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EPI-DOM approach for comprehensive assessment of integral animal welfare

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Introduction: Animal welfare is a critical component of sustainable production systems, affecting ethical practices and product quality. This review aims to clarify the concept of animal welfare, particularly regarding the mental state highlighted by the World Organization for Animal Health.

Methods: A comprehensive literature review was conducted, focusing on studies published between 1980 and 2024. Databases used included CAB Abstracts, Scopus, PubMed, ISI Web, Scielo, Google Scholar, and specialized websites for scientific and technical information dissemination. The search incorporated keywords such as animal, sentience, consciousness, intelligence, freedoms, domains, indicators, measurement, hazard, risk factor, and management, all related to animal welfare.

Results: This review presents a detailed analysis of the convergence and divergence between the Five Freedoms and the Five Domains, which are widely used for assessing animal welfare. The analysis identifies gaps in addressing the complexities of animal welfare, especially regarding mental states and risk factors.

Discussion: This analysis introduces the EPI-DOM approach, a conceptual framework that integrates basic epidemiological concepts (EPI) with a new vision and classification of animal welfare domains (DOM). The EPI-DOM approach separates indicators measured in animals from external factors influencing their welfare, offering a more holistic evaluation that includes physical, mental, and behavioral dimensions. The framework incorporates risk factors, classified into the domains of management, environment, and interaction, making it a versatile tool for improving welfare assessment across species and production systems.

Conclusion: The EPI-DOM framework provides a comprehensive and adaptable model for animal welfare evaluation, with potential to enhance management practices and ethical production. Future research should focus on validating and refining EPI-DOM across different species and production environments to optimize welfare and management strategies.

KEYWORDS

animal welfare, EPI-DOM approach, welfare indicators, risk factors, welfare domains, five freedoms

1 Introduction

Animal welfare continues to be a topic of global interest and relevance in modern animal production, with significant implications for ethics (Blaxter et al., 2024; Nallappan and Kanathasan, 2024), health (Goetschel, 2024), and planetary sustainability (Campo et al., 2024; Sardar et al., 2023). It is known that animal welfare is fundamental to sustainable production and efficiency in livestock systems (Phillips, 2024), as well as to the Sustainable Development Goals (United Nations, 2024), such as health and well-being, sustainable industrialization, and responsible production and consumption (United Nations and OMSA). Moreover, consumer perception of animal welfare impacts purchasing decisions, with an increasing demand for ethically produced and high-quality animal products (Hafez, 2023; Toyota and Tan, 2024). In Europe and Latin America, consumers generally have a positive attitude towards products from farming systems with welfare practices and are willing to pay a premium for them (Estévez-Moreno et al., 2022; Janssen et al., 2016). Animal welfare also impacts public health, animal health, and, consequently, the quality of products intended for consumption (OMSA, 2023; Oliveira et al., 2022). Thus, the science of animal welfare must have a multidisciplinary approach to be addressed correctly and comprehensively (Marchant-Forde, 2015). This involves integrating knowledge from veterinary medicine, biology, ethology, ethics, epidemiology, among others, to ensure that all aspects of animal welfare are considered in various situations and environments. Collaboration between these disciplines enables the development of more effective strategies that promote not only the physical health of animals but also their emotional and social well-being, which is essential for a fulfilling life, “a life worth living” (Yeates, 2011). This comprehensive approach not only benefits animals but also fosters greater awareness and responsibility in society about the importance of treating all living beings with respect and dignity. Therefore, it is essential to implement good welfare practices and systematically evaluate them in production units. Traditionally, animal welfare has been assessed through various methodologies, many of which are based on the Five Freedoms (Brambell, 1965; OMSA, 2023) or, more recently, the Five Domains (Mellor et al., 2020). However, these methodologies have limitations in their ability to provide a comprehensive, practical, and valid assessment method that captures both the evaluation of the indicators to be measured and the risk factors that influence and affect animal welfare.

2 Methodology

The present review aimed to a) clarify the concept of animal welfare, particularly regarding the mental state mentioned by OMSA (2023); b) provide a detailed analysis of the points of convergence and divergence between the Five Freedoms (Brambell, 1965) and the Five Domains (Mellor, 2017, 2020), which have been used up to today for evaluating the welfare animal; and c) propose a new way of organizing the indicators

and risk factors associated with animal welfare. For this purpose, a review of the literature published between 1980 and 2024 was conducted, using databases such as CAB Abstracts, PubMed, ISI Web, Scielo, Google Scholar, Scopus, and specialized websites for the dissemination of technical and scientific information. The keywords used were animal, sentience, consciousness, intelligence, freedoms, domains, indicators, measurement, hazard, risk factor, and management, all of them related to animal welfare.

3 Result

3.1 Sentience, perception, consciousness, cognition, and intelligence

To address and clarify the concept of animal welfare, particularly the mental state, the concepts of sentience, perception, consciousness, cognition, and intelligence were considered. The Merriam-Webster dictionary (www.merriam-webster.com) was used to define the concepts of sentience, perception, consciousness, cognition, and intelligence. “Sentience” is defined as “a sentient quality or state” and “feeling or sensation as distinguished from perception and thought”. The adjective “sentient” is described as “capable of sensing or feeling, conscious of or responsive to the sensations of seeing, hearing, feeling, tasting, or smelling”. Perception is “awareness of the elements of the environment through physical sensation”. Consciousness is “the quality or state of being aware especially of something within oneself” and “the state of being characterized by sensation, emotion, volition, and thought (mind)”. Meanwhile, cognition is defined as “a cognitive mental process”. The adjective “cognitive” is described as “of, relating to, being, or involving conscious intellectual activity (such as thinking, reasoning, or remembering)” and as “based on or capable of being reduced to empirical factual knowledge”. Intelligence is defined as “the ability to learn or understand or to deal with new or trying situations” and “the ability to apply knowledge to manipulate one’s environment”.

In specialized literature, sentience is identified as the capacity of an organism to have experiences and to be affected in a positive, negative, or neutral way (Tye, 2017). Sentience is defined as the capacity for conscious experience, particularly experiences with a positive or negative valence, such as pain or pleasure (Birch, 2024; Browning and Birch, 2022). Research indicates that sentience is present in a wide range of species, including most vertebrates and some invertebrates such as cephalopods and decapod crustaceans. The study of animal sentience involves indicators, such as behavioral and physiological responses, to infer the presence of subjective experiences (Browning and Birch, 2022). Currently research accepts that animals demonstrating high cognitive complexity or intelligence are sentient (Shettleworth, 2010). The concept of sentience is essential for understanding animal welfare; it is the capacity of an animal to perceive *external and internal* stimuli and experience the response to such stimuli. Perception is the action and effect of perceiving, which involves capturing images, sounds, impressions, or sensations, both external and internal, through one

of the senses. It involves gathering information from the environment. In this sense, any animal with a nervous system has specialized neuronal cells capable of perceiving this information from both the external and internal environment, processing it, and generating an appropriate response to the stimulus received, which can trigger various behavioral patterns (Gabbiani and Midtgaard, 2024).

Consciousness, on the other hand, consists of the immediate awareness an individual has of both the internal and external environment, of their own experiences and actions; that is, having a sense of self and some understanding of one's place in the world (Tye, 2017). In other words, an organism is conscious when it perceives stimuli that alters its mental or psychological state. The definition of cognition is widely accepted and refers to the process by which animals acquire, process, store, and act upon the information gathered from the environment (Shettleworth, 2010). It consists of the mental transformation of sensory information into knowledge about the environment and the flexible application of this knowledge, including processes such as learning, memory, or decision-making. While cognition focuses on the process of acquiring this knowledge, intelligence refers to the ability to apply it successfully (de Waal, 2016), particularly in solving everyday problems. It is impossible to discuss welfare without considering these fundamental aspects that help us understand what we mean when we refer to the mental state of the animal.

3.2 Evolution of animal welfare

Currently, according to the Terrestrial Code of the World Organisation for Animal Health (OIE, formerly OIE), animal welfare is defined as “the physical and mental state of an animal in relation to the conditions in which it lives and dies” (OIE, 2023). The concept emerged in the mid-20th century, when the book *Animal Machines* by Ruth Harrison was published in 1964, highlighting the deplorable conditions of animals in intensive farming and calling for improvements in their quality of life (Harrison, 1964). W. H. Thorpe, an ethologist who significantly contributed to the study of animal welfare, emphasized the importance of understanding the biology of animals, their specific needs, and their behavioral responses. His work highlights those animals are not mere machines but living beings that require the ability to express natural behaviors, a perspective reflected in the Brambell Committee Report.

The 1965 Brambell Report established the so-called Five Freedoms, which have been identified to guide the evaluation of animal welfare: 1) Freedom from hunger, thirst, or inadequate nutrition; 2) Freedom from pain, injury, or disease; 3) Freedom from fear and distress; 4) Freedom from discomfort; 5) Freedom to express natural behaviors. They focus on preventing suffering by limiting conditions that promote chronic hunger and thirst, discomfort, pain, fear, and ensuring that animals can satisfy their need to behave naturally. This marked a turning point in the history of animal welfare by establishing the foundations for the evaluation of animals used in production (Brambell, 1965). Regarding the concept, Fraser et al. (1997) define the subject of animal welfare,

represented by naturalness, affective states, and biological functioning. This means that animals must be able to behave naturally according to their species, while affective states reflect the sentience and emotions experienced by animals. At the same time, biological functioning is influenced by the environment and can be measured through productivity indices and outcomes. However, it is important to note that an animal's biological functioning may not be affected even when facing various adverse stimuli, which does not necessarily mean that the animal is experiencing a good level of welfare (Broom, 2024). Moreover, the perception of an animal's quality of life (QoL) not only involves the absence of suffering but also the quality of its interactions with the environment, allowing it to meet its needs (Stockman et al., 2011) and experience comfort. This comprehensive view of animal welfare encompasses both physical and mental well-being, emphasizing the importance of an environment that supports natural behaviors and social interactions. The integration of these elements is crucial to ensuring that animals not only survive but thrive in their environment. Quality-of-life assessment tools are indispensable in veterinary medicine for evaluating animal welfare. These tools often measure aspects such as activity levels, desire for interaction, and appetite, which are indicative of an animal's overall well-being (Fulmer et al., 2022), as well as behavioral parameters, physical condition, and resource- or management-based factors (Long et al., 2022). These instruments have been primarily employed to evaluate the health and welfare of aging zoo mammals, thereby facilitating informed decision-making concerning end-of-life care, including the determination of the appropriate timing for euthanasia (Campbell-Ward, 2023). Therefore, welfare is linked to the individual experiences and perceptions of the animals, meaning that animal welfare should be understood as the quality of life as perceived by the animal itself. Given these facts, it is incorrect to assume that simply implementing good husbandry practices will ensure good welfare for animals merely because they are “producing” or not dying.

Consequently, the concept of animal welfare is based on the balanced relationship between the animal and its environment (both external and internal), where its physical and psychological state play a crucial role (Broom, 2005). A general definition of animal welfare might be “the state of an individual in relation to its attempts to cope with its environment” (Broom, 2011). This refers to the physical, emotional, and social state of animals and their ability to express natural and normal behaviors in response to favorable or adverse environmental conditions, which may result in pain, stress, or unnecessary suffering, as well as pleasure or play. Most animal welfare scientists and the public agree that animal welfare relates to what animals individually experience and perceive, meaning that *the degree of welfare would be equivalent to the quality of life as perceived by the animal itself*.

Animal welfare refers to the state of the animal in terms of good to bad; it is measurable and quantifiable, and when evaluating it, it is essential to understand the biology of the individual, incorporating emotions and their measurement as well (Broom, 2024). In this sense, emphasis is placed on both physical and mental states, and the end-of-life stage is also incorporated. Considering this

definition and from a regulatory perspective, animals are entirely vulnerable beings, like young children; consequently, it is the ethical and moral responsibility of humans to ensure that, throughout their lives and during the end-of-life stage, animals under human care are able to have their needs met, express their natural behavior and emotions, in an ethical, dignified, and appropriate environment (Arvizu-Tovar and Téllez, 2016). Therefore, it is imperative to observe and safeguard welfare at all stages of an animal's life, particularly during critical moments such as transport and even the slaughtering process. A good level of welfare, with a higher degree of positive experiences compared to negative ones, is a fundamental part of the concept. The level or degree of welfare can be scientifically measured based on the knowledge of the species' biology and how organisms cope with the challenges of daily life. Measurement and interpretation must be objective, and once a welfare status (rating and qualification) has been determined, decisions can then be made (Broom, 2024).

3.3 Evaluation of animal welfare

As part of the evolution of the Five Freedoms and as a result of scientific findings in the field of animal welfare, the Five Domains model has also been introduced (Mellor et al., 2020; Mellor, 2017). This model consists of four physical domains, with the fifth domain being the mental domain, which is the result of the first four. It is established that the sum and interaction of factors related to survival (1: nutrition, 2: environment, and 3: health) and situational factors (4: behavior) directly influence the mental state of individuals (Domain no. 5: affective experiences, both positive and negative). It is essential to consider the intelligence, learning, and memory of the species, allowing for the assessment of the welfare status or condition of animals, both physically and mentally, at a given moment (Mellor et al., 2020; Mellor, 2017). This approach is more recent and holistic, where the mental domain also includes the emotional states of animals. When comparing both approaches, the Five Freedoms and the Five Domains in the context of animal

welfare, it becomes clear that each framework analyzes different aspects of animal care and management (Table 1).

1. **Nutrition:** The first freedom, known as freedom from hunger and thirst, establishes that animals must have constant access to fresh and clean water, as well as food that meets their nutritional needs, adapted to their species, life stage, and productive purpose. This freedom is reflected in the Nutrition Domain of the Five Domains, which focuses on ensuring that animals have access to an adequate diet and that their feeding is regularly evaluated to ensure their needs and nutritional requirements are met. It can be observed that there are similarities in both methodologies, meaning the animal must be fed and nourished, satisfying its needs and meeting its nutritional requirements.
2. **Environment and Safety:** The freedom from fear and distress emphasizes the importance of providing animals with an environment that minimizes stress and negative emotions related to fear or distress, while also providing them with safety. This aspect is addressed in the Five Domains through an approach that links the Environment and the Mental State of animals, although there is some ambiguity as to which of these two aspects this freedom best fits. The also, of these two domains is to ensure that animals live in an environment that is not only safe but also mentally comfortable.
3. **Comfort in Housing:** The freedom from discomfort highlights the need for animals to live in housing that minimizes both physical and thermal discomfort. This correlates with the Environment Domain, which examines the environmental conditions, primarily housing, to ensure that animals are in a safe and comfortable environment, protecting them from cold, heat, and other physical discomforts. Comfort also refers to the distribution of spaces: for resting, moving, interacting with conspecifics, feeding, and waste elimination such as feces and urine, among others.
4. **Health and Medical Care:** The freedom from pain, injury, and disease establishes that animals must have preventive

TABLE 1 Elements of the Five Freedoms and the Five Domains (Brambell, 1965; Mellor, 2017, 2020; OMSA, 2023).

Element	Five Freedoms	Five Domains
1. Nutrition Animals must have free access to fresh and clean water and food that meets their nutritional needs according to their species, life stage, and production purpose	Freedom from hunger and thirst Positive mental state?	Domain 1 – Nutrition: Access to appropriate food and diet evaluation Domain 5 – Positive and negative mental state
2. Environment and safety Animals should live in an environment that reduces stress and provides security	Freedom from fear and distress Positive mental state?	Domain 4 – Environment Domain 5 – Positive and negative mental state
3. Comfort in housing Animals must be housed in comfortable shelter, minimizing thermal and physical discomfort	Freedom from discomfort Positive mental state?	Domain 2 – Environment: Conditions of the environment and housing affecting safety and comfort Domain 5 – Positive and negative mental state
4. Health and medical care Animals must be guaranteed disease prevention, early diagnosis, and timely treatment	Freedom from pain, injury, and disease Positive mental state?	Domain 3 – Health: Assessment of physical health, diseases, and injuries Domain 5 – Positive and negative mental state
5. Natural behavior Animals must display their individual and social behaviors naturally, according to their species	Freedom to express normal behavior Positive mental state?	Domain 4 – Behavior: Ability to express natural behaviors Domain 5 – Positive and negative mental state

measures to avoid illness, the implementation of practices that ensure early diagnosis, and timely treatment, which aligns with the spirit of the Five Domains methodology, as it corresponds to the Health Domain. This domain evaluates the physical health, both internal and external, of individuals through the prevention and treatment of diseases and/or injuries, ensuring that animals remain in good physical condition.

5. Natural Behavior: Finally, the freedom to express normal behavior emphasizes the importance of allowing animals to exhibit individual and social behaviors according to their own nature. This aspect corresponds to the Behavior Domain, which ensures that animals have the opportunity to express natural behaviors according to species, age, physiological state, sex, breed, among other characteristics, which is essential for their overall well-being.

Regarding Domain 5, this refers to the emotional and mental welfare of an animal (Mellor, 2017), but it is limited in the approach of the Five Freedoms, as it is not clearly distinguished (Table 1). As previously mentioned, freedoms are principles that focus primarily on limiting negative emotions: preventing animals from suffering, feeling fear, or distress. In contrast, the Five Domains model proposes a comprehensive evaluation, considering not only

physical needs or the absence of suffering but also incorporating the mental states of animals, as well as the presence of positive experiences that contribute to a good general state of welfare (Mellor et al., 2020).

By conducting a more detailed analysis, fundamental differences between both approaches can be observed, both in their scope and practical application (Table 2). Both frameworks have played a crucial role in the evolution of animal welfare, but they have done so from different perspectives and philosophies that reflect the growing complexity of this field. In this sense, the Five Freedoms is a concept that has prevailed since its introduction and focuses, regarding the mental aspect, on preventing animal suffering. This approach has been widely accepted and adopted in regulations and public policies, as well as in the development of guides or protocols due to its simplicity and clarity. Each freedom addresses an essential aspect of animal welfare, from freedom from hunger and thirst to freedom to express natural behaviors. This framework, by focusing on the prevention of negative experiences, provides an accessible and easily understandable starting point for both the public and professionals involved in animal care. However, the simplicity of the Five Freedoms also constitutes its greatest limitation, as this approach, by centering on avoiding suffering, tends to overlook more positive aspects of welfare, such as promoting enriching experiences that could improve the emotional and mental state of

TABLE 2 Comparative analysis between different aspects of the Five Freedoms and the Five Domains.

Five Freedoms	References	Five Domains	References
Focus			
Emphasis on avoiding animal suffering	(Brambell, 1965; Webster, 2008; Mellor, 2016)	More holistic evaluation, includes positive emotions as a result of positive life experiences	(Mellor and Beausoleil, 2015; Yeates and Main, 2008; Dawkins, 2021)
Components			
Freedom from chronic hunger and thirst	(Broom, 1991; Webster, 2008; Fraser, 2008)	Nutrition	(Mellor, 2017)
Freedom from physical discomfort	(Brambell, 1965; Webster, 2008)	Environment	(Mellor, 2017; Baxter, 1983)
Freedom from pain, injuries, and diseases	(Dawkins, 1990; Broom, 1991; Fraser, 2008; Chandroo et al., 2004)	Physical Health	(Mellor, 2016)
Freedom to express natural behaviors	(Brambell, 1965; Dawkins, 2021)	Behavior	(Duncan, 2006; Mellor, 2016;
Freedom from fear and distress	(Fraser, 2008; Webster, 2008)	Mental and Emotional State	(Mellor and Beausoleil, 2015; Duncan, 1993) Yeates and Main, 2008;
Advantages			
Simplicity	(Webster, 2008; Fraser, 2008)	Integral focus	(Mellor, 2017; Dawkins, 2021)
Preventive focus on avoiding suffering	(Fraser, 2008; Webster, 2008)	Flexibility to adapt to different species and contexts	(Mellor and Beausoleil, 2015)
Broad acceptance for incorporation into regulations and public policies	(Broom, 1991; Fraser, 2008)	Actively promotes positive welfare	(Fraser, 2008; Mellor, 2017)
		Evaluates behavior as an inference of mental state	(Duncan, 2006; Dawkins, 2021)

(Continued)

TABLE 2 Continued

Five Freedoms	References	Five Domains	References
Disadvantages			
Limited focus and lack of clarity, especially in positive welfare	(Broom, 1991; Fraser, 2008)	Complexity in application and evaluation	(Yeates and Main, 2008; Mellor, 2017)
May lead to misinterpretations and inconsistencies	(Webster, 2008; Fraser, 2008)	Less dissemination and adoption in current regulations and public policies	(Fraser, 2008; Mellor and Beausoleil, 2015)
Perspective			
Based on eliminating suffering and deprivation	(Webster, 2008; Fraser, 2008)	Based on promoting positive experiences that enhance welfare and emotional state	(Yeates and Main, 2008; Mellor, 2017)
Ethical			
Based on preventing harm	(Webster, 2008; Fraser, 2008)	Based on maximizing positive welfare	(Duncan, 1993; Mellor and Beausoleil, 2015)
Limitations			
Does not directly address the animal's mental state	(Webster, 2008; Fraser, 2008)	More complex and subjective approach, especially in evaluating the mental state of animals	(Duncan, 2006; Mellor, 2016)
Application			
Easier to communicate the animal's physical state and environmental conditions to the public.	(Broom, 1991; Fraser, 2008)	Evaluates a wide range of physical and mental states of the animal.	(Mellor, 2016; Dawkins, 2021)
Simpler to incorporate into policies, regulations, guidelines, and operational manuals in facilities where animals are under human care.	(Webster, 2008; Fraser, 2008)	Requires scientific-technical training of involved personnel to assess welfare.	(Mellor and Beausoleil, 2015)
Practical Use			
Commonly used in regulations and ethical guidelines	(Webster, 2008; Fraser, 2008)	Increasingly adopted in research and detailed evaluations	(Mellor, 2017; Dawkins, 2021)
Measurement			
Based on the absence of negative states. More frequently evaluates the environment, management, and physical state of the animal.	(Broom, 1991; Webster, 2008; Fraser, 2008)	Considers both the absence of negative mental states and the presence of positive ones. However, it does not clearly specify which welfare indicators to use.	(Mellor, 2017; Dawkins, 2021)

For the analysis, the following factors were considered various aspects of the approach mentioned in the literature regarding the Five Freedoms and the Five Domains.

animals. Additionally, the lack of an explicit approach to the mental state can lead to erroneous or insufficient interpretations of what truly constitutes an optimal, integral state of welfare.

On the other hand, the Five Domains represent a significant advancement towards a more holistic assessment of animal welfare. This framework not only considers the absence of negative experiences but also actively promotes the inclusion of positive experiences in animals' lives. The Five Domains address both physical and mental aspects more comprehensively, incorporating a more integrated approach that considers nutrition, environment, physical health, behavior, and most importantly, the evaluation of mental state. This perspective allows for a richer and more nuanced understanding of welfare, in which not only is suffering avoided, but efforts are made to actively improve the animal's quality of life. However, the inherent complexity of this approach presents challenges in its practical application, particularly in the accurate

and objective assessment of animals' mental states and the factors affecting overall welfare. Furthermore, the adoption of the Five Domains in regulations and public policies has been slower, partly due to the technical complexity involved in its evaluation and effective implementation.

From an ethical standpoint, the Five Freedoms focus on harm prevention, a solid and widely accepted foundation in the field of animal welfare. In contrast, the Five Domains promote a more proactive ethic, centered on maximizing positive welfare. This difference highlights a paradigm shift in how animal welfare is understood and addressed: from a focus on limiting negative effects to one that also values and actively seeks to promote positive experiences. Although the Five Domains are more complex, they offer a more sophisticated tool for evaluating animal welfare by incorporating the mental aspect, ambivalent yet ambiguous. This has sparked interest in its study in research contexts and detailed

evaluations. Nevertheless, its practical application requires deeper technical training, which may limit its implementation in less specialized settings.

Finally, the measurement of welfare in both frameworks also reflect their fundamental differences. While the Five Freedoms tend to rely on the absence of negative states, focusing more on the evaluation of the environment and management as well as the animal's physical state, the Five Domains consider not only the absence of negative states but also the presence of positive states. However, this latter approach still faces challenges in clearly identifying and measuring welfare indicators, especially regarding the evaluation of mental state. Although the Five Freedoms and the Five Domains share the common goal of improving animal welfare, they approach it from different perspectives and with different tools. The Five Freedoms, with their simplicity and focus on preventing suffering or physical harm, have been essential in establishing a solid initial foundation for evaluating animal welfare. Meanwhile, the Five Domains, with their more comprehensive approach, represent a step towards a more complete and sophisticated understanding of the physical and mental welfare of animals. The choice between one framework or the other, or their combination, will depend on the context and the specific objectives of those working in this field, as well as the practical and ethical possibilities that each approach offers for implementation at the field level.

However, when evaluating and assessing animal welfare, various questions always arise: What should be measured? Where? What should the focus be on? How to evaluate? What is the factor causing welfare problems? What are the appropriate indicators? What relationship can be found between indicators and/or factors? To answer these questions, it is necessary to review welfare indicators. Therefore, it is essential to consider that animal welfare assessment should be based on measurable indicators that reflect their physical and mental state. Subsequently, the factors affecting their welfare should be identified, considering aspects such as management practices and the environment in which they live and are ultimately culled. A common oversight in animal welfare assessments is the tendency to focus on environmental conditions rather than the actual condition of the animals. This issue arises from the complexity of welfare evaluations, which require a balance between animal-based and environmental measures, along with their relationship with humans (Beaver and Golab, 2023). Animal-based measures are crucial as they directly reflect the welfare status of the animals, capturing physiological, health, and behavioral outcomes, and others. These measures are often quantitative and provide an accurate welfare assessment, independent of environmental conditions (Dalmau and Velarde, 2024). The development of welfare assessment tools is further complicated by potential biases and the need for standardized methodologies (Beaver and Golab, 2023).

According to Merriam-Webster, “indicator” is “something that indicates, an index, a pointer.” It can be described as an observable and measurable characteristic, focused, clear, and specific. It should precisely describe what is being measured and be defined in accurate terms. Indicators are data resulting from established measurement procedures, serving as tools to quantify/qualify and

verify conditions, compare situations, and anticipate trends (Copo, 2023). They are useful for assessing health, production, and management, although their accuracy varies depending on the different measures of welfare (Barry et al., 2024). Additionally, it is suggested that welfare is dynamic and should be assessed over time, focusing on the animal's ability to respond to environmental stimuli (Arndt et al., 2023). Therefore, the concept of a welfare indicator must encompass various metrics used to evaluate both the physical and mental state of the animal, reflecting both negative and positive aspects. In this way, the concept should also cover various frameworks and methodologies aimed at assessing the animal holistically, at a given moment, and, if necessary, modifying the factors that put its welfare at risk. Thus, animal welfare indicators are essential tools that measure or determine the level of an individual's welfare, and with which changes can be recorded to make decisions for timely and effective actions (Blokhuys et al., 2010).

Welfare indicators that are measured directly in animals (animal-based welfare) have been used. For example, in production animals like dairy cows, indicators include body condition score, presence or absence of lameness, hoof health, somatic cell count, among others (Linstädt et al., 2024). In rearing piglets, the presence and frequency of sneezing, the number of animals with tail-biting, the time spent on certain behaviors, and human-animal relationship tests have been studied (Witt et al., 2023). Welfare indicators measured in horses include stereotypies, aggression towards humans, lack of response to the environment, and hypervigilance, using methodologies such as scan sampling and surveys (Ruet et al., 2022). In sheep, natural behavior, lameness, body condition score, pain assessment, skin irritation scratching, presence of ocular damage, lying time, and tooth loss are considered welfare indicators (Zufferey et al., 2021). At slaughterhouses, damage grade and skin lesion size, tail length, bite injuries, lameness, coughing, rectal/vaginal prolapse, lung prolapse, pleuritis, pericarditis, and liver lesions are welfare indicators measured in finishing pigs (Hernandez et al., 2023). Additionally, slip, fall, or the number of animals showing vocalizations during stunning, or signs of consciousness post-stunning are measured (Grandin, 2010).

As can be observed, welfare in production species is significantly influenced by environmental conditions, management, and handling, meaning external factors that affect both the physical and mental welfare of the animals. Resource-based indicators, or those that can be measured outside the animal, have also been used. Among these, environmental conditions play a crucial role in animal welfare. The environment is composed of various elements, such as the physical surroundings, which include housing design, factors like available space, ventilation, and access to natural light, all of which can have a direct positive or negative effect on the animal. Well-designed environments allow animals to express natural behaviors, which in turn reduces stress and promotes their health (Li et al., 2023; Bayne and Turner, 2014). On the other hand, microbial and chemical factors are highly relevant, especially in intensive production systems. Elements such as ammonia concentration and noise levels in animal housing, and poor-quality bedding regarding type and dimensions, can have a

severe impact, triggering physiological responses that compromise the animal's welfare (Li et al., 2015).

Regarding management practices, meeting the nutritional needs of animals is fundamental. A proper diet, tailored to the specific needs and requirements of each animal while considering their physiological state, is essential for maintaining not only welfare but also productivity, reducing losses and unnecessary expenses (Hutu and Onan, 2019). Environmental enrichment in production units has become an indispensable component that enhances both physical and mental welfare, allowing animals to live in a more stimulating and healthier environment. Likewise, providing opportunities for social interaction and exercise has been shown to significantly improve welfare assessments in animals intended for

slaughter (Taylor et al., 2023). This underscores the need to implement better management practices to mitigate any type of risk that may compromise the overall welfare of the animal. In this regard, Table 3 presents an analysis with examples of welfare indicators measured in animals and the factors that may influence them.

One important detail to emphasize is that, upon analyzing the information in Table 3, it becomes evident that certain welfare indicators appear in multiple domains, reflecting the complex interconnections between them. While these interactions are expected, they may pose challenges when categorizing indicators and designing welfare assessments. The key points where such conceptual overlaps or redundancies occur are outlined below:

TABLE 3 Exemplified analysis of indicators and factors influencing animal welfare.

Category	Five Freedoms: indicators	Five Domains: indicators	Indicators (what to measure in the animal)	Factors that influence animal welfare (what to measure outside the animal)
Nutrition	Freedom from hunger and thirst: Body condition, chronic denial of access to water and food (more than 24 hours)	Nutrition: Body condition, food intake	- Body condition (Roche et al., 2009; Dud et al., 2022) - Food intake (Matthews et al., 2012) - Digestive health (Celi et al., 2017; Colombino et al., 2021) - Blood metabolites and cells (Herdt et al., 2000; Dud et al., 2022)	- Access to clean water and appropriate food for the animal (Mohammed, 2014) - Balanced diet according to species, physiological stage, and production purpose (Kamphues et al., 2007) - Quantity and nutritional quality of food (Reynolds, 2019) - Number of feeders and drinkers (Mohammed, 2014) - Feeding program (type of food, time of day, grazing time, frequency, formulation, ration) (Kamphues et al., 2007)
Environment	Freedom from discomfort: Housing conditions, space	Environment: Quality of housing, shelter, cleanliness	- Discomfort behaviors (Torcivia and McDonnell, 2021; Lechner et al., 2021) - Signs of stress (De Greef and Leenstra, 2019; Randle and Dennis, 2022). - Stereotypies (Tello-Pasos and González-Pech, 2022)	- Shade (Edwards-Callaway et al., 2021) - Type of floors (Graunke et al., 2011; Faria et al., 2023) - Floor slopes (Laporta et al., 2023) - Type and quality of bedding/sleeping areas (Canozzi et al., 2022) - Resting area (Maia et al., 2022) - Lighting (Faria et al., 2023) - Ventilation (Laporta et al., 2023) - Ambient temperature (Edwards-Callaway et al., 2021) - Relative humidity (Maia et al., 2022) - Pen surface (Canozzi et al., 2022) - Enrichment (Laporta et al., 2023)
Physical Health	Freedom from pain, injuries, and disease: Visible injuries and damage, clinical signs	Health: Presence of diseases, physical condition, injuries, and damage	- Body and homeostasis integrity (external and internal, respectively) (Wemelsfelder et al., 2014; Sanmiguel Plazas et al., 2018) - Signs of illness (coughing, sneezing, diarrhea) (Broom, 1986; Panzera, 2013) - Pain expression behavior (Góngora Medina, 2010; Weary et al., 2014) - Vocalizations (Broom, 1986; Wemelsfelder et al., 2014) - Lameness (Broom, 1986; Tadich, 2016)	- Preventive medicine programs (deworming, vaccination) (Kramer et al., 2012; Martelli and Krishnasamy, 2023) - Surgical procedures (Bain, 2020). - Biosecurity (Pokludová, 2020) - Health records and logs (Lee et al., 2023)

(Continued)

TABLE 3 Continued

Category	Five Freedoms: indicators	Five Domains: indicators	Indicators (what to measure in the animal)	Factors that influence animal welfare (what to measure outside the animal)
			- Mortality and morbidity (Blackshaw, 1986; Butterworth and Weeks, 2010) - Reproductive and productive parameters (Lopez, 2007; Tadich, 2016; Dalmau et al., 2014; Madzingira, 2018)	
Behavior	Freedom to express normal behavior: Natural behaviors according to species and physiological stage	Behavior: Expression of natural behaviors according to species and physiological stage	- Individual behaviors (feeding and excretion behaviors) (Broom, 2022c, 2022d; Saeed et al., 2023; Bukhari et al., 2024) - Grooming and brushing (Schulze Westerath et al., 2014; McDonald et al., 2022; Broom, 2022d) - Response to novel stimuli (Broom, 2021; Li et al., 2023) - Social interaction behaviors (Fraser and Broom, 1990; Mills and Marchant-Forde, 2010; Broom, 2021, 2022i). - Courtship (Broom, 2021) - Exploration (Broom, 2022e) - Mother-calf relationship (Broom, 2022f) - Play (Broom, 2022g) - Agonistic behaviors (Broom, 2021; Lupu and Militaru, 2022). - Stereotypies (Broom, 2022h) - Redirected behaviors (tail biting, pecking, etc.) (Cronin and Glatz, 2020). - Expression of fear, anxiety, boredom, pain (Broom, 2021; 2022a) - Defense and attack (Broom, 2022b) - Motivation (Broom, 2022a)	- Environmental enrichment? - Housing evaluation: dimensions, microenvironmental conditions?
Mental State	Freedom from fear and distress: Avoidance behaviors, signs of stress, anxiety?	Emotional or Mental State: Behaviors related to positive or negative well-being	- Avoidance behavior (Hutson and Grandin, 2014) - Signs of stress (Broom, 2021) - Emotional responses: anxiety, depression, boredom, loneliness (Broom, 2021) - Pleasure (Broom, 2021) - Positive response to food (Broom, 2021) - Positive interaction with conspecifics (Broom, 2021, 2022i)	- Stimuli that cause fear, environmental? - Adverse changes in environment?

1. Mental state and environment: Some environmental factors, such as novel noises in housing, can trigger emotional responses like fear. However, fear itself is categorized within the mental state domain. This raises the question: should welfare evaluation prioritize the environmental factors or the animal's emotional response? This conceptual redundancy can lead to variations in how welfare is assessed, with some approaches focusing on external conditions while others emphasize the animal's internal state.
2. Mental state and behavior: Both behavior and mental state are intrinsic to the animal, yet they are categorized into separate domains. Many behaviors are interpreted both as natural behavior and as indicators of emotional or mental state. For example, avoidance behaviors, stereotypies, and signs of

anxiety or depression can be classified under both domains, as can positive behaviors like play and social interactions. This dual classification complicates the interpretation of welfare indicators, making it difficult to distinguish between the external cause (stressor) and the behavioral expression (natural behavior vs. emotional response).

3. Behavior and environment: Environmental enrichment is traditionally considered a welfare indicator. However, does it belong to the behavior domain or the environment domain? Conceptually, indicators should be assessed in the animal, meaning behavior falls within the animal's response, while the environment serves as an external factor influencing that response. For instance, environmental modifications, such as enrichment

strategies, significantly impact the expression of natural behaviors. Similarly, housing conditions, temperature, and humidity influence welfare but should not be considered primary welfare indicators themselves. Overemphasizing environmental conditions without directly linking them to animal-based indicators may shift the focus of welfare evaluations away from the animal.

Based on this analysis, it is necessary to refine the classification criteria of indicators and reconsider the definition of domains to enhance the clarity, precision, and practical application of animal welfare assessments.

3.4 Proposal for a new approach: EPI-DOM

As derived from the analysis of [Table 3](#), the direct and indirect welfare indicators, although not contrary to the spirit of the definition of animal welfare: the physical and mental state of an animal in relation to the conditions in which it lives and dies ([OMSA, 2023](#)), are distinguished by their measurement. “Direct” indicators are assessed on the animal itself, while the so-called “indirect” indicators are evaluated in the environment. However, the latter does not address what happens to the animal both physically and mentally. Therefore, the condition or situation in which animals live and die refers to the set of external factors or circumstances that affect an individual at a specific moment in time. This leads to key questions: Who registers the changes? Whose welfare is being evaluated? Who is affected? The answer is straightforward: welfare must be assessed in the animal. So, what about everything else? How does the relationship between the animal’s state and the conditions of its environment arise? And which conditions are we referring to? To address the identified overlaps and improve the clarity and precision in the assessment of animal welfare, this document proposes a new approach: EPI-DOM. This is a conceptual framework that links basic epidemiological concepts (EPI), proposing a new vision and classification of animal welfare domains (DOM). Additionally, EPI-DOM clearly separates indicators (measured in the animal) from external factors that influence the welfare of individuals (measured outside the animal). This approach facilitates the identification of causal relationships between the factors and the animal’s response, allowing for more precise and targeted interventions to improve individual welfare.

The multidimensional approach presented by EPI-DOM for the evaluation of animal welfare indicators is essential not only for obtaining a complete understanding of the animal’s physical (internal and external) and mental state but also for implementing effective strategies to improve its quality of life in various contexts. Moreover, evaluating welfare indicators from this perspective, i.e., focused on the animal, also allows for identifying the risk factors surrounding the individual that may affect his welfare. As mentioned earlier, animal welfare is influenced by risk factors. To associate these two terms, it is necessary to apply concepts from epidemiology, such as hazard, risk, and risk

factors, which are fundamental to understanding not only the occurrence of diseases but also other events that affect the physical (and mental) health of communities. Epidemiology is the study of diseases that occur in populations and the factors that determine their occurrence, with the key word being “population.” Veterinary epidemiology, furthermore, includes the investigation and evaluation of other health-related events, particularly those impacting production ([Thrusfield, 2018](#)). Epidemiological research involves observing and making inferences based on those observations. If this same concept is applied to animal welfare, data can be obtained by observing welfare indicators in individuals, which are influenced by the factors that affect their welfare state (*risk factors*).

Another term that should be borrowed from epidemiology to analyze animal welfare is *hazard*, defined as the potential source of harm or a situation that can cause an adverse event or disease, such as poor facility conditions, inadequate diet, biosecurity failures, lack of preventive medicine, among others. A hazard is inherently dangerous by nature but does not necessarily imply that the harm will occur. On the other hand, *risk* is defined as the *probability of an adverse event occurring*, such as bodily injury, elevated cortisol levels, signs of disease, or abnormal behaviors in a population or individual over a specific period of time due to exposure to a hazard. Finally, a *risk factor* is a characteristic or condition that increases the likelihood that an animal or group of animals will suffer an adverse event or develop a disease ([Thrusfield, 2018](#)). In summary, a hazard is the source of harm, risk is the probability that this harm will occur, and a risk factor is something that increases the likelihood of an adverse event related to that hazard. When these terms are applied to animal welfare, some questions arise: where are these hazards located? Where should risk factors affecting animal welfare be evaluated? The answer lies in determining the conditions in which the individual lives and dies, which stem from the concept of animal welfare ([OMSA, 2023](#)).

The epidemiological approach to animal welfare involves the use of epidemiological methods to assess, monitor, and improve the welfare of animals in various environments, including farms, zoos, and domestic settings. This approach enables researchers to identify risk factors, understand the prevalence of welfare issues, and develop strategies to mitigate these problems. By integrating data from multiple sources and employing statistical analyses, epidemiology provides a robust framework for comprehensively assessing animal welfare. Large-scale epidemiological studies on zoo elephants in North America have highlighted the importance of social and management factors in determining welfare outcomes. These studies have provided benchmarks for welfare indicators, such as abnormal behavior and health issues, and have underscored the need for science-based welfare optimization in zoos ([Carlstead et al., 2013](#); [Meehan et al., 2016](#)). An epidemiological study in Sweden used data from official inspections to assess equine welfare. The study identified factors such as non-compliance with care requirements and facility design as significant contributors to poor welfare. This approach allowed for the identification of trends and risk factors, facilitating targeted interventions to improve welfare standards ([Hitchens et al., 2017](#)). In tilapia, an epidemiological approach was used to evaluate

the impact of different feeding rates on the incidence of adverse welfare events, such as mortality, body condition decline, and fin damage. This study found significant associations between feeding rates and these welfare indicators, suggesting that optimal feeding practices are a crucial risk factor for maintaining fish welfare (Flores-García et al., 2022). In turkeys, human interaction during inspections, such as the number of daily inspections and the number of different individuals involved, affects the prevalence of head/neck injuries, highlighting those workers can also be a risk factor for animal welfare (Leishman et al., 2022).

3.5 Recategorization of welfare indicators

In the EPI-DOM Approach, animal welfare evaluation indicators are systematically classified into three categories: External, Internal, and Behavioral Indicators (see Table 4). These, in turn, are divided

into invasive indicators, which require handling and manipulating the animal, and non-invasive indicators, which can be determined through observation without direct contact. An example of how these categories relate in practice: an animal with a physical injury (external indicator) may exhibit a stress response, leading to alterations in cortisol levels (internal indicator), and subsequently show changes in resting behavior (behavioral indicator). These relationships illustrate how welfare assessments can benefit from integrating multiple types of indicators. However, the selection of indicators should be based on the specific research question or practical context rather than a strict requirement to collect all categories in every assessment. The EPI-DOM approach provides a structured classification system that helps organize welfare indicators systematically, reducing domain conceptual overlaps or redundancies and clarifying their interpretation. Nevertheless, the interactions between indicators are complex and context-dependent, requiring careful consideration of causal relationships when designing welfare assessments.

TABLE 4 Animal welfare Indicators according to the EPI-DOM Approach.

Category	Characteristics	Evaluated by	Relationship	Determines	Examples
EXTERNAL Bodily: invasive/ non-invasive	They are visible and evident, manifesting clearly and perceptibly, like lesions or damage to the body, locomotion alterations. It's possible to determine the degree of impact.	Visual observation and/or palpation	Body and mechanical integrity	Physical aspects: Structure, morphology, and function, particularly the integrity and general condition of the body or specific organs.	- Injuries or damage to the legs, head, back, mouth, or other parts of the body, areas without hair/feathers, wounds, fractures, missing portions of organs, body condition in mammals/birds. - Scaling and hemorrhages on the body, Fulton's K, lesions in the mouth, gills, as well as fraying, hemorrhages, or missing portions of fins in fish.
INTERNAL Organic and tissue: invasive/ non-invasive	Measurable with equipment, stress responses that in most cases cannot be determined visually.	Physiological and biochemical tests	Integrity and function of organs, tissues, and homeostatic systems	Aspects of body structure and function: Physiological status, health, or physical performance, as well as hormonal, metabolic, nutritional status, or immune response.	- Heart and respiratory rates - Body temperature (homeotherms), pH, and osmolarity - Hormones such as cortisol and catecholamines - Hematocrit and leukogram - Markers of oxidative stress - Metabolites such as proteins, fatty acids, glucose, lactate, urea, or creatinine - Enzymes such as creatine kinase (CK) or lactate dehydrogenase (LDH)
		Other biochemical tests		Aspects of the composition of body fluids and tissues: Urine, saliva, sweat, or serum, as well as tissues such as blood, muscle, or liver.	
BEHAVIOR Natural behavior and mental state: non-invasive	They are visible, measurable, and based on the observation of social and individual behavior.	Ethograms and other behavioral tests, facial expression and behavior, cognitive function.	Natural behavioral integrity (individual and social) and mental state.	Aspects of relationship and interaction with the environment: Natural behavior concerning surrounding elements, conditions, and humans. Aspects that indicate mental state: Behavior as a response to emotional state (positive/negative).	- Docile or cooperative handling. - Vocalization and social, reproductive, feeding, and resting behavior, as well as learning and memory, in mammals and birds. - Feeding behavior, social interaction, learning, and memory in fish. - Behavior that indicates depression, anxiety, sadness, and hopelessness.

3.5.1 External indicators

External indicators encompass aspects of physical condition and body conformation, related to observable and quantifiable traits (degrees of impact), such as injuries or physical alterations. They are associated with structural integrity, morphology, and body function, as well as the overall physical condition of an organism. These are evaluated externally by the animal and refer to the physical attributes of the body, specifically body integrity. They are clearly visible to the naked eye without interaction with the individual (indirect indicators) but also include those that can be perceived through direct palpation during a physical examination (direct indicators), allowing the assessment of body integrity. Examples of these indicators include the body condition of mammals and birds, lesions on various parts of the body, wounds, deformities, fractures, locomotion alterations, and, in the case of fish, Fulton's condition factor (K), tears or the total or partial absence of fins.

3.5.2 Internal indicators

In contrast, internal indicators are those that are not perceptible to the naked eye and require specialized equipment to measure. These indicators provide valuable information on how animals cope with their living and dying conditions. Internal indicators reflect the animal's response to external conditions. They are essential for assessing the internal state of the individual, as they include quantifiable parameters at the physiological, biochemical, hematological, or immunological levels, among others. They are closely related to the integrity and function of organs, tissues, and homeostatic systems. Therefore, these indicators help identify the general physiological state, health, physical performance, as well as hormonal, metabolic, and nutritional states of the animal. Examples of these indicators include heart and respiratory rates, body temperature, hormonal levels such as cortisol, and various metabolites like glucose, hemoglobin, plasma proteins, lactate, and enzymes such as lactate dehydrogenase or creatine kinase, among others.

3.5.3 Behavioral indicators

Lastly, behavioral indicators encompass natural behavior and behavior as a response to the animal's mental state. These indicators are visible and measurable through the observation of social and individual behaviors typical of the species, age, sex, among others. Ethograms and other behavioral tests are used, including the evaluation of facial expressions and cognitive functions (memory and learning). These indicators provide insight into emotional and psychological well-being. They are the observable and quantifiable expressions of an animal's actions, which provide information about its welfare, specifically in relation to its emotional state and adaptability to its surrounding environment. Examples of these indicators include natural behaviors like vocalization, social interaction, feeding, resting, learning, and memory, as well as positive emotional states such as joy, pleasure, play, and negative states like depression, anxiety, and despair.

Table 4 provides a conceptual framework for evaluating welfare, integrating both the physical and emotional aspects of the animal, considering that welfare refers to the physical and mental state of an animal (OMSA, 2023), which can be assessed through the categories of indicators shown therein. The classification of animal welfare indicators presents the following opportunities/possibilities:

1. **Comprehensive assessment:** By combining external, internal, and behavioral indicators, a holistic evaluation of the animal's welfare is enabled. External indicators provide immediate information about the animal's physical condition, while internal indicators offer a deeper understanding of its physiological state. Behavioral indicators, on the other hand, reveal crucial aspects of the individual's emotional and mental well-being. This integration ensures that all important dimensions of welfare are considered, avoiding a reductionist view.
2. **Early detection of problems:** External indicators are easily observable and can alert to visible problems such as injuries or deteriorated physical conditions, allowing for timely interventions. Meanwhile, internal indicators, although some require specialized equipment, facilitate the detection of physiological imbalances before external signs appear. This is essential for implementing preventive measures and early management of diseases or conditions like malnutrition. Finally, behavioral indicators can point to problems in the animal's emotional or social welfare, often before physical signs manifest.
3. **Depth of information:** Each category of indicators provides specific but complementary types of information. Internal indicators reveal detailed physiological responses to stress and other factors, which is essential for understanding, at a biological level, how an animal is coping with and responding to its environment. This is particularly important in assessing long-term health. Additionally, behavioral indicators add a layer of depth by showing how these internal physiological responses translate into behavior, providing a more complete picture of the animal's overall welfare.
4. **Adaptability to different contexts:** This approach is flexible and can be adapted to different species and environments. The selection of specific relevant indicators should be associated with the conditions of an animal or group of animals. For example, in an environment where physical manipulation is limited, behavioral and external indicators may be prioritized, whereas in research or clinical settings, internal indicators may receive more attention.
5. **Improvement in decision-making:** Having information from multiple angles (physical, physiological, and behavioral) allows animal caretakers and managers to make more informed decisions about the management and interventions necessary to improve the individual's welfare. Additionally, timely decision-making can

optimize resources and efforts by focusing interventions on critical areas.

6. Greater accuracy in welfare assessment: The combination of external, internal, and behavioral indicators minimizes the risk of erroneous or incomplete assessments when used independently. For example, an animal with no visible injuries (external) might be suffering from significant physiological imbalances (internal) or experiencing chronic stress or pain reflected in its behavior and mental state (behavioral). By considering all these aspects, a more precise and valid evaluation of animal welfare is achieved.

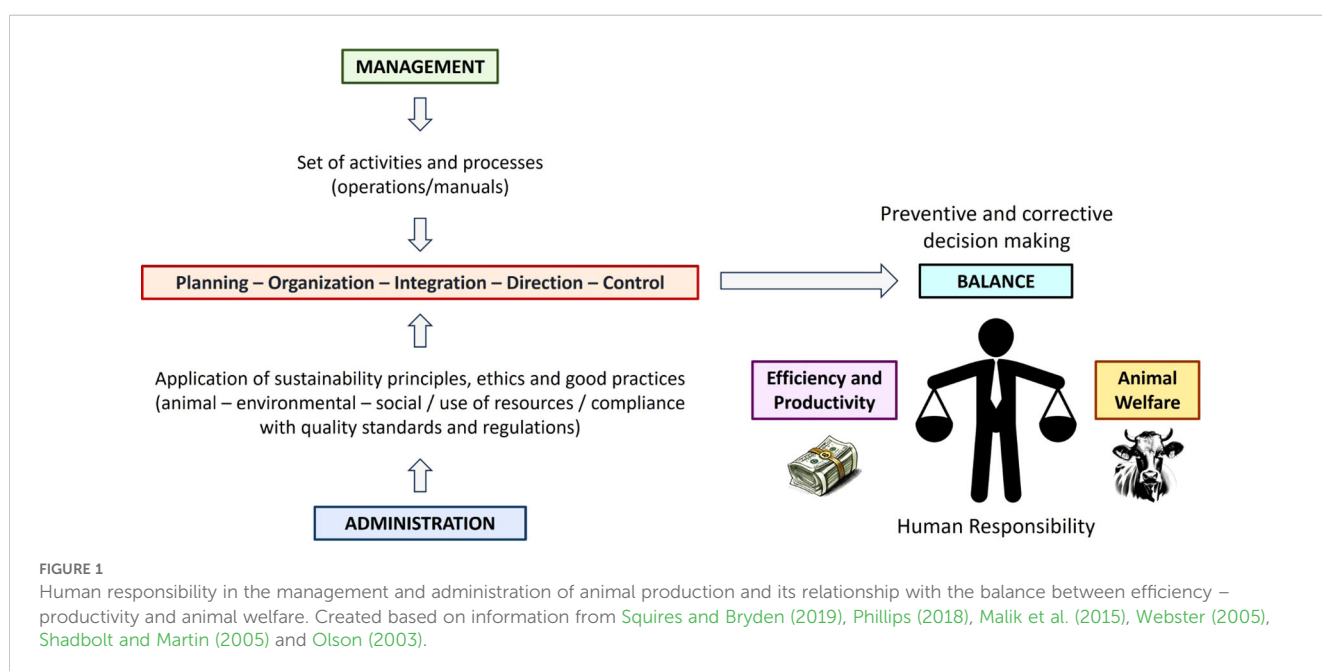
3.6 Risk factors: management, environment, and interactions

These conditions encompass the risk factors and consist of three key areas: management practices, the environment, and animal interactions.

- A. Management in animal production refers to the set of activities and processes carried out to plan, organize, integrate, direct, and control operations related to animal breeding and production. This term encompasses a variety of aspects aimed at optimizing animal efficiency and productivity (Squires and Bryden, 2019; Phillips, 2018). However, it is also necessary to include within this management the role of human actions concerning animal welfare (Webster, 2005). When the term administration is used in facilities housing animals, it refers to the planning, organization, integration, direction, and control of resources and activities involved in production. This also implies the application of management principles and practices as well

as sustainability of operations (Malik et al., 2015; Shadbolt and Martin, 2005; Olson, 2003; Zarbà et al., 2023). Therefore, administrative and management actions must aim to achieve a balance between productivity and animal welfare, meaning improving production without compromising animal welfare, while also meeting ethical and environmental sustainability requirements. This includes optimizing resource use while complying with various regulations and quality standards demanded by the market (Figure 1). In management practices, risks arise from human decision-making and related actions, such as feeding, health management, reproduction, and transportation. For instance, inadequate or poor management can lead to situations that endanger animal welfare, such as improper nutritional management or lack of timely veterinary care (Haddad, 2024; Mohammed, 2019). Therefore, it is crucial to continuously identify, control, and improve these risk factors to ensure they align with the welfare needs of the animals.

- B. In the environment, hazards manifest in the physical and environmental conditions in which both terrestrial and aquatic animals live. This includes air quality (Kang et al., 2022), temperature (Polsky and von Keyserlingk, 2017), humidity (Suárez et al., 2013), available space (Nannoni et al., 2019), cleanliness (Maji et al., 2024), or facility design, such as ponds (Khudai et al., 2023). Therefore, poor environmental management (a risk factor) can lead to the emergence of diseases, injuries, or abnormal behaviors that severely compromise animal welfare. Thus, it is essential to regularly assess the environment to prevent, identify, and mitigate any potential hazards.
- C. Regarding animal interactions, whether among conspecifics or with other species, including humans, hazards that affect



welfare may arise. Negative social interactions, such as isolation (Siebert et al., 2011), high transport density (Gerritzen et al., 2013), or poorly managed social hierarchies (Oliveira et al., 2023), can cause stress, aggression, and other behaviors that negatively impact the animals' physical and mental health. Interactions with predatory wildlife, such as canines (Temple and Manteca, 2020), or disease-carrying insects, such as vector flies (Onmaz et al., 2013), are also critical. When it comes to personnel directly working with animals, training them to implement compassionate and respectful handling practices is essential. Effective management of human resources, such as promoting a culture of learning and perseverance among workers and linking animal care outcomes with compensation, can be beneficial and, above all, crucial to improving animal welfare standards (Chen et al., 2021). Therefore, it is essential to evaluate these interactions to identify and mitigate any associated risk factors.

Moreover, these aspects of animal welfare have been incorporated into legislation. For example, the European Union's Directive 98/58/EC (updated in 2019) establishes minimum

standards for the protection of all animals in livestock units (EUR-Lex, 2019). These standards aim to mitigate the *hazards* and *risks* those animals on farms may face. Considering these terms—hazard and risk from the European directive, as well as *adverse event* or *risk*, and *risk factor* in the *evaluation of animal welfare concerning the conditions in which they live and die*—can be applied to specific examples by species, as shown in Table 5. That said, combining the categories of welfare indicators (external, internal, and behavioral) with the epidemiological concepts of hazard, risk, and risk factors could help structure the analysis of potential associations between conditions affecting animal welfare. While observational studies do not establish causal relationships, this approach can be useful for identifying patterns and generating hypotheses about possible cause-effect relationships, which can later be tested through experimental studies.

Table 6 presents examples of welfare indicators and their relationship to the previously mentioned risk factors.

3.7 Redefinition of the domains

By analyzing Tables 5 and 6 under the concept of animal welfare and recategorizing the domains a) behavior and b) mental state as

TABLE 5 Examples of the probable associations between *condition*, *hazard*, *risk* and *risk factors* in productive species.

Specie	Condition	Hazard	Adverse event or risk	RISK FACTOR	References
Cattle and Dairy	Facilities	Slippery floors in the pen.	Slips and fractures while walking.	Absence of non-slip materials on the floors.	Telezhenko et al., 2008; Lombard et al., 2010; Graunke et al., 2011; EFSA, 2020.
Pigs	Macroclimate	Intense heat waves.	Heat stroke.	Lack of ventilation or misting systems in the pen area.	Huynh et al., 2005a, b; Kpodo et al., 2019.
Tilapias	Microclimate	Low oxygen levels in the pond water.	Asphyxiation and mortality.	High density of fish in the pond without adequate aeration.	Abdel-Tawwab et al., 2014; Begum et al., 2014.
Poultry	Social environment	Aggression among individuals.	Injuries and stress.	Overcrowding and lack of space in the chicken coop.	Harlander-Matauschek and Häusler, 2009; Cronin and Glatz, 2020; Lupu and Militaru, 2022.
Sheep	Human – Animal	Rough handling during shearing.	Injuries and stress during the process.	Untrained personnel in compassionate handling techniques.	Waiblinger et al., 2006; Hutson and Grandin, 2014.
Tilapias	Nutrition	Poor diet that does not meet nutritional requirements.	Malnutrition and stunted growth.	Use of low-quality or inappropriate feed for the species or physiological/productive stage.	Yuvarajan et al., 2019; Sakyi et al., 2020; Robisalmi et al., 2021.
Pigs	Preventive medicine	Lack of vaccination against respiratory diseases.	Outbreak of respiratory disease.	Absence of a regular vaccination program.	Opriessnig et al., 2011; Sipos et al., 2021; Sipos and Sipos, 2022; Maes et al., 2023.
Cattle or dairy	Medical treatment	Incorrect diagnosis.	Antibiotic resistance and ineffective treatment.	Administration of antibiotics without a correct diagnosis or veterinary prescription.	Russell et al., 2009; Hornok et al., 2014; Admassu et al., 2015; Headley et al., 2020.
Sheep	Transportation	Prolonged transport periods without rest.	Stress and dehydration during transport.	Lack of regular stops and water during transport.	Moneva et al., 2016; Collins et al., 2018; Carnovale et al., 2021; Govindaiah et al., 2023.
Pigs	Slaughter (Ante-Mortem)	Limited resting times and no post-transport rest, inadequate pen conditions.	Suffering and pain prior to slaughter, mortality.	Lack of comfort in the resting pen, lack of resting time prior to slaughter.	Sardi et al., 2020; Rusu et al., 2021; Briefer et al., 2022; Rybarczyk and Tobolska, 2023.

TABLE 6 Examples of application of the EPI-DOM Approach in productive animals, relating welfare indicators and their risk factors.

Specie and condition	EXTERNAL INDICATOR bodily direct / indirect	INTERNAL INDICATOR Organic and tissue direct	BEHAVIOR INDICATOR		Hazard	Adverse event or risk	RISK FACTOR	References
			Natural behavior	Mental state				
Cattle and Dairy Facilities	Skin lesions (bruises, wounds), visible or palpable lameness or fractures	Inflammatory response (altered leukogram)	Clumsy movements or avoidance of walking	Stress or anxiety while walking	Slippery floors in the pen.	Slips and fractures while walking.	Absence of non-slip materials on the floors.	Telezhenko et al., 2008; Lombard et al., 2010; Graunke et al., 2011; EFSA, 2020.
Pigs Macroclimate	Rapid breathing, panting, reddened or dry skin	Increased body temperature, dehydration	Decreased activity	Lethargy or Irritability or apathy	Intense heat waves.	Heat stroke.	Lack of ventilation or misting systems in the pen area.	Huynh et al., 2005a, b; Kpodo et al., 2019.
Tilapias Microclimate	Loss of color in the gills	Hypoxia (low blood oxygen levels)	Constant mouth opening, irregular swimming, or surface swimming	Erratic behavior or lack of response to food	Low oxygen levels in the pond water.	Asphyxiation and mortality.	High density of fish in the pond without adequate aeration.	Abdel-Tawwab et al., 2014; Begum et al., 2014.
Poultry Social environment	Pulled feathers or skin lesions, worn or broken beak	Elevated cortisol levels (stress)	Avoidance of other chickens, isolation	Fear or social stress	Aggression among individuals.	Injuries and stress.	Overcrowding and lack of space in the chicken coop.	Harlander-Mataushek and Häusler, 2009; Cronin and Glatz, 2020; Lupu and Militaru, 2022.
Sheep Human - Animal	Inflamed or irritated skin, visible cuts or lesions	Inflammatory response (altered leukogram)	Resistance to handling, restlessness	Stress or agitation during handling	Rough handling during shearing.	Injuries and stress during the process.	Untrained personnel in compassionate handling techniques.	Waiblinger et al., 2006; Hutson and Grandin, 2014.
Tilapias Nutrition	Slow or Asymmetric Growth, Decreased Weight, Size, and Body Condition, Depigmentation, Eroded Fins	Protein analysis (hypoproteinemia, low blood glucose (hypoglycemia))	Reduced feeding	Lethargy, apathy or lack of interest in the environment	Poor diet that does not meet nutritional requirements.	Malnutrition and stunted growth.	Use of low-quality or inappropriate feed for the species or physiological/productive stage.	Yuvarajan et al., 2019; Sakyi et al., 2020; Robisalmi et al., 2021.
Pigs Preventive medicine	Coughing or difficulty breathing, positive cough reflex, nasal discharge, reddened eyes	Pulmonary infection (altered blood count)	Inactivity or decreased activity	Pain, anxiety, or irritability due to illness	Lack of vaccination against respiratory diseases.	Outbreak of respiratory disease.	Absence of a regular vaccination program.	Opriessnig et al., 2011; Sipos et al., 2021; Sipos and Sipos, 2022; Maes et al., 2023.
Cattle or dairy Medical treatment	Persistence of fever, signs of infection	Increased inflammation markers in blood	Decreased activity and social interaction	Depression, apathy	Incorrect diagnosis.	Antibiotic resistance and ineffective treatment.	Administration of antibiotics without a correct diagnosis or veterinary prescription.	Russell et al., 2009; Hornok et al., 2014; Admassu et al., 2015; Headley et al., 2020.
Sheep Transportation	Dehydration, dry skin, weight loss, deteriorated body condition	Hyperthermia, increased hematocrit, elevated creatine kinase (CK), lactate dehydrogenase (LDH), and aspartate	Immobility, chronic stress	Lethargy, despair.	Prolonged transport periods without rest.	Stress and dehydration during transport.	Lack of regular stops and water during transport.	Moneva et al., 2016; Collins et al., 2018; Carnovale et al., 2021; Govindaiah et al., 2023

(Continued)

TABLE 6 Continued

Specie and condition	EXTERNAL INDICATOR bodily direct / indirect	INTERNAL INDICATOR Organic and tissue direct	BEHAVIOR INDICATOR		Hazard	Adverse event or risk	RISK FACTOR	References
			Natural behavior	Mental state				
		aminotransferase (AST)						
Pigs Slaughter (Ante-Mortem)	Body reddening, dehydration	Cortisol, hyperglycemia, elevated lactate	Excessive vocalization, resistance to movement.	Panic, extreme fear	Limited resting times and no post-transport rest, inadequate pen conditions.	Suffering and pain prior to slaughter, mortality.	Lack of comfort in the resting pen, lack of resting time prior to slaughter.	Sardi et al., 2020; Rusu et al., 2021; Briefer et al., 2022; Rybaczuk and Tobolska, 2023; Dalmau and Velarde, 2024

behavioral indicators (Table 4), it becomes essential to modify Mellor et al.'s (2020) five domains model, incorporating the EPI-DOM approach based on risk factors, hazards, and risks, for the following reasons:

3.7.1 Preventive and proactive approach

- Identification and mitigation: This approach allows for more precise identification of the specific factors that can negatively affect animal welfare, enabling preventive actions before they materialize and become serious problems.
- Continuous improvement: By focusing on risk factors, management strategies can be continuously adapted and improved based on the ongoing evaluation of new emerging hazards and risks.

3.7.2 Comprehensive evaluation

- Broad coverage: Redefining the welfare domains to include risk factors allows for a more comprehensive assessment that considers not only the direct effects on the animals but also the management, environmental, and interaction factors that can directly influence their welfare.
- Adaptability: This approach can be implemented across different species and situations, offering a flexible framework for assessing welfare in various circumstances.

3.7.3 Evidence-based approach

- Objectivity: Evaluating welfare indicators and associated risk factors provides a more objective and quantifiable framework for assessing animal welfare, making it easier to measure and compare across different scenarios or interventions.
- Scientific and documented: This approach aligns with the growing trend in science to base management decisions on empirical data and solid scientific evidence, enhancing the validity and credibility of welfare assessments.

3.7.4 Alignment with regulations and standards

- Regulatory compliance: International animal welfare regulations and standards already use terminology and concepts related to risks and hazards; therefore, adopting this approach facilitates alignment and standardization, ensuring compliance and facilitating communication with auditors and regulatory bodies.
- Responsibility and transparency: A risk factor-based approach reinforces human responsibility and transparency in managing animal welfare, demonstrating a clear commitment to identifying, controlling, and mitigating the factors that could compromise welfare.

3.7.5 Ease in decision-making

- Prioritization and resource allocation: This approach helps prioritize interventions and allocate resources more efficiently, focusing on the most critical risk factors that have the greatest potential to affect animal welfare.
- Strategic planning: It provides a solid foundation for long-term strategic planning, allowing managers to anticipate potential risks and develop effective contingency plans.

3.7.6 Connection with public health and food safety

- Impact on human health: By properly managing risk factors related to animal welfare, it is also possible to mitigate risks to public health, such as the spread of zoonotic diseases or antimicrobial resistance.
- Food quality and safety: Proper management of risk factors for animal welfare can lead to improvements in the quality and safety of animal products, benefiting the entire food chain.

As a result of the above, it is proposed to redefine the domains of animal welfare through the incorporation of *risk factors*, using

the EPI-DOM Approach. This not only enhances the understanding and management of animal welfare but also integrates them into a broader context of public health, food safety, and sustainability. Therefore, the EPI-DOM Approach proposes the following domains: management, environment, and interaction (Table 7), with their respective categories, which are described below.

3.8 Management domain

The “Management” domain encompasses all aspects related to the administration and care of animals, from genetics to feeding, health, transport, and slaughter. Additionally, natural resources and economics are considered. Effective management is crucial for ensuring high levels of welfare, minimizing risks, and promoting optimal living conditions for animals.

3.8.1 Genetic and reproductive management

Genetic management plays a fundamental role in animal welfare, as inherited traits can predispose animals to certain diseases, behaviors, and physical conditions that affect their quality of life. It is a human responsibility to select genetic lines that not only maximize production but also promote health and welfare. This includes avoiding the breeding of animals with genetic predispositions to diseases, physical defects, or problematic behaviors. Reproductive management includes the planning and control of animal reproduction, ensuring that the methods used are ethical and minimize stress and suffering. Reproductive practices should be designed to avoid pregnancies and deliveries that compromise the health of females or their offspring, prevent unnecessary inbreeding, and reduce stress during reproductive management and complications during birth. It is important to balance reproductive efficiency with the long-term health and welfare of the animals.

3.8.2 Feeding and nutritional management

Proper feeding and nutrition are vital for animal welfare, as they directly influence health, growth, and the ability to cope with diseases. Feeding management involves ensuring that animals

receive a balanced diet, in sufficient quantity and frequency, that meets all their nutritional requirements according to species, age, sex, and productive stage. The amount, feeding frequency, quality, and composition of the diet should be carefully monitored to prevent malnutrition, obesity, or nutritional deficiencies. Additionally, feeding methods should be appropriate to avoid competitive, aggressive behaviors or anxiety among the animals.

3.8.3 Animal management (individual and population-level)

This category encompasses the technical management practices carried out in production units, both at the individual and population levels, and refers to the procedures and practices to be followed. It is crucial that these management practices be carried out ethically, minimizing pain, stress, and suffering. Procedures should be performed by trained personnel, following protocols based on the best available scientific evidence. Examples of these practices include immersion baths for deworming and other physical interventions that aim to optimize animal health, growth, and productivity, while avoiding unnecessary practices like tail docking, beak trimming, ear cropping, or tusk trimming. Continuous evaluation of these practices is essential to assess their impact on animal welfare and adjust or eliminate methods to reduce any negative effects.

3.8.4 Health and sanitary management

Health and sanitation management are pillars of animal welfare. This involves prevention and early diagnosis of diseases. All biosecurity measures should be included in this category. It is essential to implement preventive health programs, including vaccinations, deworming, and regular veterinary check-ups. Additionally, facilities should be hygienic and safe to reduce the risk of contagious diseases. Staff must comply with site biosecurity policies to maintain a clean and safe environment.

3.8.5 Therapeutic management

Therapeutic management refers to the treatment of diseases and medical conditions in animals, ensuring that the methods used are appropriate and minimize pain and suffering. Treatments must be administered by qualified personnel, following evidence-based

TABLE 7 Proposed Domains and Categories according to EPI-DOM approach.

DOMAINS		
MANAGEMENT	ENVIRONMENT	INTERACTION
Categories		
1. Genetic and reproductive 2. Feeding and nutritional 3. Animal (individual and population level) 4. Health and sanitary 5. Therapeutic 6. Transport 7. Slaughter 8. Natural resource 9. Human resource 10. Economic	1. Physical a. Facilities b. Space c. Materials 2. Climate a. Macroclimate b. Microclimate 3. Additional environmental factors	1. Human - Animal 2. With conspecifics 3. With other species a. Fauna b. Flora c. Microorganisms

protocols. Furthermore, animals must be monitored after treatment to ensure proper recovery and minimize the risk of adverse effects. Antibiotic management should be strict and responsible to prevent antimicrobial resistance in animals, risks to public health, or contamination of ecosystems.

3.8.6 Transport management

Animal transport must be carefully managed to prevent stress, injuries, and other welfare issues such as anxiety, fear, or distress. This includes planning, choosing vehicles with appropriate spaces for the size and volume of animals, selecting personnel with the right profile for compassionate animal handling, driving during transport, and ensuring transport conditions that allow for a comfortable journey. It is essential to ensure animals have enough space, adequate ventilation, and access to water during transport. Additionally, transport time should be minimized, and animals should be handled with care during loading and unloading to avoid stress and injury.

3.8.7 Slaughter management

Slaughter should be managed ethically, ensuring the process is quick, painless, and minimizes animal suffering. This includes handling animals in production units and during their stay at the slaughterhouse. The selection of stunning and slaughter methods and equipment should be appropriate for the species, age, quantity, and size of animals, ensuring rapid, safe, and effective loss of consciousness and death. The entire process, before and during slaughter, should be calm and avoid any type of stress or fear that could alter the animal's mental state or jeopardize the safety of workers. Staff performing these activities should be trained according to established procedures and have developed values such as empathy towards animals.

3.8.8 Natural resource management

The management of natural resources used in animal production, such as water, soil, and vegetation, is crucial for ensuring a sustainable environment that aligns with the spirit of "one welfare" for animals, people, and the environment. It is important to use these resources sustainably, avoiding overexploitation, rotating pastures without harming the ecosystem, and ensuring animals have access to quality natural resources such as shade and living fences.

3.8.9 Human resource management

Human resource management similarly involves ensuring the well-being of workers who interact with animals. Therefore, staff should be provided with wages commensurate with their duties, ongoing and comprehensive training to perform humane and compassionate animal care, social security, and retention of high-performing staff. Selecting suitable profiles before hiring and avoiding abusive practices by omission or intention are also crucial. Fostering a culture of continuous learning and resilience among staff, as well as correlating animal care outcomes with remuneration, can generate significant advantages and, most importantly, play a vital role in improving animal welfare standards.

3.8.10 Economic management

Economic management involves optimizing financial resources to ensure that both the animals' and people's needs, and requirements are met without compromising the economic viability of production and, therefore, the agricultural business. It is necessary to balance costs and benefits, ensuring that investments in animals and people are sustainable in the long term. Furthermore, economics should not hinder the implementation of appropriate integral welfare practices.

3.9 Environment domain

The "Environment" domain refers to all the physical and environmental aspects surrounding the animal, which have a direct or indirect impact on its welfare. This domain includes both the structural and spatial characteristics of the animal's habitat, as well as the climatic and environmental factors that influence its health and behavior. It is divided into three categories: Physical, Climate/Environment, and Additional Environmental Factors.

3.9.1 Physical

3.9.1.1 Facilities

The facilities where animals are housed, such as barns, pens, cages, or resting areas, are crucial for their welfare. The quantity must be sufficient, and the design functional. The facilities should have adequate capacity to house the number of animals in a way that minimizes stress and injuries and segregates animals by age and zootechnical purpose. They must be designed so that animal movement is smooth and in one direction, avoiding distractions and stress. Additionally, they must be safe for both animals and humans. This means they should not have sharp or hazardous elements that could cause injuries and should be built to make animals feel comfortable and secure, allowing personnel to perform tasks efficiently and safely. This includes the design of work areas that facilitate access to animals and the performance of procedures such as vaccinations and weighing. Without being exhaustive, the facilities should include ramps, pens, weighing areas, restraint and handling areas, feed storage areas, medication storage, administrative offices, and staff bathrooms, among others.

3.9.1.2 Space

The space or area available for each animal is crucial for its physical and mental well-being. This includes both individual spaces, necessary for moving and performing species-specific behaviors such as moving freely, resting, and accessing feeding areas and areas for elimination without, for example, cross-contamination. It is also important to consider group space, which allows for positive social interactions between animals. Insufficient space can compromise the animal's mental state, for example, by increasing aggressive behaviors, stress, and health problems related to lack of exercise or injury. The ideal space should allow the animal to express natural behaviors. Space must

also be flexible to accommodate variations in the size or number of animals and should provide safety and comfort to individuals.

3.9.1.3 Materials

The materials used in animal facilities and environments (such as floors, bedding, feeding structures) play a key role in their welfare. Inappropriate materials can cause discomfort, injury, or disease. Materials must be durable, safe, non-toxic, and suitable for the species using them. Additionally, they should be easy to clean and maintain, preventing the excessive accumulation of organic matter, pathogens, and other harmful agents.

3.9.2 Climate

3.9.2.1 Macroclimate

The macroclimate refers to the general climatic conditions of the environment where the animals are located, such as temperature, humidity, and precipitation. These conditions directly affect the comfort and health of the animals. Extreme temperature conditions (heat or cold) can lead to thermal stress, respiratory problems, or dehydration. It is essential to have mitigation measures in place, such as the use of region-specific vegetation, shade, ventilation, and access to water. If necessary, animals should be sheltered from extreme conditions.

3.9.2.2 Microclimate

The microclimate refers to the immediate environmental conditions within the facilities or in the space occupied by the animals, including ventilation, internal temperature, and air quality. An inadequate microclimate, such as poor ventilation or abrupt temperature fluctuations, can lead to decreased feed intake, health problems such as respiratory diseases, and increased discomfort, stress, reactivity, and aggression among animals, which negatively affects their overall welfare.

3.9.3 Additional environmental factors

These factors include additional environmental elements that may affect animal welfare, such as the presence of contaminants (chemical, biological), intense or persistent noise, and other environmental disturbances. Prolonged exposure to contaminants, noise, and other adverse environmental factors, such as distractors (hoses, buckets, reflections, or standing water), direct light towards the eyes, lost nets or elements in ponds, or excessive proliferation of macroalgae, can have negative physical and psychological effects, altering normal behavior and animal health, or complicating their management. It is essential to monitor and control these factors to minimize their impact.

3.10 Interaction domain

The “Interaction” domain refers to the quality and nature of the interactions animals have with humans, other animals of their own species (conspecifics), and other species, including both animals

and plants. These interactions influence the emotional, social, and behavioral welfare of the animals.

3.10.1 Human-animal

The interaction between humans and animals directly affects animal welfare, depending on the quality, frequency, and nature of these interactions. Animals that regularly interact with humans, whether in a management, care, or production context, can experience different degrees of welfare depending on the quality of such interactions. It is important that human-animal interactions are positive, respectful, and as minimally invasive as possible. Proper handling and socialization can reduce fear and stress in animals, fostering a relationship of trust. Training personnel in compassionate handling practices and animal communication techniques is essential to improving these interactions.

3.10.2 With conspecifics

Interaction with conspecifics (other animals of the same species) is crucial for the social and behavioral welfare of animals, especially for those that are naturally social, as isolation compromises their mental state. These interactions allow for the expression of natural behaviors, such as play, cooperation, and competition. An environment that facilitates positive interactions among conspecifics can prevent behavioral problems such as aggression or anxiety, reducing the occurrence of stereotypies. Conversely, in naturally solitary species, grouping can cause tension and fights. Therefore, it is essential to properly manage population density, providing enough space and resources for interactions to be balanced and beneficial for all individuals.

3.10.3 With other species

Animals also interact with other species in their environment, including both animals and plants. These interactions can be positive, neutral, or negative, depending on the circumstances and the type of relationship established.

3.10.3.1 Fauna

Interactions with other animal species may include predators or coexisting animals. These relationships can affect behavior, emotional state, and overall animal welfare. In production environments, for example, introducing compatible species and proper segregation can help avoid conflicts and promote a more harmonious environment.

3.10.3.2 Flora

Interactions with plant species, whether shrubland or forest, involve their use as food sources, shelter, or environmental enrichment. Plants can provide nutritional resources and a more natural and stimulating environment for animals. The incorporation of vegetation in animal shelters or the use of grasslands improves their welfare by offering opportunities for thermoregulation, foraging, and exploration, stimulating curiosity. This can be positive, as it indicates a healthy mental state and a

willingness to learn about their habitat. It is important to select plant species that are compatible with the ecosystem, safe, non-toxic, and appropriate for the species in question, avoiding toxic or harmful plants.

3.10.3.3 Microorganisms

Interactions with microorganisms, such as bacteria, fungi, and viruses, play a crucial role in the health and welfare of animals. These interactions can influence the immune system, digestion, and overall well-being. Beneficial microorganisms, such as those involved in the gut microbiota, can enhance nutrient absorption and contribute to a balanced immune response. However, pathogenic microorganisms can lead to infections, disease, and stress, negatively impacting welfare. Therefore, maintaining a healthy balance of microorganisms through proper hygiene, management, and health monitoring is essential for animal welfare. Additionally, interactions with microorganisms can influence behavioral responses, particularly in cases of infection or disease, leading to changes in activity levels, social interactions, and other behaviors that reflect the animal's health and mental state.

4 Conclusion

The comparative analysis between the Five Freedoms and the Five Domains conducted in this study highlights areas of convergence and divergence between these approaches, underscoring the need to design tools capable of capturing the complexity and multifactorial nature of animal welfare. However, both methodologies face challenges in identifying and accurately quantifying welfare indicators, particularly in relation to assessing mental state. When developing the proposed EPI-DOM Approach, the identification and classification of indicators (external, internal, and behavioral) were considered, along with the categories in which risk factors are located, grouped under the domains (management, environment, and interaction). This approach details the general condition of individuals at a specific time and under specific circumstances, reflecting the complexity of welfare more effectively, expanding the scope of assessment, and providing valuable data to improve management practices and animal welfare.

Moreover, it can be used as a guide for adopting preventive and corrective measures to improve individual welfare conditions. It is hoped that the implementation of the EPI-DOM Approach will not only contribute to a significant improvement in the evaluation of animal welfare but also promote more ethical and sustainable management practices. Likewise, it addresses the shortcomings detected in previous approaches and provides an adaptable framework for different species, identifying welfare indicators under the various conditions in which animals live and die, which

may represent risk factors. The methodology provides a solid foundation for informed decision-making in management, which can reduce the incidence of adverse welfare events and improve animal quality of life. In the future, EPI-DOM is expected to be used to develop predictive models and management systems that optimize animal welfare in real time, using dynamic data to proactively adjust management strategies. Finally, although this study focuses on providing an overview of the elements that make up the approach, the importance of future research aimed at its validation and refinement is recognized. It is suggested to conduct studies that address the application of the method across various species and contexts, to maximize its impact and practical efficacy for the welfare of animals, people, and ecosystems.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

RM-Y: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. PM-M: Formal analysis, Investigation, Writing – original draft. PA-A: Investigation, Writing – original draft, Formal analysis.

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