

Painted Ferocity: The Social Behaviors of African Wild Dogs, Threats to Survival, and Resulting Conservation Initiatives

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Abstract

African Wild Dogs (*Lycaon pictus*) are an endangered species of canid from Sub-Saharan Africa. They are very social communal hunters, and are capable of chasing down prey for long stretches of time. Wild dogs benefit a savannah ecosystem by regulating the populations of their prey so that it does not become unhealthy and overgrown. Like many organisms, wild dogs are also in competition with other predators for resources, namely lions and hyenas, who are capable of stealing their kills and occasionally injuring and killing them. Due to the depletion of their wild prey, wild dogs may also prey upon farmers' livestock, which puts the dogs at risk of being shot or poisoned by humans. Domestic dogs can also transmit deadly diseases to wild dogs, hindering their chances of survival. Conservation efforts are focused on educating local populations on the ecological importance of wild dogs as well as cooperating with local communities to implement traditional methods of livestock husbandry to reduce rates of livestock predation by wild dogs. Conservationists have also been attempting to vaccinate packs who are at risk of contracting diseases like rabies, as well as reintroducing groups of dogs to areas they once resided in the hopes of re-establishing small populations. It is crucial that these animals are protected so that future generations can learn about their behaviors and so be motivated to conserve them.

Keywords: conservation, endangered species, African Wild Dog, human conflict, threats to survival

Painted Ferocity: The Social Behaviors of African Wild Dogs, Conflicts with Humans,
and Resulting Conservation Initiatives

African Painted Dogs, or African Wild Dogs (*Lycaon pictus*), are a critically endangered species of canid that can be found in Sub-Saharan Africa, specifically in a savannah habitat. Like most wild canids, they reside in packs of varying numbers, with wild dogs capable of forming packs from as little as two individuals to as many as 50 (Fanshawe & Fitzgibbon, 1993). They are medium-sized with large, rounded ears, and their coats are colored black, tan, and white. Coat patterns vary from dog to dog, so no two individuals appear the same. African Wild Dogs are very social pack animals, and this is most notably seen during their hunts. When a prey animal is spotted, they coordinate in order to cut off possible escape routes and wear it down by following it for miles. Once prey is captured, another more gruesome aspect of wild dogs is manifested: their ferociousness. Wild dogs have been documented to tear chunks of flesh off of their prey while it is still alive, and may sometimes eviscerate prey in the process.

In recent years, the habitat of African Wild Dogs has been dwindling due to humans creating more space for agriculture. Human encroachment on this habitat results in competition for space and food (livestock and stocked games) as well as threatening human safety (Fraser-Celin et al., 2017). This has caused conflicts between farmers and the wild dogs, with the dogs sometimes being shot at by farmers. This, as well as other factors such as disease, has prompted researchers and conservationists to find ways to engage the communities that live near reserves containing wild dogs and to educate them about the animals' importance to the ecosystem. Conservationists also wish to help alleviate the conflicts that farmers have with wild dogs so that both groups can live peacefully with one another. African Wild Dogs are a very important carnivore in the savannah ecosystem, and knowing how they behave and interact with their

environment is crucial to understanding how to create effective conservation plans to protect the species from extinction.

Behavioral Dynamics

Wild dog packs exhibit a dominance hierarchy, with the production of young being monopolized almost entirely by the dominant male and female of the pack, similar to how a pack of wolves operate (Creel et al., 1997). However, research that has analyzed behavioral and endocrine data has suggested that reproductive duties within the pack could potentially be shared between the dominant pair of wild dogs and subordinates, which is called cooperative breeding (Spiering et al., 2010). One example of this behavior was observed in Kruger National Park, where it was suggested that 19% of the litters born in the park were from subordinate females (Spiering et al., 2010). Dominance within a wild dog pack is typically determined by body size, age, or the rank of relatives (Creel et al., 1997). In addition, the size of litters and the rate of pup survival to the first year of life can be affected by pack size as well as the age of the breeding female, as was observed in a cooperatively breeding pack in Northern Botswana over a course of fifteen years (McNutt & Silk, 2008). Adult males also had a profound effect on the reproductive success of a female compared to adult females (McNutt & Silk, 2008).

Hunting

In order to understand the importance of wild dogs to the African ecosystem, one must first understand their hunting behavior and tactics, as this is by far the most well-known and important aspect of these animals. Like wolves, they are pack hunters who are capable of traveling for many miles in search of their quarry, and are obligate carnivores. They also consume more meat per day relative to its size than any other carnivore (Hayward et al., 2006).

Due to the tremendous amount of species diversity within Sub-Saharan Africa, wild dogs can hunt a wide variety of prey. There have been reports in the past of wild dog packs hunting animals as small as hares and Bat-eared Foxes (*Otocyon megalotis*), to much larger animals like the Eland (*Taurotragus oryx*) and juvenile African Buffalo (*Syncerus caffer*) (Hayward et al., 2006). One of the most notorious characteristics of African Wild Dogs is the ferocity in the methods of taking down their prey. When a prey animal is captured, it is often torn apart limb from limb and disemboweled while it is still alive, highlighting the wild nature of the African Wild Dog. Occasionally, a wild dog pack may cache meat leftover from a hunt and bury it in small holes so that it can be eaten at a later time.

Communal hunting and pack size. African Wild Dogs are cooperative diurnal predators, hunting daily at dawn and dusk (Creel & Creel, 1995). In order to start a hunt, a wild dog pack must first get itself organized and ready. One study that was conducted on a pack residing in the Selous Game Reserve in Tanzania showed that in order to signal that a hunting party was being prepared, a rallying call was given to make sure that all members of the hunting party were awake and ready to hunt (Creel & Creel 1995). They will then set off together in search of prey. Once the hunt has started, participating pack members will trot or canter at a speed of 10 km/h, and spread themselves out over 10-100 m (Creel & Creel, 1995). Nevertheless, one pack was shown to not be traveling together for the remainder of the hunt once they had separated, and some individuals were seen hunting smaller prey for themselves, such as hares and young gazelles, before a primary target had been found (Estes & Goddard, 1967). Some dogs would sometimes play with each other or stop to sniff at a hole or grass tufts at 10-20 minute intervals before catching up with the rest of the group (Estes & Goddard, 1967).

There are two main ways that a wild dog may approach its prey. First, a dog may start running towards prey in full view, and secondly, it may conceal itself in the undergrowth and approach slowly (Fanshawe & Fitzgibbon, 1993). What happens next usually depends on the size of the animal. If the prey is small, then the chase and capture of said prey is fairly quick if it does not run away first. However, if the prey is a large animal such as a wildebeest, then the pack will start a pursuit, utilizing their great stamina to wear down the prey and nip at its hindquarters and moving to cut off any possible escape routes. There is usually one dominant member of the hunting party who leads the chase and captures the prey on its own before the other pack members arrive to assist in killing it by disembowelment, and it is also possible for dogs to capture other vulnerable prey opportunistically during the chase, and in the case of larger packs, there may even be multiple prey kills (Hayward et al., 2006). However, prey that possess defensive instincts will often stand their ground instead of fleeing, such as a wildebeest herd who will stand and facing outward in a pinwheel formation with young protected in the center, while the adults charge and use their horns for defense (Creel & Creel, 1995). There is a great risk to a wild dog pack in attempting to capture a wildebeest that could injure them, so they will often test the prey to see if some or all of the herd will run and increase their vulnerability. But if there is nothing the pack can do to cause this, then they will leave after testing the herd for ten seconds to five minutes (Creel & Creel, 1995). Cooperation is crucial in taking down a dangerous prey animal, so several dogs are often seen distracting the animal from the front while other dogs attack from behind and begin to disembowel the prey (Creel & Creel, 1995).

There is a possible correlation between the size of a hunting pack and the success of capturing prey. In one pack residing in Serengeti National Park, Tanzania, the success of hunting wildebeest did vary with the size of the hunting party, with four or more dogs finding the most

success during hunts (Fanshawe & Fitzgibbon, 1993). During the observed hunt, one of the dogs would grab the wildebeest by the snout while the rest of the pack members would start to disembowel the animal, although one or two dogs were never able to immobilize an adult wildebeest on their own (Fanshawe & Fitzgibbon, 1993). Individual adults were observed hunting wildebeest calves, but were never successful, while larger groups were more successful since some dogs would distract the wildebeest mother while the others would go after the calf (Fanshawe & Fitzgibbon, 1993). Another pack of wild dogs near Aitong, Kenya was observed to have a fairly large pack as well as a high population density of ungulates within its range (Fanshawe & Fitzgibbon, 1993). It was recorded that its large size was reflected in its high successful capture rate, showing that a larger pack size can contribute to the capture of more prey (Fuller & Kat, 1993).

One of the methods used to determine the optimal pack size for the most success while hunting was to measure the amount of kilograms of prey eaten or killed per dog per day, such as for the Selous Game Reserve pack studied by the Creels (1995). According to the standard prediction for the relationship between hunting success and pack size, as the size of the hunting party increases, kilograms of prey killed per dog per day initially decreases, reaches a minimum pack size of eight to nine adults, and then starts to increase (Creel & Creel, 1995). Under predicted circumstances, natural selection would favor the wild dog packs who avoided an adult pack size of seven to eleven individuals, and would instead form larger packs, but on the contrary, the wild dogs at Selous Game Reserve were usually found in packs of around 10 adults, opposing the predicted measurements (Creel & Creel, 1995).

Prey preferences and selection. There are many different types of prey animals available for an African Wild Dog pack to hunt, so it is important that a pack chooses its prey

carefully in order to maximize the effort it takes to hunt as well as the rewards. This is shown by the wild dogs possessing a preferred weight range for their prey, with the average body mass of preferred prey being up to 200 kg (Hayward et al., 2006). It has been found that ten prey species had preferred weight ranges of 16-32 kg and 120-140 kg, with four of the prey species being significantly preferred (Hayward et al., 2006). A study conducted on a pack living in the Ngorongoro Crater, Tanzania, showed that out of the 39 kills recorded, 69% were from Thompson's Gazelles (*Eudorcas thomsonii*), 18% were from juveniles wildebeests, 10% were from Grant's Gazelles (*Nanger granti*), and one kill came from a Kongoni (Estes & Goddard, 1967). The prey preferences of a wild dog pack can also depend on the region the pack is located. In the Serengeti, for example, Thompson's Gazelles occur in very abundant numbers, and is thus a staple prey species for wild dogs living in that region (Estes & Goddard, 1967). In areas like the Ngorongoro Crater, where Thompson's Gazelles occur in much smaller numbers, wildebeest tend to be the preferred prey for the wild dog (Estes & Goddard, 1967). This suggests that a wild dog pack may choose its prey based on its general abundance in the area. There is also some evidence that African Wild Dog packs will choose prey based on their age, sex, and overall health. This would include animals that are young, old, sick, or females who are pregnant. Surprisingly, it has also been found that wild dogs, like lions and cheetahs, tend to hunt more male gazelles than females, due to males being less vigilant and found in smaller groups than females (Fanshawe & Fitzgibbon, 1993). Males are also more territorial than females, and tend to be some of the last animals to flee from danger, making them vulnerable targets for a hunting wild dog pack (Estes & Goddard, 1967).

External factors such as changes in the climate and man-made fences designating reserves may have an effect on the hunting behaviors of African Wild Dogs and their interactions

with prey. For example, temperature changes in the overall environment may play a role, as one study demonstrated. According to the study, on days that were hotter than expected, wild dogs had more successful hunting trips, the time it took to chase prey decreased, and this effect was doubled when chases ended in a kill (Creel et al., 2016). The hypothesis of the study was that heat dissipation uses more energy in larger animals than in smaller ones, and it would thus affect the prey of wild dogs more than the wild dogs themselves, who are generally smaller than the prey they hunt (Creel et al., 2016). The research suggested that these changes in behavior resulting from overall temperature can alter interactions between predators and their prey intensifying or offsetting direct effects of climate change, and that wild dogs in particular are strongly affected by these drastic changes in hunting behavior (Creel et al., 2016).

One way that a man-made perimeter fence can affect wild dog hunting behavior includes preventing large prey like Kudu (*Tragelaphus strepsiceros*) from escaping, increasing the chances of a successful catch since hunts were more likely to end in a catch when they take place in thick vegetation, which can be comparable to a perimeter fence (Davies-Mostert et al., 2013). Wild dogs may even take advantage of man-made barriers during their hunts. Shambala Private Game Reserve in South Africa is a relatively small area, and it was observed that the wild dog pack had a preference for large prey, namely Kudu, and appeared as though the pack was utilizing the barrier for more energy efficient hunts of large game, although whether the pack was actively seeking to use the barrier to trap Kudu or the dogs just happened to intercept Kudu at the barrier is debatable (Rhodes & Rhodes, 2004).

Wild dog prey densities. The densities of prey animals may also affect how a pack will select its prey. Since wild dogs have preferred weight ranges for their prey, it would be important for the populations of prey to be sustainable in order to provide wild dog packs with adequate

amounts of food. In the past, one method suggested to maximize wild dog conservation was to manipulate the abundance of the wild dogs' preferred prey species at the expense of the preferred prey of dominant competitors so that other predators can be managed, although this can cause problems as it may drastically affect the ecosystem as a whole by affecting the ability of dominant competitors to find enough prey, as well as altering the demography of large carnivores (Hayward et al., 2006).

Depending on where a pack is located, wild dogs have been shown to sustain themselves on small prey that they would not regularly hunt such as Kirt's dikdiks (*Madoqua kirkii*). This may be a means of creating a suitable conservation plan (Woodroffe et al., 2007). Wild dogs can typically take down ungulates that weigh more than 100% of a dog's individual mass since they hunt in cooperative packs, and most populations specialize in hunting large ungulates like Impala (*Aepyceros melampus*) (Woodroffe et al., 2007). However, under certain circumstances, large ungulate species may be scarce, and so hunting smaller ungulates can help sustain a pack. This was the case with wild dogs living in the districts of Laikipia, Samburu, Isolo, and Baringo located in northern Kenya (Woodroffe et al., 2007). None of the 5,700 km² area was formally protected, and consisted mainly of privately owned commercial ranches and commercial lands owned by local Samburu, Masai, or Pokot communities (Woodroffe et al., 2007). Population densities of Impala were found to be low in community lands due to a much higher density of livestock, with dikdiks being the preferred prey of wild dogs and occurring in high densities, while on commercial ranches the Impala density was comparable to that of other study areas where they were the preferred prey species of wild dogs (Woodroffe et al., 2007).

Energy cost and return. Like many of the wild dogs' behaviors, hunting requires energy, and it is essential for a wild dog pack to assess if catching a certain species of prey will

be worth the amount of energy it will need in order to catch it. Hunting requires an animal to use its speed, stamina, and agility in order to successfully capture its prey, and the African Wild Dog is no exception. One study that was conducted in Northern Botswana used GPS IMU (inertial measurement unit) collars to record the movements of a pack of six wild dogs and compare them to the movements of Cheetahs (*Acinonyx jubatus*) (Hubel et al., 2016). The main difference between African Wild Dogs and cheetahs in regards to hunting is that cheetahs rely on their ability to stalk their prey as well as their sheer athleticism and very high speed and maneuverability to catch prey in a relatively short amount of time, while wild dogs travel together at a consistently higher speed, and use their endurance and reliance on other pack members to wear down prey over a longer period of time at a moderate speed (Hubel et al., 2016). Hubel et al. (2016) tested the hypothesis that African Wild Dog hunts have a lower hunt return than cheetahs due to lower individual kill rates and longer hunts, despite the benefits of cooperative hunting and group feeding. It was discovered that wild dogs can cover twice as much ground as cheetahs in a given day (Hubel et al., 2016). While cheetahs use much more energy during their hunts than wild dogs, they possess a higher individual kill rate, yielding a high kill gain to kill cost ratio for solitary animals, which is more balanced in wild dogs since they share kills (Hubel et al., 2016).

In Hwange National Park, Zimbabwe, the foraging cost and hunting success for a pack of wild dogs both inside and outside the park was studied to determine if living in a protected area versus a non-protected one makes a difference in the length of foraging distance as well as the success of hunts (Van et al., 2013). In regards to foraging costs, there were no differences for wild dogs both inside and outside the park, although it was found that hunting success rates were higher outside the park (Van et al., 2013). Hunting success may be lower inside the park due to

the presence of large open grassland, which may decrease the chances of a successful kill (Van et al., 2013). However, wild dogs leaving the safety of Hwange National Park due to higher hunting success rates poses a risk, as the dogs are not protected by humans who may kill them for trespassing on farmland (Van et al., 2013).

Competition with Other Predators

African Wild Dogs, like all of Africa's prominent carnivorous species, are constantly competing with other predators as well as scavengers for resources like food and habitat space. These interactions between competitors are known as intraguild interactions, and despite how they affect the community structure between predators as well as the ecosystem, they are still poorly understood (Vanak et al., 2013). This is due to the difficulty of studying large, free-roaming predators since they all have differing behaviors, and the interactions they have with each other may vary at different times. According to Vanak et al. (2013), these intraguild interactions can determine which carnivores will dominate in areas with high prey availability, and ultimately determine the hierarchy within the carnivore guild in certain areas.

Use of Space

Wild dog interactions with their competitors can affect how much space they have to live in. This is especially prevalent in today's world where the vast majority of wild dogs and other carnivores are restricted to protected reserves and national parks, and there is therefore a higher frequency of interactions and interference competition (Darnell et al., 2014). It is even more obvious in smaller parks where carnivores are vastly separated from other populations, and this is especially true for the heavily fragmented metapopulations of wild dogs in South Africa (Darnell et al., 2014). In Hluhluwe-iMfolozi Park, South Africa, Darnell et al. (2014) tested the

hypothesis that the space used by African Wild Dogs was influenced by other large predators like the African Lion (*Panthera leo*), who regularly injure and kill wild dogs, and the Spotted Hyena (*Crocuta crocuta*), who is known to steal prey killed by wild dog packs. It was also predicted that space use by wild dogs would differ relative to lions and hyenas, and the dogs would avoid lions more strongly than hyenas (Darnell et al., 2014). It would also depend on whether or not the breeding season is currently happening as well as what season, wet or dry, is currently active (Darnell et al., 2014).

The home ranges among all three carnivores shared some overlap with each other in the park, and it was found that for interactions between wild dogs and lions within these home ranges, wild dogs spatially avoided the overlap area 78% of the time and randomly used of the areas 22% of the time (Darnell et al., 2014). Lions were spatially attracted to the home range overlap area about 67% percent of the time, while lions randomly used the area 22% of the time, with one instance of avoidance occurring (Darnell et al., 2014). Hyenas, on the other hand, displayed spatial avoidance of wild dogs 80% of the time with one instance of spatial attraction, and in core use areas, wild dogs displayed 60% spatial attraction and 40% non-significant random use of the areas, while hyenas showed 100% spatial avoidance of wild dogs (Darnell et al., 2014). These data appear to be taking normal interactions into account, meaning that no prey carcasses were involved, which in those cases hyenas are more likely to display spatial attraction due to their tendency to antagonize wild dogs for their kills.

Another way that wild dogs avoid their competitors is through temporal partitioning. Among the guild of large carnivores living in Africa, it has been frequently described that wild dogs are diurnal and crepuscular, meaning they are active during twilight hours, and this behavior stems from the need to avoid nocturnal competitors like lions and hyenas (Cozzi et al.,

2012). However, during a three year study in the Okavango Delta, it was discovered that there was an unexpectedly high degree of temporal overlap between lions, hyenas, cheetahs, and wild dogs, and this was mainly due to the previously undescribed nocturnal activities of wild dogs (Cozzi et al., 2012). The availability of moonlight was also a factor in the activity patterns of the four main carnivores. The nocturnal activity for wild dogs were observed to be directly correlated with the presence of moonlight, while lions and hyena nocturnal activity did not vary over the course of a lunar cycle (Cozzi et al., 2012). Wild dogs take precaution in avoiding competition for prey, and this raises the question of why they don't avoid nocturnal activity altogether if lions and hyenas threaten them. One possible explanation for this is since wild dogs rely on sufficient light and visibility in order to keep track of their prey during their long high-speed chases, they must take every opportunity they have in order to catch prey for their pack, even if it means potentially running into lions or hyenas (Cozzi et al., 2012). This also means that wild dogs may have developed certain adaptations that would aid them in the event that there are nearby other predators, such as fleeing at the sound of lions roaring in order to avoid unnecessary risks of injury or death (Cozzi et al., 2012).

An interesting study was conducted in the eastern Okavango Delta in northern Botswana where a playback device and loudspeaker were used in order to gauge the reactions of wild dogs to lion roars and hyenas whoops (Webster et al., 2012). When confronted with the sound of roaring lions from the loudspeaker in moderately dense areas, wild dogs were typically observed to stand up and face towards the direction of the loudspeaker with their ears pricked, with one or more dogs approaching a short distance towards the source of the sound (Webster et al., 2012). Also in intermediate-density areas, wild dogs may rear up on their hind legs in order to get a visual on the perceived lions, and in much denser habitats, dogs would immediately run away

from the roars of lions (Webster et al., 2012). This behavior highlights the immediate danger lions pose to wild dogs since they have the capability to seriously injure or kill them. It can also affect the hunting behavior of wild dogs due to their tendency to avoid areas that are heavily occupied with lions, reducing the options of a wild dog pack searching for prey.

Dröge et al. (2017) in Liuwa Plain National Park, Zambia, conducted a study that gauged how wild dogs reduce the limiting effects of more dominant predators by avoiding them in use of space at certain times or through differing patterns of prey selection. In regards to prey selection in the national park, lions and hyenas specialized in hunting wildebeest, while wild dogs and cheetahs selected a wider range of prey that included smaller and less abundant prey like oribi (Dröge et al., 2017). Since wildebeest were the most abundant prey animal in the park and all four carnivore species preyed on them, there was a substantial overlap between their diets, and therefore a high potential for interference competition (Dröge et al., 2017). Wild dogs were also observed to avoid areas that were heavily occupied by lions, but not for areas with hyenas, despite the fact that hyenas vastly outnumbered lions (Dröge et al., 2017). A possible explanation for this behavior could be that a small pride of lions is much easier to avoid than many hyenas in several clans, and that predation on wild dogs is more commonly carried out by lions rather than hyenas (Dröge et al., 2017). Wild dog packs were also able to dominate hyena clans in competitive interactions as long as they outnumbered them (Dröge et al., 2017). Temporally, wild dogs were shown to favor day and crepuscular times over nighttime when they were far less active, as lions frequently hunt under the cover of total darkness (Dröge et al., 2017).

Competition for Prey

While African Wild Dogs may be formidable and ferocious carnivores, they are still outnumbered by larger predators, and often face many challenges because of this. Vultures are a

frequently occurring scavenger in Africa and may appear at wild dog kills in hopes of picking off a few scraps of meat from a carcass, but since wild dogs often hunt in the early morning and late afternoon, larger vulture species like the White-backed Vulture (*Pseudogyps africanus*) and Ruppell's Griffon (*Gyps ruppelli*) do not benefit much from their kills since the activities of these vultures depend on the presence or absence of thermal updrafts (Estes & Goddard, 1967). Smaller species like the Hooded Vulture (*Necrosyrtes monachus*) have been seen following a pack chasing prey, and once prey had been killed, they would attempt to pick off pieces of the kill that scattered, otherwise they would have to wait until the wild dogs were finished before they could descend onto the carcass (Estes & Goddard, 1967). Young dogs may sometimes chase away vultures that got too close to a kill, but wild dogs are generally tolerant towards vultures and other avian scavengers (Estes & Goddard, 1967). Jackals are also another minor predator that wild dogs can encounter, specifically the Asiatic Jackal (*Canis aureus*) and the Black-backed Jackal (*Canis mesomelas*) (Estes & Goddard, 1967). The latter species tends to be more active at night and congregate around lion and hyena kills, while the former appears to be diurnal and behave more aggressively at kills (Estes & Goddard, 1967). When near wild dogs, jackals will typically crouch down low, fluff up their bodies, and snarl if a wild dog approaches too close for comfort, but this display of intimidation can be perceived as a bluff since a jackal will run away if a wild dog attempts an attack, and just like with vultures, wild dogs are relatively tolerant of jackals in a general sense (Estes & Goddard, 1967).

Lions and Spotted Hyenas are the wild dog's most dominant competitors, and prey preferences of the three carnivores tend to share a general diet overlap that is associated with high levels of competition (Darnell et al., 2014). This diet overlap is primarily made up of ungulates, and thus creates the possibility for interference competition within the large carnivore

guild (Dröge et al., 2017). Lions are by far the most dominant of these large predators due to their tendency to select areas with the richest abundance of prey as well as being the only carnivore species that move towards all other species (Vanak et al., 2013).

Kleptoparasitism. Hyenas follow just behind lions in the dominance hierarchy due to their large clans and ability to overwhelm their competitors with their persistence and mob mentality in order to steal kills from other predators, and wild dogs are common victims of this behavior, known as kleptoparasitism. The likelihood of a wild dog pack being subjected to this behavior seems to increase with hyena population density, as was observed in a study conducted by Van et al. (2011) in Hwange National Park, Zimbabwe. In this study, the risks and costs of kleptoparasitism were weighed by the population densities of hyenas and lions inside and outside the park, since lions have also displayed kleptoparasitic behavior (Van et al., 2011). It was found that hyena densities were much higher inside the park than outside, while lion densities fluctuated in both areas (Van et al., 2011). In addition, the risk for wild dogs being victims of kleptoparasitism was found to be higher inside the park's territory than outside it since the densities of hyenas were higher there (Van et al., 2011). Outside the park, where hyena densities were lower, wild dogs had a better chance of holding possession of their kills due to the reduced hyena population (Van et al., 2011).

There is also some evidence that kleptoparasitism by hyenas may affect the hunting group size of wild dogs. Since the energetic cost and risk of hunting is so high, wild dog packs have to maximize consumption from prey taken down, and due to the ever prevailing threat of kleptoparasitism, wild dogs may have to increase the size of their hunting parties in order to increase their access time to kills and ability to fend off hyenas that may try to steal said kills (Carbon et al., 1997). Larger hunting groups can possess benefits such as an increase in access

time to a carcass as well as an increase in the probability of capturing large prey like wildebeest, but group sizes larger than at least four wild dogs can experience a reduction in the amount of meat that each individual dog is able to consume, so that pack may have to increase the frequency in which they kill smaller prey in order to meet their daily metabolic demands (Carbon et al., 1997). In the Serengeti, it was discovered that the presence of hyenas can have a strong effect on the profitability of small prey, so this can add more pressure to a hunting wild dog pack since they have to further compete for access to prey (Carbon et al., 1997). However, smaller prey can be consumed much quicker than larger prey, so this could be perceived as a possible mechanism used by wild dogs to combat kleptoparasitism (Carbon et al., 1997).

Conflicts with Native Human Populations

Not only do African Wild Dogs have to compete with other predators for resources within their own hierarchy, they are also competing with native human populations and occasionally domestic dogs in order to survive. One of the causes of these negative impacts is loss of habitat. As the human population grows, more living space is needed to accommodate for new homes and especially farmland. In addition, the reduction of suitable habitat means that wild dogs and their competitors will be forced to live in closer proximity with one another, increasing the difficulty of avoidance for wild dog packs. It would also mean that wild dogs can come into contact with humans more frequently, and for humans that raise livestock for a living, wild dogs are seen as a threat to their animals and are therefore persecuted. This often comes in the form of shooting and poisoning, and the main claim by farmers regarding wild dog predation is that they are seriously detrimental to their economic income due to their livestock being preyed upon (Woodroffe et al., 2005).

Livestock Predation

Despite the fact that the majority of wild dog packs live within protected national parks and reserves, they can still freely move to unprotected areas and come across farmer-owned land. This can often lead to wild dogs finding free-ranging livestock and hunting them. In one study that was conducted from January 2001 to March 2004 in the Laikipia District located in northern Kenya, the first two years showed a minimal amount of wild dog attacks on livestock, with only five confirmed attacks reported in 2001 and two confirmed in 2002 (Woodroffe et al., 2005). However, in 2003, the number of reported predation attacks rose to 49 confirmed attacks, with 44 of them occurring on the border between the Laikipia and Baringo districts (Woodroffe et al., 2005). This sudden spike in livestock attacks was mainly due to the colonization of another wild dog pack codenamed the Churo Pack, and they were found to prey on livestock far more heavily than any of the other packs in the study (Woodroffe et al., 2005). One of the most important discoveries made in the study was that in areas where the rates of livestock predation were high, the densities of wild ungulates were very low (Woodroffe et al., 2005). This was partially due to the prevalence of heavily grazed land where livestock roam, as opposed to the tall grasslands that wild ungulates prefer, and as a result, the prey populations needed to sustain wild dogs and minimize livestock predation was greatly reduced (Woodroffe et al., 2005). This would mean that wild ungulate populations need to be conserved in order to prevent frequent livestock predation, but traditional livestock husbandry can also play a role, as farmers in the Laikipia region carefully herd their livestock during the day and enclose them in a structure called a boma at night (Woodroffe et al., 2005).

In northern Botswana a survey was conducted to gauge how wild dogs factor into the loss of livestock. It was found that only 2% of reported attacks on livestock were from wild dogs,

while 77% were carried out by Black-backed Jackals (Gusset et al., 2009). However, despite these findings, most of the wild dogs belonging to the two known resident packs in the area were killed in the months following the survey, highlighting the resentment that some farmers hold towards them (Gusset et al., 2009).

Pathogen Transmission by Domestic Dogs

One of the other issues that threaten the survival of wild dogs is the risk of contracting diseases from domestic dogs, which can greatly impact the already fragile population of wild dogs. Some of the most common diseases carried by domestic dogs include the rabies virus, canine distemper virus, the bacterial pathogen *Ehrlichia canis*, and canine parvovirus, which has been linked with mortality in wild dog pups (Woodroffe et al., 2012). In certain parts of Africa jackals also have the potential to act as a host for the rabies virus (Hofmeyr et al., 2004). However, the likelihood of these diseases spreading from pack to pack is minimal because of the territorial nature of wild dogs as well as their population densities already being low (Woodroffe et al., 2012). Domestic dogs are assumed to act as reservoir hosts for these pathogens, which means they often do not fall ill to the diseases they are carrying. This also means that pathogens are ever-present as they transfer between domestic dogs, increasing the risk of infecting wild dogs. Rabies is spread by the saliva of infected animals, so a wild dog could be infected if a domestic dog bites them and is acting as a reservoir host. In northern Kenya from 2001 through 2009, blood samples were taken from 90 individual wild dogs in 19 different packs as well as from 184 domestic dogs who were reported by their owners to have no history of vaccination against any kind of pathogen (Woodroffe et al., 2012). The samples were then screened for antibodies for all of the aforementioned diseases, and it was found that they were detectable,

indicating the possibility that wild dogs had previously been exposed to the pathogens (Woodroffe et al., 2012).

Despite the unlikelihood that two separate wild dogs packs would transfer domestic dog pathogens, the effects that such diseases can have on a pack has the potential to devastate the general wild dog population, especially if there is an outbreak. As a result, initiatives like the KwaZulu-Natal (KZN) African Wild Dog Reintroduction and Conservation Programme in South Africa are using surveillance techniques to monitor infectious pathogens and diseases in order to study wild dog populations in the area, with the long-term goal of helping to establish a self-sustaining packs of wild dogs within KZN's protected areas (Flacke et al., 2013). The surveillance techniques used by the program include immobilizing wild dogs for tracking collar attachment/removal and translocating dogs within and between reserves, with blood sample being collected opportunistically during immobilization (Flacke et al., 2013). Outbreaks of diseases such as canine distemper virus can affect individuals whose immune systems are compromised, and in packs who are immunologically compromised, outbreaks can reach epidemic proportions. In the case of one pack from South Africa in 2005, canine distemper virus wiped out an entire pack (Flacke et al., 2013). The rabies virus also has the potential to decimate wild dog packs, and one outbreak that lasted from August-September 1989 was responsible for the deaths of 21 out of 23 members of a pack near Masai Mara National Reserve, Kenya (Kat, Alexander, Smith, Richardson, & Munson, 1996). Another pack that resided in Madikwe Game Reserve, South Africa, also experienced an outbreak of rabies in the early 2000s, resulting in the death or disappearance of 10 out of 12 wild dog pups (Hofmeyer et al., 2003). This event was especially devastating to this pack since it was the second rabies outbreak since 1997 (Hofmeyer et al., 2003). Clinical signs of a rabies infection in wild dogs include salivation, muscle tremors

in the hind legs, and unusual levels of submission or aggression towards other pack members, which can make the monitoring of packs for disease a little bit easier (Hofmeyer et al., 2003).

African Wild Dog Conservation and Human Involvement

As is the case with many endangered species on Earth, wild dogs are struggling to survive due to dwindling habitat, human encroachment and persecution, and more frequent competition for resources with other predators. Conservation efforts to help protect and stabilize fragmented wild dog populations are important because as one of the major carnivores of the Sub-Sahara Africa region, they help regulate the ungulate populations that they primarily prey upon, and in essence help keep the entire ecosystem healthy. However, since wild dogs are not observed as extensively as other predators like lions, cheetahs, or hyenas, it is beneficial to understand how wild dog behavior should influence how conservation initiatives are developed.

Education

In a general sense, farmers in Sub-Saharan Africa are in conflict with wild dogs and, although wild dogs prey on livestock at lower rates than other carnivores, they are still sometimes shot indiscriminately and in retaliation for the deaths of livestock (Fraser-Celin et al., 2017). Livestock have cultural and sentimental value for many people groups such as the Masai and Sonjo tribes, so even the loss of one animal due to predation can cause an outcry (Lyamuya et al., 2014). One method that can be implemented into conservation programs in order to improve farmers' perceptions of wild dogs is to inform them about the importance of wild dogs to the ecosystem, and educating the general public in addition to local populations about what they can do to play a part in helping wild dogs survive can help increase the amount of positive receptions towards the animals. Since wild dog behavior is generally not well-known to the local

populace or to the world in general compared to other large African carnivores, explaining how they are beneficial to the ecosystem and why they should be protected may be somewhat difficult.

However, not all farmers hold a negative view of wild dogs. One survey of commercial game farmers showed them to view wild dogs positively despite livestock predation and no compensation for stocked game animals, and to even support efforts for wild dog conservation outside protected areas (Fraser-Celin et al., 2017). This was because of their understanding of the ecological significance of wild dogs, as well as an emphasis on the dogs' natural characteristics (Fraser-Celin et al., 2017). Tourism was also cited as a positive benefit to conserving wild dogs because tourists would want to see the animals in their natural habitat. This in turn helps boost the national economy as ecotourists travel to the area (Fraser-Celin et al., 2017).

Another way that conservationists can encourage the local people to support conservation efforts is having villages report when they see a lone wild dog or a pack nearby so that researchers can record the possible presence of a self-sustaining pack in the area. This way, conservationists can take any necessary actions in order for both the wild dogs and local people to live safely. Holding small seminars that teach about wild dog behavior may also help local people gain a better understanding of the animals, and hopefully appreciate them enough to take action in order to help conserve them.

Traditional Farming Practices

It has been observed that wild dog prey densities can be affected by the farming practices of the native people groups. For instance, Masai and Samburu pastoralists do not traditionally hunt ungulates on their commercial ranch land, leading to an abundance of wild ungulates in the

study area as well as a reduction in conflicts with wild dogs and other major predators (Woodroffe et al., 2007). In contrast, the areas where the Pokot people reside have very low densities of large wild ungulates due to their hunting traditions, despite the fact that all forms of commercial hunting are banned in Kenya, and livestock predation by wild dogs is prevalent as a result of this practice (Woodroffe et al., 2007). Traditional livestock husbandry has helped wild dogs recolonize in the region, and the observation of wild dogs being capable of sustaining themselves on dikdiks holds potential for future wild dog conservation (Woodroffe et al., 2007). Long-standing pastoralist traditions have also allowed wild dog packs to grow, and in turn, produce larger litters even in a landscape dominated by humans (Woodroffe & Van Vuren, 2011). Ultimately, the conservation of wild prey combined with proper husbandry practices will help reduce the effects of livestock predation and help keep both wild dogs and humans safe.

There may be an additional viable method that farmers can use to deter wild dogs away from their land without the use of lethal force. As observed in the study by Webster et al. (2012), wild dogs usually react to the sound of roaring lions by running away from the source, so a method that may help deter them from hunting livestock is for farmers to place speakers that play lion roars on a loop in locations where wild dogs may appear in a similar fashion to how farmers use bee hives to deter elephants from farmers' crops, thus protecting both the animals and the farmers' livelihoods.

Vaccination

One commonly suggested method of preventing more disease outbreaks is vaccination. After the second rabies outbreak of 1997, a new policy was created so that wild dogs in Madikwe Game Reserve could be vaccinated whenever there was an opportunity, such as during relocation or by darting (Hofmeyer et al., 2003). The pack consisted of two adult males, three adult

females, and 12 pups at the start of the outbreak in January 2000, and between February 1 and 4, two pups died and one was euthanized after showing neurological signs of disease (Hofmeyer et al., 2003). Four more pups disappeared during the same time frame, and the three bodies that were recovered had severe bite wounds around the cranial region caused by attacks from other pack members, with brain samples from the bodies testing positive for rabies (Hofmeyer et al., 2003). After this occurrence, the pack was placed in a boma until May 2000 so they could be monitored (Hofmeyer et al., 2003). Sick dogs were removed to prevent spreading infection to healthy individuals, and were observed at least once a day and fed (Hofmeyer et al., 2003). It should also be noted that before the outbreak started, all five adults were vaccinated for rabies at least twice, while the 12 pups were not since there was no opportunity to do so, and the remaining dogs kept in the boma were also vaccinated (Hofmeyer et al., 2003). Unfortunately, two more pups were euthanized after exhibiting 1-day illnesses and another was found dead, with all of them possessing wounds around the head and neck (Hofmeyer et al., 2003). It is possible that the pups in the boma died of rabies despite being vaccinated because it was their first time, unlike the adults, who had already been vaccinated once before (Hofmeyer et al., 2003).

Reintroduction of Wild Dog Packs

A common tactic used by conservationists to help increase the chances of survival for an endangered species is to reintroduce them to areas that were once part of their historical range in the hopes of re-establishing viable populations. However, packs that are relocated to a new location may possess different social dynamics than their long-established counterparts due to being in an unfamiliar space. An attempt to re-establish one pack at Mkhuze Game Reserve in South Africa was unsuccessful, but it was discovered that the home range of the pack was

estimated to be around 383.9 km², which is larger than the 360 km² area that makes up the reserve (Jenkins et al., 2015). This is significant because reserves are protected by rangers who monitor the area for poaching and other illegal activities, and since the land outside of reserves is unprotected, it can be difficult to monitor a pack that has been relocated if their home range is larger than the reserve.

While the general public and some farmers seem to be in favor of reintroducing wild dogs into new areas, there has been some opposition from people of different walks of life. Local community members, private landowners, and tourists were given a survey regarding a plan to manage several sub-populations of wild dogs as a single meta-population in several isolated conservation areas located in South Africa (Gusset et al., 2008). The survey was conducted to assess reactions to reintroduce wild dogs to a specific area known as Hluhluwe-iMfolozi Park (HiP), and the responses varied among the stakeholders, with tourists showing an overwhelmingly positive response to the plan, made even more apparent if respondents had seen free-ranging wild dogs (Gusset et al., 2008). Contrasting the positive reactions from tourists, there was a more negative response to the plan by the local rural population around the park based on the threat of losing livestock, and those who were more educated on the ecological importance of wild dogs displayed a more positive outlook (Gusset et al., 2008).

Conclusion

The most prevalent threat that wild dogs face in the wild is habitat destruction. It can be fairly difficult to appropriately reduce this threat since the human population continues to rise steadily. National parks and reserves are locations that are already protected from habitat loss, but it is still imperative that they remain that way indefinitely. Stricter protections for national parks and reserves may help to keep them safe from possible land encroachment. Outbreaks of

disease, specifically rabies, are also a threat to the long-term survival of wild dogs. One plausible method of reducing the rate of infection in wild dogs is by encouraging the local populations to vaccinate their dogs for the rabies virus, since they act as a reservoir host. Vaccinating wild dogs may also mitigate the problem of outbreaks, although the dogs would have to be extensively tracked to see if the vaccine is effective and to make sure they are up to date with their shots.

Another threat to wild dogs is the sometimes fatal retaliation by farmers for the deaths of livestock. As humans move closer to the dogs' habitat, the animals come into closer contact with their livestock, which can be seen as easy prey for a hungry pack. The reduction in the population of wild ungulates has also partially contributed to this issue. Creating conservation plans that will protect wild ungulates from overhunting will be the first step in reducing the number of encounters between wild dogs and farmer's livestock. The next step would be to see how farmers manage their livestock at night, since that is when wild dogs are most active. Farmers from the Laikipia District in Kenya keep their livestock in bomas at night, so this could be used as a starting point to educate other farmers on farming techniques that will help both protect their livestock and the wild dogs.

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