming industrial livestock production serves the bad animal narrative in numerous ways. First, and most apparent, assuming industrial livestock production maximizes the comparative improvement of AP as a replacement for livestock agriculture. This assumption also works hand-in-hand with the implied problem framing structure that is frequently used by AP. It is uncommon in the corpus of sources assessed for this research for an AP producer or booster to explicitly state that livestock *per se* are the drivers of the environmental problems of animal agriculture. Assuming industrial production means that any effort that removes animals from the equation *also* removes the industrial livestock system, which narratively implies that the incumbent environmental benefits are pegged to the animal itself. This assumption then relieves AP of the burden of demonstrating that livestock are clearly the source of problems associated with industrial systems. This type of explicit problem framing would be more difficult for AP, as I demonstrate in the following section on LCA. Acknowledging other modes of livestock production would also create space for a broader dialog about whether or not AP technologies are, in fact, that best or only solution to the environmental problems of animal agriculture. This is the complicated conversation that we *should* be having, but it is not a compelling sales pitch for capital investment or consumer purchasing.

The bad animal narrative also assumes that current very high rates of ASF consumption in developed countries will persist, and that projected increases in global ASF consumption levels are a given. The cultivated AP seafood company Forsea, for instance, posits that, "curbing seafood demand is impossible, so we are using science to create a positive disruption." Similarly, the cultivated AP pork company Mewery declares:

> [T]here will be 10 billion people living on this planet by 2050. Most of them will eat meat to satisfy the need for proteins. Producing meat in the current way is not sustainable and plant-based solutions won't satisfy everyone. That's why our focus lies in bringing clean meat on the table (emphasis in original).

The assumptions that underlie comments like these are that consumer demand is the ultimate driver of ASF production, and that very high levels of production are necessary to feed future populations. Unacknowledged is the fact that for most of human history ASF consumption was drastically lower, and that it is only in the latter half of the Twentieth Century, when new industrial production methods made ASF abundant and cheap, that consumption levels rose to what they are today (Godfray et al., 2018; Bonnet et al., 2020). Relatedly, the bad animal narrative assumes that the primary reason that livestock are produced is to meet growing consumer demand for ASF, and not, for instance, because it is profitable for lead firms directing ASF supply chains, as a result of national economic policy, or a host of other cultural, economic, or food security reasons. There is little reason, in other words, to assume that consumption of ASF will necessarily remain high in the future, or that a future in which humans consume far less ASF is any less possible than one where we mostly consume AP products. This is especially true considering the significant capital investment necessary to transition to an AP-based food system and the significant structural change and policy intervention that will be necessary to transition to a sustainable food system, whether it is based on AP or otherwise (Hayek and Garrett, 2018; Mouat and Prince, 2018; Van der Weele et al., 2019).

Assuming high levels of ASF consumption also offers key support to the bad animal narrative. First, high and rising levels of ASF consumption augment the sense of urgency in the bad animal narrative. In keeping with the narrative of destruction, ever-increasing levels of ASF consumption and production will only compound existing problems, compelling financial interests to invest and skeptical consumers to make the transition to AP-based diets. High and rising ASF consumption also places the bad animal narrative in a very lucrative position as the necessary heir to a global market in excess of $1 trillion U.S. dollars (Howard et al., 2021). I am not suggesting that actors in the AP sector are not genuinely concerned for the environment. I have no reason to believe that the vast majority of people working in the AP sector do not honestly believe that AP technologies are the best solution to the problems of Animal agriculture. It is also true that the viability of the AP solution requires significant capital and selling things to consumers. Following Mouat and Prince (2018), it would be difficult to justify the capital investment necessary to transition to an AP-based food system without guaranteed markets to provide returns on investment. Thus this assumption positions the bad animal narrative as a means of attracting investment, and by omitting the possibility that ASF consumption could decrease, this assumption lends credence to AP as a singular solution (see also: Metcalf, 2013; Mouat and Prince, 2018).

Despite these and other problematic assumptions, the bad animal narrative has received very little scrutiny in the popular media. Painter et al. (2020), for instance, observed that media coverage of cultivated AP in the USA and UK between 2013–2019 was largely positive, with only 3% of articles offering a clearly negative tone. While some scholars have observed that the AP framing on the problems of animal agriculture is only one among many narratives circulating in popular culture (McGregor and Houston, 2018; Mouat and Prince, 2018), other perspectives in this debate are beginning to frame their narratives in terms of efficiency and environmental restoration just like AP's bad animal narrative (Mitloehner, 2018; Moyer et al., 2020; Tickell and Tickell, 2020).

LCA: narrow statistics for a broad narrative

A critical component of the bad animal narrative is the practice used by AP to present their arguments as established science by validating their claims with statistics from LCA models. LCAs in this context are an attempt at comprehensive assessment of the environmental impacts of the production and distribution of ASF and AP food products. LCA have become a hallmark of corporate sustainability in the food system (Freidberg, 2014) as well as the standard package for assessing and reporting the environmental impacts of agriculture for international organizations like the IPCC and FAO (McGregor et al., 2021). The explicit incorporation of LCA statistics in the bad animal narrative thus brings a familiar weight of scientific authority to the discourse. And following Freidberg (2014), the weight of this authority lies directly with the perception of completeness offered by LCA.

LCA can be a highly useful tool, yet for all the claims of completeness they are often highly reductive models (Freidberg,

2015) that are easy to misinterpret without significant context that is often not provided. For instance, the LCA commissioned by AP typically focus only on greenhouse gas emission in CO_2 equivalents (CO_2e), land use (m^2), and water consumption from cradle to retail distribution. In other words, these LCAs are tailor made to focus on just a few of the environmental problems associated with animal agriculture for which animal-free diets tend to perform especially well by comparison (Sevenster and Ridoutt, 2019). LCA also require large amounts of data in particular formats that allow for standardization and attribution to specific components of the life cycle (Freidberg, 2014; Gheewala et al., 2020; Sevenster et al., 2020). The upshot of these data requirements is that LCA have a tendency to mask a great deal of variation in things like agricultural production and they struggle to effectively incorporate complex components of the life cycle that are either difficult to quantify (e.g., social processes) (Freidberg, 2014), or difficult to directly attribute to specific life cycle components, such as soil carbon dynamics (Sevenster et al., 2020). These limitations and challenges are well known in the community of LCA practitioners (Gheewala et al., 2020) and are often noted in the full LCA reports commissioned by AP. These caveats are not part of the bad animal narrative, however, allowing the bare LCA statistics to speak into this silence and maintain their scientific authority.

Many of the AP companies included in this analysis do not have publicly available LCA. In some cases, particularly for cultivated AP, this is partly due to the fact that the technologies and manufacturing processes have not been scaled to production levels that would allow for accurate LCA. Following Guthman and Biltekoff (2021), the dearth of available LCA reports is likely also a reflection of corporate efforts to protect intellectual property. Nonetheless, many of the AP products that retail in major grocery stores have LCAs that are publicly available, and these are the source of their marketing claims. When you read, for instance, on the Beyond Burger promotional materials that it uses 99% less water and emits 90% fewer greenhouse gases, this is directly taken from their LCA. And as I noted above, many AP companies that do not have comparative LCA of their own still use LCA statistics from agencies like the IPCC and FAO to verify their narrative claims.

Given the importance of LCA to the bad animal narrative, I turn this analysis now to the handful of available AP LCA reports noted earlier. My goal here is not to pull apart each statistic, but rather to consider these documents for what they are: models that tell a particular story about animal agriculture. In order to broaden the narrative possibilities of LCA statistics, I also consider LCA of alternative livestock systems and traditional vegan products. Importantly, I find this broader set of LCA to offer a perspective on the environmental problems of animal agriculture that differs from the bad animal narrative—a perspective that is effectively silenced by the problem framing of this AP discourse.

Table 1 presents the primary results for LCA from a number of diverse sources in an effort to provide a broad reference point for what LCA tells us about the environmental impacts of some AP products as well as traditional sources of ASF. In addition to the results from AP-commissioned LCA, included here are LCA results for a range of conventionally produced ASF, three LCA of diversified livestock production that include soil carbon sinks, and two traditional meat substitutes. These additional LCA results are taken either from the peer-reviewed literature or comparative case studies found in AP LCA reports (many of which are drawn from peer-reviewed research). In each case the source of the statistics is noted.

A resource like this data table naturally lends itself to comparison across products in just the way that AP's bad animal narrative presents it. Yet any comparisons made using this table should be tentative. Accurately comparing LCA results requires very careful tuning of the models to control for system boundaries, inputs and outputs counted at various stages of the life cycle, and standardization of the data across cases. For instance, the LCA commissioned by the plant-based AP company Beyond Meat used an LCA of conventional beef commissioned by the National Cattlemen's Beef Association for comparison. Making this comparison required the authors of the report to significantly reconfigure the beef LCA (and thus alter the results) to allow for direct comparison (Heller and Keoleian, 2018)—a process that is not clearly delineated in the report. I have converted the statistics to reflect equivalent functional units so that quantities can be compared. Yet most of the LCA in Table 1 do not have the necessary symmetry for more than approximate comparisons, except in cases that come from the same source document. Again, my point here is not to technically dissect these statistics but rather to draw a broad conclusion about the work of these statistics in the AP discourse. I argue that when considered together, these LCA do not clearly indicate that AP products are more efficient or less environmentally destructive, nor do they provide a compelling case that the central problem is livestock as a technology.

Several trends emerge from the statistics compiled in Table 1. First, the LCA of AP products are generally lower than the LCA of conventional (i.e., industrial) beef. This is a common comparison in the LCA use by AP companies, and in a side-by-side comparison this is a clear win. While AP does perform better than conventional beef, many of these products are generally comparable to conventionally produced chicken and pork. In this broader context, it is reasonable to suggest that simply switching chicken for beef could provide much of the same benefit as adopting AP technologies. Secondly, the inclusion of soil carbon dynamics in LCA, as they are in the alternative livestock production systems represented here, suggest that the carbon footprint of ASF may be greatly reduced in these production systems, possibly becoming carbon-negative for beef. While the literature is not clear on how long soil carbon sequestration will remain positive in these alternative systems, some analyses suggests that these dynamics may persist for decades (Rowntree et al., 2020; Sevenster et al., 2020). The implication, here, of course, is that alternative livestock systems reduce the environmental impacts of animal agriculture, and in terms of greenhouse gas emissions may offer the best alternative. Lastly, traditional vegan substitutes for ASF are comparable or lower than AP products on the metrics typically assessed in these LCA. When considered outside the confines of the bad animal narrative and in the context of other LCA on ASF and vegan alternatives, AP is not clearly the best option in regard to efficiency and environmental impact.

Further scrutiny of these LCA reports beyond the headline statistics also suggests a counter-narrative: that it is not livestock, but modern intensive livestock production practices that are the bad technology. This is the same system of production that the bad animal narrative implies is a necessary component of livestock production—one that is defined by confining animals, concentrating their waste, and feeding them a diet comprised of high quantities of grain that could otherwise be eaten by humans. First, consider that the comparative LCA commissioned by Impossible Foods explicitly states

that fully 82% of water use in conventional beef is irrigation used in the production of maize as a feed crop (Khan et al., 2019). Furthermore, the only land use the Beyond Meat LCA associates with beef is the land for growing feed grain (Heller and Keoleian, 2018). The LCA of cultivated AP conducted by CE-Delft offers additional insight on the problems of CAFO through its use of an environmental single-score metric that aggregates the various LCA statistics into a single index. The single score in this study indicates that for all cases, the primary factor contributing to higher environmental impacts for conventional ASF is the emission of fine particulate matter associated with ammonia emissions produced from waste concentrated in animal houses and feedlots found in CAFO operations (Todd et al., 2008; Sinke and Odegard, 2021). Recall from earlier that the assumptions and implied problem framing structure used by the bad animal narrative allows AP to credit all of the environmental benefits of AP production systems to the removal of animals without needing to indicate which variables in the industrial livestock system actually explain the improvement. In each case noted here, the clear improvement of AP products over their ASF counterparts are direct reflections of livestock practices that result from industrial systems (which are also agricultural technologies) and not the bodies of livestock. And when considered in conjunction with the potential environmental benefits of alternative livestock systems, the bad animal narrative becomes even more tenuous.

Most of the LCA reports considered here are publicly available, and the handful of peer-reviewed LCA that are not open-access publications could, at the very least, be easily obtained by curious journalists through straight-forward database searches. Yet the complexities that emerge from closer consideration of LCA reports are, perhaps unsurprisingly, not even implied in the AP discourse that produces the bad animal narrative and seem largely absent from mainstream coverage of AP in the media (Painter et al., 2020). Perhaps, as others have noted, adding these nuances would make for less compelling fund-raising efforts for AP start-ups (Guthman and Biltekoff, 2021; Fairbairn et al., 2022). Indeed, adding caveats to the bad animal narrative clearly suggests that AP technologies may not be the best and only solution to the environmental problems of animal agriculture, and thus a risky investment.

In addition to a fundraising strategy, this silence in the bad animal narrative makes good business sense for AP for an additional reason: changing livestock production practices would likely reduce consumption of ASF in many countries. Domesticated animals have been a part of the human food system for around 10,000 years, yet industrial livestock systems did not become a significant mode of production until the latter half of the Twentieth Century (Martinez, 1999; Montefiore et al., 2022), and even today the dominance of these practices is varied and geographically specific (Mottet et al., 2017). This period of the Twentieth Century precisely aligns with significant observed increases in global ASF consumption (Godfray et al., 2018). I do not wish to assign too much explanatory power to industrial livestock practices, only to note that the coincidence of increased consumption and new technologies that made ASF abundant and cheap are likely related. Modelling suggests that eliminating industrial livestock practices would greatly reduce production of ASF in wealthy countries (Eshel et al., 2018; Hayek and Garrett, 2018), likely making these foods more expensive and reducing consumption. The trouble here is that AP products are not marketed as substitutes for ASF that could support reduced consumption, but rather as the genuine article. The cultivated AP company Meatable, for instance, describes their product as, "identical [to ASF] on every level, without any of the drawbacks." Furthermore, AP promotional materials commonly claim that their products allow consumers to continue to eat their favorite foods without the environmental cost. The plant-based AP company Nobell plainly declares that their cheese product is, "sustainable decadence for everyone…everyone deserves a righteous mozza dripping pie and a planet that is not on fire." In other words, suggesting the possibility that human diets could or should shift away from ASF is bad business for AP. The bad animal narrative implies that the goal of the AP sector is for people to keep eating the same kinds of foods and simply change which products they purchase. This may help explain why many of the dominant multi-national corporations that profit from the current livestock system are investing heavily in the AP sector (Howard et al., 2021).

Framing sustainable food systems: questions un-asked

The bad animal narrative frames the environmental problems of ASF on destructive and inefficient technologies that necessitate AP solutions. Not only does this discourse gloss over important nuances like the ones mentioned above, but its silences also render certain questions about the future of the food system unaskable. In closing, I briefly consider two such questions that deserve more attention in public discourse on the future of livestock in the food system.

Can livestock contribute to an environmentally efficient food system?

The bad animal narrative presents livestock as necessarily inefficient because they require more land and water than AP, emit more planet-warming gases, and consume more feed than they produce in food. Stepping back from the dueling LCA statistics presented by the AP sector, it is fair to say that the industrial food system is environmentally inefficient. A critical question is whether livestock can be an important part of a more efficient food future. To this question I offer two observations.

First, the primary inefficiency levelled against livestock is the so-called feed-conversion-ratio, with many metrics noting that the weight of feed consumed by livestock is generally greater than the weight of ASF that is produced. Yet this is only an inefficiency in so far as the feed consumed by the livestock could otherwise be consumed directly by a human. An extensive global survey of feed conversion in livestock indicates that most of what livestock around the world eat is not human-edible food—especially for cattle which are often considered to have the largest feed-conversion-ratio (Mottet et al., 2017). Furthermore, when this conversion is adjusted to account only for human-edible protein, rather than total mass, global livestock actually produce more human-edible protein than they consume, particularly in non-industrial systems (Mottet et al., 2017). Other studies have found that livestock actually increase land-use efficiency by converting marginal lands and waste streams into human-edible foods, thus reducing pressure on global croplands that only represent around 30% arable land (Van Kernebeek et al., 2016; Alexander et al., 2017).

Secondly, livestock (can) play an important role as nutrient cyclers in agricultural systems, thus reducing reliance on non-renewable

resources. Billen et al. (2012), for instance, found that sustainably localizing the nitrogen supply for agriculture in the Seine River watershed in France would require, among other things, increased stocking rates of livestock to provide manure fertilizer. Similarly, sustainably managing phosphorus fertility in the U.S. requires the regional recycling of livestock waste as fertilizer to break cycles of dependence on non-renewable mineral phosphates (Metson et al., 2016; Hedberg, 2020). And LCA of mixed crop and livestock systems suggest that they require fewer external inputs and produce more total food per hectare than current industrial monocropping practices (Costa et al., 2018).

What would an AP-based food system actually look like?

The bad animal narrative presents itself as a relatively straightforward yet profound change to the food system. I agree with others that read into this narrative significant world-making ambition (Metcalf, 2013; Guthman and Biltekoff, 2021). Yet what would actually change? The obvious, if unspoken, answer is that this food future looks just like the food system we have now, even if there are no livestock.

This is a food system dominated by large scale monocrops, albeit with a slightly different handful of varieties. Evan cultivated AP would remain dependent on industrial copping systems for several key feedstocks (Sinke and Odegard, 2021). There may be no more CAFOs, but these facilities will be replaced with others that produce pea protein isolate and house bioreactors for cultivated AP. They could probably even use some of the same buildings! This is a system reliant on synthetic fertilizers, herbicides, pesticides, and patented seed technologies. This is a system that exploits labor, decimates rural livelihoods and indigenous knowledge and lifeways. And to boot, research suggests that a food future that eliminates livestock without otherwise changing the food system will only reduce global greenhouse gas emissions between 2.5–5% (Teague et al., 2016; Mottet and Steinfeld, 2018).

Perhaps most importantly, this AP food system is one that still uses food production as a means of generating profit that concentrates with a cadre of major corporations and their investors, which is a major reason that industrial livestock production is currently so destructive. Following Ormond (2020), in silencing this critical question, the bad animal narrative directs our attention away from the systems that produce, distribute, and profit from our food and onto the products themselves. The juiciest irony of the bad animal narrative is that it likely offers, as with many green capitalist initiatives, very little disruption at all (Goldstein, 2018).

Conclusion

Throughout this paper I have analyzed the ways that the AP sector has constructed and circulated a narrative formation that blames the biology of livestock bodies for the environmental problems of animal agriculture and presents AP technologies as the necessary solution. In so doing, this discourse simplifies many of the environmental problems in the food system in a way that favors techno-fixes, entrenches existing power imbalances, and forecloses the possibility of alternative food futures.

I am no apologist for the livestock sector. My primary concern is not that AP products exist, or even the notion that these technologies could play a role in a sustainable food system, for indeed they may. The real danger of the bad animal narrative is the growing dominance of its totalizing argument, amplified by its multi-billion dollar megaphone of venture capital (AgFunder, 2021) and unchallenged by a media environment that seems all too willing to believe the hype. My fear is that public debate on the future of the food system will be distilled into a battle of LCA statistics. LCA have their uses, but they cannot tell us what our food system should look like—no model can. An environmentally efficient, sustainable, and socially just food system is within reach, but it will require the messy and maddening work of political, economic, and social change. I suspect that this future food system will still have at least a few animals in the mix.

Data availability statement

Publicly available datasets were analyzed in this study. The corpus of data used for this discourse analysis is gathered from many public websites and other media sources. A database of web addresses that are not included in the references section of the paper can be provided upon request from rchedberg@ship.edu.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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