

Commercial Livestock Systems: Explaining the Welfare-Productivity Disconnect Under Normal Production

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ABSTRACT

This study examined whether apparently normal productive performance could coexist with adverse animal-based welfare evidence in commercial livestock systems. A qualitative conceptual design was used through an integrative review of peer-reviewed literature and institutional scientific sources. Literature identified through Scopus, Web of Science, and PubMed was purposively synthesized around productive performance, adaptive regulation, welfare state, and animal-based indicators. The analysis showed that productive output and welfare evidence overlapped but did not carry equivalent inferential value. Maintained output could remain compatible with changing regulatory demand, particularly when animals compensated for continuing environmental or biological challenges. This created a period in which welfare-related changes could become visible before clear production loss occurred. The study developed the Welfare-Productivity Disconnect to describe this mismatch between expected output and credible welfare concern. The framework did not treat productivity as irrelevant to welfare. Instead, it clarified that normal output alone could not certify a favourable welfare state. The study concluded that welfare assessment was better supported when production records were interpreted alongside a small set of context-appropriate animal-based indicators.



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INTRODUCTION

Productivity is indispensable in commercial livestock management. Growth, milk yield, egg output and reproductive performance tell managers whether animals and production systems are delivering expected biological and economic results. Those measures are also welfare relevant because serious disease or prolonged environmental challenge can eventually depress output. The problem begins when output is asked to answer a broader question about the animal's welfare state. Broom (1991), Fraser (2008) and Mellor et al. (2020) describe welfare as a multidimensional condition that cannot be reduced to productive function. Recent work on on-farm assessment reaches the same point from a measurement perspective (Dwyer et al., 2026).

Commercial systems make this distinction difficult because they are built to preserve output under variation. Feeding, housing, health control and genetic selection can keep performance within an expected operating range even when the animal is working harder to cope. Here, apparently normal productive performance means output that remains within the range expected for the relevant production stage and management context, so that output itself gives no clear reason to suspect welfare deterioration. It does not mean biologically optimal performance. Nor does it imply that animals with the same output have reached that output under the same physiological demand. This distinction matters most in high-performing systems, where stable production can coexist with marked differences in locomotion, thermal comfort or other animal-based outcomes.

Evidence across production sectors shows why output and welfare should not be treated as equivalent. Hartcher and Lum (2020) and Riber and Wurtz (2024) show that rapid broiler growth remains associated with locomotor and other welfare concerns despite major gains in production

efficiency. In pigs, selection for large litters has raised reproductive output while creating recognised welfare risks for sows and piglets (Rutherford et al., 2013). These patterns do not prove an inherent trade-off. They show that productivity and welfare can move together in some settings and separate in others.

The direction of inference is uneven. Good welfare can support robust and efficient production without making welfare and efficiency natural opponents (Dawkins, 2017). Normal productivity has much less power to rule out welfare compromise. A production record shows what was produced, but gives less direct information about pain or behavioural restriction. Animal-based assessment developed partly for this reason. The EFSA Panel on Animal Health and Welfare (2012) placed outcomes in the animal at the centre of welfare assessment, and Linstädt et al. (2024) retain that emphasis.

Adaptation complicates the inference further. Animals do not meet environmental and biological demands through passive stability. Regulatory activity changes as the animal copes with heat, disease pressure, social challenge or high productive demand. McEwen (1998) described this broader process through allostasis, and Korte et al. (2007) applied allostatic reasoning to animal welfare. Farm-animal research later developed related ideas through resilience and functional capacity (Colditz & Hine, 2016). Resilience is especially important here because it is inferred from how an animal responds over time rather than from one static production value (Taghipoor et al., 2023). Stable output can therefore describe the result of successful compensation without fully describing what that compensation costs the animal.

The article develops the Welfare-Productivity Disconnect as a specific inferential condition. It occurs when productive performance remains apparently normal while credible animal-based evidence indicates a less favourable welfare state. Latent welfare deterioration refers to deterioration that remains poorly visible when assessment relies mainly on productive output. The contribution is not the familiar claim that welfare is multidimensional. It is the more precise argument that productivity and welfare can diverge because they differ in inferential direction, in the timing of their response and in what they make visible about the animal. Two questions guide the analysis. Why can apparently normal performance coexist with unfavourable welfare conditions, and how should productive performance, adaptive regulation and animal-based evidence be organised to recognise that disconnect without making causal or diagnostic claims?

RESEARCH METHODS

This study used qualitative conceptual research based on an integrative literature review and conceptual synthesis. The design suits a problem that depends on clarifying constructs and relationships rather than estimating prevalence or an intervention effect. Integrative reviews allow literature from related but partly separate traditions to be brought together around a theoretical problem (Snyder, 2019). Conceptual research also requires the logic of knowledge development and the role of the selected literature to be made explicit (Jaakkola, 2020). The unit of analysis was therefore the relationship among productive performance, adaptive regulation, welfare state and animal-based welfare evidence reported in published research.

Relevant literature was identified through Scopus, Web of Science and PubMed, followed by backward citation tracing. Searches covered animal welfare, productive performance, allostasis, resilience and animal-based indicators, with species-specific terms used when examples were needed. Literature from 2010 to 2026 was prioritised. Earlier work was retained when it established concepts still central to welfare assessment or adaptation. Peer-reviewed journal articles formed the main material, supplemented by authoritative scientific opinions where they clarified animal-based welfare measures.

Selection was purposive rather than exhaustive. Sources were retained when they contributed directly to one of four questions. The first concerned what productive performance can reasonably tell us about welfare. The second concerned how adaptive regulation can maintain function under challenge. The third concerned what constitutes welfare evidence beyond output. The fourth concerned when production and animal-based information may point in different directions. The review did not count findings or pool effect sizes. It also did not treat the number of papers supporting a statement as a measure of theoretical importance. This kept the method aligned with construct clarification and framework development rather than systematic evidence grading.

Analysis used conceptual comparison and synthesis. Productive performance was compared with animal-based welfare evidence in terms of what each signal measures, how quickly it may change and what inference it can support. Allostasis and resilience were used to explain how maintained output may coexist with changing regulatory demand, but neither was treated as a measured variable in this paper. The synthesis then specified the boundary of the Welfare-Productivity Disconnect and derived a small set of propositions that can be examined in future observational studies. Claims are limited to conceptual plausibility and explanatory coherence. The review does not estimate how common the disconnect is, diagnose individual animals or establish a causal sequence between adaptation and welfare deterioration.

RESULTS AND DISCUSSION

Productivity has asymmetric value as welfare evidence

Productive performance carries genuine welfare information, but the information is incomplete. Severe illness, major thermal strain or impaired mobility can reduce intake and output, so a marked production decline may strengthen concern that the animal is not coping well. The reverse inference is weaker. A cow that maintains expected milk yield, a broiler that reaches target weight or a sow that remains reproductively productive has demonstrated maintained function. None of those observations alone establishes comfort, freedom from pain or a favourable affective state. Positive-welfare research makes the same distinction from another direction because absence of production loss is not evidence that positive experience is present (Boissy et al., 2007).

Welfare frameworks have moved steadily toward animal-centred and multidimensional assessment. Fraser (2008) treated biological functioning, affective state and natural living as overlapping concerns rather than interchangeable measures. Mellor (2016), Webster (2016) and Mellor et al. (2020) further widened assessment beyond avoidance of obvious harm, while Lawrence et al. (2019) showed that positive welfare cannot be reduced to the absence of negative states. The implication for production records is modest but important. Output should remain part of welfare surveillance, yet its evidentiary role is limited to the dimension it actually represents. It cannot compensate for strong evidence of pain, impaired movement or persistent behavioural restriction elsewhere in the assessment.

Inferential asymmetry is the central issue. Welfare compromise that becomes severe may eventually affect production, but normal production cannot exclude welfare compromise with the same confidence. Commercial animals are selected and managed to maintain function under demanding conditions. Output is therefore a result of the animal and its production environment, not a direct welfare reading. Animal-based indicators add information closer to the animal's condition, although validity still depends on context (Spigarelli et al., 2020). No single indicator resolves the welfare question in dairy cattle either (Linstädt et al., 2024).

Maintained output can conceal changing adaptive demand

An animal can maintain familiar output while the regulatory work required to do so changes. Allostasis describes stability achieved through adjustment rather than unchanged internal conditions (McEwen, 1998). Korte et al. (2007) used this idea to frame welfare around the animal's capacity to meet demand. Regulatory responses are not inherently harmful, and short adjustments can be effective. Concern becomes more relevant when challenge persists and welfare-related signals change even though commercial output has not yet fallen.

Resilience research gives this argument a temporal basis. Colditz and Hine (2016) describe resilience through the capacity to recover from perturbation, while Taghipoor et al. (2023) emphasise that resilience is inferred from response trajectories. A single milk yield or growth value cannot reveal that trajectory. Colditz et al. (2024) also connect functional capacity with positive welfare, which helps separate successful adaptation from the narrower fact of maintained output. The distinction matters because output can remain stable during different biological states. One animal may maintain performance with little disruption. Another may reach the same output while behaviour, locomotion or thermal responses indicate a less favourable state.

The term adaptive cost is used here only as a broad explanatory label for welfare-relevant burdens that may accompany sustained regulation. It is not an allostatic-load score. Seeley et al. (2022) found considerable heterogeneity in how allostasis and allostatic load have been operationalised across animal studies. Some work relies heavily on single physiological markers, although cumulative

dysregulation is unlikely to be captured adequately by one measure. The present framework therefore does not claim that adaptive cost has been quantified. Allostatic reasoning is used more cautiously to explain why welfare-related changes and production changes need not appear at the same time.

Livestock evidence makes that timing plausible without testing the proposed framework directly. Dairy cattle exposed to heat stress show physiological and behavioural responses whose expression does not map perfectly onto milk production at every moment (Becker et al., 2020). Behavioural responses to pain, social stress and disease can also provide information before a large production change attracts attention (Jurkovich et al., 2024). Rapidly growing broilers present another form of divergence because high efficiency can coexist with locomotor concerns (Hartcher & Lum, 2020). In pigs, larger litters illustrate how reproductive output can increase while welfare risks emerge for mothers and offspring (Rutherford et al., 2013). These sectors differ biologically, yet each warns against treating productive success as a complete account of animal state. Huber (2024) reaches the same caution from an explicitly animal-centred account of high-performance farming.

Defining the Welfare-Productivity Disconnect

The Welfare-Productivity Disconnect is not another label for poor welfare or production disease. It requires a mismatch between two information streams. Productive performance remains within the expected range for the relevant stage and management context while animal-based evidence indicates meaningful welfare concern. Both elements are necessary. Poor welfare with obvious production loss is already visible in the production signal. Reduced production without clear welfare evidence also does not qualify because output can change for reasons that are not themselves evidence of poor welfare.

A disconnect should also be based on animal-based evidence that is interpretable within the species and production context. A single isolated behavioural change is not enough simply because it differs from a production record. The indicator must have a defensible relation to welfare and must be interpreted with attention to duration, severity and context. The EFSA Panel on Animal Health and Welfare (2012) made this logic central to animal-based assessment. Dwyer et al. (2026) show why the problem remains difficult, since many on-farm measures are proxies and no practical measure directly reads mental state. The disconnect is therefore an inference from converging welfare evidence, not a diagnosis created by one abnormal observation.

Table 1 separates the constructs that are easily blurred in this debate. Productive performance describes output. Adaptive regulation concerns the processes through which function is maintained or restored. Welfare state is the evaluative target, while animal-based evidence supplies observations that help infer that state. Keeping those roles separate prevents a common error in which a successful production outcome is allowed to stand in for the process that produced it and for the welfare state that accompanied it. Botreau et al. (2007a) and Botreau et al. (2007b) make a related point in welfare aggregation. Strong performance in one dimension should not simply cancel substantial compromise in another.

Table 2 shows the joint patterns. Expected performance with no substantial welfare concern is concordant. Reduced performance with welfare concern makes deterioration visible in both streams. Reduced performance with uncertain welfare evidence requires another explanation. The distinctive state is maintained performance alongside credible welfare concern. Here, productivity-centred assessment is most likely to miss information that matters to the animal. The framework therefore gives productivity a narrower role. It reports output rather than certifying total welfare.

Table 1 Construct Boundaries Within the Welfare-Productivity Disconnect

Construct	Meaning in this paper	What it does not mean	Role in the disconnect
Productive performance	Output expected for the relevant production stage and management context	A direct measure of total welfare or positive affect	Defines whether output itself gives an obvious warning
Adaptive regulation	Adjustment that helps maintain or restore function under challenge	Proof of welfare compromise or a measured allostatic-load score	Explains why stable output can coexist with changing biological demand
Welfare state	The animal-centred condition inferred from health, behaviour, comfort and affect-related evidence	A single production outcome or one isolated proxy	Provides the evaluative target that production alone cannot certify

Construct	Meaning in this paper	What it does not mean	Role in the disconnect
Animal-based welfare evidence	Validated observations made on the animal that inform welfare inference	A universal gold standard independent of species and context	Reveals welfare information that may not appear in output records

Table 2 Joint Patterns of Productive Performance and Animal-Based Welfare Evidence

Productive performance	Animal-based welfare evidence	Interpretation
Expected or maintained	No substantial concern detected	Concordance between production and welfare evidence
Reduced	Welfare concern indicated	Visible deterioration in which output and welfare evidence change together
Reduced	No clear concern or evidence remains uncertain	Production change requires another explanation and is not proof of poor welfare
Expected or maintained	Welfare concern indicated	Welfare-Productivity Disconnect

Animal-based evidence changes what can be seen

Animal-based measures matter because they alter the information available to the assessment. Production records can be frequent and objective, but they are not designed to capture every welfare domain. Direct observations of locomotion, injury, behaviour or comfort can reveal states that are not obvious from output. The practical challenge is to use measures with demonstrated relevance rather than to accumulate indicators without purpose. Spigarelli et al. (2020) emphasise context when reviewing welfare measures for grazing ruminants, and Linstädt et al. (2024) reach a similar conclusion for dairy cattle. More indicators do not automatically produce better welfare inference. Better alignment between the indicator and the welfare question does.

This becomes especially important when welfare dimensions do not change together. High milk yield does not erase pain from lameness, and lameness remains a major welfare concern even when its production effects vary across animals or stages of disease (Whay & Shearer, 2017). Rapid growth does not neutralise locomotor difficulty in broilers. Nor does high litter output remove welfare concerns linked with very large litters in pigs. These are not arguments for ignoring performance. They show why performance should not be given compensatory authority over animal-based evidence. The animal's state remains the evaluative target, not the commercial value of the output produced during that state.

Reading output alongside animal-based evidence also fits current work on sustainability and resilience. Lanzoni et al. (2023) note the difficulty of integrating welfare into life-cycle assessment when production efficiency dominates the analysis. Resilience research raises a similar caution. Stability or recovery of production is useful, but it does not define a favourable welfare trajectory by itself (Taghipoor et al., 2023). Maintained output shows that output was maintained. Whether welfare was maintained requires additional evidence from the animal.

Boundary conditions and empirical implications

The disconnect should not be assumed whenever animals perform at a high level. A mild challenge may be resolved without meaningful welfare deterioration, while a severe challenge may quickly reduce both welfare and performance. The concept is most relevant between those extremes, when regulatory adjustment can preserve output for a period but animal-based evidence indicates that welfare is becoming less favourable. Biological capacity will influence that interval. So will production stage and the nature of the challenge. This is why a universal threshold for the disconnect would be difficult to defend and why species-specific interpretation remains necessary.

Three propositions follow from the framework. First, animals with similar productive output can differ in their animal-based welfare profiles. Second, under some sustained challenges, changes in welfare indicators may appear before or more clearly than a change in productive output. Third, assessment that considers production together with validated animal-based measures should provide a more differentiated account of welfare than production records alone. These are deliberately modest propositions. They can be examined with cross-sectional comparisons or repeated observational monitoring and do not require complex experiments. Their purpose is to make the framework testable without converting a conceptual argument into claims that the present review cannot support.

Several limits remain. The review does not identify how often latent welfare deterioration occurs in commercial systems, and it cannot specify one biomarker or behavioural measure that works across species. Weighting welfare dimensions also remains contested. Positive welfare adds another difficulty because avoiding negative states is not the same as providing opportunities for positive experience (Yeates & Main, 2008). Mattiello et al. (2019) make the same point for ruminants, while Lawrence et al. (2019) show that the meaning of positive welfare itself requires care. These limits do not weaken the central inference. They define where empirical work is needed and where the concept should remain deliberately narrow.

Table 3 Propositions and Light Empirical Tests

Proposition	Rationale	Observable implication	Light empirical test
P1 Inferential asymmetry	Normal output has limited ability to rule out welfare compromise	Animals with similar output can show different welfare profiles	Cross-sectional comparison among animals at a similar production level
P2 Temporal divergence	Adaptive regulation can preserve output during a continuing challenge	Some welfare indicators may change before or more clearly than output	Repeated observational monitoring around a routine challenge
P3 Joint assessment	Production and animal-based measures carry partly different information	Their combination should describe welfare state more fully than production alone	Compare interpretations obtained from production-only and combined assessment

CONCLUSION

Commercial livestock systems need productivity metrics, but those metrics should not certify welfare on their own. Performance and welfare can move together without carrying equal informational value. A decline in output may strengthen welfare concern, while normal output cannot rule out a less favourable animal state with the same confidence. Adaptive regulation offers one plausible explanation because function can be maintained while welfare-related signals change. The Welfare-Productivity Disconnect names that specific condition rather than assuming a general conflict between welfare and productivity.

The practical consequence is a change in interpretation rather than a demand for complex monitoring. Production records remain useful, but they should be read alongside a small set of validated animal-based measures that fit the species, production stage and welfare question. This approach keeps the claim proportionate to the evidence. The framework does not diagnose animals, estimate prevalence or prove a causal pathway from compensation to welfare deterioration. It clarifies when apparently normal output is not enough. Future observational studies can now test the proposed asymmetry, timing and divergence directly while retaining productivity as an important, but partial, part of welfare assessment.

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