

North American Black Bear Mating: A Review of the Processes and Behaviors as a Result of External and Environmental Factors

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Introduction and Background

Ursus americanus, better known as the North American black bear, is by no means an unfamiliar face for residents in rural Pennsylvania. Their presence is well established in the area and therefore, it is not uncommon to come across these beautiful creatures from time to time. However, Pennsylvania is not the only region in which these large bears are found to be indigenous to. True to their name they are found to inhabit a large portion of the North American continent, spanning across approximately eighty percent of the United States of America and a small portion of Canada (1). Due to their close proximity to human populations it is not uncommon for their very existence to arouse the curiosity of many individuals. Therefore, it should come as no surprise that we as human beings want to learn more about these large animals that we share the earth with. This is due in part to the fact that the natural behaviors that they exhibit are both unique and foreign to the species as a whole. All in all when it comes to black bears the behaviors and processes that are observed can be very helpful in allowing us to better understand the species as a whole.

Prior to taking a more extensive look into the natural behaviors and physiology exhibited by North American black bears it is important to acquire a little bit of knowledge about their background. Bears are characteristically known for having a longer dog-like snout, non-retractile claws, and a plantigrade stance which serves to better illustrate why they are lumped into

Caniformia, a suborder of the order Carnivora (2). Following the taxonomic rank further, black bears are categorized as a group of large omnivorous mammals who belong to the family Ursidae (2). North American black bears in particular are distinctively known for having varying shades of black-brown fur, which varies depending upon the environment that they inhabit. In addition to this they have a stocky build with a facial profile that supports small eyes, and rounded ears that are set back further along their skull (3). When it comes to size, these bears can achieve a weight of anywhere from one hundred and fifty to five hundred or more pounds (4). All in all these creatures are rather impressive in appearance, but that is only one of the many captivating facets of their lives.

Black bears are a group of animals that tend to favor a more solitary lifestyle, however they will forgo their separation from the rest of the species when they are doing one of two things, mating or caring for offspring (5). Reproduction for black bears is actually a rather unique phenomenon, with promiscuous mating occurring throughout the months of June and July (5). After copulation occurs, females undergo a specialized physiological process in which the fertilized egg does not immediately implant within the uterine wall; rather it remains suspended within the uterus until the onset of early winter (6). Following mating season, the black bears go their separate ways and forage in order to accumulate fat stores that will sustain them throughout a period of hibernation. During hibernation the bears den down and enter a period of fasting in which they do not eat, drink, defecate or urinate (7). Come the spring the bears will emerge from their dens, some with cubs and some without. From here on out the cubs will remain with their mother for approximately sixteen to seventeen months, in which she will guard and care for them

(5). Subsequently, the small family will break up and go their separate ways and the reproductive cycle of the bears will begin anew.

In order to acquire a more in depth understanding of how these bears function throughout their lives it is important that a closer look is taken into how they have survived the passing of time (8). Observing the various behaviors and physiological processes of a black bear during their reproductive cycle is informative of the proximate mechanisms that underlay the ultimate effects of their evolutionary past. These mechanisms are important in that they are adaptations that have arisen in order to ensure that the species thrives as a whole. By looking at these mechanisms, individuals are able to garner a great deal of information about the evolutionary course of history surrounding the black bear (9). More importantly however, we can learn just how black bear reproductive behaviors and physiological processes have adapted to benefit the species in the context of external factors such as their environment.

Reproductive Nature of Male Black Bears

The reproductive behaviors and physiological processes exhibited by male North American black bears, also known as boars, have been found in studies to revolve indefinitely around the animal's drive to reproduce both efficiently and effectively. The mechanisms that these bears employ in order to successfully reproduce are what really seems important to comprehending the overall nature of male black bear reproduction (9). Research exploring these mechanisms indicated that male reproductive success is strongly influenced by three main factors; body size, sperm competition and enduring search efforts for receptive females (10,11).

Body Size and Age

The overall size of black bears may not upon initial inspection seem to be of utmost importance, however when you look more into courting behaviors it seems to be that size is in fact a trait that the female black bears, also known as sows, find favorable. In one study, the effects of body size and how they correlated with the reproductive success of the males of the species was monitored (10). Multiple bears in a sanctuary zone were captured and processed under standard procedures, which involved being tattooed, tagged, and fitted with motion-sensitive radio-transmitter collars. At the time of capture the bear's age, genetics, and size were all assessed, with the bears being lumped into one of three body size categories; large, medium, or small (10). Tracking of the male bears during the peak breeding season via the radio collars allowed researchers to view probable interactions with females. Larger boars were found to have significantly more interactions with females than medium and smaller boars (10). One possible explanation to this relationship could be that competition is increased amongst males of the species due to the asynchronous periods of estrus that females exhibit (1). Boars with a large body size tended to monopolize the receptive female's time in addition to driving any smaller bears away from them (10). Thus, allowing fewer opportunities for small bears to mate with receptive females. Successful reproduction of the males was determined by a genetic assessment of cubs born to any females that were a part of the study. It was concluded that paternity in North American black bears was positively skewed such that it correlated with the body size of the boar; indicating that the larger boars, or those of a more intermediate size, were more successful in reproducing than the smaller boars (10).

In another study done focusing upon the reproductive success rates of male North American black bears, size was also observed as was a more complex set of variables. A total of five hundred and fifteen black bears were captured, processed, fitted with radio-telemetry collars and assessed in this study. Assessments included; genotypic assay, cementum aging, and body scaling (11). The bears were monitored over the breeding season and data was collected via recapture, den entrance, or monitoring through the use of radio collars (11). It has been noted in previous experiments that size and age have a positive correlation when it comes to North American black bears (10). Age in addition to resultant size was found to be a strong determinant of reproductive success in black bears. It was also ascertained that older males appeared to have a distinct advantage over younger males when it came time to mate (10, 11).

Mechanisms Driving Success through Body Size and Age

The success of mating that is observed due to body size and age of boars of the American black bear species can be attributed to a number of evolutionary processes. Currently a few studies have been done investigating the ultimate causation of why the sows hold a preference to older and larger males. Each study shares the commonality of attempting to answer the same question and that is why? No findings have been definitive up until now, but there are a number of explanations that really appear to hold some sound reasoning.

One possible explanation of why sows choose to mate with larger and more mature boars could be the physiological need to produce offspring with genetic superiority in the areas of longevity and fitness. In multiple studies it has been proven that black bears have a higher rate of survival in adults than in juveniles (1, 11). Being that the male bears are most vulnerable in their juvenile years, it makes sense that those who have the genetics to obtain a greater size could beat

the odds and therefore, survive to an older age (1). In a study done by Beck and Powell similar results were obtained when the overall evolution of female mate choice based on age was assessed. The driving force behind this phenomenon was thought to have arisen in response to female preference in mating with a male who has survived to a mature age in the environment (9). The idea behind this is that these males are genetically superior to others when it comes to surviving in the wild (9).

Another explanation that has been found to warrant some attention in the scientific world is the overall impact of male to male competition during mating season. The idea behind this explanation is that males of a more intermediate age have acquired a greater size and therefore, they are found to prevent younger and typically smaller males from mating with receptive females (11). This idea insinuates that females are not choosy at all, but rather they will mate with whichever male successfully overpowers the other. This is a concept which has also been proven to be true in a number of black bear reproductive studies (11, 12). This selection of mates is an evolutionary process that female bears have adopted in order to ensure that only the most viable of offspring are produced. Currently it appears that the most logical reasoning behind older and larger males being more successful in mating is that male to male competition is extremely intense and overall rather deterring to younger males.

Sperm Competition

In addition to age and body size, there are other more physiological processes that also play a role in the reproductive success of male black bears. One major process that is thought to occur in the North American species of black bears is that of sperm competition. Sperm

competition is a competing process that occurs when sperm from multiple individuals work towards fertilizing one egg (10). Currently, not a lot has been done to study this phenomenon in black bears, but some studies have shown that there is in fact sincere evidential support that it does occur in this species. Female black bears are known for having an average of two to three cubs in each litter (1,6,13). Another fact that is also important to take into account is that these large mammals are a polygamous species. When genetic analyses were done upon cubs in a study of paternity in recolonizing populations, it was discovered that dual paternity took place amongst the offspring (14). This finding indicates that a receptive female mated with more than one male throughout the breeding season. It is possible that numerous males mated with the female and the sperm that joined with the egg to form the resulting zygote was the most fit (14). As mentioned previously, not a lot of research has been done upon sperm competition in black bears. However, if it is in fact true that these animals exhibit this process and due to this reasoning there are a number of hypotheses that have been proposed to better explain it.

Mechanisms Driving Success Sperm Competition

In terms of how this physiological process first arose there a few pertinent theories that should be taken into account. First and foremost there is the idea that sperm competition could quite simply have arisen as a result of needing to produce the strongest and most viable of offspring. The logic in this possibility is that these bears have a long gestation period and an even longer weaning period in which maternal care is highly focused upon both protecting and caring for their young (2). This means that the females are investing a lot of time and energy into

their offspring, which indicates that the species focuses a great deal upon ensuring healthy cubs are maintained in the population.

Another possible explanation behind why this process could occur in the bears is that of male to male competition. The need to produce the best offspring possible that can survive the passing of time is oftentimes the driving force of reproduction. In the case of the black bears sperm competition may serve as a method to select for the most viable of offspring (14). For instance, if a larger bear with superior genetics has a higher rate of fertility, then their sperm will likely fertilize the egg of a female over that of a lower uncompetitive bear that is not quite as fertile. Therefore, if males of the black bear species are determined to be superior to other sperm competition would be beneficial to the continuation of the species as a whole.

Locating of Receptive Females

A rather crucial aspect of successful male reproduction in this species of bear is the locating and courting of the females. This is perhaps the most energy consuming aspect of the male's reproductive nature. In addition it is an essential aspect due to the fact that these animals lead solitary lifestyles. The disbursement of females and variability of receptive mating times in relation to boars locating sows was a concept that was minutely evaluated at first by Costello et. al. and then again more in depth by Lewis and Rachlow.

As mentioned previously Costello studied varied aspects of male reproductive success in black bears. His findings on the topic of search efforts for potential mates were not the overall focal point of the study; however he did accrue significant findings. He found that success in male reproduction was more effective when bears traveled around searching for multiple mates

outside of their home ranges (11). This was an indication that males would undergo substantial search efforts in order to find females to mate with. It was also discovered that females who are in closer proximity to the home ranges of male black bears are found to be more of an asset to their reproductive strategies. This is due to the fact that boars were likely to frequently encounter sows whose home ranges overlapped with theirs (11). This allowed for more successful copulations to occur, however having females in the immediate vicinity is not always the case. Therefore, the study determined that male black bears that stay within their home range are less likely to mate successfully with multiple females than those who travel extensively to find mates.

In Lewis and Rachlow's study, black bear movements and activity patterns were further analyzed between the different sexes for seasonal times in relation to mating and foraging behaviors. Usually both males and females of the species maintain similar activity patterns that tend to increase notably during the months in which these bears forage for foods to get them through the winter. In addition to this however, it is dually noted that male bears tend to increase their movement patterns during mating seasons in order to increase fitness (15). In the study, males were found to significantly increase their movement rates during peak mating times of spring and early summer, while female patterns were not significantly different. The findings of this study served to strengthen the idea that these bear participate in an extensive mate seeking behaviors in order to ensure that they successfully reproduce.

Mechanisms Driving Success through Locating Female

The start of mating season for male American black bears necessitates a long and onerous pursuit of receptive females. This mate seeking behavior is rather unique and has been observed

and validated in a number of studies that analyzed the overall activity patterns of male black bears (11, 15). Each study done upon the male's movement patterns has incurred very similar results in regards to what these bears do. It has been found that the cumbersome search that the bears undergo is a relevant mating behavior to their fitness however, the question remains as to why it is necessary?

It is presumed that the bears undergo this particular mate seeking behavior due to the fact that these animals lead a solitary lifestyle (7). This presumption is further supported by the results of a study done by Noyce and Garshelis, which focused on the causes and consequences of seasonal migrations in American black bears. In their study they monitored black bears and the patterns of movement that they exhibited over the course of ten years (17). The data that they received from the study was analyzed by using chi-square tests to assess differences in seasonal movements based on sex, age and reproductive class. The analysis of these results showed that these solitary animals will increase their movement patterns during mating season (17). In addition it was noted that the paths of the opposite sexes overlapped more readily than usual during mating season. This seems to only strengthen the idea that this mate seeking behavior arose in order to contest the solitary lifestyle of the bears (15, 17).

Conclusion of Mechanisms Driving Male Black Bear Reproduction

The ultimate goal of reproduction for male black bears of North America is quite simple, reproduce and procure viable offspring that will carry along their genes into the future. It seems simple enough, but this process is anything but simple. In fact there are a number of physiological and behavioral aspects of the male black bear's life that really serve to make it the unique and specialized procedure that it is. In a physiological sense, sperm competition and age

paired with maturity enable the boar to express his phenotypic strengths to receptive females (11, 14). This serves to improve his attractiveness as a mate to females, while at the same time competing with the other males of the population for the right to mate (10). However, before these physiological processes are given a chance to occur these bears must first locate a mate. This takes a substantial amount of effort on the male's part, because he must track the receptive females down (15). This is an energetic and time consuming process that should by no means be overlooked as being of minimal importance to successful reproduction (17). Finding a mate is crucial to allowing the physiological processes to occur. When the physiological and behavioral aspects of the male American black bears lifestyle are further analyzed it can be seen that the two are specialized processes that have coevolved in order to increase the overall fitness of the species as a whole (1, 2, 17).

Reproductive Nature of Female Black Bears

When it comes to females of the North American black bear populations there are a multitude of factors that have been found to play a role in the reproductive behaviors and physiological processes that they exhibit. Numerous studies have been done upon the females of this species, most of which seem to revolve upon how these females go about successfully producing the future generations of offspring. Overall, there are two combined factors that really seem to be of the utmost importance to achieving successful reproduction in bears. These include two postzygotic mechanisms, which are maintaining a satisfactory maternal condition of the female bear prior to gestation and a state of reproductive embryonic diapause which delays the implantation of a fertilized egg (4, 6).

Accumulation of Fat Stores

One of the most notable behaviors exhibited by American black bears occurs in the months preceding hibernation in which they amass a supply of fat stores to help them get through an extended period of fasting. Typically the diet of black bears during this time period is largely that of hard mast, or the fruit that forest trees produce (2). Hard mast has been found in various studies to be one of the bear's main sources of nutrients for building fat stores for the winter, because it is usually plentiful and easy to forage in the fall months (2, 4, 6). Therefore, it can be said that reproductive success in female black bears relies a great deal upon the availability of seasonal foods. This is due to the fact that they allow the bears to accumulate fat stores that will sustain them throughout a period of hibernation (6, 13).

When it comes to reproductive females, the amount of fat stores needed for winter is increased due to the fact that the bears give birth and nurse their young while at the same time denning down for the winter to hibernate (4). Harlow, Grogan, and Beck looked further into how fat stores differ between reproductive and nonreproductive female bears, by tracking sows through the winter months and measuring their overall body fat content. During the early months of winter it was discovered that reproductive females had a mass that was fifty percent greater than that of nonreproductive females (4). This value seems to be the norm for reproductive females, as it is similar to the data of other studies surrounding female bears and their body weight when pregnant (3, 6). In addition to this, Harlow and his associates analyzed the expenditure of body mass, body fat and proteins throughout the course of winter.

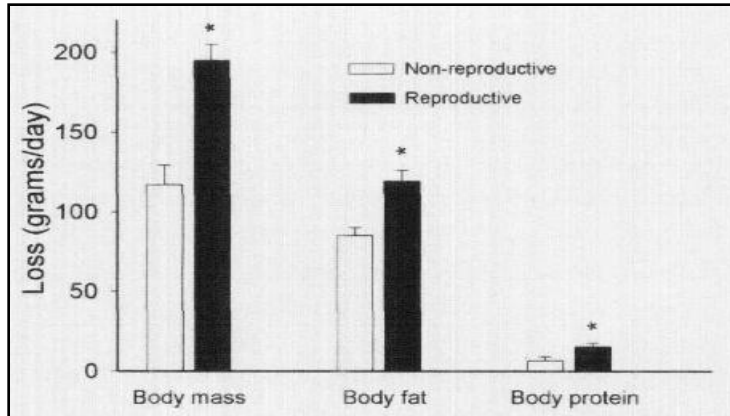


Figure 2: Comparison of the loss of nutrient stores between non-reproductive and reproductive females during hibernation

*Asterisk's denote significant differences

This portion of their study accumulated the results seen in Figure 2, which supports their theory that reproductive females have a higher energy cost during the winter months of hibernation (4).

Mechanisms Driving a Higher Accumulation of Fat Stores

Following the early spring and summer months of the black bear's mating season, the bears set out on a campaign in order to accumulate as many fat stores as they can to sustain them through a period of hibernation. For female bears that are in a reproductive state these fat stores are exceptionally important in that they provide nutrition to the offspring that are born as well as the mother (6). This energetic cost of reproduction has been shown in studies to prompt the reproductive sows to virtually double their intake of fat stores that they accumulate prior to denning down for the winter months (4). By increasing their fat stores they are ensuring that any cubs that they birth are well cared for during their first few weeks of life.

Maintenance of an exceptional maternal condition is a very important aspect of producing strong viable offspring. The evolutionary theory behind this particular behavior of foraging up as many nutrients as possible prior to den entrance has been found to be based more upon the energetic costs of caring for young (2). Female black bears undergo parturition during

hibernation (6). This means that they must have an overabundance of nutrients in order to sustain both them and their newborn cubs. One benefit that has been noted in a study done on the maternal milk composition of black bears was that not a whole lot of nutrients are used to produce milk (2). In fact it was concluded that the milk was high in fat, insinuating that it had been derived from depot fat stores of the female (2). Therefore, when females spend time building up their fat stores in the months prior to hibernation it is in order to provide their newborn cubs with a means of obtaining nutrition.

Delayed Implantation

Perhaps the most interesting process that female black bears exhibit is a physiological upset of reproduction which is termed embryonic diapause. Embryonic diapause, also known as delayed implantation is best defined as the condition in which the development of a fertilized egg arrests at the blastocyst stage (16). This temporary delay in gestation appears to be due to a suppression of proliferation that occurs in the blastocyst stage of a zygote (16). The benefit of delayed implantation to female bears is that it allots a flexible period of timing in which both conception and birth can occur. Since it has been well documented that breeding and parturition in black bears is largely dependent upon maternal and environmental conditions, delayed implantation is beneficial in that it allows for a more flexible period of time in which reproductive factors can be addressed (4,18).

In order to determine whether or not these bears really undergo a delay in implantation prior to gestation, studies are performed that take a closer look at the time interval between

mating and parturition (19). In the case of North American black bears it is noted in various studies that females mate in the early spring and summer months and refrain from giving birth until late January or early February (20). This is a clear indicator that the fertilized egg is not immediately implanting within the walls of the uterus, because black bears are known to have a gestation period of around two months (20).

Mechanisms Driving Delayed Implantation

Embryonic diapause or delayed implantation is a physiological process that most likely arose in order to effectively ensure successful reproduction amongst mammals (16). However, the more important question that needs to be addressed is; what external factors were forcing this specialized process to evolve in the North American black bear species. Embryonic diapause is a really interesting phenomenon that has been the topic for a number of scientific studies. One study in particular done by Ferguson et. al. focused upon the evolution of delayed implantation in North American carnivores, such as the black bear. This study hypothesized and concluded that mammals that exhibit delayed implantation as a gestational extender are commonly found to evolve in response to highly seasonal environments (18). However, in addition to seasonal variations Ferguson and his colleagues also concluded what many other studies have also confirmed and that is that maternal conditions play a role in the implantation of the fertilized egg.

When analyzed with the overall maternal condition of the female, delayed implantation is found to allow sows to not undergo large energy expenditures prior to den entrance. This means that fat reserves accumulated by the females will not be wasted on the maintenance of a

pregnancy at a time in which the female needs to focus upon preparing for the point in time in which not food resources will be present (6). In a study performed by Flavia Lopes et. al. a more in depth look was taken into the evolution behind embryonic diapause and its regulatory processes. This study made some very pertinent assessments of the reasoning behind why this physiological process is observed in the North American black bear species. First off, it supported the idea that delaying implantation allows for embryological development to occur at a time that is beneficial to the mother in a sense of energetic costs. Delayed implantation in female black bears is essential to ensuring that the species can thrive in their temperate environments which do not provide enough nutrients for the bears year round. Overall, the factors that are found to impact delayed implantation in temperate bears, such as black bears, appear to be rather dependent upon maternal condition and environmental factors (19).

Conclusion of Mechanisms Driving Female Black Bear Reproduction

Ultimately, it has been found that female North American black bears have adopted a number of specialized postzygotic mechanisms that aid in a higher reproductive output. Each one upon further investigation appears to have arisen in response to the temperate environment that these bears reside within, along with a few other minor external factors (16, 19). The various physiological and behavioral mechanisms that female black bears exhibit, are rather helpful in discerning the ultimate effects of evolution. In a physiological sense delayed implantation has arisen such that female black bears can increase their overall reproductive fitness. In addition to this reproductive females are found to virtually double that amount of fat stores that they accumulate for hibernation (4). It is important to take note that the behavioral side of the

equation is directly linked to the physiological side, as each impacts the other in some shape or form. That being said it should come as no surprise that a number of the processes viewed in female black bears tend to overlap with one another. The reproductive nature of female black bears is largely dependent upon two major aspects of the bear's unique lifestyle; embryonic diapause, and accumulation of fat stores (4, 16, 19).

Mercy Values

The four core mercy values that our school adheres to and inculcates into their students; Mercy, Service, Hospitality, and Justice are associated with the study of sciences in a much stronger bond than most would at first think. Science is geared towards bettering our world through the discovery of new knowledge upon a multitude of subjects. Through the many processes that it requires there are various instances which benefit from the adherence to our school's values. In the scientific study of the reproductive behaviors and physiological processes that North American black bears exhibit, this is no different.

Mercy

The first of our school's values is that of Mercy; which has a rather strong role in the scientific studies surrounding American black bears. Being merciful towards others entails that you show both a compassionate and an empathetic nature towards others and their various plights. The value of mercy can easily be seen within each researcher's treatment of all the animals that were handled within the various studies that this paper set out to review. In order to ensure that each animal was allotted a more salubrious lifestyle, nothing was done to

intentionally harm them. This meant that a standard set of ethics was adhered to as each bear that was either captured or observed was not harmed at all by any of the researchers.

Service

The next value of service is also rather apparent in this study, because it encompasses the whole purpose of the study; which is to educate individuals about this magnificent species of bears. The researchers that spent countless hours studying and analyzing the North American black bear species are doing a didactic service to all of their fellow human beings. They are gathering new information that is meant to educate both us and future generations about this animal. By educating people on this species of bear, researchers are doing a major service to general population as a whole. Their work is very notable when it comes to the conservation of animals in preservation for the future of our world. The researcher's work truly does set out to pave the way for many others to continue on in the pursuit of knowledge of this species of bear.

Hospitality

Implementing the third mercy value of hospitality into any type of research that deals with living organisms is crucial to ensuring humane practices are adhered to. This is also true for each study that was cited in this review. In the case of the North American black bear studies, researchers were hospitable to all of the animals by pretty much allowing them to live their lives in their select environments. For the most part the bears in each study were simply observed and not manipulated in any shape or form. By doing this researchers could observe the natural behaviors of the bears, while at the same time leaving them to their own devices. Another thing

that is important to remember about these studies is that they are not done by one individual, but rather many people play a part in their occurrence. It is here that hospitality also comes into play, because as human beings we want to be comfortable working with those around us. Entering into a study that includes many individuals willing to open up and share their knowledge makes for a more efficient team to study these large mammals.

Justice

The fourth and final mercy value that can be found within this area of study is that of justice. Justice is the act of being fair to those around you and ensuring that nothing untoward happens. North American black bear populations represent one of many species that we are found to coexist with in this world. As it is we sometimes have difficulty ensuring that we are just towards these creatures. We neglect to take into account that we share this earth with them and therefore, that we must not feel entirely threatened when their paths cross with ours. One of the benefits of looking more into these animals' natural behaviors and tendencies is that we can learn more about them and be able to ensure that we do not intentionally do something that is unfair to them. These studies are paving the way, so that we can better understand black bears and learn to respect their natural behaviors.

Conclusion

The overriding goal of this research was to determine how North American black bear reproductive behaviors and physiological processes have adapted to benefit the species in the context of their environment. The information that we acquire from studying the proximate

mechanisms of the North American black bear are very indicative of how the ultimate effects of evolution may have preceded. Black bears are many things if not fascinating creatures.

Physiologically they are a marvel to the human species in their ability to undergo processes such as delayed implantation and hibernation. These behaviors that they exhibit all serve a purpose and that is ultimately the sustainability of the black bear species. Yet, the reproductive end is not the only thing that ensures this continuation. In further research studies, a closer look should be taken into the maternal care that the sows exhibit. Cubs are solely dependent upon birth and without the mothers care they would perish. Overall the manner in which these mammals create and care for their offspring is very pertinent to the survival and continuation of the species as a whole. Over time they have adapted their behaviors so that they can reproduce in the most beneficial way. Without these unique behavioral advances the North American black bear species would not remain in existence.

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