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Review Article

THE IMPLICATIONS OF FEAR ECOLOGY FOR INTERACTIONS AMONG PREDATORS, PREY AND MESOPREDATORS

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ABSTRACT

Wildlife, as well as human beings, are prone to be affected by fear. Large predators and mesopredators usually produce this fear in animals. This effect is recognised in the form of various behavioural changes and adaptations, which, in turn, affects the whole ecosystem. However, we often overlook the role of large predators and mesopredators in the sustenance of our ecosystem by such non-lethal effects, because fear is often seen as a psychological effect rather than something that can be found through explicit scientific means. Indeed, the fear that predators trigger inside their prey may play a significant role in the maintenance of the natural environment. This paper aims to analyse this hypothesis by reviewing the function of the ecology of fear based on the interaction among predators, prey, and mesopredators. We consider the factors involved in the effective functionality of the ecology of fear, including habitat landscape, season, weather, and predation risk. We also assess the extent of influence of large predators on behaviour and distribution of prey and mesopredators in terms of predation cues and prey grouping as responses to predation risk. Finally, we discuss the implications of fear ecology for wildlife conservation and management and new challenges.

Keywords: Fear ecology, Grouping behaviour, Prey, Mesopredators, Predation risk, Predation cues.

INTRODUCTION

The carnivores and their lethal nature had inspired much fear in the animals and human beings alike (Mark, 2015). Most of the evolutionary adaptations of animals and human beings can be attributed to these predators. Their fear-triggering presence has led to the emergence of a new field in the ecology known as the ecology of fear. The study of fear ecology has acquired much attention in recent years. According to Brown *et al.* (1999), the interaction between predator and prey is mostly based on surreptitiousness and alarm produced. This statement goes at the core of the ecology of fear. Most of the studies have failed to observe the sustainable role of the predator risk that is prominent in the landscape of fear. Traditional studies have considered it as an arbitrary response of individuals as if in "Brownian motion". This is where the ecology of fear aids in analysing the effects produced by predators in a non-threatening manner (Brown *et al.*, 2001). The recent works have started delving on other aspects or "non-lethal" of the subject at hand. Goulson. (1999), touched the subject of the benefit of the interaction between prey and predators. He focused on the foraging habits of insects, and their effects on the flowers' responses and population. The studies of Willems and Hill. (2009) discussed the predator-specific landscape of fear and resource distribution based on spatial range use.

Matassa and Trussell. (2011), studied the predation risk that influences the consumptive habits of prey. The predation risk has strongly dictated the distribution of spatial resources. Moreover, the non-consumptive effects on foraging behaviour are stronger than the consumptive effects on resource distribution. Even parasitic creatures such as ticks *Ixodes scapularis*, if seen through the lens of the ecology of fear acquire predator-like attributes. They are as efficient in producing fear in their prey as any large carnivore such as lions. Due to their presence, raccoons *Procyon lotor* and squirrels *Sciuridae* give up their foraging. Fisher. (2012), examined the ecology of fear concerning fearlessness. The meta-motivation of fear is considered as the shell of the ecology of fear. To maintain harmonious living in the natural world, the stability provided by the ecology of fear cannot be ignored.

Creel *et al.* (2014) found the influence of predation risk to be an essential factor in many respects when it comes to grazing animals. The ecology of fear has played an important role among these behavioural aspects of the prey. The strength of anti-predator responses is dependent on the attributes of predator and prey. The anti-predatory responses have known to carry costs by reducing the rates of feeding and provoking responses of psychological stress.

According to Wu. (2015), the heterogeneity of space and individual systems are critical for the conception and study of the ecology of fear. During this time, the ecology of landscapes evolved to understand the differences in the space occupied in terms of energy, water, plants, and animals based on their habitat or landscape (Forman and Godron, 1981). Penteriani *et al.*

(2013), reported that predator-prey interactions are trending to be the most researched topics in the fear ecology and the study of animal behaviour. The general drift in fear ecology has shown the temporal range of predation risk perception and fear of predation recovery when compared to other studies. However, as seen above the studies are exploring all the aspects of the ecology of fear, which were not looked beyond a certain point. The following sections will discuss those aspects in detail.

Factors associated with the functionality of fear ecology

Habitat landscapes: The ecology of fear effectively utilises the environment over space and time. The resource distribution and density are considered as the informative predictors of the species spatial utilisation and predator distribution. It is understood that the landscape plays a vital role in the ecology of fear. The resources and predator distribution is the reason for that. For example, Ripple and Beschta. (2004) had explained how the landscape suffers when there are changes made in the environment, affecting fear ecology in one way or another. Bennett *et al.* (2015), found that increased competition for resources often affects the ability of species to search for food, which in turn discourage the addition of more members in the group as well as longevity and survival of species. Due to fear of predation young killifish and shrimp prefer to keep vigilant in the intertidal zone microhabitat during low tide in order to avoid predation by high concentration adults in the sub-tidal marsh habitats (Kneib, 1987).

Ritchie and Johnson. (2009) in their examination of the interaction between predators, mesopredators, and biodiversity conservation, found that the landscape of fear in relation with mesopredators is considered a treacherous terrain with few safety patches. Habitat loss and modification have resulted in changes in the availability of resources. They have further altered the competitive dynamics and predatory interactions. Direct lethal encounters and the behavioural and distribution adjustments due to the fear of apex predators are considered as the distinct mechanisms of mesopredators deficit. It has been pointed out that the mesopredators are strongly motivated to avoid interactions with the dominant predators. The affected distribution of the species has a massive influence on the landscape or instead ecosystem.

Dorresteijn *et al.* (2015), inspected the influence of humans on the ecology of fear concerning predator-prey interactions in a human-dominated landscape. Top-down and bottom-up processes have differed in human-dominated landscapes. Most of the large carnivore population has existed outside the protected areas embedded within the human-dominated landscape. The cascading effects have differed in human-dominated landscapes such as agriculture, forestry, and land use. Human has created an impact on top-down processes. Researchers have observed that the human presence has affected the interactions between apex predators (directly and indirectly), mesopredators and herbivores throughout the landscapes. The humans have played a significant role in the ecosystem through the modification of landscape directly.

Spier and Fontaine. (2015), examined the effects of urbanisation on fear ecology in wildlife. The alteration of habitat has forced the animal population to move outside to the urban landscapes. Reaction to predators has altered when the species exposed to the disturbance of human. In urban areas, the predation has occurred at the aerial and terrestrial level. The terrestrial predators are mostly affected by the habitat fragmentation resulting in their diminishing population, has and leading to the rise of mesopredators. This is mainly a matter of concern as it tells a lot about the role of fear ecology.

Matter of seasons: Treves. (2009), checked the influence of hunting season on animals situated at different levels. Participation in the hunting season has varied with unexpected instability in the carnivore population. Also, the carnivores have altered their behaviour to avoid their fear, especially during the season of hunting. On the contrary, sensitive monitoring cautious designing of the hunting seasons have helped to achieve satisfactory hunting results, successfully conserving large carnivores. A predator-prey interaction and foraging games have many complexities, which also have hampered the generalisation process consistently.

Kittle. (2014), has examined the use of space by carnivores concerning various factors such as prey availability. He observed that the habitat attributes had been influenced across seasons. The permeability of the landscape into the intra-territorial movement has determined the resource types and quantity available in seasonal movements. Further, it also has influenced the reproduction and survival of animals individually. Group size, seasonal population's measure of use is some of the terms, which are used to quantify the usage of predator space successfully. The newly distributed areas are preferred in summer and avoided in winter whereas, during the dry seasons, lions have disproportionately used the flat areas in the proximity to water.

Bastille-Rousseau *et al.* (2016), has demonstrated the use of habitat temporarily. Bears and caribou have exhibited less similarity in the usage of habitat during the calving season than the coyotes. Ecologically relevant seasons for each species are defined to understand the interactions of caribou predator. Some of the seasons of the caribou species are winter, calving, summer, and rut. These seasons revealed the presence of clusters over the year for caribou in Newfoundland. The fear of ecology tends to predict the predation rates of animals consistently. It also determines some of the

global approaches to the interactions of predator-prey highly.

Susceptibility to weather: Along with seasons, the weather conditions at a particular place and at a particular time also affect the predator-prey interactions. In the case of harsh weather, the prey not only has to gain energy by foraging in better locations but also have to survey for habitable locations. According to Lima *et al.* (1985) and Houston *et al.* (1993), the prey in this situation, faces the challenge of bargaining energy for survival from predators. The stronger predators have the advantage of being immune to harsh weather conditions with some energy involved in searching its prey. However, the ecology of fear increases manifold in prey, and their survival is at more risk than usual.

The weather will also affect the distribution of resources across the terrain. The temperature and precipitation affect the growth of vegetation and other resources. Thus, the harsh weather conditions will inhibit the availability of natural resources while the normal weather will ensure a better distribution of resources across the landscape. (Nemani *et al.*, 2003; Cornelius *et al.*, 2013). The preys are then forced to move across the terrain accordingly. The usual foraging area, which, Willems and Hill. (2009) refer to as their home ground defined as the area usually utilised by animals in their daily activities. This is a risky business as the pattern of predators is not uniform in the landscape.

Role of predation risk: The predation risk plays a vital role in regulating the behaviour of the prey (Preston *et al.*, 2014). The behaviour of the prey is highly responsive to the danger around them- imagined or otherwise (Heupel *et al.*, 2014). Their fear factors if reduced can cause a cascading effect on the surrounding environment. This needs to be discussed how the low predation risk can cause such massive changes in the ecology. The predation risk affects landscape usage as well as foraging activities. In the study conducted by Thurfjell *et al.* (2013), the wild boars preyed upon by humans were monitored through GPS. It was observed that human hunting determined their behaviour when it comes to hiding or fleeing. The boars fled to refuge ranges where they looked for locations with more cover and crops.

In another research, the population of grey wolves substantially affected the nearby area and their prey, especially the elk population in West America (Ripple and Beschta, 2012). The grey wolves which are nearing their extinction had a massive impact on their surrounding area than was realised. The ecology of fear played out here in the form of the altered behaviour of elk and another grazing behaviour that now, almost reckless, started consuming the surrounding vegetation. The vegetation surrounding the area rapidly depleted as these prey animals consumed them before its growth. The almost extinct wolves were reintroduced to the area in the hope of controlling the population of prey as well as to ensure the maintenance of the ecosystem. As expected, the presence of wolves made other animals cautious, and their preference changed from food to safety.

In this regard, it is worth mentioning the research of (Packer *et al.*, 2011). In their study, they focused on the inherent fear of darkness in human beings about the activity of nocturnal animals. They found that the fear of full moon and darkness can be attributed to the survival instincts induced by the nocturnal predators, specifical lions in this case. The lions tend to hunt after the full moon and in a darkness, which explains the fear. The researchers collected a huge quantity of data concerning lion attacks juxtaposing it with the moon patterns. They found that lions are likely to attack immediately after the first weeks of the full moon. As a result, the full moon becomes a symbol of danger. Thus, the fear of darkness is more of an adaptation adopted through the evolutionary cycle of human beings. A study by Røskaft *et al.* (2003) in Norway point out that human express much fear on the apex carnivorous of the area that is brown bear *Ursus arctos* wolverines *Gulo gulo*, Lynx *lynx lynx*, and wolves *Canis lupus*. They experienced less fear of wolverine and lynx. Females are more fearing to both of the species (Røskaft *et al.*, 2003).

In general, these researches have made it clear that the factors above are of great consequence to the behaviour and distribution of prey and mesopredators. The season, landscape, weather conditions and predatory risks, all play a profound role in shaping the natural ecosystem. It will not be surprising if we deeply understand and will find even more factors and mechanisms playing out in the prey-predator dynamics.

Mechanism of fear ecology operation: The above sections are enough to explain the extent to which these large predators affect the behaviour of prey and mesopredators. However, we need to understand the operations of fear ecology on the interaction between large predators, mesopredators and prey. The cascades related to how these interactions among large predators, mesopredators, and prey happen (Elmhagen *et al.*, 2010).

Predation cues influencing preys and mesopredators: The instinctual response to danger is one of the vital functions of an animal as it ensures survival. The large carnivores often inspire fear in their prey despite the absence of actual killing (Fig. 1). This fact is quite useful in studying predator-prey interaction (Boonstra, 2013). In aquatic ecosystems chemical cues by predators are carefully considered by prey to detect the presence of danger, most prey has evolved adaptation structures for detecting predation risk (Chivers and Smith, 2016). Different studies explain that the presence of predator releases stress hormones in prey (Clinchy *et al.*, 2013; Creel *et al.*, 2013). The prey reacts to the fear of predator almost instinctively. Their whole body becomes alert, and

their first instinct is to run and hide away. This is what is called "predation-induced stress." Kondoh *et al.* (2016), found that even scent of predators ensued behavioural changes and an increase in stress hormones, encouraging their whole physical body to escape from that situation. Alarm produced by predators helps prey to detect risk habitats and certainly avoid the use of such habitat in the future (Chivers and Smith, 2016). Both chemical and visual predator cues prey vital role in creating a landscape of fear in prey and mesopredators (Mpemba *et al.*, in press) (Fig.1).

Figure. 1. Photos of predator (Brown bear photo) visual cue and chemical cue (Brown bear feces in a plastic bottle) in Hanma National Reserve, China. An experiment to study the influence of predation risk by predator cues on prey and mesopredator behaviours in the ecosystem using camera trap (Mpemba *et al.*, in press).

Large predators and their influences on ecosystem: The impact of large carnivores on the ecosystem had stayed unrecognised for quite some time. However, with a plethora of experiments being conducted, their roles in conserving the ecosystem have been understood step by step. These animals, which are usually seen as a threat or a problem, actually are detrimental in conserving the ecosystem. The experiment on the free-living mesopredators raccoons proved this theory. The researchers played the vocalisation of large predators for a month and observed the effect it had on these mesopredators. It was observed that the fear of large predators itself brought a significant change in the foraging habits of raccoons. This affected not only the prey of raccoons but also the prey and competitors of raccoons' prey (Suraci *et al.*, 2016). The experiment showed that raccoons were 66 % less likely to forage at intertidal. This fear extended to raccoons' prey red crabs whose competitor is *staghorn sculpins* which are not preyed upon by raccoons. Red crabs were significantly benefitted by this instigated fear of raccoons. They, in turn, in the absence of the risk of raccoons, faced fewer problems competing with *staghorn sculpins*. Their population showed abundance increased while their prey periwinkle snails, which are grazing prey, saw a decline in their population. Wild dog (Lycaon pictus) competition with large predators such as *Spotted hyena* (Crocuta crocuta) and *Lion (Panthera* leo) may result into hyenas outnumbering and hence eliminating wild dogs into the Selous Game Reserve, Tanzania (Creel and Creel, 1996). Again, lion killing wild dog statistics is minimal but cannot be ignored for the healthier ecosystem (Creel and Creel, 1996).

The above studies show that large predators play a crucial role in being on top of the food chain. Their presence or absence reverberates around the whole ecosystem. It is important to note that even their fear produces a long-lasting effect on the smaller animals. The

whole structure of the ecosystem is based on the landscape of fear build by these large carnivores. The predation cues used in the above studies aided significantly in determining the role of large carnivores. It only goes on to enlighten us about the urgency of conserving these large animals, which we talk about in the next section.

Role of predation risk in prey grouping behavior: The effect of the predation risk is visible now at temporal, spatial and at a seasonal level for the prey. The predator affects the foraging habits, vigilance and other behaviours of the prey at multiple levels. One of the essential effects the risk produce is that of change in grouping formation of the prey (Fig. 2). The group formation comes with a set of advantages such as aid in hunting, escape from predators and care for young ones (Johnson *et al.*, 2002). Here, we will talk about all the aspects affected by predation risk.

Predatory risk often leads the prey to become more social (Fig. 2). The social aspect or community ensures many advantages when it comes to predation risk. This is especially true when it comes to resource management. As discussed above, the risk of predators complicates things for the prey. They are forced to bargain intake of energy for the safety or shelter from the predators. With the group formation, there is an allocation of work, including hunting for food. The behavioural ecologists have found a connection between the grouping behaviour and the distribution of resources (Johnson *et al.*, 2002). The social organisation of the various species is dependent on resource availability. The researchers proposed the resource dispersion hypothesis theory, according to which the heterogeneous distribution of resources is, in fact, cheap in case of group living regardless of direct benefit to an individual.

The group formation is especially useful when it involves predation risk. The risk of being killed by predators often leads prey into the formation of groups as the proactive response to the use of unsafe habitat (Creel *et al.*, 2014). It is the more significant factor in comparison to resource management as survival is more of an issue than food. Human beings, despite being on top of the food chain, have formed groups since ages to survive. Whether it is ostriches or apes, the benefits of group formation are apparent among most of the beings. The group members' chance of being caught gets lower as the predator gets confused, the vigilante multiplies and the likelihood of another individual being attacked increases. The group formation contributes to the vigilance of the species (Fig. 2) as with so many eyes watching out for the predator while feeding, the alarm call is made quicker and more efficiently. This ensures safety while foraging, see (Blumstein, 1996; Creel *et al.*, 2014)

The groups also ensure fewer chances of attack per individual (Fig. 2). This commonly refers to a dilution effect. The group living's evolution is attributed to the fact that it benefits individuals more than the whole group. According to the experiments conducted by Duncan and Vigne. (1979), it was seen that horses often formed groups during an attack by blood-sucking horse flies. With many horses together, the attack on individuals decreased significantly. Hamilton. (1971), proposed another theory called "Selfish herd theory," in this regard. According to this theory, the prey often seeks a central position in the group to be away from the danger zone (Fig. 2). This danger zone is the outer part of the group in which the animals have the highest risk of predation.

Other benefits of the groups are alarm calls. In case of a risk, an individual signals other members of the groups, which helps them to escape quickly or prepare themselves to fight. For example, in the case of Vervet monkeys, the alarm calls are made based on the predator like loud barking noise for leopard, disyllabic cough for an eagle or another predator. They respond according to the type of alarm call that they receive (Smith and Harper, 2003). The group size has also been connected with the predator's focus. In the case of large groups, the predator is unable to target one single prey and in a state of confusion, miss the killing altogether. Another advantage is the rise of morale among animals to fight back. They can mob and harass the predator more effectively. This is seen in Fieldfares birds, which often mob or excrete upon their predators in order to defend themselves. This has helped in their survival a lot by reducing the number of attacks (Andersson and Wiklund, 1978).

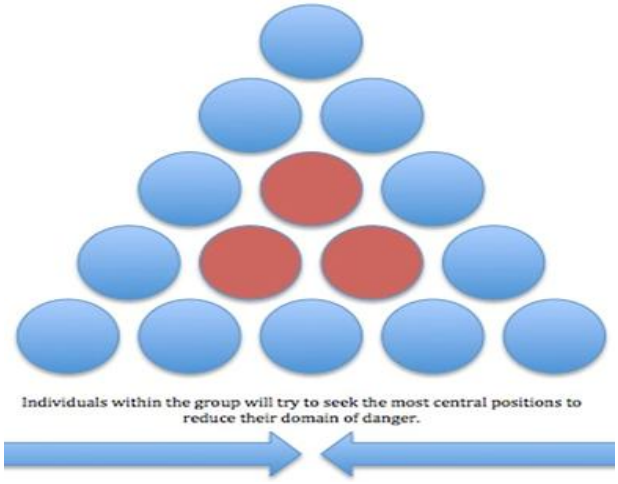

Figure. 2. Shows group formation as a social adaptation to predation risk by prey species. In a group, prey seeks central positions in order to reduce its domain of danger. Individuals along the outer edges of the group are more at risk of being targeted by the predator. Group formation also increases social life. (Taken from Open source).

DISCUSSION

The above evidence points out the significance of predation risk in the social behaviour of the prey animals. It will not be far-fetched to say that the social behaviour of humans is an after-effect of long-held fear of predators. This can help us to understand many evolutionary aspects of animals and humans.

Fear ecology implications for wildlife management and new challenges: Fear ecology is gaining much interest thanks to its significance in the conservation and management of wildlife. We have observed in the previous sections that how predators can bring remarkable changes in the food chain of the natural ecosystem, see (Ripple and Beschta, 2004; Bruno and Cardinale, 2008; Beschta and Ripple, 2009; Ripple and Beschta, 2012; Le Saout *et al.*, 2014). Their presence or absence makes a humongous difference in the ecosystem. The predation risk drives the tropical ecosystem forward. The full study until now has been a testimony to that. Now, the question is how one can effectively use this ecology of fear in wildlife conservation.

Precisely, the following may be a useful application of fear ecology theory in the future. (Hamenya Mpemba1) Improve habitat vegetation through the introduction and reintroduction of predators that regulate the population of ungulates and other herbivores (Ripple and Beschta, 2004; Ripple and Beschta, 2012; Ripple *et al.*, 2014). The growing concern is a consequence of the growth in the population of ungulates. In turn, this has caused the scarcity of vegetation all around the world. The unhinged state of the ecosystem has agitated the policy makers into taking severe actions. (2) Maintenance of ungulates or other prey in the ecosystem by reintroducing predators and mesopredators (Jones, 2010). It can either be reintroduced into the habitat predators that have been there before and gone extinct due to various circumstances; or first-time introduction where the habitat has had prey species only. Alternatively, wildlife managers may maintain a sustainable number of prey species in the habitat through hunting for fear (Cromsigt *et al.*, 2013; Le Saout *et al.*, 2014). (**3**) Resource Management**.** Predatory fear often leads the prey to become more social. The social aspect or community ensures many advantages when it comes to predation risk, especially when it comes to the management of resources. As discussed earlier, the risks of predators complicate things for the prey. They are forced to bargain intake of energy for the safety or shelter from the predators. With the group formation, there is an allocation of work, including hunting for food. The behavioural ecologists have found a connection between "social behaviour and the distribution and predictability of resources" (Johnson *et al.*, 2002). (4) Pest control using predator cues, sound, and chemicals. This helps in the management of problematic animals that usually attack people or destroy crops living nearby the parks or farmlands. For example, when a lion or tiger faeces and urine are speeded around the house or farm, prey species tend to run away from the area. Predator cues, sound, and smell imagination result in prey behaviour changes (Clinchy *et al.*, 2013; Kondoh *et al.*, 2016).

The predators are killed without a second thought in the sustenance of the environment (Valeix *et al.*, 2012). Cromsigt *et al.* (2013), had discussed the concept of hunting for fear instead of which human beings hunt on wild animals or predators to defend themselves and increase their survival rate. This reckless hunting has led to escalated growth in the population of ungulates. This, in turn, has led to receding of the vegetation all around the world. The increase in the population has led to the disarrangement in the ecosystem. A new challenge is being faced to end the disruption of an ecosystem which can be attacked with the help of predation-risk. By inciting the fear of predators, the behaviour of the ungulates can be controlled to a certain extent.

However, this approach has limitations as animals keep on changing their foraging habits regarding time, location and season. This only helps us to realize the importance of the actual presence of predators in nature. There is a necessity of ungulate management system, which considers the spatial distribution of the prey. They can create the hunting landscape, high-level risk, and low-level risk areas. These areas can be distributed where sparse vegetation can be turned into high-level risk areas while the low-level areas with abundant vegetation can be left for the ungulates for the necessary intake of food. If done considerably, these practices can have a lasting impact on the problem of wildlife conservation. This study has proved that the food chain is not as simple as we thought it to be because of its intricate design. Nevertheless, the recent focus on the predation risk has illuminated several aspects of the predator-prey relationship. In the study, our main aim was to understand the interaction between the prey, predators, and mesopredators based on the ecology of fear. The ecology of fear has gained momentum in recent years. Its contribution to the ecosystem cannot be ignored as it is estimated to be larger than the direct predator-prey hunting game. The previous assumption that predators are lethal and kill their prey has now been transformed as predators being non-lethal and creates fear in their prey who forgoes feeding and other opportunities (Sih, 1980; Lima, 1998). The contribution of the ecology of fear is analysed across various levels of the food chain. The study further looked upon the factors that contributed to moulding the behaviour of the prey. This was examined in the context of prey's foraging habits, their response system, social behaviour (survival instincts), et al. The factors related to this phenomenon were discussed in

detail, which states that the landscape, season, weather and predation-risk have a considerable role in distributing the prey species across the land. The spatial and temporal distribution of predators and prey is based on this ecology of fear. The landscape of fear conditions most of their instincts. The large predators have more influences on prey as well as mesopredators. The predation cues or the predation-induced stress helps us to comprehend the extent of the dominion that predators held over the entire ecosystem. This influence has contributed to making us believe that predator plays a vital role in the sustenance of ecosystem (Bruno and Cardinale, 2008; Beschta and Ripple, 2009).

The social behaviour of the prey was observed based on predatory risk. It was apparent that its role is more significant than previously thought. The advantages of group formation provided further insight into the behaviour of the prey. The group formation not only helps in the better intake of food, but it improves the defence mechanism. The myriad techniques employed by prey to defend themselves helps us to understand the significance of ecology of fear residing inside them. The study is vital because of the role that it plays in wildlife conservation. As discussed above the understanding of predation risk is crucial in order to face the challenge of the ever-increasing population of the ungulates. This expansion has led to unrestrained foraging habits, which, in turn, has caused dwindling in the natural vegetation. For this problem, the creation of artificial predatory risk environment is suggested. This has to be done by taking into consideration the spatial distribution of vegetation and its scarcity or abundance for that matter. In some studies, the use of tools such as Markov chains has yield results in the examination of population changes in competing species, which can further help in management, and preservation of the species (López-López *et al.*, 2009).

Conclusions: The whole study conducted based on fear ecology has been enlightening. With changes made in the environment, fear ecology is affected in one way or another. These are challenges within the field of fear ecology. (Hamenya Mpemba1) Increased competition in the ecosystem which influences and modify the ability of species to search for food. This results in downgrading the number of members and the longevity and survival of the species. (2) The direct impact of urbanisation on the fear ecology as discussed by Spier and Fontaine (2015), results in habitat degradation. Hence, it reduces the valuable habitat for predator-prey interaction. (3) Human disturbance is another challenge of fear ecology in various ways but, commonly being crop cultivation and grazing within wildlife habitat. This activity interferes with natural fear among wild animals. (4) Climate change affects predator-prey interaction by altering vegetation cover as well as body stimulation by the weather conditions (Nemani *et al.*, 2003; Cornelius *et al.*, 2013). The whole arrangement of the natural ecosystem is based on the landscape of fear created by these large carnivores. This study is beneficial because it opens up many avenues for further studies. The growing concern is a consequence of the growth in the population of ungulates, which has, in turn, caused the scarcity of vegetation all around the world (Hatfield and Krafft, 2009; Kraft and Hatfield, 2011). The unhinged state of the ecosystem has agitated the policy makers into taking severe actions. The predators play a significant role in the preservation of the ecosystem. Consequently, it is the need of the hour to preserve large predators that are being hunted on the grounds of fear.

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