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"Landscape of Stress" for Sheep Owners in the Swedish Wolf Region

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Farmers who keep livestock in large carnivore areas are exposed to threat of predation directly impacting on finances and workload as well as the associated psychological stress indirectly impacting on farmers well-being. So far, little is known about such stress responses. The concept of "stress" or "stress reaction" is often used as an undifferentiated umbrella concept for the experience of negative emotional episodes. However, the stress reactions could be divided into cognitive, physiological, and behavioural aspects. This study aimed to develop and apply a theory-based approach to identify stress responses among sheep farmers in the Swedish "wolf-region." A thematic analysis of interviews conducted with sheep farmers showed ample support for stress responses among the informants in relation to large carnivores and their management, although the interviews were conducted with a different focal topic. The findings support the idea that stress responses could be categorised into cognitive, physiological, and behavioural aspects. This distinction would help to identify and fully understand the cumulative impact of stress from the presence of large carnivores on farmers' well-being.

Keywords: stress, cognitive, physiological, behavioural, wolf

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INTRODUCTION

According to evolutionary theory human stress responses have evolved in parallel with other mammals over millions of years (e.g., Adolphs, 2013; Nesse et al., 2016). Despite that stress responses are elicited by different stimuli for different species, the stress responses are at least functionally similar between species. That is, to help the individual out of potentially harmful situations. Also, the perceived imminence of a threat will shift physiology, vigilance and behaviour across species (see e.g., Fanselow and Lester, 1988; Davis, 1996; Fernandes et al., 2013). Here we will make a parallel to a lesson to be learned from wildlife ecology.

In the new century of wolf conservation, multiuse landscapes with human-wolf co-occurrence have become a central setting for conflict management. Interdisciplinary approaches are needed to see such systems as a unity that integrates humans as well as domestic and wild animals (Lischka et al., 2018). This study conceptualises human stress responses in the Swedish wolf range ecological system through the conceptual ecology of fear (Brown et al., 1999). The ecology of fear posits that impact of predators on prey animals is not limited to direct predation. Rather, the presence of predators in an ecosystem will at all times influence the behaviours of prey animals by forcing a reallocation of time and energy from preferred behaviours (such as feeding and reproducing) to predator avoidance behaviours and vigilance (Lima and Dill, 1990; Brown et al., 1999), inducing physiological and neurobiological costs to the prey animal (Zanette and Clinchy, 2019). The reestablishment of wolves (Canis lupus) in Yellowstone national park illustrates

the concept, as increasing levels of vigilance in elk and bison is observed in areas with wolves in comparison to areas without wolves, generating a "landscape of fear" for the prey (Laundré et al., 2001). This effect was particularly pronounced in females caring for their young, likely reflecting a cost-benefit evaluation in relation to the prey's or the protégé's vulnerability (Laundré et al., 2001).

Following the same ecological reasoning for predators in multiuse landscapes, such as wolves on the Scandinavian peninsula, a landscape of fear may cause wolves to avoid areas with human settlements and activity (Carricondo-Sanchez et al., 2020). Nevertheless, attacks on livestock and pets do occur (Frank et al., 2021), making people fear for the safety of pets and livestock (Frank et al., 2015). In such an interaction, wolves and humans alike can be considered the feared or fearful party in this socio-ecological system (Lischka et al., 2018). In this context, we will focus on the individual human perspective and use a basic psychological approach focusing on the fundamental responses to describe this "multiuse landscape of stress," applying it on the sheep owners in the Swedish wolf range. The use of *stress* instead of *fear* is because the concept of stress in psychology encompasses a wider variety and blends of vaguely defined negative emotions (Lazarus, 1993). Stress is here referring to a response that from an evolutionary perspective has evolved to help the individual to handle threats. Human stress responses have evolved over millions of years, together with that of other mammalian species (Adolphs, 2013). Therefore, just as the wild prey, humans may respond to the mere presence of wolves with changes in behaviour, vigilance (cognition), heart rate, and other physiological responses (Lima and Dill, 1990; Brown et al., 1999; Zanette and Clinchy, 2019).

The elicitation of stress in humans, whether physical or mental, is based on appraisals in relation to the individual's goals (i.e., to what extent is a stimulus threatening the goals of the individual) based on the individuals' experience during the course of their lifetime (Arnold, 1960). Following Leventhal and Scherer (1987) such appraisal processes are made at different levels of cognitive elaboration, from automatic processing till highly cognitively elaborated processes, reflecting ontological learning in the specific cultural setting of the individual. Highly cognitively elaborated processes are therefore likely to involve people's social context and the related values and norms of their society belonging.

From the psychological perspective, interactions between people and wildlife may take many shapes. Interactions may, as with species in an ecological system, occur either as direct interaction in an encounter situation or as indirect interaction based on memories of previous personal experiences, stories about other people's experiences, or on new information. People who live within wildlife ranges are likely to be consciously and/or non-consciously affected by their experiences of wildlife in their daily life. These experiences could be perceived as both positive and/or negative. The latter are often triggered by feelings of insecurity due to unsafe conditions, exposure to danger, risk, or fear (for a review see Methorst et al., 2020).

In areas with wolves, sheep owners are particularly susceptible to direct and indirect wolf interactions. Similar to the vulnerability of female elk and bison with young offspring in Yellowstone's wolf areas (Laundré et al., 2001), livestock farmers care for their livestock, and are expected to become more vigilant at the presence of potential threats to their animals. Direct interactions with wolves may imply financial losses if sheep are injured or killed. However, the sheep owners' concern for the welfare of their animals may also imply that indirect interactions, in which the mere perception of the presence of wildlife or reflection on previous experiences and learning, can trigger negative thoughts and feelings (Eklund et al., 2020). Notably, these "intangible effects," are more likely to be associated with negative attitudes toward large mammals, which also includes large carnivores (Kansky and Knight, 2014) such as wolves.

The number of people directly affected by wolf predation on sheep, cattle, and dogs in Sweden is limited to roughly some hundred per year (for sheep $\sim$ 200 people) according to Frank et al. (2019). However, the number of people who are indirectly affected is substantially larger as the mere thought of a predation event may elicit stress, involving emotions of anxiety, fear, anger, worry, despair, and sadness. This stress can be expressed through a combination of various subjective experiences and physiological and behavioural responses.

The occurrence of stress and its impact on farmers', also including sheep owners', mental well-being has been observed worldwide (Hagen et al., 2019; Yazd et al., 2019). Sources of stress have been attributed to heavy workload and financial issues, as well as to concerns over potential threats to animals (Yazd et al., 2019). In Scandinavia, the growing wolf population is recurrently pointed out as a source of stress to sheep owners by the farming associations (LRF [The Federation of Swedish Farmers], 2013). Zahl-Tanem et al. (2020) investigated stress among Norwegian sheep owners in relation to wolf areas and wolf attacks. In this particular case, stress levels were impacted by the farmers' attachment to their livestock, their lack of control in reducing their own stress after predation events (combined with a lack of trust in the authorities), and their perceived need to make changes to their everyday lives in order to handle the ambient pressures caused by the presence of wolves.

Sheep owners who lived in areas where sheep had been lost to wolves during the past 5 years scored significantly higher on psychological stress than did farmers without sheep production in these areas, as well as sheep owners elsewhere in Norway (Zahl-Tanem et al., 2020). Sheep owners who had experienced wolf attacks, also reported in follow-up interviews that they had experienced sleeplessness, guilt, and a constant state of anxiety. These results may not be directly transferable to Swedish conditions due to the different sheep farming practices employed in the two countries. However, stress among Swedish livestock keepers including sheep owners has also been described in a recent report from the Swedish Environmental Protection Agency (Sjölander-Lindqvist et al., 2021). This report indicated that a larger percentage of sheep owners put up protective fences than other livestock owners. However, the reported reduction of worries and stress was at best only partial for those using these fences. Thus, there are indications that stress could be trigged by perceived risks of direct interactions with wolves also in the Swedish context. However, due to the relatively lower risk of a

direct interaction in an attack on the sheep (which are to a greater extent free ranging in Norway, but kept in enclosures in Sweden), it is reasonable to assume, that the stress is often elicited by the mere awareness that wolves may be present in the vicinity.

Considering sheep owners as part of the same social-ecological system in which wolves occur, we can depart from established psychological theory on human stress and describe a theoretical framework that facilitates understanding and systematic documentation of wolf-induced stress on sheep owners. The paper is divided into two parts. First, we present a framework based on psychological research on stress responses. Starting with a brief history of the use of the concept of stress, we introduce the current terminology, we describe the concepts of stressor (e.g., the stimulus causing the stress in the individual) and how the stressors can be acute or ambient, and how effect of low intensive stressors over time can accumulate. We also outline how stress responses can be expressed within three different domains: Behavioural, Cognitive, and Somatic. Second, we apply the framework on information collected in focus groups discussions among sheep owners in Sweden to illustrate the impact that carnivores have on the "landscape of stress." Moreover, we outline different aspects of the stress caused by the perceived threat by wolves.

A THEORETICAL FRAMEWORK

Stress as a General Response

The use of the concept of stress in psychology derives from physics, and originates from the Latin word *stringere*, which mean to tighten, or to tie around tightly. Selye (1993) introduced stress in psychology in the 1930s (originally referred to as General adoption syndrome (GAS), or Biological stress syndrome). Selye (1993) considered stress, as a non-specific response constituting of a bodily response that was the same independently of what triggered it, meaning that the stimulus could be either physical or mental. This general response was described as an activation of the body to help the individual to maintain ongoing activities, or to try to go back to an activity that had been interrupted (Feuerstein et al., 1986). This idea of stress as a broad concept is still relevant in psychology and has a broad use in society. Thus, it is important to recall that the stress is referring to a response that from an evolutionary perspective has evolved to help the individual to handle threats, but that in many circumstances for humans in society of today the stress response may be irrelevant, as the context is different compared to when the reaction evolved (see e.g., Nesse et al., 2016). Although stress involves a broad range of negative emotions, the emotion of fear is often a main ingredient (Steimer, 2002; Adolphs, 2013).

Stressors

Despite that the stressor varies due to ontological learning in the specific cultural setting of the individual, stressors elicit the same kind of basic stress responses. When no stressor (/threat) is present or expected, the individual (humans, as well as most other mammals) will engage in their preferred activity. However, as soon as the individual experiences a probability of encountering a stressor (e.g., threat), different aspects of the preferred activity will change. As an example, foraging could become more efficient/rushed in between episodes of heightened vigilance when an encounter of a stressor is considered probable (Fanselow and Lester, 1988). Such a behavioural response would have evolved to help the individual handle the stressor by directing attention toward the stressor, assuming that the cost of the behavioural change is less than that of being eaten by the carnivore. That is, the frequency, location, time of the day for the activity or some other aspect will change to reduce the probability of encountering the stressor.

Acute Respectively Ambient Stressors

Stress could be triggered either by an abrupt change in the environment (acute stressor), or by a slow or accumulative increase over time (stressor). The experience of how close in time or space the stressor is (i.e., the imminence) will affect the following response (Fanselow and Lester, 1988; Maren, 2007; Fernandes et al., 2013; Löw et al., 2015). The sudden onset by an acute stressor may result in a stress response that helps the individual manage the stressor. An example of an acute stressor for a sheep owner could be if the sheep are attacked by a wolf. Here, the stress response would imply actions that result in deterring the wolf from killing more sheep. When the sheep are saved from the wolf attack, the sheep owners' acute stress would be temporally relieved.

On the contrary, a slow increase in a number of different demands and threats may instead accumulate low intensity physiological effects of the stress response(s), for example, muscle aches from low intensive muscle tension. This is often the case with the presence of so-called ambient stressors, such as low intense stimuli in the environment (e.g., presence of background noise and air pollution, Glass and Singer, 1972). The presence of wolves in the landscape may constitute an ambient stressor to the sheep owner, which could on its own be manageable, but could be detrimental if it occurs alongside other stressors.

Cumulative Stress

The theory on cumulative stress can explain why the wolf, as an ambient stressor which co-occurs with other stressors, can have a large impact on the sheep owner's psychological well-being. This theory suggests that low intensive exposure to several ambient environmental stressors, in parallel or temporally close in time, can result in negative effects on psychological well-being (Evans, 1996), because the mental cost of handling one stressor reduces the capacity to handle an additional stressor (Baum et al., 1982). As such, stressors within different domains must be considered in parallel (Evans et al., 2012). As an example, sheep owners are subject to a number of different stressors in their daily life (see Yazd et al., 2019). Such stressors are, for example, filling out government forms, bad weather, adjusting to new government regulations and policies (McGregor et al., 1995), concerns about the future of the farm, outsiders not understanding the nature of farming (Kearney et al., 2014), and these stressors have been shown to negatively affect psychological wellbeing among farmers (Yazd et al., 2019). This means that if a sheep owner is already concerned about the financial situation and heavy

workload, regardless of the risk of an attack, the mere presence of wolves in the surrounding landscape could exponentially increase the amount of stress the sheep owner experiences (Zahl-Tanem et al., 2020). The cumulative effect of the various stressors must therefore be considered in order to fully understand farmers' stress responses to the presence of wolves. Cumulative effects of stress should be understood both as the presence of stressors (e.g., the perceived imminence of wolf attacks or workload associated with implementation of protective measures), and as the absence of coping ability to reduce the effect of the stressors (e.g., social support, financial compensation etc.). Intrusive thoughts about wolves as a looming threat of an encounter (direct or vicariously *via* the livestock) add to the stress response and are likely to impact on perceived quality of life.

Three Domains of Interlinked Stress Responses

Similar to the responses of wild prey with changes in behaviour, vigilance (cognition), and physiological responses to wolves (Lima and Dill, 1990; Brown et al., 1999; Zanette and Clinchy, 2019), human stress responses can also be categorised into three domains: Behaviour, Cognitive, and Physiological responses (**Figures 1**, **2**). The three response domains are interconnected and may occur simultaneously or as direct consequence of one another. However, a response in one domain may be more salient in one situation to one person than to another person, or to the same person in another situation.

To illustrate the close interlinkage of stress responses we will slightly shift the focus from the broad concept of stress to one specific emotional part of stress, fear. A situation where a person perceives a stressor that is appraised as involving some type of threat triggers fear. Fear stimulates *behaviours* that have provided an evolutionary advantage for the individual to handle the situation. That could be through fight or flight. The behaviour is accompanied by *physiological changes* (Fanselow and Lester, 1988; Fanselow, 1994), and changes in the possibilities for higher *cognitive functioning* in humans such as simple decision making (e.g., Flykt et al., 2013). These interlinked responses have been described as a defence cascade (Kozlowska et al., 2015). If a fight or flight response is not possible in a specific situation, or might not relieve the experience of an increased probability of encountering the stressor, the response may translate into an intrusive thought that takes mental resources from attention to other issues and thus impair learning and memory. Below we take a closer look at the domains of stress responses.

Behavioural Responses

The human stress responses can be categorised into *operational* and *non-operational* (i.e., made to obtain a goal or not) behaviours. Operational behaviours can be further divided into functional (i.e., enable the individual to handle the situation to some extent, to reach the goal of avoiding the threat) and non-functional (i.e., will not help the individual to handle the situation) behaviour. When faced with the stressor there will be a freezing response that might be too small to experience by the naked eye, but that could still be measured (Davis, 1996).

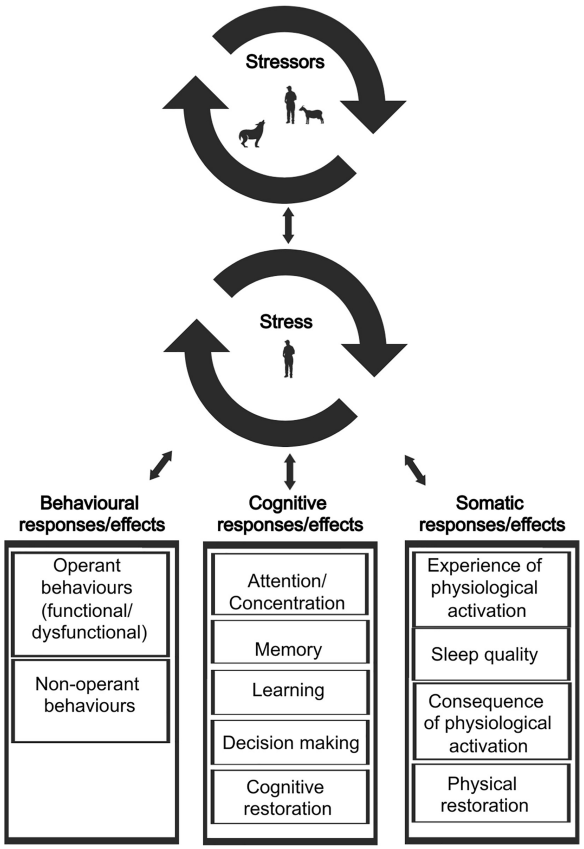

FIGURE 1 | The theoretical model with the three different response domains of stress responses: behavioural, cognitive, and somatic. Each domain is divided into subcategories.

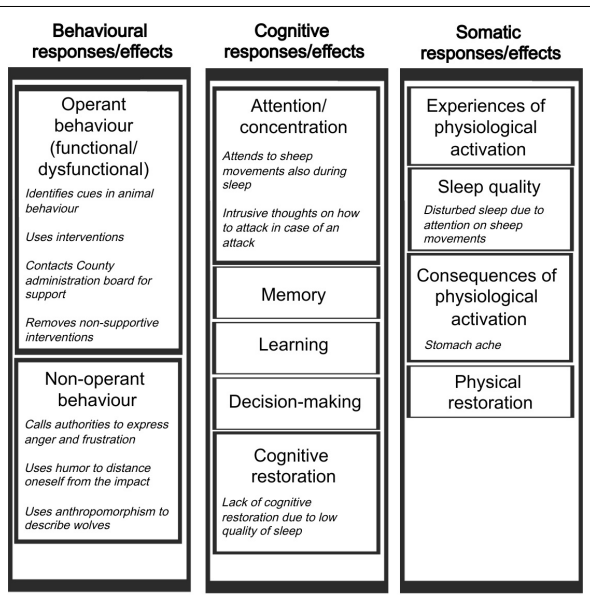

FIGURE 2 | The results from the analysis. Not all subcategories have annotations, as these aspects of the stress response were not reported during the group discussions.

Freezing is a muscle tension intended to prepare the individual for initiating an abrupt action that is aimed at increasing the distance to the stressor by fleeing from, or when flight is not an option attacking (/handling), the stressor (Azrin et al., 1967) when it gets too close.

Cognitive Responses

Cognitive aspects of the stress responses can be expressed as problems with *attention*, *memory*, and *learning* (Kausche and Schwabe, 2020), as well as decision-making (Starcke and Brand, 2012). As an example, exposure to a threat (e.g., large carnivores, or other animals experienced as threats/stressors) also requires mental resources which in turn reduces speed and accuracy of relatively simple tasks (e.g., Flykt and Bjärtå, 2008; Flykt et al., 2013). This is coherent with the fact that that humans blood flow in the prefrontal cortex (a region associated with cognitive control, see Miller and Cohen, 2001) decreases during intensive stress (Garcia et al., 1999). The frequencies of cognitive responses will indicate the possibility for *cognitive restoration*.

Physiological Responses

Physiological or somatic aspects of the stress responses can be a direct experience of *physiological activation*, such as an increase in heart rate (Tyra et al., 2020), sweaty palms (Boucsein, 1992, p. 284–285), and a shortness of breath (Kreibig, 2010), but can also be experienced as *consequences of physiological activation*, such as muscle tension (Bird et al., 1985), stomach pain (Brobeck et al., 2007), and headaches (Nash and Thebarge, 2006). Reduced *sleep quality* (Åkerstedt et al., 2012; Cardoso and Ramos, 2018) could also be a result of stress in the somatic/physiological domain. A prolonged stressor that cannot be relieved in fight or flight actions, but that lingers over a long period of time, results in an accumulation of stress and could result in muscle aches and other physiological consequences, as well as a lack of physical restoration. One reason for why such an accumulation occurs for sheep owners in wolf areas, is that they are regularly exposed to stimuli associated with the wolf that triggers the stress response (e.g., by seeing tracks, scratches, or remains of prey carcasses), but rarely encounter the wolf itself. These behaviours are all related to physiological effects, for example an increase in sweat gland activity and blood pressure and changes in heart rate. The frequencies of these responses will indicate the possibility for *physical restoration*.

AN EMPIRICAL APPLICATION OF THE FRAMEWORK: METHODS

This section reports on the application of the theoretical framework to focus group interviews carried out among sheep owners in large carnivore areas in Sweden.

Participants and Procedure

Interviews were conducted as three focus group meetings with sheep owners in the spring of 2016. All participants were active sheep breeders within the regions that represent the main distribution range of lynx and wolves in Sweden. Participants owning small herds held on average 50 ewes (range 10–120), participants with medium herds held on average 136 ewes (range 60–300), and participants with large herds held on average 345 ewes (range 130–500). Participants were recruited through the Swedish sheep breeders' association, where a contact person on the board was asked to suggest participants based on their geographical location and the size of their herd. Focus groups were held in three different counties, including participants with smaller herds in Uppsala, medium sized herds in Värmland, and larger herds in Örebro county. All three counties are in the south-central parts of Sweden, an area mainly dominated by a mosaic landscape of agriculture, lakes, and boreal forest production.

Because the participants of each group were active in the same region, and within the same organisation, they were familiar with each other since before and appeared comfortable in sharing their experiences in the group setting. The interviewer ensured all were actively participating in the discussion and that no single participant dominated the discussion. There were 4–5 participants in each group, and the semi-structured interviews lasted approximately 2 h following an interview guide. In total, 10 female and 3 male sheep owners participated in the focus groups, and the average age was 49 years (range 32–61). The main focus of the interviews related to the animal owners' views on using various interventions intended to prevent large carnivore attacks on their sheep (see Eklund et al., 2020). The reason for including participants with various sized herds was that they were expected to face differing challenges in relation to intervention use, which was the main focus of the interviews. However, discussions relating to the contextual appraisals of direct interaction with carnivores spontaneously occurred. Also, the interviews did not specifically focus on wolves, but large carnivores in general, nevertheless the wolf had a pronounced role in the discussions. An event covered in media at the time of the interviews, which was likely salient among the sheep owners and may have influenced the focus on wolves, was the conflict that occurred between the wildlife managing authorities and a large sheep farm in another county. There, the authorities had filed a report on "lack of animal protection" against the farm which had suffered major losses of sheep to wolves. This event was brought up by the sheep owners as a horrific example of wolf management, or as a contrast to their positive experience with the authorities in their counties. All interviews were recorded and transcribed verbatim using Atlas TI 7.0.

Analysis

We took a deductive approach in our analysis of the interview material. A theoretical framework based in previous research guided the creation of thematic codes on three levels of detail (**Figure 1**). The first level related to the mentioning of stress or other words describing negative emotions, the second level to the mentioning of behavioural, and cognitive or somatic/physiological responses. The third level of detail related to specification of these responses. Stress would in some instances relate directly to interactions with large carnivores but in are other situations related to indirect responses to carnivore management interventions as previously described by Eklund

et al. (2020). Codes were therefore specified as direct or indirect in relation to carnivore interactions.

Intercoder reliability was established by a parallel coding of approximately half an interview, i.e., 1/6th of the total transcribed interview material, undertaken by two co-authors (AF and AE). The initial inter-coder agreement was 72%, and with uncertainties discussed between the two co-authors, inter-coder agreement reached 93%. The remaining uncertainties were discussed with a third co-author (MJ). This discussion highlighted the need for creating an additional coding-theme relating to consequences for social interactions. Several of the uncertainties brought to this discussion specifically related to problematic social communication following carnivore interactions.

RESULTS/FINDINGS

The Presence of Reported Stress and Other Words for Negative Emotion

Sheep owners used word like stress and other negative emotion words (worry and anxiety) in relation to wolves and other large carnivores. The sheep owners describe the summer as the time of the year when they would expect the least stress from taking care of the sheep, as the sheep are out grazing in the pasture and only need daily supervision and water. The summer is thus expected to represent a welcome break from the extra work of feeding and cleaning out in the stables. Yet, with the return of the large carnivores, keeping the sheep in the summer pasture is also described as a time which is associated with worry and anxiety. It is during this time that the sheep are kept further from the house and stables and are at higher risk of being predated. This stress would likely not be described as an acute onset of stress, but rather illustrates the prolonged sense of anxiety that would come from an ambient stressor.

> *"... it was perhaps a month before we were set to release. . .release them [the sheep]. It's a bit stressful too, because essentially they [the tracked wolves] were coming closer and closer. And then I saw. . .after I was out tracking, because we had had some snow, and then I became even more concerned because I had tracks all around my yard. . ."* (Värmland)

These citations illustrate how the mere presence of wolves and other large carnivores are appraised stressors, which goes in line with the findings in previous studies (Yazd et al., 2019; Sjölander-Lindqvist et al., 2021). In the participants' references to the stressor they talk about stress as closely connected to feelings such as worry and anxiety (Lazarus, 1993).

> *"The entire summer is one prolonged agony"* (Örebro)

> *"You can never quite describe that worry"* (Örebro)

The onset of such negative emotional outcomes may stimulate behavioural reactions to deal with the stressor and reduce the negative emotion. Worry has for instance been identified as a link between the experienced carnivore presence and behavioural adjustments used to cope with the threat (Eklund et al., 2020).

Operant Behaviours

The expanding carnivore populations have resulted in an increased vigilance among sheep owners. Such increased vigilance is part of an operant behaviour directed at handling the situation, for instance through attempts of identifying cues in the animals' behaviour and predict the risk of a large carnivore attack:

> *"Because you always go around listening and being attentive: Is the herd unsettled? In a way it should not be? How are they grazing, how are they standing? Have they herded together? And you kind of register all of those things a lot more than you used to"* (Örebro)

To cope with the threat of attacks and in order to reduce stress, sheep owners report using a variety of interventions including carnivore deterring fences and night-time confinement, lambing indoors, removing carcasses and similar attractants as well as the use of scaring devices. In situations where large carnivores have been observed in the vicinity of the farm or pastures, or when attacks on sheep have occurred, the sheep owners may contact the county administration board for support. The use of some interventions, such as keeping animals in small night pens, are undertaken to prevent repeated carnivore attacks subsequent to an initial depredation event. It should be noted that although the interventions intended to prevent large carnivore attacks on sheep are provided as tools for sheep owners coping with the large carnivore threat, the interventions themselves can sometimes evoke additional stress for sheep owners if the intervention is unsuitable for their life situation or provide an increased awareness of threat. This implies cumulative stress. In such cases a functional operant behaviour to reduce the experienced stress can be to remove the intervention, although it contradicts the aim of reducing the threat of an large carnivore attack.

> "*I got to borrow three of them [sound deterrents], and that scream is really powerful and loud. And because there are two different sounds. . .And considering the fact that I work in shifts and so on, no. . .no I just couldn't handle it. . ..I became nervous in the middle of everything. I just said: "these are going XXXX down!" You know, don't get me wrong, because it was a really good thought that they [the county administration board] offered me, "I think you should use this." Well that's great, really great you know, but I just can't handle hearing "huhhh, it just went off" and then you quickly run up to the bedroom window and sort of hang there halfway out the window and check, there's that one, there's that one. . .which one of them just went off? And then you need to scan the perimeter. . .and we're talking a few hundred meters distance and you go "damn, the binoculars are in the kitchen." Well it's like. . .it was really stressful!"* (Värmland)

In many cases the reported operant behaviours, such as intervention use, are direct attempts initiated by the sheep owners themselves to cope with the worry of an attack with or without a preceding predation event having occurred. These behaviours include the use of interventions previously mentioned as well as increased supervision of the sheep. The sheep owners themselves describe the behaviours as an urge to do something, whether the behaviour should be regarded as functional or dysfunctional is dependent on if the behaviour have any actual effect on reducing the risk of large carnivore attacks or not:

"I try to walk with the dogs. I have no idea if it matters but I think that if they [the wolves] walk here, then at least it might smell of dogs. Around the pastures like that, when I'm out walking them anyway – [Do they care about it?] – I have no idea" (Örebro)

*"Every night, when I need to take the dogs out for a walk anyway, I walk around the entire yard. But it's really just my own belief that it might leave behind some tracks that will prevent something [*large carnivores*] from entering. I don't have any proof that it works or not though. But I do it anyway since I'm going out anyway, I might as well walk around. . ." (Uppsala)*

Operational behaviours are here viewed as the use of different interventions. For example, putting up carnivore deterring fences and having the livestock indoors during the night. These behaviours, aiming at reducing the possibility of a wolf attack decreased stress, albeit moderately.

Non-operant Behaviours

Some of the behavioural responses that sheep owners employ to reduce the onset of stress cannot clearly be defined as operant behaviours. One example would be to, refrain from a earning a desired income from rental grazing on other people's land. Such "business" is considered a potential income and an opportunity to contribute to maintaining an open landscape outside of the own property. However, letting the sheep graze on someone else's land also implies less control over the well-being of the sheep, and the worry prevents the owners from letting the sheep go. This behaviour corresponds to changes in strategies to avoid the stressor in the Fanselow and Lester (1988) model for threat imminence. The mere knowledge that a threat may occur results in a changed behavioural pattern, in this case to not have the livestock too far from oneself. Without the perceived risk of large carnivores attacking the animals there would be no reason to refrain from letting the sheep for rental grazing. Further non-operant behaviours may include calling the appropriate authorities simply to express the experienced anger and frustration. This behaviour does not directly handle the situation with the wolves but may be explained by the fact that imminent threats reduce the blood flow in the prefrontal cortex, (Garcia et al., 1999) thereby reducing the possibilities for elaborated mental activity. The need for action might be larger than any premeditated idea with the phone call to the authorities. However, if the phone call could result in a calm discussion about possible and acceptable interventions, it might turn into an operant behaviour.

Some behavioural responses to the negative emotions and stress are clearly non-operant in relation to handling the threat of a large carnivore attack on the sheep. Coding of the interview material revealed a social dimension of such behavioural expressions, either as emotional outbursts or as the anxiety of stirring up a fuss. The negative emotions and stress may thus have indirect consequences for social relations, and examples were provided for such social interactions with partners, peers, and authorities:

"Well it is the county administrative board that. . .serve us [information about interventions]. When I'm pissed off then I call them" (Örebro)

"...but when he came home then he [partner] says – I don't dare to tell you this" –"We...I think we had a wolf in front of us on the track. . ." (Värmland)

Another non-operant response for dealing with the stress that large carnivore situations evoke can be to use humour to distance oneself from the impact that the situation has had. Although this behaviour is non-operant for dealing with an actual carnivore-sheep interaction situation, it could provide a means to deal with the emotional onset and generate a sense of control in the social (interview) setting. During the interviews, humour was repeatedly used when describing stressful situations with large carnivores, as sheep owners were highlighting the absurdness of behaviours and reactions, evoking laughs and giggles in the focus group. Anthropomorphism was used to describe wolves with names or behaviours. When talking about self-experienced negative events or being exposed to unpleasant stimuli people might smile, or even laugh (Marci et al., 2004; Ansfield, 2007; Hess and Bourgeois, 2010; Flykt et al., 2021). Thus, using humour when talking about large carnivores may be a form of emotion regulation (Gross, 1998).

"And I've seen wolf, so I have! Yeah, I was going out. . .yes in a crossing at home. . .I was driving to a hockey game, that's when I met what was Mr. Wolf. That's a bit so. . ." (Värmland)

"They [wolves] are so scared. We've seen them. They are, well they don't get off the road. Because we have. . .They're. . .if there are two poles like this they don't like to go between two poles like this. . .because maybe they think there's wire between them. Really scared. They walk past and say "howdy howdy" to the sheep and it's not like. . .Yeah but seriously. . .yeah we've seen them. They stood outside and watched when the friend [the sheep dog] herded sheep inside the fence. They were standing on the road like this and were kind of checking like "oooh, that's exciting." But I mean, if they come inside and start taking, then there is no fence that will be able to stop them" (Örebro)

Using humour when talking about pressing matters is non-operational as it will not handle the problem per se. However, it might be a way of emotion regulation (see e.g., Gross, 1998) to reduce the intensity of negative emotions. Thus, a humoristic approach should probably not be regarded as that the situation being fun or even as the retrospective aspects of being amusing, but rather as a way to handle the situation without being overwhelmed with negative feelings.

Cognitive Effects

The interview material revealed some examples of how the potential carnivore presence and interaction generated cognitive stress responses among sheep owners, particularly in relation to attention/concentration, potential effects on the memory (Kausche and Schwabe, 2020), and lack of cognitive restoration. Effects on learning and decision-making as a direct result of carnivore presence were not identified from the interviews in our case study. That is not to say that there are no such aspects of stress in these situations, but rather that associations between wolf activity in the learning or decision-making were not as salient to the interview persons as other cognitive effects.

One adaptation that sheep owners use to relieve the intruding thoughts and in order to get some sleep is to supervise the sheep during the night as well. By fitting one of the sheep with a collar and bell and keeping the bedroom windows open, the sheep owners attempt to keep their attention on the sheep herd's movements when they are sleeping also. A sheep owner pointed out that while this may have consequences for the quality of sleep (and cognitive restoration) at least then there is some sleep.

*"Starting when the sheep are let out in the pasture, then *participant* and *partner* sleep with open windows, and open doors. No, but the windows are open. And it. . . then it depends on which side of they yard they are at. And it's because we put a bell on one of the ewes. And we do that partly to hear what sound it makes, and you do that even while you are sleeping. So I don't know how well you sleep, but at least you sleep. But you do hear it, yeah you do. If it moves, and then it's supposed to. . .well it makes a certain sound when they are just grazing. And if it's quiet it means they are lying still. And if it starts sounding an awful lot like this, then it means you need to get up to check on what's going on? (Laughter) And you wake up.*

The vigilance for sounds of wolf presence indicates that intrusive thoughts are easily triggered and that some sheep owners in the interview materials were sensitised to certain sounds. With such sensitisation triggering potential catastrophic appraisals and intrusive thoughts, cognitive restoration would be hard to achieve. That sensitisation to certain aspects of the environment occurs are essential for most mammals, humans are no exception. However, if the triggers are not specific enough, many sounds trigger an orientation toward the sound, which may have accumulative negative effects over time (see e.g., Lovibond et al., 1993).

Somatic/Physiological Effects

Some examples of sheep owners experiencing a physiological activation or consequences of physiological activation were provided in the interviews. These included a sense of feeling bad or experiencing a stomach ache at times of stress or negative emotions, also associated with a lack of cognitive restoration.

"It's like a lump in the stomach when we release the animals. Yeah, and that anxiety can never be described. And I don't think any animal owner can say that it's calm and pleasurable anymore. . ." (Örebro)

"I'm retiring now. And now I've waited many years to see if my daughters, or one of them, would like to take over. And then I just got to a point where I thought. . ..no, I don't want any of my daughters to take over. It's devastating. They. . .they'll go under. It's not possible. They can't take over. They will not be able to cope with it, physically psychologically that is. It's insane" (Örebro)

GENERAL DISCUSSION AND CONCLUSION

The application of a theoretical framework, based in the established basic psychological research on stress, reveals that sheep owners in focus group discussions about large carnivores describe the presence of wolves and other large carnivores primarily as an ambient stressor. In similar contexts the effects have previously been addressed as intangible or psycho-social effects of large carnivores (Kansky and Knight, 2014; Sjölander-Lindqvist et al., 2021), which we are able to describe in more detail from a basic psychological perspective. Owning sheep in a large carnivore area appears to imply stress of a relatively low intensity, but that is present over a prolonged period, i.e., an ambient stressor. This on top of many other stressors of daily life for farmers and animal owners will accumulate stress, especially if the potential to take action to safeguard the animals and/or the opportunities to obtain relief and restoration are limited (Evans et al., 2012). The sheep owners reported such alarming, but not surprising, experiences as the constant perception of threat that the wolves represent. This is particularly evident during summer times when the sheep owners' anxiety may cause reduced possibility for cognitive restoration. Although stress induced by wolves may be the onset of acute stress in response to a single event, for example in case of an attack, it seems highly relevant to take the perspective of cumulative stress.

In the literature on "landscape of fear" (e.g., Laundré et al., 2001) predators are understood to have a similar impact on co-occurring species, i.e., they elicit fear not only through direct interactions and predation, but also indirectly by causing vulnerable prey to reallocate time toward safer, but from an energetic and reproductive point of view less preferred, options. Here we show that the same effect may also apply to humans, in our case study illustrated by sheep farmers in the Swedish wolf range. While natural prey may reallocate time to spend more time on the lookout for approaching carnivores, sheep farmers may keep their windows open to listen for unsettled herds. While prey animals may move into open fields with hesitance, sheep owners experience a lump and anxiety in their stomach when releasing their sheep in the field. Although the indirect effect of carnivore presence is similar for humans and natural prey species alike (Clinchy et al., 2013), for humans it may be more appropriate to use the term "landscape of stress" to illustrate the indirect effects on, for instance, sheep owners' everyday life. Even though humans are not directly comparable to other species in some ways, all mammals share much resemblance and millions of years of evolution (see Nesse et al., 2016). It is therefore highly plausible that psychological understandings of different domains of human stress responses, such the one presented here, are helpful to further understand reactions and behaviour in a framework of the ecology of fear.

The unique contribution of the present work is that our analysis goes beyond reported stressors and stress, and makes use of a psychological theoretical framework adapted to provide a detailed description of different domains of stress responses. Behaviours, operational as well as non-operational, somatic/physiological reactions, and cognitive responses were identified. Drawing on well-established theory on human stress, the framework can be applied also to other human wildlife interactions. A limitation of our work is that it is solely based on interviews. It might be that reports on behaviour are more easily communicated and therefore reported in a group discussion

than somatic/physiological reactions or cognitive responses. Psychology offers a broad range of standardised methods used to capture stress responses in the domains of somatic/physiological reactions, such as cardiovascular measures, and cognitive effects. Further studies would benefit from complementing interviews with established questionnaire batteries, cognitive tests and physiological measures. The distinctions of the sheep owners stress responses into the three domains helps to more closely tie the cumulative stress in response to large carnivores to the psycho-physiological processes involved. It thereby becomes possible to gain a more nuanced understanding of the potential health and well-being outcomes for sheep owners in wolf/large carnivore areas.

The "landscape of stress" for sheep owners when coexisting with wolves and other large carnivores suggest that sheep owners' behaviour is somewhat similar to behaviour described for prey in the ecology of fear (Laundré et al., 2001). They respond to the carnivore presence and change their behaviours in accordance with the experienced probability of a predator attack. Such changes will be adaptive as long as the behavioural changes are proportional to the probability of an encounter. One emerging question is if the landscape of stress is similar to the landscape of fear based on the cognitively elaborated appraisals made by humans involving higher cognitive functioning as well as cognitive bias. That is, despite the possibility to logical reasoning there is no need that these higher mental processes should overrule evolutionary more old processes. Humans might overestimate the probability of an encounter or attack and thus have stronger responses than necessary based on the actual probability. It should be noted that all anxiety disorders are to the ground an overestimation of threat encounters, and the lifetime prevalence of anxiety disorders in humans is >30% (Bandelow and Michaelis, 2015). This overestimation of threat encounters could involve a number of factors associated with appraisals based on ontogenetic learning coloured by the prevailing vales and norms of their society. Humans will, on the other hand, be much more capable of modifying both their situation and the environment in the landscape of stress to a much larger extent than a prey animal will ever be capable of, thus providing a greater control over the situation. However, the higher cognitive functions in humans also provide opportunity to dwell on the possible ways of dealing with the threat, which might result in a prolonged exposure to intrusive thoughts and elaborations. Such thoughts may act as ambient stressor and to the cumulative stress.

Although the coexistence between humans and large carnivores in multiuse landscapes imply other challenges than those between prey animals and wolves in areas such as Yellowstone national park, there are also striking similarities (Clinchy et al., 2013). Here we focus entirely on the responses of the individual farmer to the large carnivore as a stressor, but in a next step, it is also plausible that the responses that sheep owners have to their stress of large carnivores can have consequences or cascading effects on the species composition in the landscape. When sheep farming is closed down, or if sheep are gathered in fields near human settlements, trees, bushes and grasses take over the abandoned grazing areas and the abundance and species richness of flowering plants and herbs diminish. This can have severe effects for pollinators and biodiversity conservation in the Swedish landscapes (Winsa et al., 2017; Rotchés-Ribalta et al., 2018). Interventions to prevent carnivore attacks on sheep may also impact other species, carnivore deterring fences will for instance limit the movements of various medium and large sized wildlife (Woodroffe et al., 2014), and livestock guarding dogs may have a local impact on target and non-target wildlife including mesopredators such as foxes and badgers (Smith et al., 2020). Thus, the landscape of stress could, just like the landscape of fear, imply cascading effects for biodiversity and species richness/abundance on a landscape level. Moreover, also social processes may be altered in the landscape of stress. It can be speculated that time for nurturing social relationships decrease, the social interaction with family members might get tense due to underlying stress (Novaco et al., 1991), and in turn breaking down relationships. Another possible social effect of the landscape of stress might be more intense polemic interactions between different interest groups. By incorporating psychological theory with an ecological concept, we can better understand the systems in which humans and carnivores live. These are not separate worlds, but rather they are depicted by different scientific perspectives providing multiple views of one system, where interactions occur and where carnivores influence humans and humans influence carnivores (Carricondo-Sanchez et al., 2020) at some level of coexistence. This type of interdisciplinary understanding of coexistence provides a starting point for the new century of wolf conservation.

This study shows that stress affects behaviours, cognitions, and physiological activity and that this becomes apparent even when the focus is not on stress. Apart from introspection of experience of states that humans would label stress, this study show that other sources of information are available for gaining a more nuanced picture of stress responses. Thus, this indicates that investigation of stress responses could and should address all components of stress. Despite that humans by some are considered as more cognitively developed, some basic psychological processes could be parallel to processes in other mammals. In the present case that a landscape of fear in prey animals can transpose to a landscape of stress for sheep owners in wolf areas.

DATA AVAILABILITY STATEMENT

The data analysed in this study is subject to the following licenses/restrictions: Anonymised and transcripted group interview data in Swedish could be granted for appropriate purposes. Requests to access these datasets should be directed to JF, Jens.Frank@slu.se.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the Local Legislation and Institutional Requirements. Written informed consent was obtained from the patients/participants.

AUTHOR CONTRIBUTIONS

AF and AE drafted the different parts of the first version of the manuscript. All authors have rewriting and restructuring the first draft to its present form.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.