
The Burden of Psychological Pain in Laying Hens: Behavioral Deprivation

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Over millions of years, evolution has shaped the motivation of animals to explore the environment for critical resources and information, to be alert for subtle signs of danger and to opportunities, and to constantly resolve fluid social standings. Hence, it comes at no surprise that severe limitations on the realization of these motivations imposed on confined animals can be major sources of poor welfare. This is of special relevance for animals kept in the barren and tight spaces that are typical of intensive production systems, as is the case of caged housing. Despite over 8,000 years of domestication (West & Zhou 1988), there is no evidence that the cognitive abilities and complex behavior of farmed breeds has changed substantially compared to that of their wild ancestors (Broom 2011). Given the opportunity, modern laying hens will forage and explore the environment for several hours per day (Nicol 2019), go through the typical behavioral sequence involved in the search for and the construction of a nest, roost at night, dustbathe, flap their wings, and move around - in the same way that their ancestor, the red jungle fowl, do. However, under intensive housing conditions, the motivation to express these behaviors is neither properly fulfilled, nor are hens able to exert any control over the circumstances affecting their well-being.

The International Association for the Study of Pain (IASP) defines pain as “*an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage*” (IASP 2020). Accordingly, any unpleasant experience that potentially threatens the integrity of an individual, or her kin, immediately or in the future, can be treated as a painful experience. Similarly, experiences of psychological pain (also referred to as emotional pain), namely negative affective states such as fear, anxiety, boredom, helplessness and depression, can be operationally classified using the same criteria (Chapter 1 (Alonso & Schuck-Paim 2021)).

Here we apply the analytical framework described in Chapter 1 (Alonso & Schuck-Paim 2021) to the measurement of pain of the latter nature (psychological), particularly that associated with the deprivation of various behavioral needs as experienced by commercial laying hens. To this end, we examine the possible intensity of the pain suffered as a consequence of each type of behavioral deprivation, in addition to its duration and temporal evolution. Although the deprivation of highly motivated behaviors can affect welfare in multiple ways (e.g., leading to the development of abnormal behaviors such as injurious pecking - Chapter 4 (Schuck-Paim & Alonso 2021d) - or increasing the likelihood of disease through immunosuppression (Umar et al. 2017)), our interest here is only in the potential psychological pain caused in each case.

Measuring the burden of psychological pain in laying hens

Despite a long history of domestication and intense artificial selection for elevated egg production under confined conditions, laying hens still retain a behavioral repertoire comparable to that of their wild ancestors. Although not every behavior performed in the wild is necessarily important for the welfare of hens kept in captivity (Dawkins 1988; Mason & Burn 2011), evidence shows that behaviors such as foraging, nest building, dustbathing and the search for elevated roosting areas are largely driven by internal factors, with the motivations to perform these behaviors best reduced via their performance (Nicol 2015). Here we explore the burden of psychological pain associated with the deprivation of each of these behaviors.



Figure 6.1. Laying hens in a typical conventional cage used in commercial production. Illustration: Olga Kurkina.

Estimating Intensity

As discussed in Chapter 1 (Alonso & Schuck-Paim 2021), the degree to which behavior and attention to other ongoing experiences are disrupted can be used as a yardstick to infer the intensity of painful

sensations. As adaptive warning messages of actual or potential danger, the degree of unpleasantness associated with a negative affective state should also be related to the extent that failure to attend to it compromises the biological fitness of the individual, either as perceived or hardwired by natural selection (Fraser & Duncan 1998). In other words, the intensity of psychological pain should signify the corresponding degree of importance of the stimulus (Panksepp 2004). For instance, the rarer a critical resource (or the higher the cost to obtain it), the greater should be the unpleasantness associated with its lack or loss (e.g., the psychological distress associated with the severance of the maternal bond should be higher for mammals with heavy parental investment, as in such cases a stronger emotional bond to the offspring is favored by natural selection). Likewise, the more imminent a threat (e.g., the closer a predator), the greater should be the intensity of fear.

The classification used for the attribution of intensity to psychological harms is therefore the same as that used for physical harms (see Box 1.2 in Chapter 1 (Alonso & Schuck-Paim 2021)). For example, psychological pain at the first (annoying) level should include experiences representing nuisances and discomfort that can be ignored most of the time, whereas at the second level (hurtful), the effect of drugs (in this case, drugs such as anxiolytics and antidepressants) on the alleviation of symptoms should be more easily observable. Psychological pain at the disabling level involves a higher degree of fear, anxiety, helplessness or despair that should prevent individuals from enjoying virtually any positive experience. The excruciating level represents the point of psychological breakdown, where self-harm and other maladaptive outbursts may be observed.

One rule of thumb to help estimate the intensity of a specific harm is to establish whether the affected individual trades the sensation produced by the harm for another with a better known intensity. For example, the pain associated with exposure to extreme cold can reach a disabling level (avoidance of extreme cold is critical for survival). Pain at the disabling level could be then attributed to the hunger sensation felt by individuals willing to endure that level of cold exposure to obtain food. The classifications of the intensity of the unpleasantness associated with negative affective states of psychological nature can be assisted by similar heuristics. For example, laying hens sustain multiple fractures that accumulate over the laying cycle, with clear evidence of chronic pain long after a fracture has healed (Chapter 3 (Schuck-Paim & Alonso 2021c)). Because behaviors such as jumps and short flights have been shown to be painful for fractured hens, the performance of these behaviors by fractured individuals would indicate their willingness to pay a cost (in terms of physical pain) for access to these behavioral opportunities (though there are subtleties that must be considered, such as the possible analgesic effect of engaging in distractions; Box 9.4 in Chapter 9 (Schuck-Paim & Alonso 2021b)). This approach makes minimal external assumptions about the importance of behavioral opportunities to animals, as it is based on the observation of their motivations and preferences.

A related experimental paradigm is widely employed in animal research to quantify the motivational value of different activities and resources: the measurement of demand elasticity as derived from behavioral demand functions. Demand elasticity is the degree to which the desire or motivation for something changes as its cost changes, and can be quantified by measuring the slope of the function relating the quantity of a resource (amount, time with access) to the cost an individual is prepared to pay for it (effort). Slopes that are shallower (less steep than 1.0) are described as inelastic (individuals are willing to pay high costs to access the resource), whereas those steeper than 1.0 are elastic (increasing costs decreases motivation to obtain the resource). Here, the demand for food is often used as a yardstick for assessing the value of other resources or to rank the slopes to produce a hierarchy of behavioral priorities (Weeks & Nicol 2007)), thus helping establish how much animals value different behaviors and the degree to which their deprivation may affect them negatively.

Estimating Duration

Understanding the burden of psychological pain endured by laying hens housed in different contexts requires examining not only the intensity, but also the duration of the effects of thwarted behavioral needs; namely, understanding whether the frustration associated with the inability to perform behaviors like forage and move around is felt continuously, or if it is restricted temporally (e.g., coinciding with the circadian rhythms that dictate the motivation to perform certain behaviors).

On one hand, it is well known that the intensity of some unpleasant feelings representing unmet physiological needs, such as hunger or thirst, increases over time; unmet psychosocial needs may behave similarly. For example, in dogs, the magnitude of the distress caused by social isolation and boredom is time-dependent, increasing over time (McMillan 2003). In laying hens, there is evidence to suggest that this is also the case for some behaviors. Hens deprived of dustbathing material, or of the possibility to sham dustbathe (van Lier & Wiepkema 1992), increase their dustbathing behavior when dustbathing is made possible again; some studies suggest that the longer the duration of the deprivation, the higher the amount of subsequent bathing behavior (Vestergaard 1980; Vestergaard et al. 1997). A similar 'rebound' pattern has been observed in hens deprived of the possibility to perform comfort behaviors, such as wing stretching and wing flapping, suggesting an increase in the motivational tendency to perform these behaviors with increased time of deprivation (Nicol 1987).

In other cases, behavioral deprivation is unlikely to exert its effect on the animal with a constant intensity over time, but rather to have an effect in bouts (Ladewig 2000). For example, it is possible that, while eating, a hen kept in a furnished cage does not find movement restriction aversive at that particular time, not until she is disrupted by a cage companion, or wants to move about, explore the environment or stretch her wings. In such cases, it makes more sense to think in terms of chronic intermittent stress (Ladewig 2000), namely a succession of repeated stressors. Similarly, while the motivation to search for and build a nest has been shown to be extremely strong in the hours preceding oviposition (Follensbee et al. 1992), there is little evidence to suggest that it would be present after an egg has been laid.

It is also important to realize that the time spent in pain may not necessarily match the duration of the stressors immediately causing it. Chronic pain, whether physical or psychological, is predominantly maladaptive (not benefiting the survival or reproduction of the individual), and may be triggered by traumatic interventions. In the same way that debeaking can lead to the development of neuropathic pain, a chronic fearful state can also emerge from a trauma (e.g., transportation, handling, mutilation) at a sensitive moment during development.

In the next sections the potential negative effects emerging from the deprivation of highly motivated behaviors are discussed. Estimates of duration are provided in time endured in pain **per day** (daily time budget), with an assumed total of 280-420 days of experience (occurrences) in each housing environment (conventional cages, furnished cages and aviaries). The latter estimate assumes that flocks are depopulated at 60-80 weeks, and that the laying cycle starts at 20 weeks (the rearing phase is not considered). For each of the housing situations, we also explore the proportion of individuals in the flock affected by behavioral deprivation. The sensitivity of the final estimates to these assumptions can be tested at the interactive online tool available at <http://www.pain-track.org/hens>.

Deprivation of specific behavioral needs

Nest building

“The worst torture to which a battery hen is exposed is the inability to retire somewhere for the laying act. For the person who knows something about animals it is truly heart-rending to watch how a chicken tries again and again to crawl beneath her fellow-cage mates to search there in vain for cover”

Konrad Lorenz (Lorenz 1980)

Nests are a highly valued resource for laying hens (Duncan 2001; Nicol 2015; Duncan 2020; Freire et al. 1996; Odén et al. 2002; Cooper & Albentosa 2003). Driven by hormonal changes preceding ovulation, hens perform a sequence of behavioral patterns prior to oviposition that start with the search for a suitable nest site - a quiet and secluded location where they can safely incubate their clutch (Figure 6.2). Once a nest is selected, a sitting phase commences, in which the hen adopts a sitting posture, occasionally interspersed with short bouts of nest building activities, such as scratching the floor, rotating the body and collecting litter (Cronin et al. 2012).



Figure 6.2. Laying hen incubating her clutch. Illustration: Olga Kurkina.

These behavioral patterns are under endocrine control, and can start as early as 100 min before oviposition (Sherwin & Nicol 1993), with most birds sitting for 25–40 min before oviposition. During this time, hens exhibit increased activity, restlessness and vocalizations (Meijsser & Hughes 1989; Wood-Gush & Gilbert 1969; Nicol 2015). Among hens kept in conventional cages, where they are denied a nest, these changes include unsettled behaviors that are reported to be symptomatic of frustration, such as stereotyped pacing, increased aggression and displacement preening (Meijsser & Hughes 1989; Duncan 2020). For example, one study compared the pacing behavior of hens in cages with a nest box, without a nest box and with access to the nest box blocked when hens were 28, 32 and 36 weeks of age (Yue & Duncan 2003). Hens with access to the nest box spent significantly less time pacing in the hour before egg laying compared with hens that had no experience of a nest box or those that had their nest box blocked, with no change in behavior as birds aged, suggesting that they did not adapt to the lack of a nest.

The high priority that hens attribute to finding and using a suitable nest has been demonstrated in a variety of other ways. Not only do most hens lay eggs in a nest box when provided with one (Appleby et al. 2002; Weeks & Nicol 2006), but considerable aggression has also been shown to occur outside nest boxes, indicating a high level of competition for the boxes (Odén et al. 2002). In general, hens will pay high costs for access to a nest site, including walking past dominant or unfamiliar birds in narrow corridors, squeezing through narrow gaps and pushing through weighted doors (Duncan 2001; Nicol 2015; Duncan 2020). As the sitting phase approaches, the costs paid to access a nest become increasingly higher (Freire et al. 1996). In one experiment (Cooper & Albentosa 2003), the authors demonstrated that the motivation to access a nest increases as the oviposition draws near. In this experiment, ISA Brown hens were trained to push a door sealed with an electromagnet. Birds tested 20 min prior to oviposition had a work rate that was approximately three times higher than that of birds tested 40 min or more prior to oviposition, and significantly higher than the rate to access food after 4 hours of food deprivation. In earlier experiments, the price paid (in terms of work) to reach a suitable nest during the pre-laying phase was as high as that employed to obtain food after being food deprived for 28 hours (Follensbee et al. 1992).

These patterns show that the inability to find a nest is highly disruptive for the hen, with all attention drawn to this seeking drive in the moments prior to oviposition. At this time, hens are willing to pay high prices for access to a nest site. Likewise, the ability to conduct other routine activities is greatly impaired as sitting time approaches. Such a degree of disruption, along with the evolutionary value of finding suitable nests, indicates that the lack of a suitable site most likely leads to disabling feelings of frustration (see Box 1.2, Chapter 1 (Alonso & Schuck-Paim 2021), for definitions of intensity), in line with the suggestion that the absence of a nest box is one the most severe sources of frustration for laying hens (Duncan 2001). In Pain-Track 6.1, we assume that the intensity of frustration during the first half of the search phase is likely of a hurtful nature, increasing to a disabling nature during the second half (hence the 50% probability assigned to each category). The disabling nature of the pain is more prevalent during the sitting phase, as oviposition approaches, subsiding during oviposition. Here, we conservatively assume that the frustration associated with the lack of a nest is linked to the timing of nesting motivation prior to and during oviposition, but that it is completely absent after an egg has been laid.

Pain-Track 6.1. Hypothesis for the intensity and duration of the psychological pain endured per day as a result of nest building deprivation in laying hens. The estimated prevalence of birds affected by the deprivation in conventional cages, furnished cages and aviaries are respectively: 100%, 2-23% and 2-8% (see text for justification). The definition of each intensity category is provided in Box 1.2 (Chapter 1 (Alonso & Schuck-Paim 2021)).

	i. Nest search	ii. Pre-oviposition sitting	iii. Oviposition and pos-oviposition sitting
Excruciating			
Disabling	50%	80%	50%
Hurtful	50%	20%	50%
Annoying			
	30-60 min	25-45 min	5-15 min

Pain-Track 6.1 applies to all hens deprived of a nest box. In the case of layers kept in furnished cages and cage-free aviaries, where a commercial nest box is provided, a fraction of individuals may still undergo the distress that lack of a suitable nesting site triggers. In these systems, a proportion of birds may lay their eggs on the floor (often referred to as ‘floor layers’), even though a nest box is provided. We suggest that rather than indicating that these hens do not value the presence of a nest, floor laying reflects either exclusion of the nest box due to competition (Odén et al. 2002) (e.g., there may not be enough nest boxes, particularly if they all want to use them at the same time), and/or the outcome of some birds not finding the provided commercial nest boxes suitable. The latter possibility is suggested by the observation that floor layers are willing to pay high costs to keep looking for possible nests, even in the presence of a commercial box. In an experiment where hens had to squeeze through a narrow gap to move to an exploration pen where a nest box could be found, the birds continued to squeeze through the narrowest gaps to explore further, even when a commercial nest was made available (Cooper & Appleby 1997). Indeed, although most hens will accept different types of nests, they also show marked preferences for some types. In general, highly preferred sites are secluded and dark, containing some form of manipulable material (Clausen & Riber 2012). Based on the average proportion of eggs laid outside the nest in each housing system, we assume that 2-8% of hens experience the frustration of not finding a suitable nest in cage-free aviaries (Icken et al. 2013; Oliveira et al. 2019; Sørensen et al. 2017) and 2-23% in furnished cages (Hunniford et al. 2014; Cepero & Hernandiz 2015).

Perching and Roosting in Elevated Areas

Under natural conditions, free-living chickens seek elevated structures such as tree branches to perch on during the day (Duncan et al. 1978) and to roost on at night (Blokhuys 1984) as a strategy against ground predators (Jordania 2011). Elevated perches also allow hens to monitor the environment and escape from other hens. The motivation to seek elevation is particularly strong at night (Blokhuys 1984), and remains strong in commercial layer breeds. Hens of all currently studied breeds will perch at night and, to a lesser extent, during daytime (O'Connor et al. 2015). The anti-predator function of

accessing an elevated structure is supported by the finding that perch usage rates are higher in small groups, where individuals must be more vigilant (Newberry et al. 2001).

The provision of perches in commercial systems can affect hen welfare in multiple ways beyond fulfilling laying hens' potential behavioral need to perch. On one hand, the use of perches have been shown to improve bone and muscle strength, reduce injurious pecking and reduce stocking density on the floor in aviary systems. On the other hand, perches may also lead to a higher incidence of keel bone fractures and vent pecking, depending on their structural properties, positioning and height (O'Connor et al. 2015). In this chapter, our interest is only in the potential psychological pain caused by the deprivation of proper perching opportunities. The effects of fractures, injuries and other welfare harms are explored in other chapters.

As with other behavioral deprivations, the extent to which laying hens 'miss' absent perches they have never experienced remains to be determined. However, research suggests that roosting at night on an elevated perch remains a behavioral priority for modern layers, even in commercial indoor housing systems where they are protected from predation (Weeks & Nicol 2006; O'Connor et al. 2015). Several lines of evidence support this view. First, the overwhelming majority of hens use perches at night (Braastad 1990) when adequate perch space is available, which suggests that this is a highly motivated behavior. If roosting is prevented, hens show signs of unrest (Olsson & Keeling 2000). Further evidence comes from studies showing that hens will work to obtain access to a perch at night. Olsson and Keeling (Olsson & Keeling 2002) increased the force required for a hen to open a weighted push-door to gain access to a perch from 25% of an individual's capacity to 100%, the maximum possible for that individual hen (calculated based on the force required to obtain food after 24 hours of food deprivation). The median resistance laying hens were willing to push was 75% of their maximum capacity, compared with 0% for a sham perch. These results indicate that laying hens assign a high priority to perching, a finding compatible with the expectation that behaviors favoring protection from predators (such as the preference to roost in elevated sites) should be under strong selection. Accordingly, there is also some evidence that laying hens provisioned with continuous access to elevated structures in free-range farms are less fearful than those deprived of aerial perches (Donaldson & O'Connell 2012), likely as a result of the perceived reduction of the threat of predation (or aggression) when an animal is able to monitor their environment from a safe spot.

In light of these findings, we tentatively assume that the inability to use a perch to roost at night is distressing for hens kept in conventional cages. Specifically, we assume that the distress endured should be particularly intense during the time when the hen would be looking for a perch to roost; in general, about 1 h before sunset (or before lights are turned off), hens start perching for the night, a process that commonly takes about 30 to 60 minutes (Blokhuys 1984). Given the high levels of motivation to access a perch, similar to those required to access food after 24 hours of deprivation, and the highly adaptive value of protection from predation, the intensity of the pain at this particular time is more likely of a hurtful nature. Since preference for perching is substantially stronger during the night, with a much less frequent use of perches during the day (Blokhuys 1984), we conservatively assume that the absence of perches during the day is not a major driver of psychological pain in commercial layers. Such an assumption also avoids inflating the psychological pain endured by caged hens during active hours, at a time when we assume they might also endure the pain associated with deprivation of other behavioral needs, such as foraging and nesting.

Unfortunately, data on the behavior (or other welfare indicators) of caged layers during the night compared to that of hens who have the opportunity to spend the night on aerial perches is scant. Whether the sleep and vigilance patterns of caged hens are in any way altered when they are forced

to sleep in locations potentially perceived as less safe remains to be determined. Blokhuis (Blokhuis 1984) observed that standing during the evening occurred more frequently in alarming situations, though it is not clear whether such a disruption is also present under typical commercial conditions or detrimental to hen welfare. Chickens have an additional phase of sleep that humans lack: unihemispheric slow-wave sleep, during which one half of the brain rests while the other half is awake; this is why chickens can sleep with one eye open and the other eye closed, an adaptation that allows them to be concurrently alert for predators and asleep (Mascetti 2016). For example, on average, hens spend 75% of dark hours in a sleeping posture, 7% active and 18% motionless with at least one eye open (van Luijckeljaar et al. 1987), during which they may exhibit fully developed large amplitude slow waves characteristic of electrophysiological sleep. Although unihemispheric sleep would mean a reduction of the time spent sleeping compared to bihemispheric sleep, the behavior and health of birds does not seem to be impaired by a reduction of sleep (Mascetti 2016). Therefore, we conservatively assume that a lack of elevated structures upon which to roost at night has a low likelihood of being mildly distressing to hens in conventional cages (Pain-Track 6.2), during 5-15% of sleeping time. Further research is needed to address the possibilities raised here.

Pain-Track 6.2. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of deprivation of an elevated site for roosting in conventional cages. The estimated prevalence of birds affected is 100% (see Box 1.2, Chapter 1 (Alonso & Schuck-Paim 2021), for the definition of each intensity category).

	i. Search for safe, elevated site	ii. Dark hours
Excruciating		
Disabling		
Hurtful	80%	5%
Annoying	20%	10%
	30-60 min	6-8 hours

In furnished cages, perches are usually placed in two or more parallel rows along the length of the cage, but the cage height limits the perch height, and normal hen movement within the cage may disrupt perching (O'Connor et al. 2015). In these cages, about 80–95% of hens have been shown to roost on perches at night (Nicol 2015), even though evidence suggests that hens strongly favor more elevated areas relative to those perceived to be close to the ground (O'Connor et al. 2015). Therefore, we assume that the inability to use an elevated location to roost during the evening is still distressing for hens kept in furnished cages, although the presence of a perch partially satisfies this need. The likelihood of experiencing higher levels of distress is therefore reduced in Pain-Track 6.3.

Pain-Track 6.3. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of deprivation of an elevated site for roosting in furnished cages. The estimated prevalence of birds affected is 100%. The definition of intensity categories is provided in Box 1.2 (Chapter 1 (Alonso & Schuck-Paim 2021)).

	i. Search for safe, elevated site	ii. Dark hours
Excruciating		
Disabling		
Hurtful	50%	
Annoying	50%	15%
	30-60 min	6-8 hours

In cage-free aviaries (Pain-Track 6.4), perch use is high, especially at night, when up to 90% of hens are observed roosting on the top-level perch (Odén et al. 2002; Abrahamsson & Tauson 1995). In line with this observation, we assume that 75-95% of hens in aviaries are able to find a suitable elevated perch to roost at night. The remaining birds (5-25%) are assumed to use lower level perches. In such cases, the level of distress endured is conservatively assumed to be similar to that experienced by perching hens in furnished cages.

Pain-Track 6.4. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of deprivation of an elevated site for roosting in cage-free aviaries. The estimated prevalence of birds affected ranges between 5 to 25% (see text for justification).

	i. Search for safe, elevated site	ii. Dark hours
Excruciating		
Disabling		
Hurtful	50%	
Annoying	50%	15%
	30-60 min	6-8 hours

Foraging and Exploration

To insure against the risk of starvation associated with the unpredictable availability of food, animals must constantly gather information about the presence, nature and location of alternative food sources. Foraging, namely the exploration of the environment for the (immediate or future)

acquisition of food, is one of the most important elements in the behavioral repertoire of animals, particularly omnivorous species such as chickens. According to the “information hypothesis”, investing energy to gather information about potential food sources pays off by increasing the likelihood of survival when individuals are faced with fluctuations in food availability (Inglis & Ferguson 1986). In this section we explore the possible psychological pain emerging from the deprivation of foraging and of the possibility of exploring the environment; since they are so closely intertwined, we explore the degree of frustration emerging from the deprivation of these behaviors jointly.

In a study that observed the behavior of junglefowl in captive conditions (Dawkins 1989), the proportion of the day spent foraging for food dominated the birds’ time budgets, with 60% of active time spent pecking the ground (even though the birds were regularly fed) and 34% spent scratching the ground. Among commercial layers in cage-free settings, a large proportion of the active hours remain dedicated to foraging (from 25% to around 40% of daytime (Nicol 2015; Schutz & Jensen 2001)) and moving about, even though the environment is much more predictable, and selection for high productivity diverts a larger share of energy to the metabolic processes associated with egg production.

Accordingly, there is evidence to suggest that modern layer breeds still exhibit a high demand for a litter substrate, consistently working to access it (Gunnarsson et al. 2000; Matthews & Chandler 1996; Nicol 2015; Dawkins & Beardsley 1986), even in the presence of freely available food (a phenomenon known as ‘contrafreeloading’) and in the absence of food rewards within the substrate. It is sometimes difficult to distinguish whether hens are motivated to gain access to litter in order to forage or dustbathe (they can perform both behaviors in some litter substrates such as sand) (Hemsworth & Edwards 2020); however, experiments aimed at establishing the cost layers were prepared to pay for the opportunity to access foraging substrates revealed that demand for substrates such as straw, which is not used for dustbathing, remains very high and inelastic (Gunnarsson et al. 2000) and similar to that observed for food. In these experiments, the imposition of a cost did not alter the amount of time spent pecking and scratching, suggesting that foraging remains a behavioral need in modern commercial layer strains.

Observations that hens continue to forage and move around after sustaining multiple fractures known to be painful (Chapter 3 (Schuck-Paim & Alonso 2021c)) indicate their willingness to pay a cost, in terms of physical pain, to be able to perform these behaviors (though it is possible that, while distracted, the salience of physical pain is reduced; Chapter 9 (Schuck-Paim & Alonso 2021b)). In video observations of laying hens kept in aviaries, the mean number of hens in the open litter area was similar at the end of lay (when the pain associated with fractures was likely worse) compared to mid or peak lay (Campbell et al. 2016a). In another study, up to 85% of hens were simultaneously observed on the litter shavings at 68 weeks of age, a higher percentage than that observed at 28 weeks of age (Campbell et al. 2017).

Other lines of evidence also suggest that foraging deprivation is detrimental to the well-being of layers. For example, aggressive pecking has been shown to be more frequent if litter space is insufficient (Odén et al. 2002). Lower baseline levels of corticosterone (a marker of physiological arousal) are also observed in layers who choose areas with additional foraging opportunities, compared to those who choose environments devoid of such opportunities (C. J. Nicol et al. 2011; C. Nicol et al. 2011). Additionally, differences in the degree of exploratory behavior of layers deprived of litter for six weeks have been also taken to indicate that they ‘miss’ access to foraging opportunities during the deprivation period, as opposed to simply working to obtain access to these opportunities

when they are made available (Nicol & Guilford 1991; Nicol 2015). Finally, when given a choice between ‘the lesser of two evils’, hen’s preferences suggest that being deprived of the opportunity to forage and explore the environment is the worst of them. For example, even though caged hens prefer larger cages (Lindberg & Nicol 1996)), they have been shown to prefer a tiny cage (0.38 x 0.215 m), which prevented even the most basic movements such as turning around, with litter on the floor more than a much larger cage (0.76 x 0.86 m) with a wire floor (Dawkins 1981). These observations were consistent even after hens had experience with the cramped conditions of the tiny cage (ruling out the possibility that they were simply attracted to the litter when they first saw it), indicating that hens assign a higher priority to litter than to space, at least over the short term.

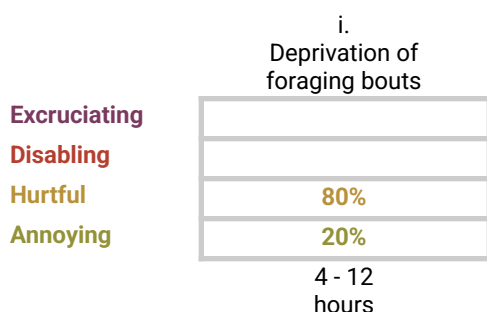
By contrasting these observations with our definitions of pain intensity (Box 1.2, Chapter 1 (Alonso & Schuck-Paim 2021)), some inferences are possible. First, because hens deprived of the ability to forage do not refrain from activities such as eating, drinking, and reacting to external stimuli, the degree to which foraging deprivation affects them is unlikely to be of a disabling (or more intense) nature. Conversely, the observation that hens are motivated to pay a high energetic cost for access to foraging opportunities (similar to that paid for access to food) suggests that this deprivation is more than an annoyance to the animal, at least one that cannot be ignored most of the time. The fact that fractured hens keep visiting the litter area lends support to this possibility. Indeed, of the core instincts identified in mammalian brains (anger, fear, panic-grief, maternal care, pleasure/lust, play, and seeking), seeking is the most important (Panksepp 2004), and there is no evolutionary reason to expect that this selective pressure would not be as strong in birds (Grandin & Johnson 2010). However, given the lack of a preference for foraging substrates over wire under some circumstances (Ingrid C. de Jong et al. 2007), we conservatively assume that the inability to forage and explore the environment is only associated with discomfort in some cases (hence the probability assigned to the annoying category in the Pain-Tracks). These probabilities can also be interpreted as representing fluctuations in the level of distress over a day and over the laying cycle.

In terms of duration, the extent to which this frustration is sustained over an entire day and laying cycle is not clear. On one hand, it is possible that the drive to forage and gather information is only interrupted when other, more immediate, needs are present (Hemsworth & Edwards 2020); the fact that wild junglefowl dedicate about 90% of their time to foraging and exploration supports this expectation. Unlike other behaviors clearly associated with a circadian rhythm (e.g., nesting), the frustration emerging from the thwarted motivation to forage and explore may thus be present at all times, with the exception of the time the hen’s attention is focused on activities such as feeding, drinking, nesting and dustbathing; other than when engaged in these behaviors, hens offered the opportunity to forage will majoritarily take it. Therefore, it would not be unreasonable to assume that hens would be frustrated for approximately 60-80% of active hours, or for approximately 8 to 12 hours given a typical light:dark regime of 16:8 hours. On the other hand, we cannot rule out the possibility that psychological pain is restricted to the time periods when a commercially-raised hen would be foraging given the availability of proper resources (i.e., space, light, litter), with it being completely absent at all other times. Assuming that 25-40% of the active daytime is dedicated to foraging and exploration, this translates into approximately 4 to 6.4 hours per day. Uncertainty regarding the more appropriate hypothesis is represented by the wide uncertainty intervals in Pain-Tracks 6.5 to 6.7, ranging from 4 to 12 hours.

Foraging and exploration are not possible in conventional cages (Pain-Track 6.5). In furnished cages, these behaviors are only minimally accommodated. The scratch pad provided to encourage foraging quickly becomes depleted of any litter and contaminated with manure. Accordingly, the time budget allocated to behaviors such as ground pecking is significantly reduced compared to cage-free housing

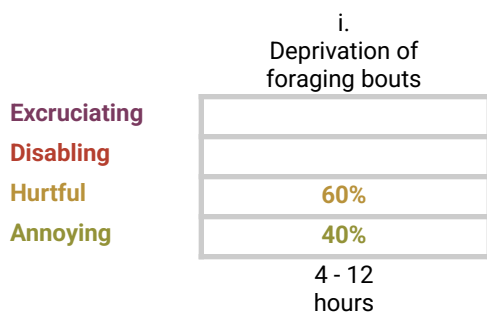
(Rodenburg et al. 2008). Additionally, the extent to which a lack of space, litter, positive feedback from foraging and novelty add to the frustration derived from the inability to perform typical foraging activities in furnished cages is currently unknown.

Pain-Track 6.5. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of the deprivation to forage and explore the environment in conventional cages. The estimated prevalence of birds affected is 100%.



In Pain-Track 6.6 we assume that the distress associated with the thwarting of foraging behavior in furnished cages is only slightly improved relative to conventional cages, represented by the higher likelihood that the pain is only annoying.

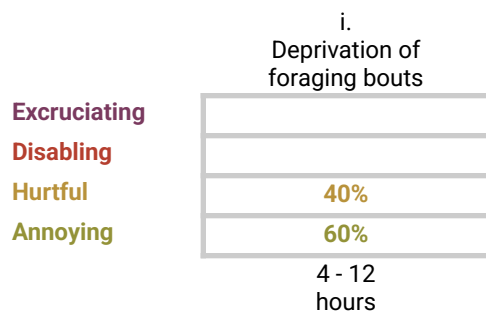
Pain-Track 6.6. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of the deprivation to forage and explore the environment in furnished cages. The estimated prevalence of birds affected is 100%



Foraging and exploration needs are better fulfilled in cage-free aviaries, provided that sufficient space, lighting levels and adequate litter materials are available. In these circumstances, no loss of welfare arising from the deprivation of foraging would be expected. However, some factors may impair the full expression of behavioral opportunities by all birds in cage-free aviaries. Even though the extent of potential deprivations is small relative to a caged environment (where virtually all behavioral needs are thwarted), they must still be considered. In addition to high stocking densities and the lack of proper litter material, movement may be restricted by the use of divisions between units or limited points of entry between the litter and the aviary tiers (Ali et al. 2016; Campbell et al. 2016a). In addition, factors such as social facilitation and circadian rhythms may lead to the temporal aggregation of individuals in the litter area, which may then become insufficient to accommodate all

hens (Ali et al. 2016; Campbell et al. 2016a). Consequently, despite having more freedom of movement, some hens may not fully experience all the intended foraging benefits of cage-free environments. Additionally, foraging may be constrained if the health of the hen is somehow impaired. As discussed in previous chapters, layers are likely to experience painful reproductive disorders (Chapter 5 (Schuck-Paim & Alonso 2021a)) and bone fractures (Chapter 3 (Schuck-Paim & Alonso 2021c)) that may accumulate over the laying cycle, so that by the end of lay their motivation to forage and explore the environment may be reduced as a by-product of physical pain. In a longitudinal study that followed focal birds over an entire laying cycle, there were no significant differences in the average time allocated to foraging as the hens aged, though the maximum and minimum times spent foraging were longer in the beginning of the cycle (Daigle & Siegford 2014). Understanding the extent to which animals can fulfil their behavioral needs in cage-free facilities is critical, so further research is very much needed to enable an estimation of not only the proportion of animals within a flock that do not have access to important behavioral opportunities, but also the proportion of cage-free houses that provide hens with adequate resources for their fulfillment. Here, we estimate that 5 to 20% of hens in cage-free aviaries are incapable of fulfilling their foraging needs. This range encompasses both our uncertainty regarding this proportion, as well as the natural variability expected across genetic breeds (Ali et al. 2016) and management conditions. This estimate can also be interpreted as the average proportion of time that hens are unable to forage (when they were supposed to), despite a strong motivation to engage in this behavior. In such cases (Pain-Track 6.7), we assume that the distress associated with the thwarting of foraging behavior is slightly improved relative to furnished cages, given the higher freedom of movement in cage-free conditions.

Pain-Track 6.7. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of the deprivation to forage and explore the environment in aviaries. The estimated prevalence of birds affected ranges between 5 and 20% (see text for justification).



Dustbathing

Dustbathing, which is common in poultry and other bird species, consists of a sequence of coordinated movements. Initially, the bird squats in the substrate and uses their wings to throw dust through their feathers, next rising and shaking off the dust. Other elements include raking of the substrate with the beak, ground scratching, wing shaking, and head and side rubbing (van Liere 1992). From a functional perspective, dustbathing has been associated with the removal of surplus stale lipids (Olsson & Keeling 2005) (improving the insulation capacity of the feathers), dandruff and possibly ectoparasites (Martin & Mullens 2012) from the feathers, although the latter function is still controversial (Vezzoli et al. 2015).

In laying hens, dustbathing seems to be regulated by interactions between external factors (e.g., the sight of a suitable substrate (Carol Petherick et al. 1995), light, heat) and internal drivers, with a clear diurnal rhythm (Vestergaard 1982). In general, dustbathing occurs more frequently in the middle of the day and afternoon in systems in which hens have continuous access to appropriate substrates. When given access to soil, sand or litter, hens will dustbathe about once every other day, often for 20 to 35 minutes at a time (Vestergaard 1982).

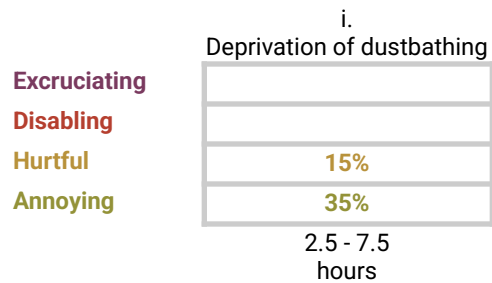
Laying hens kept in conventional cage systems are unable to dustbathe. Nonetheless, despite the lack of space and litter, caged hens will try to perform the behavioral elements of dustbathing, a process often referred to as 'sham' dustbathing. Sham dustbathing lacks positive feedback for the hen (Widowski & Duncan 2000; Wichman & Keelin 2009), involving an incomplete behavioral sequence that does not seem to reduce the hen's motivation to dustbathe (Olsson et al. 2002).

Hens have been shown to be more motivated to dustbathe after a period of deprivation; overall, the longer the deprivation, the higher the amount of dustbathing behavior that is performed when the opportunity arises (Vestergaard 1980; Vestergaard et al. 1997; Vestergaard 1982). Similarly, caged hens deprived of a litter area have been shown to be more motivated to dustbathe than aviary-housed hens: their latency to dustbathe is shorter, dust baths were longer and more numerous and more hens dust-bathed among caged hens than among aviary hens (Colson et al. 2007). These findings suggest an increase in motivation after deprivation, hence the influence of internal factors (Olsson & Keeling 2005), although the possibility that deprived hens are simply reacting to the novelty of the presence of the dustbathing material has also been considered (Nicol 1987). Additionally, the removal of dustbathing materials has been shown to elicit gake-calls (Zimmerman et al. 2000) and increase exploratory behavior (Nicol & Guilford 1991), suggesting that layers 'miss' this behavioral opportunity. This possibility is also supported by observations showing a higher number of stereotypic pecks performed by birds kept in wire cages compared to caged birds with access to sand (Vestergaard et al. 1997). Moreover, the low performance of dustbathing in red junglefowl has been associated with increased fear (Vestergaard et al. 1993), although causality cannot be inferred from these findings. Notwithstanding, a number of studies has failed to produce evidence of a motivation to dustbathe (Faure 1991; Lagadic & Faure 1987; I. C. de Jong et al. 2007; Ors g et al. 2011). This has led to suggestions that dustbathing could be of a lesser priority than other behaviors (Keeling 1994; Weeks & Nicol 2006), with some authors proposing that rather than a need, dustbathing may be a pleasurable activity that layers engage in when given the opportunity (Widowski & Duncan 2000).

In light of the conflicting evidence as to whether the deprivation of proper dustbathing opportunities has a negative impact on welfare, we tentatively assign a 50% probability that the welfare of hens is not negatively impacted in any way, and similarly a 50% probability that there is some frustration associated with deprivation, predominantly of an annoying nature (Pain-Track 6.8). In the latter case, observations that dustbathing increases with time since its last performance, with compensatory adjustments when the amount of previous dustbathing is reduced (Vestergaard 1980; Vestergaard et al. 1997; Vestergaard 1982; Vestergaard et al. 1999), indicate that the putative need to dustbathe during periods of deprivation may accumulate over time. Thus, we consider that there is some chance that the annoyance increases to a more intense level. These probabilities can also be interpreted as a temporal distribution of frustration levels in the intensity categories, with 35% of the time spent at the annoying level, 15% at the hurtful, and 50% of the interval with no distress. In terms of duration, we conservatively assume that frustration would be present during the hours typically associated with the performance of the behavior, namely in the middle of the day and afternoon (from approximately 11:00 to 16:00). In addition to this five-hour interval, we add the possibility of a 50%

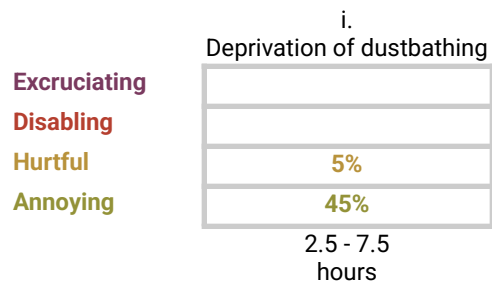
shorter or 50% longer interval (hence ranging from 2.5 to 7.5 hours), given the high level of uncertainty associated with these assumptions.

Pain-Track 6.8. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of dustbathing deprivation in conventional cages. The estimated prevalence of birds affected is 100%.



Dustbathing is not properly accommodated in furnished cages (Tauson 2005), where sham dustbathing is often observed (Cooper et al. 2004). In general, any material that is added to plastic turf mats (Astroturf) placed in the cage to allow for foraging and dustbathing is rapidly depleted; this is particularly the case given the frequent use of food particles as litter substrate (Scholz et al. 2014). Additionally, only one hen can dustbathe on these mats at a time, which may cause frustration in the other hens given the synchronous nature of this behavior (Campbell et al. 2016b). Also, substrates with fine particles such as peat and sand are preferred over Astroturf, and behavior on less preferred substrates is generally more unsettled, with shorter bouts that may indicate some degree of frustration (Alvino et al. 2013). Pain-Track 6.9 thus considers the possibility that dustbathing in furnished cages may also be frustrating for most laying hens, although less so (hence a lower pain intensity) than in conventional cages .

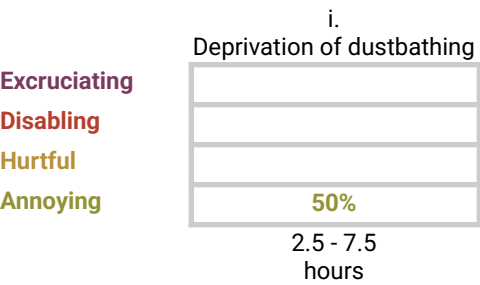
Pain-Track 6.9. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of dustbathing deprivation in furnished cages. The estimated prevalence of birds affected is 100%



In cage-free aviaries, opportunities for dustbathing are not constrained as long as the appropriate substrates are provided and the space available is sufficient for the hens to all simultaneously dustbathe, considering the synchronicity of the behavior. Naturally, in aviaries with only plastic or wire floors, or where litter is non-friable, shallow or becomes too wet, proper dustbathing is not possible (Campbell et al. 2017). Given the high level of heterogeneity in management practices, and

uncertainty surrounding this parameter, we assume that anywhere from 10 to 50% of hens will be unable to properly dustbathe, when motivated to do so, in indoor aviary systems. Because of their greater freedom of movement, the intensity distribution in such cases is slightly milder than in furnished cages (Pain-Track 6.10).

Pain-Track 6.10. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of dustbathing deprivation in conventional cages. The estimated prevalence of birds affected ranges between 10 and 50% (see text for justification)



Movement restriction

Hens need space to stretch and flap their wings, preen their feathers, shake their bodies and move around. In conventional cage systems, and to a greater extent in furnished cages, laying hens do not have enough space to engage in these behaviors, or enough space to even adopt postures (e.g., standing posture with the head erect) that are typical of their behavioral repertoire (Duncan 1998). Space and movement restriction is so severe that individuals spend most of their time spatially restrained by direct physical contact with other birds (Figure 6.3).

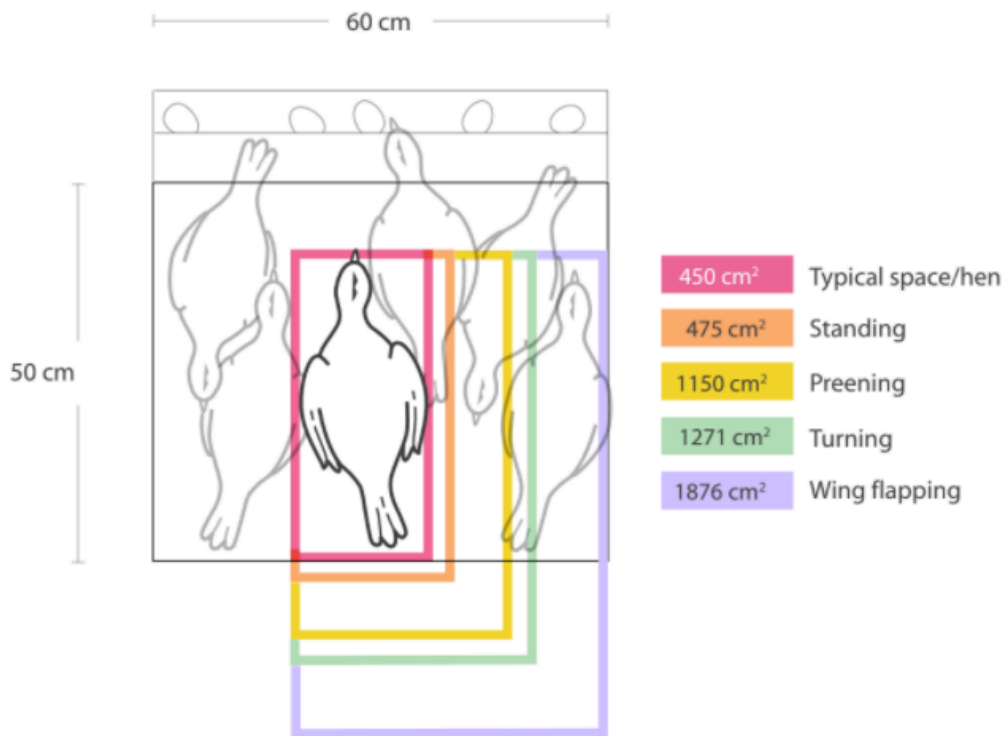
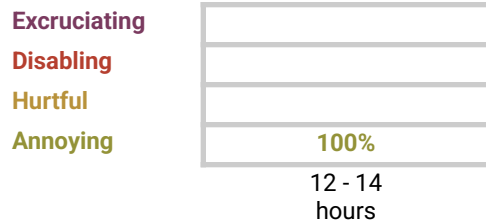


Figure 6.3. Area required to perform several comfort behaviors relative to the space typically available in conventional cage systems. Adapted from Dawkins and Hardie (Dawkins & Hardie 1989). Illustration: Alberto Gareppe.

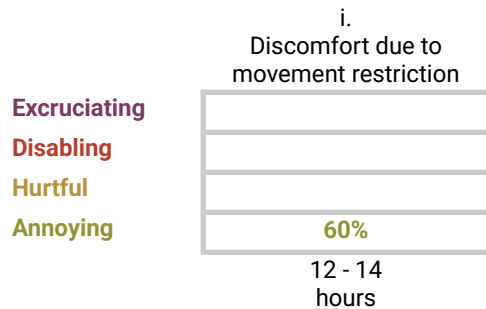
The inability to move around, perform comforting behaviors and adopt typical postures most likely leads to a permanent feeling of discomfort. It has indeed been suggested that such constraints lead to frustration (Appleby & Hughes 1991; Nicol 1987). Here, we assume that hens in conventional cages are likely to endure a discomforting feeling (only of an annoying nature) during the 14-16 hours of light typically employed in commercial systems (Pain-Track 6.11). However, we subtract the time spent feeding (2-4 hours) from this interval, to a total of 10-14 hours endured with discomfort due to crowding and the severe restriction of movement. In furnished cages, this discomfort is somewhat reduced given the greater availability of space (600 square centimeters per hen), though this space is clearly still not sufficient for the performance of many behavioral patterns (Figure 6.3); we tentatively assume a 40% reduction in discomfort in hens kept in this system (Pain-Track 6.12). In aviaries, this sustained state of movement restriction is not present, hence no Pain-Track was developed for this housing type.

Pain-Track 6.11. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of discomfort due to movement restriction in conventional cages. The estimated prevalence of birds affected is 100%.

i.
Discomfort due to
movement restriction



Pain-Track 6.12. Hypothesis for the intensity and duration of the psychological pain endured per day by commercial layers as a result of discomfort due to movement restriction in furnished cages. The estimated prevalence of birds affected is 100%.



Burden of Pain

Here we quantify the time spent in psychological pain (in hours) as a result of the deprivation of various motivated behaviors as experienced by laying hens raised commercially. Figure 6.4 shows the expected time endured at each level of pain intensity (hours), per bird affected, as a result of the deprivation of each behavior in each housing system. In the case of cage-free aviaries, the chart depicts the expected time in pain for an individual that is prevented from expressing the behavior, either due to a lack of conditions or poor health. In all cases, estimated times are based on the Pain-Tracks presented and justified previously. Only hours spent awake (16 hours/day) are considered. The results presented in Figure 6.4 consider the uncertainty regarding the intensity of pain and duration of each time segment in the Pain-Tracks, propagated through the model. However, if the reader wants to change any of the assumptions regarding the durations and pain intensities, an interactive web application can be used for this purpose, available at <https://pain-track.org/hens>.

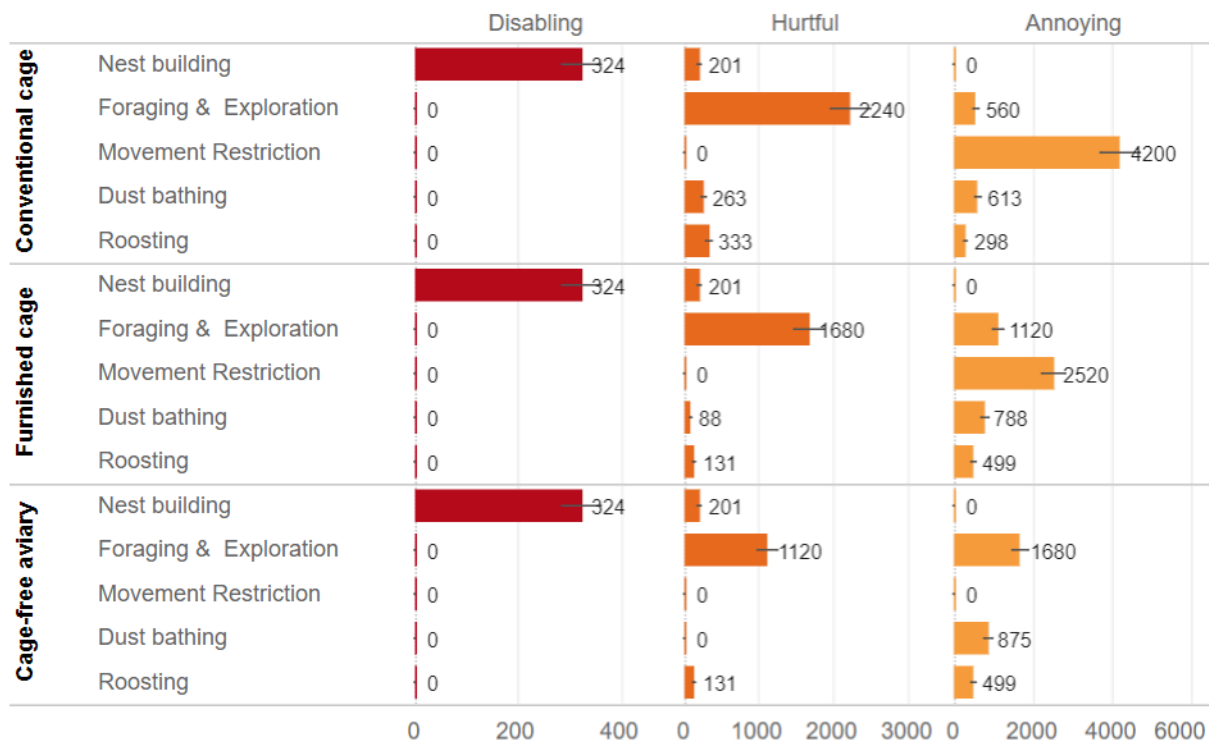


Figure 6.4. Time endured at each level of pain intensity (hours), per bird affected, as a result of the deprivation of behaviors that laying hens are highly motivated to perform. Note the different time scales for different intensities of pain. In the case of cage-free aviaries, the chart depicts the expected time in pain for an individual that is prevented from expressing the behavior, either due to a lack of conditions or poor health. Error bars represent 95% confidence intervals. An interactive comparison with other harms is available at <https://www.hen-welfare.org/charts>.

Although the frustration emerging from the inability to find a nest in which to lay an egg is shorter than the inability to perform other motivated behaviors (given the circadian nature of the behavior), it leads to an average of 324 hours of disabling pain over one laying cycle (or nearly one hour per day), more than any other source of disabling pain analysed in this book. In turn, the inability to forage and seek resources/novelty underlies the longest time in frustration at the Hurtful level, a finding naturally emerging from the observation that most of the daily time budget of hens is dedicated to this activity. The inability to dustbathe, roost in elevated areas and, especially, to move and perform a series of comfort behaviors (Figure 6.3) add to this burden, leading to long hours of discomfort (pain at the annoying level) in conventional cages, and to a lower extent in furnished cages.



Figure 6.5. Beak-trimmed laying hen. Illustration: Olga Kurkina.

Research Gaps

- ❑ The extent to which behavioral opportunities are realized in cage-free systems must be better established in terms of (1) the conditions offered (e.g., surveys determining the proportion of facilities that offer hens proper litter material, space and lighting conditions) and (2) the extent to which the hens make use of them. To this end, the entire laying cycle must be considered (e.g., behavior may be constrained if the health of the hen is somehow impaired).
- ❑ Data on the behavior (and other welfare indicators) of layers during the night is scant. It remains unknown whether the sleep and vigilance patterns of caged hens are in any way altered when they are forced to sleep in locations potentially perceived as less safe .
- ❑ Currently, little is known about the evolution of feelings of frustration (associated with the thwarted motivation to forage and explore the environment) with time (e.g., whether it accumulates , or remains unchanged, over the laying cycle). Research on motivational preferences, coupled with ethological observations of caged hens over the laying cycle, controlling for differences in health, egg production and feed consumption, could shed light on this question.
- ❑ Evidence on the extent to which the deprivation of proper dustbathing opportunities has a negative impact on welfare is conflicting. Little is known about the duration and evolution of its adverse (psychological) effects over the day and the laying cycle.

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