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Animal sentience and the precautionary principle

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Abstract: In debates about animal sentience, the precautionary principle is often invoked. The idea is that when the evidence of sentience is inconclusive, we should "give the animal the benefit of the doubt" or "err on the side of caution" in formulating animal protection legislation. Yet there remains confusion as to whether it is appropriate to apply the precautionary principle in this context, and, if so, what "applying the precautionary principle" means in practice regarding the burden of proof for animal sentience. Here I construct a version of the precautionary principle tailored to the question of animal sentience together with a practical framework for implementing it. I explain and defend the key features of this framework, argue that it is well-aligned current practice in animal welfare science, and consider and reject a number of influential counterarguments to the use of precautionary reasoning in this area.

Keywords: animal sentience, animal protection, precautionary principle, burden of proof

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1. Introduction

How much evidence should it take to convince us that an animal is sentient? In discussions of animal sentience, and especially animal pain, the "precautionary principle" (O'Riordan, & Cameron 1994) is often invoked. It is often stated, for example, that, in the absence of certainty as to whether an animal feels pain, the precautionary principle requires giving the animal the benefit of the doubt (Bradshaw 1998). This has been cited as a reason for extending the scope of animal protection legislation to encompass fish and some invertebrates, such as cephalopods (Andrews 2011; Jones 2013; Sneddon et al. 2014). In a recent issue of this journal, a number of authors appealed to the precautionary principle to argue that, in the absence of strong evidence to the contrary, we should take seriously the hypothesis that fish feel pain (Jones 2016; Brown 2016; Seth 2016).

Yet there remains a significant amount of disagreement and confusion over this issue. Is it appropriate, in this context, to apply the precautionary principle? If so, what exactly does "applying the precautionary principle" mean? In broad terms, the idea is clearly that we should not require absolute certainty that a species is sentient before affording it a degree of legal protection. Absolute certainty will never be attained (indeed, the "problem of other minds" suggests it cannot even be attained with respect to human minds), and its absence is not a good reason to deny basic legal protections to potentially sentient animals.

What is still needed, however, is a precise, practical framework for deciding whether the evidence of sentience in a particular species is sufficient to justify bringing that species within the scope of animal protection legislation. Broad appeals to the precautionary principle can only take us so far, because the precautionary principle is general, abstract and rather vague. To help adjudicate disputes about particular cases, and to provide meaningful guidance to scientists and policymakers working in this area, we need a framework that provides a practically applicable burden of proof.

In this target article, I propose such a framework. I begin with a general and abstract formulation of a precautionary principle for animal sentience (Section 2), and then develop a more precise, practically oriented formulation (Section 3). I present some considerations in its favour, argue that it aligns well with current practice in the field of animal welfare science (Section 4), and defend it from a number of counterarguments (Section 5). My proposal is intended as a starting point for further discussion of this issue. My hope is that discussion of this proposal will lead to further refinements and amendments, and that this will lead, ultimately, to a framework for setting the burden of proof that commands wide assent across the interdisciplinary field of animal sentience research.

Before I turn to the burden of proof for sentience, I should first comment on the term *sentience*. This term has broader and narrower senses. In the broader sense, it encompasses all of an organism's subjective experiences of the world and of its own body: any form of what philosophers call *phenomenal consciousness* (Block 1995). In this sense, an organism is sentient when there is "something that it is like to *be* that organism" (Nagel 1974, p. 346). However, when the term is used in animal welfare science and animal ethics, it usually refers specifically to subjective experiences with an attractive or aversive quality, such as experiences of pain, suffering, pleasure, frustration, anxiety, fear, happiness and joy (Singer 1975; Varner 2012). Sentience in the narrower sense requires sentience in the broader sense, but the converse is not true: an animal might, in principle at least, have experiences of bodily movements and external objects without feeling any of these experiences to be attractive or

aversive (the plausibility of this is open to debate; Peter Godfrey-Smith, quoted in Gorman 2016, has suggested that it may be true of insects).

For my purposes in this target article, it is the narrower meaning of sentience — subjective experiences with an attractive or aversive quality — that I have in mind. This is because I take sentience in this narrower sense to be the sort that matters when we ask whether an animal should be brought within the scope of animal protection legislation.

2. The precautionary principle and animal sentience

The original precautionary principle states that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (United Nations 1992). Although initially intended as a guide to environmental policy, the principle has also been applied to questions of public health. To apply the principle in this context, we simply replace "serious or irreversible damage [to the environment]" with "serious, negative public health outcomes" (John 2011).

To apply the principle to questions of animal sentience, we need to make an analogous move, replacing "serious or irreversible damage to the environment" with "serious, negative *animal welfare* outcomes." The following, therefore, is the principle I take defenders of the precautionary principle in the context of animal sentience to have in mind. I will call it the Animal Sentience Precautionary Principle, or ASPP:

> **ASPP:** Where there are threats of serious, negative animal welfare outcomes, lack of full scientific certainty as to the sentience of the animals in question shall not be used as a reason for postponing cost-effective measures to prevent those outcomes.

The widespread influence of the original precautionary principle can be credited partly to its extremely broad, non-specific nature: it has been applied to environmental threats as diverse as climate change and neonicotinoids. The public health version of the principle is similarly broad. The drawback to this incredible breadth is that it does not offer much in the way of detailed policy guidance, leading critics to suggest that it is unscientific, vacuous, vague, incoherent, paradoxical or ill-defined (e.g., Sunstein 2005; for responses, see Steel 2013, 2014).

What, then, does endorsing ASPP actually require of us? Stephen John (2011) offers what I take to be a particularly helpful way of interpreting precautionary principles. He suggests we think of them as a combination of two rules. First, there is an *epistemic* rule (a rule about the *burden of proof*): when there is a live scientific hypothesis that posits a causal relationship between human action and a seriously bad outcome, we should set an *intentionally low evidential bar* for the acceptance of that hypothesis in the context of formulating policy. Consider, for example, the hypothesis that there is a causal relationship between neonicotinoids and colony collapse in bees. We should require *some* evidence for this hypothesis before regulating the use of neonicotinoids, but the bar should be set at a level low enough to avoid a prolonged period of inaction that may turn out, retrospectively, to have allowed serious and preventable harm to occur.

Second, there is a *decision* rule (a rule about *action*): once we have sufficient evidence of a threat of a seriously bad outcome, *we should act*, in a timely and cost-effective manner, to

prevent that outcome. The implication is that the goal of preventing the seriously bad outcome deserves sufficient priority that, once the evidential bar is cleared, it is inappropriate to delay action further while we attempt to weigh the expected costs and benefits of this goal in comparison to other policy goals. We should not ask: "Is this outcome really worth preventing at this time, given the other goals we have?" We instead move directly to the question: "What are the most cost-effective means of preventing this outcome?"

Both rules are motivated by considerations of time. The wheels of both science and policy turn slowly, and the costs of waiting for overwhelming evidence and clear consensus can be very high. Precautionary reasoning aims to create a pathway from evidence to action that allows for timely responses to serious, developing threats. The overarching imperative, as Daniel Steel (2013, p. 321) puts it, is that "policy [should] not be susceptible to paralysis by scientific uncertainty." While few would disagree with this imperative, the above rules are, admittedly, controversial ways of implementing it. If one feels it is never appropriate to set an intentionally low burden of proof for a factual claim, or if one feels that it is never appropriate to act without weighing expected costs against expected benefits, then one will be led to reject the precautionary principle. My aim is not to convince the critics (on this, see John 2011; Steel 2013, 2014), but rather to articulate, for those already sympathetic to the precautionary principle, what its application in a particular context actually requires.

The key to precautionary reasoning is to delimit carefully the class of "seriously bad outcomes" that merit this kind of epistemic and normative priority. Climate change seems a clear-cut case. The use of ASPP as a guide to policy relies on the idea that animal welfare outcomes can also meet the appropriate standard of seriousness, and I agree with those who have invoked the precautionary principle in this context that they can indeed do so. One might suppose, at first glance, that an animal's pain, though surely bad, is not a bad outcome on a large enough scale to justify precautionary reasoning. This can be rebutted, however, by noting some relevant figures. For example, if our policy target is the treatment of fish by commercial fisheries, we should note that approximately 1 to 3 trillion fish are caught annually in wild fisheries, excluding fish farms (Mood and Brook 2010; Balcombe 2016; Jones 2016). If we fail to regulate effectively the way fish are treated, the threat to animal welfare is not simply that one animal will be subjected to preventable pain, but that over one trillion animals per year will.

Similarly, if our policy target is the regulation of animals used in scientific research, we should note that, according to European Union (EU) statistics, about 11.5 million vertebrates and countless invertebrates (at the time of writing, there are still no published figures for cephalopods, the only protected class of invertebrates) are used every year for scientific purposes in the EU alone (European Commission 2013). If we underestimate the taxonomic range of animal sentience, and thereby exclude from the scope of animal protection some species that should be included, the threat to animal welfare is not simply that one animal will be subjected to preventable pain in the laboratory, but that millions of animals per year will.

These are seriously bad outcomes: the sort of outcome for which precautionary reasoning was designed. The case for ASPP is therefore strong. However, this is where the real work starts. ASPP indicates that, if a threat of serious, negative animal welfare outcomes is present, the evidential bar for sentience should be set at an *intentionally low* level, but it leaves open the question of how exactly this evidential bar should be set. How, then, should

it be set?

An extreme proposal would be that we should assume an animal is sentient unless there is conclusive evidence to the contrary. This is extreme because, for two main reasons, it would invite the charge of being unscientific or anti-scientific. First, the science of animal sentience would become more or less irrelevant to the scope of animal protection law: all animals would be assumed sentient unless proven otherwise, and it is hard to see how research could "prove otherwise" in any interesting case. Second, it would require the inclusion of model organisms such as nematodes (*Caenorhabditis elegans*) and fruit flies (*Drosophila melangaster*) within the scope of animal protection legislation, creating significant practical obstacles to biomedical research.

I am not suggesting that nematodes and fruit flies should not be included under any circumstances, but it seems reasonable that some evidential bar for sentience should have to be cleared. There cannot be a default presumption of sentience in all cases. Let us turn, then, to the task of formulating an appropriate evidential bar.

3. Applying the precautionary principle: A practical proposal

I want to start by simply stating my proposals directly, before explaining and defending their key features. We noted above that a precautionary principle such as ASPP can be interpreted as combining an epistemic rule and a decision rule. Here is a concrete, practical proposal for the epistemic rule, which I will call BAR (because it proposes an evidential *bar*):

> **BAR:** For the purposes of formulating animal protection legislation, there is sufficient evidence that animals of a particular order are sentient if there is statistically significant evidence, obtained by experiments that meet normal scientific standards, of the presence of at least one credible indicator of sentience in at least one species of that order.

Here is a concrete, practical proposal for the corresponding decision rule, which I will call ACT (because it is an imperative to *act*):

> **ACT:** We should aim to include within the scope of animal protection legislation all animals for which the evidence of sentience is sufficient, according to the standard of sufficiency outlined in BAR.

The combination of BAR and ACT provides a concrete, practical way of implementing ASPP. These are the main proposals of this target article, and my hope is that, by stating them directly and precisely, I have created a good platform for revision, improvement and critical commentary. The rest of this section provides further explanation of BAR and ACT.

3.1. Grain of analysis

BAR proposes the *order*, and not, for example, the species, genus or class, as the appropriate level of analysis for precautionary reasoning. For example, Octopoda is an order comprising around 300 species of octopus. The proposal is that, if at least one species in this order meets the relevant criteria for sentience, then all species of that order should be considered sentient for the purposes of formulating animal protection legislation. For instance, if one takes the

evidence of sentience to be sufficient in the common octopus, *Octopus vulgaris*, one should also extend the scope of animal protection to all other genera of the order Octopoda without waiting for further evidence specific to those genera. However, separate evidence should be sought for other orders of cephalopod, such as squid and cuttlefish.

What is the principled justification for this? It is, of course, possible in principle that some species of a particular order are sentient and others are not. This seems like a particularly salient possibility when one looks at orders such as the octopods or the decapod crustaceans. However, pragmatic considerations justify attributing sentience at a coarser grain than the species or genus. It is simply not practical to test separately for sentience in all species or genera of a given order. If we have evidence of sentience in one species of an order, we should act to protect the whole order: to demand evidence of sentience *specific to each species* before taking action to cover these species would generate paralysis of precisely the sort the precautionary principle is intended to block. There are, for example, around 15,000 species of decapod crustacean, of which only a handful have been studied by animal sentience researchers.

Why not be even coarser-grained, and regard all species of an entire class, such as Cephalopoda or Malacostraca, as sentient when one species of that class meets the appropriate criteria? Again, my answer is a pragmatic one. To the extent that it is feasible to investigate sentience separately in different orders, we should. Malacostraca, for example, contains animals as diverse as crabs, amphipods and krill. To take evidence of sentience in crabs as evidence of sentience in krill seems a strikingly large jump, given the phylogenetic distance covered; a more reasonable approach is to require that krill be investigated separately. With regard to the Cephalopoda, the same might be said of taking evidence of sentience in octopuses as evidence of sentience in nautiloids. My proposal is that the order provides the best compromise: it allows animal welfare policy to respond appropriately to science, avoiding the charge of being unscientific, while at the same time allowing the science of animal sentience to proceed in a feasible way that involves studying one model organism per order, rather than attempting to study every species or genus separately.

One might still worry that to require evidence specific to each order is to impose a demanding requirement, given that, for example, there are over 40 orders of bony fish. Three things can be said in response to this worry. First, note that ACT proposes a sufficient but not necessary criterion for protection: there is an imperative to include *all* orders for which the evidence of sentience is sufficient, but not *only* such orders. ACT does not provide a reason for removing protection from any order; so, it does not provide a reason for withdrawing existing protections, such as they are, from understudied orders of bony fish. Second, the goal of testing for sentience in every order of bony fish, though demanding, is not unfeasible if interpreted as a long-term goal for animal sentience research, a field that is still at an early stage of development. Third, human exploitation of bony fish for food production and scientific research does not fall equally across all orders, and the most exploited orders (such as Salmoniformes, Gadiformes and Cypriniformes) tend to be the most studied. We do not need to wait for evidence concerning other, less-studied orders before extending protection to orders for which the evidence is already sufficient.

3.2. Credible indicators of sentience

BAR further proposes that, within each order, we should require at least one credible

indicator of sentience. What is a credible indicator of sentience? At minimum, an indicator must be an observable phenomenon that experiments can be designed to detect, and it must be credible that the presence of this indicator is explained by sentience. I do not intend to propose a definitive list of credible indicators. The proposal is rather that animal sentience researchers should, collectively, maintain, revise and update a list of the traits that are taken by the community to be credible indicators of sentience.

Such lists, comprising a mix of neurological and behavioural criteria, already exist with respect to animal pain (Bateson 1991; Smith and Boyd 1991; Sneddon et al. 2014). I will not reproduce the criteria in full here. Particularly important indicators include the *self-delivery of analgesics*, whereby the animal learns to administer pain relief drugs such as opioids in an operant-conditioning setup; *motivational trade-offs*, whereby the animal behaves as if weighing its preference to avoid a noxious stimulus against other preferences; and *conditioned place avoidance*, whereby the animal learns to avoid locations at which it previously encountered noxious stimuli.

There is a theoretical justification for regarding these as good indicators of pain, as opposed to mere nociception, insofar as they require the brain to integrate information about tissue damage with other kinds of information, and to make that integrated information available to mechanisms of motivation, decision-making, memory and learning. Although theoretical perspectives on the origin and nature of subjective experience vary greatly, one theme common to many approaches is that subjective experience involves the integration in the brain of information from multiple sources (Dehaene 2014; Tononi and Koch 2015; Feinberg and Mallatt 2016) so as to enable its use in sophisticated forms of action-guidance, decision-making, memory and learning (Merker 2005, 2007; Ginsburg and Jablonka 2007a,b; Klein and Barron 2016).

However, there is also a simpler way to justify taking these behaviours as indicative of pain: the *best explanation* for the self-delivery of analgesics, motivational trade-offs and conditioned place avoidance involves postulating pain experiences; and this provides a reason, albeit not a conclusive reason, in favour of the hypothesis that pain is experienced (Tye 2016). This sort of "inference to the best explanation" is widespread in science (Lipton 2004) and provides a reasonable way to justify the choice of indicators of sentience in the absence of an agreed theory of consciousness.

Existing lists of credible indicators of pain should be subject to continuing review and revision if they are to serve as a reliable guide to animal protection legislation. More pressingly, however, there is a need for similar lists with respect to other dimensions of subjective experience, such as suffering, anxiety and fear. The project of compiling such lists lies outside the scope of this paper, but it is an important precondition for the reliable application of BAR.

BAR, importantly, states that *one* credible indicator of sentience is enough to justify action: we should not demand multiple indicators before acting to protect the animals concerned. The rationale for this is pragmatic: in taxa where sentience is contested, such as the decapod crustaceans, achieving high-quality evidence of one credible indicator is already a formidable task. In this context, responding to such evidence by demanding evidence of more indicators will have the effect of further delaying action, and the purpose of a precautionary principle is to prevent such delays.

3.3. Normal scientific standards

BAR proposes that, with respect to each credible indicator of sentience, statistically

significant evidence of the presence of that indicator in organisms of a particular order should be required, and normal scientific standards should be applied. Some kinds of evidence, such as anatomical evidence, do not readily admit of degrees of statistical significance: for these kinds of evidence, the normal scientific standards appropriate to that kind of evidence should be applied.

I do not intend to propose a detailed set of methodological criteria that must be met (although I welcome commentary on this issue). My point is simply that normal methodological standards still apply: applying the precautionary principle does *not* imply that one's methodological standards should be lowered, or that purely anecdotal evidence should be considered admissible. High-quality research in the field of animal sentience already meets this requirement. Consider, for example, Robert Elwood and Mirjam Appel's well-known studies of motivational trade-offs in hermit crabs (*Pagurus bernhardus)* (Elwood and Appel 2009; Appel and Elwood 2009). These studies provide credible evidence that hermit crabs trade off the quality of a shell against the intensity of the electric shock received within it. The evidence of trade-off behaviour, a credible indicator of sentience, is not simply anecdotal and meets normal scientific standards: a large sample was collected, a careful experimental protocol was developed, and precise statistical methods were applied in the analysis of data. This is exemplary work for thinking about the practical implications of BAR and ACT. According to BAR, Elwood and Appel's work provides sufficient evidence for a precautionary attribution of sentience to decapod crustaceans. According to ACT, decapods should therefore be brought within the scope of animal protection legislation.

The aim of this appeal to "normal scientific standards" is to resist any suggestion, of the sort sometimes made by critics of the precautionary principle, that applying the precautionary principle implies lowering one's scientific standards. At least in the case of animal sentience, I deny that this is the case. A low evidential bar should not be applied when inferring the presence of credible indicators of sentience. It should instead be applied at a later stage: it should be applied when making a precautionary attribution of sentience on the basis of a single credible indicator, and when extrapolating across a whole order from a single species. There should *not* be any lowering of standards with regard to the methodology of experiments, or with regard to the analysis of experimental data.

3.4. The scope of animal protection legislation

ACT proposes that when the burden of proof outlined in BAR is satisfied, the animals in question should be *brought within the scope of animal protection legislation*. This deliberately leaves open the questions of how, and to what extent, the treatment of these animals should be regulated: that is, it leaves open the proper content and implementation of the regulations. This is appropriate since the content and implementation is likely to vary a great deal depending on the animals in question: the components of good welfare for octopods, for example, differ from the components of good welfare for sheep or cattle (Broom 2014). The most we can say in general is that animals that satisfy BAR should, in some appropriate way, be brought within the purview of animal protection. Note that, according to ASPP, considerations of cost-effectiveness can legitimately be raised at this point: the regulatory means taken to prevent serious, negative animal welfare outcomes should be cost-effective, in comparison to other feasible means. This should be highlighted so as to pre-empt some potential concerns (see Section 5).

4. Alignment with current practice

I take it to be a mark in favour of my proposal that it is well-aligned with existing views on this question in animal welfare science. The proposal can thus be seen as articulating and making precise what I take to be the conventional wisdom in large areas of the field, rather than as calling for substantial changes to current practice.

A case in point is the reasoning that led to the 2010 EU directive on the protection of animals used for scientific purposes. This is a rare example of policymakers acting, albeit not in full, on expert advice from animal welfare scientists. The story behind this directive, in broad outline, is as follows. In 2003, a Technical Expert Working Group was asked to advise on revisions to the original 1986 directive. One of the sub-groups was tasked with deciding the appropriate scope of the directive, and in particular whether it should be extended to encompass some invertebrates. They recommended supplementing the directive with an annex listing protected invertebrate species, proposing that:

> "*Inclusion of any invertebrate species in this Annex should only occur on the basis of sound scientific evidence as to their sentience and ability to feel pain, as assessed by a Scientific Committee of experts appointed by the EC [European Commission] (but applying the precautionary principle)*." (TEWG 2003, p. 6)

Following the reports of the working group, the Animal Health and Animal Welfare Panel of the European Food Standards Agency was invited to give an opinion, including a precise recommendation as to which invertebrates should be included (AHAW 2005). Their report did not mention the precautionary principle explicitly, yet the reasoning in the report seems implicitly well-aligned with ASPP, BAR and ACT.

For example, the AHAW panel recommended the inclusion of decapod crustaceans in the scope of the directive, primarily on the basis of the experiments of Hector Maldonado and colleagues on the effects of morphine and naloxone on defensive responses in crabs (Lozada et al. 1988; Bergamo et al. 1992). This is an example of good precautionary reasoning of precisely the sort I have advocated: high-quality evidence of one credible indicator of sentience was used as a basis for advising that protection be extended to the whole order. As it happens, a more recent study by Stuart Barr and Robert Elwood (2011) has cast doubt on the evidence for morphine analgesia in crabs, so the evidence for this particular indicator is now more mixed than it was in 2005. However, as noted above, the evidence for other credible indicators of sentience in decapods, such as trade-off behaviour, is now stronger, and so the overall case for including decapods remains strong.

A 2008 draft directive incorporated the recommendations of the AHAW panel. Ultimately, however, the recommendation to include decapods was not implemented in the final directive, which extended protection to cephalopods and cyclostomes (lampreys and hagfish) but not to decapods. The inclusion of decapods within the scope of the draft directive met with fierce resistance from the biomedical research community, especially in the UK (Bioscience Sector 2009); and, following negotiations between the EC and the EU member states, the proposed extension was dropped.

Many of the arguments against the inclusion of decapods within the scope of this directive can be interpreted as general arguments against the form of precautionary reasoning on which the draft directive was based. We should therefore consider these

counterarguments.

5. Considering the counterarguments

The UK Bioscience Sector response to the EC's 2008 draft directive, together with the testimony delivered in person by representatives of the Bioscience Sector to the House of Lords, provides a rich source of influential counterarguments to the use of precautionary reasoning in relation to animal sentience. Three main counterarguments can be identified. All of them focus on the potential for unforeseen costs and exaggerated benefits in applying the precautionary principle.

5.1. Bureaucracy does not improve welfare

First, there is what we might call the "bureaucracy does not improve welfare" argument. The concern is that bringing a species within the scope of animal protection legislation merely increases the bureaucracy involved in using that species for scientific purposes, without materially improving the welfare of the animals studied. The Bioscience Sector (2009) claimed, for example, that extending the scope of EU animal protection law "would bring large areas of research that were previously not regulated under bureaucratic control without any tangible animal welfare benefits."

The underlying assumption of this argument is that scientists already treat animals well, and that additional bureaucracy merely imposes on scientists the burden of proving that they do so. If this is correct, then extending the scope of animal protection law (in relation to animals used for scientific purposes) is not a cost-effective means of preventing serious, negative welfare outcomes. Although this argument is specific to animals used for scientific purposes, one can easily imagine farmers making a parallel argument about animals used in food production.

We should observe, however, that this argument is really expressing a general concern about *all* regulation of the use of animals for scientific purposes: if scientists can invariably be trusted to treat animals well, then there is no need for a regulatory framework at all. We have such a framework because we do not consider it appropriate to take it wholly on trust that sentient animals will be treated well. A lack of proper regulatory oversight creates a risk of serious, negative welfare outcomes, and we can acknowledge the importance of mitigating this risk while also acknowledging that the vast majority of biomedical researchers have a genuine concern for animal welfare.

Given that the need for some such framework is not in dispute, further reasons are needed to justify the exclusion from that framework of invertebrates that satisfy BAR. One might even argue that it is especially important to include such invertebrates precisely because they are not always regarded as sentient. If an animal is not regarded as sentient, practices that would be considered clearly inhumane if performed on a vertebrate, such as the removal of limbs without anesthetic or analgesic, may be allowed to persist.

5.2. International competition

The second counterargument is what we might call the "international competition" argument. The concern here is that extending the scope of animal protection legislation, by increasing the bureaucratic burden on scientists, undermines the international scientific competitiveness of the nation or region (in this case, the EU) and creates an incentive for

scientists to conduct some of their experimental work outside that region, or perhaps to relocate entirely. The Bioscience Sector (2009) made this argument, writing that extending the scope of the EU directive "would impede scientific research and markedly restrict our ability to compete internationally in areas of considerable commercial and scientific importance."

This is an understandable concern. Two things can be said in response. First, recall that measures taken when applying the precautionary principle should always be subjected to a test of cost-effectiveness in comparison to other feasible measures. If the regulation of the use of animals for scientific purposes in Europe were to become so burdensome that large numbers of scientists were induced to work outside Europe, leaving them outside the reach of those regulations, this would indicate that the measures had not been effective, and had instead been counterproductive. This would be a reason to streamline the implementation of the framework by (for example) making reporting procedures less burdensome, but not a reason to reject the precautionary principle.

Second, I suggest that this concern, while non-trivial, is not sufficiently serious to justify the exclusion of invertebrates that satisfy BAR from the scope of animal protection. To the extent that this reason formed part of the justification for excluding decapods from the 2010 EU directive, this was a mistake. By way of analogy, consider climate change. It might be argued that substantial measures to reduce carbon emissions could undermine the international economic competitiveness of the countries that implement them. This is something to be minimized, as far as possible, but it is not a reason to reject the need for such measures. The imperative to prevent serious harm may sometimes override the economic, or even scientific, interests of a particular nation or region.

5.3. Perverse incentives

The third counterargument, and the one I consider most concerning, is what we might call the "perverse incentives" argument. The maxim to "reduce, refine and replace" is an important principle in biomedical research. In some cases, "replacement" may take the form of replacing vertebrates with invertebrates: for example, in environmental safety tests designed to test the effects of a chemical on marine life, decapod crustaceans may be used in preference to fish. One might grant that decapods have some degree of sentience and yet still approve of these replacements, on the grounds that fish may have a richer, more complex form of sentience than decapods (although the idea of degrees or grades of sentience requires further articulation and is open to debate). To the extent that these replacements are justified (and I grant that there is room for further debate here), it seems appropriate to incentivize them.

Here a concern arises: if decapods fall outside the scope of animal protection legislation, this creates an incentive, in the form of a lower bureaucratic burden, to use them in preference to vertebrates. Bringing decapods within the scope of animal protection removes that incentive, potentially discouraging reasonable replacements. This argument was made by the Bioscience Sector (2009) and was put forcefully to the House of Lords EU Committee by Sir Leszek Borysiewicz, then head of the UK's Medical Research Council:

> "*The question of whether there is sentience within some of these lower forms of life is inherent as to why they should actually come under this particular Directive. The evidence*

> *base on which that is based is very limited indeed, and is, in fact, very difficult to prove one way or the other, in some of these animals. The problem is that many of these animals will also form the basis on which we can eventually look for substitutions of non-human primates and other species, so that if you begin to restrict their potential use and investigation in this area it does cause major problems for reasonable movement in the 3Rs direction. That is the main reason why I, in particular, find that extremely difficult to engage with*." (House of Lords 2009, Minutes of Evidence, Q245)

I agree that we should take seriously the need to incentivize reasonable replacements. However, I suggest that this is best interpreted as a concern properly relating to the *content* and *implementation* of animal protection law, not a concern properly relating to its *scope*. It is possible in principle to bring decapods within the scope of animal protection law while ensuring that there are still incentives to use them in preference to fish (or indeed, as Borysiewicz surprisingly suggests, non-human primates). These incentives might take the form of streamlined reporting and authorization procedures.

In short, what is needed here is a different kind of "replacement": the replacement of a crude and problematic way of incentivizing replacements (i.e., through intentionally leaving potentially sentient "lower" animals outside the scope of animal protection) by a more sophisticated incentive structure. This more sophisticated structure should be based on the principle that, while all animals that satisfy BAR should be given legislative protection, it is appropriate that the protection is more burdensome for some orders than others. As a rule of thumb, it seems reasonable that a greater degree of sentience should imply a greater degree of regulatory oversight, although (as noted above) this raises the question of how degrees of sentience are to be conceptualized and estimated (if such comparisons are even possible). I cannot do justice to this complex and difficult issue here.

6. Conclusion

The overarching principle ASPP, and its practical implementations BAR and ACT, provide a framework for applying the precautionary principle to the question of animal sentience. There is no doubt room for further refinement of many aspects of the framework, and I welcome critical commentary on this. In constructing a framework for setting the burden of proof, I have not aimed to review, in any systematic way, those orders that merit protection by the lights of this framework and those that do not. In closing, I will simply note that the appropriate burden of proof has, in my view, been attained in the case of octopods, decapod crustaceans and many orders of bony fish. There are, however, many orders of mollusc and arthropod for which the burden of proof has not yet been attained. The status of the jawless fish (lampreys and hagfish) and cartilaginous fish in relation to the proposed burden of proof is difficult to assess, so I especially welcome commentary on this issue.

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Steve Chang: Neurobiology of Monkeys Thinking About Other Monkeys

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