

1 **Enriching the lives of dairy cattle with opportunities to express adaptive behaviors**

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4 **Abstract**

5 Good animal welfare means that cattle are not only healthy and productive, but also that they can
6 express important behavioral adaptations, and that negative experiences are minimized while
7 opportunities for positive ones are provided. Environmental enrichments allow cattle to express
8 species-specific and life-stage-appropriate adaptive behaviors in captivity. To be effective,
9 environmental enrichments must be used and wanted by the animals and result in measurable
10 benefits to welfare. These benefits may be transient (i.e., positive emotions while using the
11 enrichments) or long-term, such as improved coping skills or stress resilience, resulting in
12 cumulative positive welfare balance. Scientific studies have identified both experimental and
13 practical options for relevant environmental enrichment for dairy cattle of different life stages.

14 **Key words:** environmental enrichment, animal welfare, positive welfare

15
16 **Introduction**

17 The term animal welfare is used to describe either the subjective current status or
18 cumulative quality of life of animals. The animals' experiences are directly affected by animal
19 care decisions made by humans, including housing environments, management and husbandry
20 practices, and direct human-animal interactions or handling. A common framework for thinking
21 about animal welfare⁶ is typically described as 3 overlapping types of ethical values about an
22 animal's biological functioning, internal affective states (i.e., subjective emotions or feelings),
23 and their ability to live a reasonably natural life (i.e., express behavioral adaptations). These

24 concepts provide a structure to frame the priorities commonly found in other definitions of
25 animal welfare. For example, the AABP supports the World Organization for Animal Health
26 definition (2019), positing that cattle are considered to experience good welfare if they are
27 healthy, safe, and well-nourished (i.e., functioning well biologically), comfortable and not
28 suffering from unpleasant states (i.e., negative affective states such as pain, fear, or distress); and
29 are able to express innate (i.e., adaptive) behaviors.

30 Decades of research in the animal and veterinary sciences have provided a wealth of
31 knowledge on the biological functioning of dairy cattle, including measures of health, growth or
32 production, and reproduction. In the field of applied ethology, techniques to test cattle's
33 preferences and motivation⁵ can be used to determine how valuable particular resources or
34 behaviors are from the animal's perspective. Specifically, preference testing generates
35 information about animals' rank-order choices among provided resources; however, one
36 limitation of this technique is that it cannot distinguish between valences (i.e., things that are
37 desirable vs. aversive). In motivation testing, animals are required to pay a "price" (e.g., pushing
38 increasingly heavy weights or pressing a button an increasing number of times) to access a
39 resource; willingness to pay greater prices indicates the animals place a higher importance on a
40 given resource. This concept is borrowed from consumer demand theory and can be used to
41 describe resources as relative necessities or luxuries (i.e., relatively inelastic vs. elastic demand).
42 The resulting inferences can be used to determine which resources could be provided in captive
43 environments to mimic important aspects of natural living, which can in turn improve affective
44 states⁷. A growing body of literature has sought to evaluate animals' subjective internal
45 experiences¹¹, with applied goals of minimizing negative affective states and providing
46 opportunities to promote positive ones.

47 Indeed, in recent years, a global trend has emerged focusing on “positive welfare.” This
48 concept proposes that, even if animals are not currently experiencing negative emotions, this
49 does not necessarily mean they have “good” welfare – merely that they are not suffering⁹; to
50 experience good welfare, they should also have positive experiences. Some authors clarify that it
51 is unrealistic to expect animals to never have negative experiences in the course of their
52 lifetimes; however, it is important to balance those with positive experiences to ensure an overall
53 good quality of life (i.e., positive welfare balance¹⁵). Through this lens, it is possible to enrich
54 animals’ lives and provide them with opportunities for positive experiences through
55 environmental enrichment.

56 **What is or is not enrichment?**

57 Definitions and examples of environmental enrichment have varied in the literature, but
58 with the common understanding that enrichment resources are used by the animals and provide
59 some kind of measurable benefit to at least one aspect of welfare. However, the term enrichment
60 is often misapplied to any objects added to an animal’s environment, regardless of evidence that
61 the animals use them, want them, or benefit from them. Such items would be termed “pseudo-
62 enrichment²².” Such objects may be provided with good intentions, but without evidence for
63 benefits to welfare for that particular species or life stage. For example, “toys” such as balls,
64 commonly marketed for horses or dogs, are often cited in literature reviews as examples of
65 enrichment items for cattle, but without specific evidence to support their relevance to cattle
66 welfare. Indeed, some recent experiments failed to find evidence of interest in balls by weaning-
67 age beef cattle^{1,3}, let alone positive animal welfare outcomes.

68 In addition, other items or environmental modifications may measurably improve animal
69 welfare, yet should more appropriately be considered “environmental improvement²²,” rather

70 than enrichment per se. These improvements describe basic resources to primarily address
71 biological or physiological needs and counteract negative welfare status. By fulfilling these types
72 of needs, “suffering” is reduced, such as the negative affective states of hunger, thirst, or
73 discomfort. For example, a wealth of literature has demonstrated the importance of heat
74 abatement for protecting both production and welfare in dairy cattle of all ages²³. Without access
75 to shade to prevent heat gain or active cooling to dissipate heat, cattle can experience great
76 discomfort and negative welfare. Therefore, heat abatement resources to prevent or reduce heat
77 stress should be considered basic or essential environmental resources, rather than enrichment.

78 To be considered environmental enrichment, a resource must address a behavioral
79 need, allowing cattle to express relevant behavioral adaptations appropriate to their life stage. The
80 enrichment should produce positive emotions (e.g., pleasure, reward) instead of merely
81 providing relief from negative states⁹. Some recent literature reviews define environmental
82 enrichments, compared to “improvements”, as those identified through preference or motivation
83 testing to address animals’ behavioral needs or wants²². However, it should be noted that these
84 techniques can also be used to identify important environmental “improvements”, such as heat
85 abatement²³. Indeed, evidence from preference or motivation testing can emphasize the
86 importance of improvements, such as heat abatement, from the animal’s perspective. These
87 techniques are not limited to identifying behavioral needs or enrichments per se.

88 Some authors take this concept a step further and define either “true” enrichment²⁶ or
89 higher-tier enrichments²² as resources that lead to longer-lasting improvements to animal welfare
90 beyond immediate positive emotions – that is, contributing to positive welfare balance¹⁵. These
91 types of enrichments contribute to long-term positive welfare balance by equipping the animal

92 with improved coping skills, stress resilience, improved cognitive abilities, or flexibility and
93 adaptability to challenges.

94 **Types of enrichment**

95 To describe types and examples of enrichments for cattle, some commonly cited
96 classifications have included physical, sensory, occupational, nutritional, and social⁸. More recent
97 reviews have expanded these classifications to physical, sensory, exercise, cognitive, feeding-
98 based, and social, as well as clarified that they are not mutually exclusive²⁶. Here, I describe
99 these classifications with brief examples.

100 Physical enrichment describes modifications to the structure of the animals' environment,
101 such as greater space, or partitions within the space to define different functional areas. For
102 example, experimental studies have shown that leading up to and during parturition, dairy cows
103 prefer blinds or partitions that can provide seclusion from herd-mates¹³; this mimics their natural
104 behavior of distancing from the herd in extensive production systems. Some commercial dairy
105 farms have adapted this concept by providing curtains or other solid barriers to give cows an
106 element of privacy at calving¹⁴. Exercise, a form of physical occupational enrichment, is often
107 combined with physical enrichment, as larger or more open spaces can stimulate activity. For
108 example, cows housed in freestall barns prefer additional access to pastures or outdoor exercise
109 yards with soft footing (e.g., sand or bark mulch^{20,21}).

110 Sensory enrichment refers to objects that stimulate the senses (i.e., visual, auditory,
111 olfactory, gustatory, or tactile). Grooming brushes are a common form of tactile enrichment.
112 Adult cows are highly motivated to access automatic mechanical rotating brushes¹⁰. They push
113 increasingly heavy weights, equivalent to their willingness to push for access to fresh feed after a
114 period of deprivation; their demand for brushes (and feed) is less elastic than for access to an

115 empty pen (i.e., a negative control)¹⁰. From a practical perspective, mechanical brushes can be an
116 expensive investment for farmers; however, cattle also willingly use simpler stationary brushes.
117 Weaned dairy heifers naïve to brushes approach stationary brushes within seconds or a few
118 minutes on first exposure^{17,24}, and continue to use them daily – not only for grooming, but also
119 for oral manipulation (licking or chewing the bristles). This illustrates the importance of testing
120 potential enrichments for the target age class of cattle, as adaptive behaviors vary with age. For
121 example, feeding-based enrichment for pre-weaned calves includes feeding through a nipple to
122 provide an appropriate outlet for innate suckling behavior. Nipple-feeding reduces abnormal oral
123 behaviors, including calves cross-suckling on each other¹⁸. Another experimental way to mimic
124 natural feeding behavior is to provide hay through a simple pipe-based device with holes so that
125 calves grasp the hay with their tongues, similar to when grazing⁴.

126 Feeding-based enrichments can also overlap with cognitive enrichment, with the
127 distinction that the latter aims to stimulate cognitive abilities, rather than primarily to mimic
128 natural feeding behavior. To date, no practical cognitive enrichments have been developed for
129 cattle. However, in many experiments designed to test other research questions, cattle have
130 shown interest in completing tasks and solving problems. For example, cattle demonstrate a
131 concept known as contrafreeloading, in which they expend effort to obtain a resource that is
132 simultaneously and freely available (e.g., hay from behind a weighted gate, when it is
133 concurrently offered ad libitum in an open bunk²⁵). Opportunities to overcome solvable
134 challenges and express choices and agency may provide cattle with enriching, positive
135 experiences that can result in positive welfare balance^{15,26}.

136 Lastly, social enrichment for herd species such as cattle can also provide opportunities for
137 long-term coping benefits and positive welfare balance. For pre-weaned calves, the industry

138 status quo is individual housing through weaning. However, a wealth of literature has
139 documented a variety of animal welfare benefits from social housing (i.e., pair or group
140 housing), which fulfills calves' motivation and preference for full social contact. Early-life social
141 housing has been shown to facilitate calves' social development, physical development (e.g.,
142 coping with cold stress¹⁶; greater solid feed intake and weight gain²), and cognitive development,
143 which translates into resilience to stress during weaning, and greater adaptability to new feeds
144 and situations. Furthermore, some social science research suggests that pair or group housing of
145 calves may be more acceptable to the public than individual housing¹², although not when the
146 practice of cow-calf separation is highlighted¹⁹. Nonetheless, social housing of pre-weaned
147 calves is a clear example of a type of enrichment that results in numerous long-term animal
148 welfare benefits and contributes to positive welfare balance.

149 **Conclusion**

150 Environmental enrichment allows dairy cattle to express behavioral adaptations, which is
151 an important dimension of animal welfare. Enrichments can take many non-mutually exclusive
152 forms, including larger or more complex physical spaces, opportunities for exercise, sensory
153 stimulation, feed-delivery methods to mimic natural feeding behavior, cognitive challenges, and
154 social contact. Because enrichment can provide cattle with the opportunity to experience positive
155 welfare, this concept is important from an ethical standpoint. Furthermore, giving cattle the
156 opportunity for positive experiences may boost public perception of dairy farming practices.
157 Therefore, dairy farmers may consider providing meaningful environmental enrichment to cattle
158 to promote good animal welfare and contribute to the social sustainability of the industry.

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