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Faculty of Tropical AgriSciences

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Cattle antipredation strategies: may acoustic stimuli affect the vigilance of cattle on pasture?

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled "Cattle antipredation strategies: may acoustic, visual and olfactory stimuli affect the vigilance and social behaviour of cattle on pasture?" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague, 16.4.2021

Marie Žabková

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Abstract

The aims of the thesis were 1) to gather the knowledge about large herbivores and cattle behaviour on pastures with a focus on social behaviour, antipredation strategies and domestication, based on scientific literature review, and 2) to test responses of grazing cattle on pastures to acoustic stimuli of sympatric and allopatric predators in a field experiment. The experiment was conducted on cattle herds in two social groups (herds of suckler cows n = 7, and herds of steers n = 6) on the experimental farm Grünshweige (Technical University of Munich, Erding, Germany). Videos of cattle behaviour as responses on sequences of sounds were recorded using 3 sounds of predators and 1 control sound in randomized block design. Sounds were standardized and belonged to dog (*Canis familiaris*), wolf (*Canis lupus*), hyena (*Crocuta crocuta*) and chaffinch (*Fringilla coelebs*). Behavioural responses were recorded and quantified as frequencies and durations, then tested using non-parametric tests in TIBCO Statistica® 13.5. programme. Results showed that cows did not display any behavioural response to any acoustic stimuli representing predators, but also no response to control sound. The low level of vigilance can be caused by intensive breeding practices, which may result in suppressed natural behaviour of cattle due to frequent contact with human and selection to production traits, and it can be strengthened by the presence of an international airport nearby the farm, therefore the cows are habituated to a high level of noise. We can therefore conclude that human management may strongly affect the behaviour of domesticated animals, including essential behaviours related to survival in natural conditions.

Keywords: animal behaviour; cattle grazing; pasture; vigilance; antipredation strategies

Abstrakt

Cílem této práce bylo 1) shromáždit informace o chování velkých býložravců a skotu na pastvinách se zaměřením na jejich sociální chování, antipredační strategie a domestikaci na základě přehledu vědecké literatury, a 2) otestovat reakce pasoucího se skotu na akustické podněty sympatrických a alopatrických predátorů pomocí kontrolovaného experimentu. Experiment byl proveden na stádech obsahující dvě sociální skupiny (krávy s telaty n = 7 a býci n = 6) na experimentální farmě Grünschweige (Technická univerzita Mnichov, Erding, Německo). Reakce skotu byly zaznamenány na video. Sekvence zvuků pouštěné v náhodném blokovém designu obsahovaly celkově 4 zvuky. Ve skupině predátorů byl pes domácí (*Canis familiaris*), vlk obecný (*Canis lupus*) a hyena skvrnitá (*Crocuta crocuta*), a jako kontrolní zvuk byla použita pěnkava obecná (*Fringilla coelebs*). Reakce byly zaznamenány a poté kvantifikovány jako frekvence a doba trvání. Následně byly otestovány pomocí neparametrických testů v programu TIBCO Statistica® 13.5. Výsledky ukázaly, že skot, celkově, ani žádná ze sociálních skupin zvlášť, nevykazoval žádnou odezvu na akustické podněty představující predátory, ale ani na kontrolní zvuk. Nízká míra bdělosti nám může napovídat, že z důsledku intenzivního chovu a častého kontaktu s člověkem může být přirozené chování skotu a jeho reakce potlačené. Dalším důvodem pro nízkou míru bdělosti může být přítomnost frekventovaného letiště v blízkosti experimentální farmy – skot může být zvyklý na hlasité zvuky. Můžeme tedy dojít k závěru, že intenzivní chovy mohou silně ovlivnit chování domestikovaných zvířat, a to včetně naprosto zásadního chování souvisejícího s přežitím v divoké přírodě.

Klíčová slova: chování zvířat; pastva skotu; pastva; obezřetnost; antipredační strategie

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1. Introduction

Predation is a common part of our world and creates natural balance. It is a type of feeding behaviour since the only goal of predation in the animal's world is to get food. Because of that, prey animals have developed antipredation strategies that help them to reduce the risk of becoming prey, which we call antipredation behaviour. These actions can include for example camouflage, playing dead, warning marks, colours or vigilance. To be able to respond with suitable behaviour, animals need to rely on their knowledge and skills to distinguish a predator and share it with each other.

Cattle antipredation behaviour consists mostly of vigilance. Vigilance means the animal is being alert and is scanning the environment in order to examine the presence of a predator. If they are not alert, they cannot determine the risk level and cannot choose possibly needed antipredation strategy, and they may become prey in case the predator is nearby. Vigilant behaviour can have many forms, with the most basic one being simply having a head up and looking around.

Depending on geographical location, cattle can be preyed by wolves, dogs, bears, foxes, coyotes or even badgers. This study aims to gather and evaluate information about cattle behaviour, their social connections and antipredation strategies, using literature and our own research in the field.

2. Aims of the Thesis

The present thesis aimed to gather knowledge about cattle behaviour on pastures with a focus on antipredation strategies and to evaluate these behaviour forms from the perspective of connection with domestication.

Specific objectives were:

1) To explore and provide an overview of available knowledge regarding antipredator behaviour of large herbivores, namely of cattle grazing on pastures in the scientific literature with a special focus on their social behaviour, vigilance and reactions to acoustic stimuli.
2) To determine and quantify responses of cattle to acoustic stimuli, i.e. sounds of sympatric and allopatric predators in a controlled experiment using a design including besides predator call also neutral sounds as a control reference stimulus.

3. Methodology

3.1. Theoretical background

For my literature review, I have used our university library and scientific databases, such as ScienceDirect, Scopus, Web of Science or BioOne. On those, I have been searching articles by key words - animal behaviour; cattle grazing; cattle; pasture; vigilance; antipredation strategies. I also used recommended literature provided by my supervisor or scientific web pages.

3.2. Practical part

3.2.1. Study site

The study site was conducted on Grünschwaige experimental farm (School of Life Sciences, Technical University of Munich, Germany), located in Erding, Bavaria region, Germany. The farm is located 434 m above sea level and the terrain is flat. With annual precipitation of 750 mm and an average temperature of 7.4 °C, the environment creates ideal conditions for pasture, therefore for cattle grazing. The size of the farm covers 160 ha out of which 136.65 ha was grassland (85.4 %), divided into several paddocks. The rest, 23.35 ha (14.6 %), were forest, windrows and infrastructure. As for soil types, we can find few various soils – peat soils, rendzinas and gley soils. This research was done on 14 out of 21 paddocks. Their staff contained one agricultural specialist, two agricultural workers, one apprentice, three research technicians and one clerk. By the year 2000, they owned 200 cattle individuals, divided into pastures (

Table 1) and according to their purpose - reproduction or fattening. Data were collected in July 2011 during the day.

The observed cattle were Limousin (*Bos taurus*). Limousin breed has been used mainly as a drafting animal, but through history, they became one of the top breeds for meat production. It produces beef with a low proportion of bone and fat and a high yield of saleable meat (73.3%), and in France, they are called "the butcher's animal" (Limousin editors 2017). Cattle were on the pasture all year long, except winter months. Pastures used for the experiment were K1, K3, K4, K5, K6, K7, K8, K9, K11, K12, K13, K14 and

K15, the division can be seen in Figure 1. Pasture height (Figure 2) refers to the height of grass, therefore to the grazing intensity. The lower the grass, the higher the pasture intensity, i.e. grazing pressure.

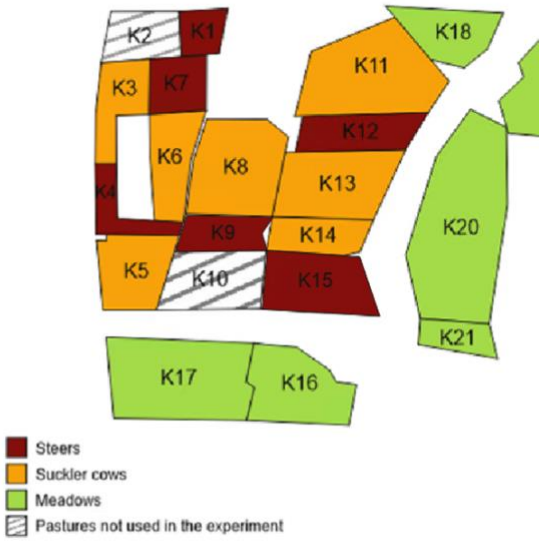

Figure 1: Distribution of types of herds in paddocks according to the social group.

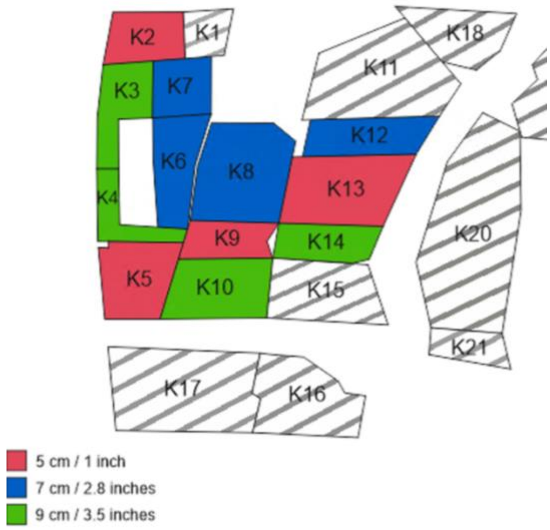

Figure 2: Distribution of managed grazing intensity in paddocks according to target grazing sward herd.

Table 1: Herd structure in separate paddocks (Source: TUM 2011).

Pasture	Type of animals
K1	Steers
K3	Suckler cows
K4	Steers
K5	Suckler cows
K6	Suckler cows
K7	Steers
K8	Suckler cows
K9	Steers
K11	Suckler cows
K12	Steers
K13	Suckler cows
K14	Suckler cows
K15	Steers

3.2.2. **Design of the experiment**

The acoustic experiment was consisting of testing the responses of cattle to acoustic stimuli represented by sounds of four different animal species, i.e. two potential sympatric predators, one allopatric predator and one neutral bird sound as a control sample. Animals chosen for this experiment were grey wolf (*Canis lupus*) and dog (*Canis lupus familiaris*) as species sympatric to cattle, spotted hyena (*Crocuta crocuta*) as an allopatric species and common chaffinch (*Fringilla coelebs*) as a control sample. Sympatry means when two animal species live, including evolutionary history, in the same environment. Allopatry is when species live in geographically separate areas, different countries, continents, so any interactions, neither any gene flow in between species in their evolutionary history have never been there (BD Editors 2019). The control sample is needed to see if animals are reacting to any sound at all. Different sequences are needed to avoid habituation to sounds. Habituation is a decrease of responses to stimuli after a repeated presentation (Cherry 2020). If cows would get used to those sounds, their responses to those particular stimuli would diminish, because they would pay less attention to them. Changing the sequences of sounds can prevent this phenomenon (Cherry 2020). Sounds were therefore arranged in sequences following the completely randomized block design (Table 2).

Sounds were standardized to WAV audio format and played by modified loud-speaker. Cattle are very sensitive to high-frequency sounds and have a wider range of hearing than humans (human hearing range ranges from 64 to 23 000 Hz, cattle hearing range ranges from 23 to 35 000 Hz) (Moran & Doyle 2015). So high pitched sounds like whistling can be unpleasant for cows. Also, sudden sounds like shouting are stressful. Despite having a wider range of hearing than people, cattle have difficulties with locating the source of the sound around them and they have to rely also on their sight (Moran & Doyle 2015).

Sounds were selected and played in 5 minutes intervals after the previous sound. All observations were recorded by video camera from around 100 – 200 m.

Table 2: Sequences for the acoustic experiment.

Sequences for acoustic experiment			
chaffinch	hyena	dog	wolf
wolf	chaffinch	hyena	dog
dog	wolf	chaffinch	hyena
hyena	dog	wolf	chaffinch
chaffinch	hyena	dog	wolf
wolf	chaffinch	hyena	dog

3.2.3. Data analysis

There were 34 videos in total and 31 of them were analysed. The reason for this was that some videos either did not contain any data or they were of poor quality and could not be analysed. The length of the videos ranged from 15 to 20 minutes. In the majority of videos, 4 sounds were played in a completely randomized block design (Table 2). There were cases when the cows were not in a relaxed state from the beginning, and they were aware of the camera and the people. As a consequence, it was hard to analyse whether they are vigilant because of the sounds played or because they see a possible danger in advance. In the end I decided to keep those videos in case I would find even the smallest reactions. Analysed subject (focal individual) was chosen randomly from the herd. Sometimes it was difficult to keep track of only one individual in a herd due to their movements or movements of the camera, therefore in few cases I analysed more than only one individual in a herd. I analysed 13 herds in total, divided into two types: suckler cows n = 7, and steers n = 6.

I have decided to follow a similar methodology as in Randler (2006) and Kitchen et al. (2010) articles. The first step was a careful analysis where I measured *vigilance latency* (how fast/if the cow recognizes the sound), *vigilance frequency* (how many vigilant behaviours it executes) and *vigilance duration* (how long does the vigilant behaviour lasts) and *intensity of response*. The intensity of response was divided on a scale from number 1 to 5, as follows: 1 – no response at all; 2 – vigilant (stepping to the sides or backwards, raising the head, interruption of activity); 3 – looking towards the source of a sound; number; 4 – walking away; 5 – running away (flight behaviour). I detected when the sounds were played in the video using a simple iMovie editing program (Apple, Cupertino, CA, USA). The behaviour of individuals was analysed 15 s before and 15 s after each sound played. In some videos, sounds were played too soon or too late, so there was not enough time for analyses. Those sounds were therefore not used. The reactions I was looking for were any interruption of previous activities; stepping backwards or sideways; raising head above shoulders; head movements from left to right, right to left or up and down (not associated with grooming or social contact); looking around the environment; looking at the source of a sound; ear movements (sound location); walking away; running away. The data were also simultaneously analysed by my consultant to obtain unbiased data. After discussing the approach of analysis, we got the same results. After analysing all of the videos, I quantified the responses and recorded the data into an Excel table (Appendix 1). The table contained various data from the basics such as date, name of the video being analysed or name of the audio file, including those that could affect cattle's reactions like some environmental and technical variables – weather, mating season, distance of recorders, age or sex of analysed subject or their activity, which I further divided into grazing, ruminating, being social, grooming, watching and looking into the camera. After recording them into a table, I calculated the frequency and duration by subtracting the number of frequencies or duration before the sound played from the number of frequencies and duration after the sound played, to obtain the real reaction. Then to those numbers I added the smallest negative number to make positive values, to enable data transformations during statistical data processing if necessary.

All statistical analyses were performed in the TIBCO® Statistica™ package (StatSoft, Palo Alto, CA, USA). First, to test if they are normally distributed, I used the Kolmogorov-Smirnov tests. All analyses showed $p < 0.01$, therefore the data were not normally distributed, i.e. the data did not meet assumptions for application of parametric tests. Therefore, due to the smaller sample size and the fact that my data were not normally distributed, I used non-parametric tests. The level of significance was set to 5% for all tests.

To explore if response variables correlate, Spearman's rank correlation test was performed among all behaviour response variables.

To test the differences in behaviour responses of animals to different sounds and between type of herd (steers x suckler cows), generalized linear models (GLZ) were used separately for each response variable. The response dependent variables were: vigilance latency, vigilance frequency, and vigilance duration. Tests were performed in a factorial design with the type of call and type of herd and their interactions as predictors. Then, I examined the effects of type of sounds and type of herd, and their interaction on the intensity of animal response, i.e. the ordinal variable with the scale from 1 to 5, as a dependent was tested using the ordinal logistic regression with the type of sounds, type of herd, and their interaction as categorical predictors.

To examine the effects of type of call and type of herd, the intensity of animal response (i.e. the ordinal variable with the scale from 1 to 5) as a dependent variable was tested using the ordinal logistic regression with type of call, type of herd, and their interaction as categorical predictors.

Generalized linear models were used to test the differences of variables (intensity of response, vigilance latency, vigilance frequency, vigilance duration) between type of herd (suckler cows x steers), type of calls (wolf, dog, hyena, chaffinch), and their interaction (type of herd * type of calls).

4. Results – Theoretical background

4.1. Predator and antipredator strategies in large mammals

Predation means obtaining food by killing other animals. It is a natural process, however, if there is no balance between predators and preys, problems may occur. For example, predators help with the health of our ecosystems. By killing an injured or ill animal, they are slowing down the possible spread of disease. Besides, predators also help to reduce the negative impacts such as excessive exploitation an overpopulation of prey species could potentially cause. The presence of a predator makes the prey move around, which prevents for example overgrazing of one area (Cheetah Conservation Fund 2011). According to the location, we can determine which species are the most common predators to a specific prey species. For large prey mammals, the predators are big cats like lions, cheetahs, jaguars, or hyenas and jackals in tropical regions, while in temperate latitudes we can find wolves, coyotes, dogs or bears.

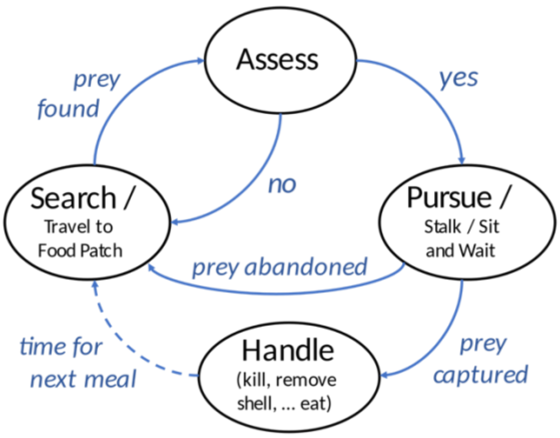

Figure 3: Predation cycle (Source: Alexandr I.).

Hunting has a basic simple form – search, assess, pursue, handle (Figure 3). But throughout the years, major upgrades to this cycle should be expected. During evolution, it could be anticipated that by natural selection predators will "upgrade" with every reproduction, and therefore increase their hunting efficiency. But at the same time, a similar result would be with prey species too. Natural selection would enable them to increase their ability to detect the predator and/or escape (Davies & Krebs 2008). So why one of them does not outperform the other one, and we see only stable predator-prey relationships? There are three hypotheses (Davies & Krebs 2008): (1) First one is "group extinctions". Group extinction is a massive extinction of a certain species. If group extinctions would be happening, the reason for the actual stable predator-prey relationship in nature would be that all unstable groups have gone extinct. (2) The second one is called "prudent predation". This hypothesis raises a question – since man is being prudent over his resources, what would happen if animals did it too? In theory, predators could be prudent if they had control over a supply of some food, then choose to hoard it for the future. They would be considering their future in contrast with the immediate desire to eat. Therefore, prey species should stay stable, or not go extinct, if predators are acting prudently. (3) And the last one is about prey being dominant in the arms race. The system of predator-prey relationship may be stable because prey species are always one step ahead of predators. We can use the "life-dinner" principle as an example. An antelope always runs faster than its predator, for example cheetah, because the antelope runs for its life, while the cheetah runs "only" for its food. The cost of a mistake is higher in the antelope's case and would make it impossible to reproduce, while not getting food may be problematic for the cheetah but would certainly not pose an immediate threat of death.

It has been found that we can divide the predator-prey interactions into two groups, symmetric and asymmetric. Symmetric interactions are based on a theory where the interactions are stronger when phenotypic traits of predator and prey are similar, like body size. Predator maximizes its predation efficiency by matching the prey's phenotype (Abrams 2000). For example, larger predators gain more from larger prey and smaller predators from smaller prey. Therefore, the predation efficiency is a symmetrical function of predator's and prey's phenotypic traits (Zu et al. 2016). With symmetric interactions an evolutionary branching is possible, plus, evolutionary branching in prey species can cause evolutionary branching in predators (Brown & Vincent 1992; Marrow et al. 1992). Evolutionary branching means that a phenotypically monomorphic population divides into two different phenotypic clusters (Doebeli & Dieckmann 2000).

In contrast, asymmetric interactions are based on a theory where the similarity in traits of predator and prey are making the interactions weaker, because predator's traits increase the possibility of capture, while prey's traits reduce the possibility of capture. So into the phenotypic traits we include either defensive skills or attacking skills of those two species. Therefore, the predator's efficiency is an asymmetric function of the prey and predator's phenotypic traits. This can be seen as predator-prey traits that clash against each other, such as speed-speed, weapon-armour or toxin-antitoxin (Abrams 2000; Mougi 2010). It was found that such asymmetric interactions occur widely in nature, and is therefore likely to be an important driving force for species diversity (Zu et al. 2016).

In almost all cases, the impact of predators on livestock is measured in terms of the number of livestock killed, which we call the direct effects or direct impacts. But mortality might not be the only impact that predators have on livestock, and those we call the indirect effects. Above injuries, diseases and therefore reduced production we can include behaviour changes. Many studies regarding large ungulates have shown that predators have important indirect effects that can consequence in major behavioural changes, and especially in their antipredation strategies (Kluever et al. 2008).

Antipredatory behaviour has been formed throughout history and modified by different animals. Predators that create high levels of vigilance are known to cause larger and long-term modification in antipredatory behaviour (Kluever et al. 2009). This may be particularly frequent in social animals since they are able to learn and they are almost dependent on learning from their own experiences or experiences of other species. Those antipredation strategies get stronger if predator-prey species share a common natural history (Kluever et al. 2009). For example, a case study from Parsons et al. (2007) about reactions of kangaroos to predator urines shown that a sympatric predator, in this case, dingo dog (*Canis dingo*), caused a stronger response than a non-native allopatric predator, coyote (*Canis latrans*). This fact may suggest that the response of prey species might be dependent on their evolutionary history.

There is also a dilution effect, which could be applied to cattle. It was proven that the vigilance decreases as the group size increases. Usually, there is only one victim per predator attack. Because of that, the chances of getting eaten by a predator decrease with a larger group, and therefore the chances of being eaten as an individual dilute. If there is for example 50 individuals in a herd, the cow has 1:50 chance of getting killed, and not even in the future, because predators will rather choose more solitary animal (Davies & Krebs 2008).

Therefore, prey species have developed strategies to protect themselves from attacks of predators. Those we call antipredation strategies or antipredatory behaviour.

4.2. Antipredator behaviour in large herbivores

Prey species have developed different traits that aid the recognition of the predator, avoidance and active defence against predators – the goal of the prey animal is to not get killed by a predator. These behaviours, which are measured typically as vigilance, have been researched and they vary based on several predatory characteristics, such as speed of the predator, its size, or numbers (Kluever et al. 2009). Anti-predatory behaviour can be transferred throughout generations or can be learned from each other, so social contact in between animals plays an important role in their knowledge.

The most common antipredation strategy known by every species on planet Earth is a fight or flight response. It happens as a response of a body to a stressful situation, where organisms feel they have only two possibilities– fight with the danger (predator) or flight, meaning escaping the situation. Choosing between fighting or escaping depends on various factors including size, health status, distance from predator or hereditary of specific species. Responses to predators also include spatial redistribution, changes in activity patterns, alertness of animals or shortening of foraging times (Valeix et al. 2009). The most obvious signs of a cow being alert are ear movements, raising its head, walking or running away – the flight reaction.

We can observe one basic pattern, but not necessarily a rule, in groups of animals. With an increasing number of individuals in the group, the individual's vigilance decreases (Quenette 1990). We call this the "group size effect", also known as the "many eyes effect" (Elgar 1989). This effect points out the fact that the vigilance of an individual is changing according to the number of individuals in the group – less vigilant with a higher number and more vigilant with a lower number. As even people say, "two heads are better than one", and "four eyes see more than two". Therefore, with a larger group, more eyes are looking around and checking the environment.

In the case of individual mothers with calves, some of them have a highly defensive approach against predators and they protect their calves from attack. But majority of them in the presence of predator panics, runs away in all different directions and leaves the small calves alone. Here is the difference between domesticated and non-domesticated species. Cattle, being domesticated by man in almost total absence of predators, are reacting differently. For example, Asian water buffaloes (*Bubalus bubalis*) have extremely protective and gregarious behaviour, since they have evolved in the presence of a large predator, a tiger (*Panthera tigris*). When they are under attack, the females form a circle around calves, while the bull or bulls of the groups are walking around the created circle, trying to chase away the predator (Hoogesteijn & Hoogesteijn 2014).

Many studies are discussing the issue of antipredation strategies in social or gregarious animals. But what about solitary species? The study by Périquet et al. (2010) investigated the response of solitary species to present predator at the water tank. Species chosen for this experiment were giraffes, zebras and greater kudus, living in Hwange National Park, Zimbabwe. In this case, the chosen predators were lions. The study had shown that all species of the selected game were 30 - 40 % more vigilant than when they were among their group of conspecifics. In this way, we can prove the already mentioned theory that individual vigilance decreases as the number of individuals increases. Thus, the vigilance of a solitary animal can be up to half greater. The authors also came across the "many eyes effect" and the "dilution effect". Also, the vigilance of selected animals was at its highest when they were entering the area, and then when they are drinking. After drinking, it is likely that they leave quickly to minimize the time spent at risk. Prey species entering the open area surrounding a water tank probably assess predation risk before encountering the tank, explaining why they are most vigilant during the approach phase.

However, they also encountered the grouping behaviour when predators were present, and when other herbivores were present. Although the study was focused on solitary species, it was found that even solitary species can help each other, but perhaps unknowingly. Prey species at the water tank, where all animals congregate, show cooperative behaviour during drinking, even though they are not from the same “family”. They change guard the same way as cattle do so that individuals are given more time for drinking.

4.2.1. **Vigilance**

One of the most important antipredation strategies, especially for large herbivores, is vigilance, which is the key to survival for every prey species. A study from Hunter & Skinner (1998) suggests we can almost universally assume that the risk of becoming prey is the principal and main reason ungulates are vigilant.

Vigilant behaviour serves together with other antipredation strategies as a protection against predators and therefore, against losses and injuries. The most common demonstration of vigilant behaviour is when an animal's head is raised above their shoulders and they are looking around, scanning the environment (Laporte et al. 2010). Important information for us with measuring vigilance is how many times an animal raises its head, how much time the animal spends by grazing, then by looking around, and/or how many animals are looking around. What should be taken into consideration is the herd size, predation risk (high or low), number of individuals (preys and predators), pregnant females, presence of offspring and location (Kluever et al. 2008). Then we can measure rates of foraging versus scanning the environment and calculate vigilance. But not less important elements of vigilance besides a raised head is the movement of the ears, interruption of any activity, animal's alertness, i.e. we can see when the animal is in a so-called stiff state, as if frozen, and is ready to run away in a different direction if we, or another predator, take the next step towards it, or after all, running.

Vigilant behaviour in prey animals can be influenced by more factors than by the presence of the predator itself – social and environmental factors are contributing to the overall pattern (Lung & Childress 2006). By social and environmental factors we mean for example location of the animal in the herd (central animals are less vigilant than those standing on the edge of the herd), lactation status, presence of juveniles, size of the group, or some visual obstacles (Kluever et al. 2008). Visual obstacles may include bushes or trees on pasture or a bale of hay behind the fence. Anything that makes the female not being able to scan the environment around itself results in greater alertness and greater vigilance. For example, a cow on an open pasture in the middle of the field might be less vigilant and have different risk assessment strategies than a cow that is grazing on an enclosed pasture surrounded by dense forest with tall trees. The herd can also unintentionally divide roles (Treves 2000). Since the central animals are less vigilant, the edge animal is an observer, and they can take turns, as we can see in meerkats (Moran 2010).

In the case of wild ungulates, prey species usually have to decide between two equally important elements – safety and food. Deciding between them does not mean they cannot achieve both, but one may prevail over the other. The choice is "enough of quality feed but being at risk of predators, or safety at expense of lower quality feeding location?" These conflicting demands have three basic possible solutions. Animals may: (1) increase their vigilance while continuing grazing on high-quality forage, but possibly risky, location, (2) the other way around, to move temporarily to another less risky, but possibly lower quality forage location, or (3) to demonstrate escape manoeuvres to avoid the threat of becoming a prey (Kluever et al. 2009). All of these solutions may be helpful, but they give animals less time for feeding, either in form of being more vigilant or in form of moving and searching (energy expenditure) other more suitable places with food and safety is (energy gain).

An interesting case study by Kluever et al. (2008) on vigilance in cattle versus vigilance in other ungulates have shown that other ungulates are much more vigilant than cattle. The reason remains unknown. It could be either a result of domestication, or it can be due to some inherited behaviour. But since cattle ancestor, Auroch, is extinct, there is no way how to prove this theory. The same case study also made a point on vigilance in mother cows. Mother cows whose calves were killed by predators increased vigilance immediately after the predator attack and reduced their foraging. Vigilance rates in these cows were 10 times higher than in mother cows that were separated from their calves temporarily (Kluever et al. 2008). Calves are easy prey because they are smaller in size, with reduced ability to run and their understanding of predation is not fully developed.

4.3. Cattle

Cattle are domesticated animals from the Bovinae subfamily raised for different purposes, like meat, dairy and skin production, and as draft animals (Blowey 2016). Usually overlooked fact is that in some countries, cattle have a strong position in culture and spiritual life, animals are worshipped for religious reasons, kept as pets, or to show wealthiness. Cattle produce 82% of world milk production, followed by buffaloes with 14%. About one-third of milk production comes from developing countries, but this number consists of buffaloes, goats, camels and sheep altogether. If we talk about developed countries, almost all of the milk comes strictly from cattle. Depending on the breed, mature bulls weigh around 450–1,800 kg and cows around 360–1,100 kg. Chianina is considered to be the largest and heaviest cattle breed and holds the world record for the heaviest cow ever recorded with over 1,700 kg (The Editors of Encyclopaedia Britannica 1999).

Cattle's diet is mostly based on tall grass from pastures, but also hay, straws, grains, pellets, minerals, vitamins and lots of water. Since they are unable to break down cellulose, they cannot digest the plant material directly, therefore, they had to find different ways to obtain nutrients. Fermentation is the key to their nutrient intake, so we call them ruminants. Because of that, they have special stomachs consisting of 4 compartments – 3 foreguts (rumen, reticulum, omasum) and 1 "true" stomach (abomasum). When grazing, a cow chews its food just so it can be swallowed. The food enters the first foregut, rumen, where fermentation takes place using microbial actions. Then the cow casts up a portion of this partially digested food, known as fermented ingesta or cud, into the reticulum and then into its mouth and chews it again, which we call rumination. The re-chewed food mixed with saliva is then swallowed and transferred into omasum, where the food is broken down into even smaller pieces. After that, food is finally sent into the last chamber, abomasum, also called "a true stomach" (Hall & Silver 2005).

Based on data from Statista (Figure 4), the global cattle population amounted to about 989.03 million head in 2019, down from over one billion cattle in 2014 (Shahbandeh 2020), showing that the cattle population is again slowly decreasing.

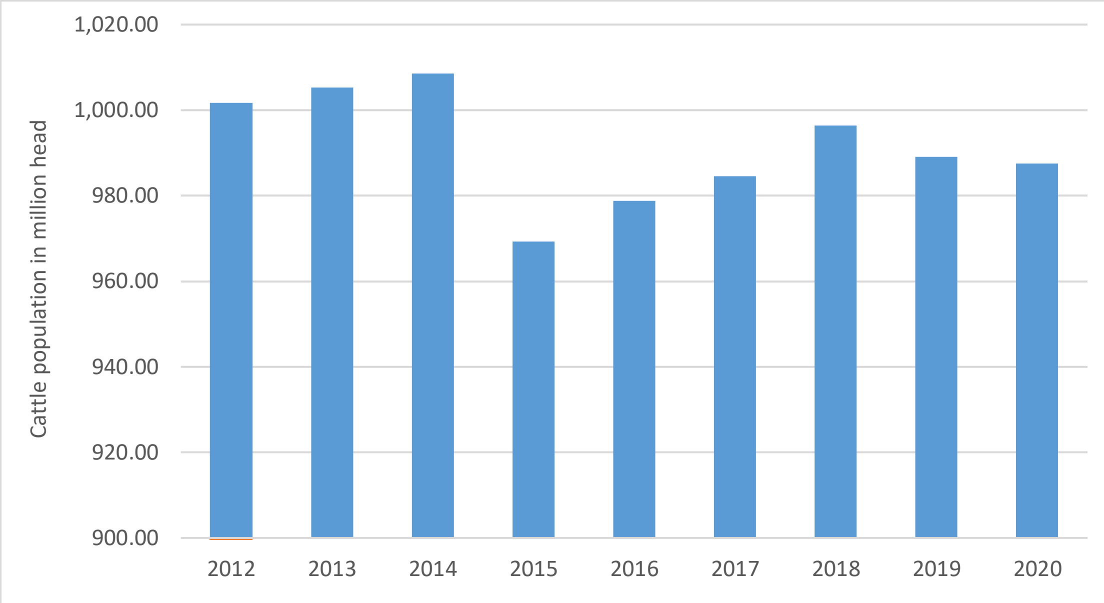

Figure 4: Number of cattle worldwide through years (Source: Statista 2021).

There are extensive terms and names to specifically divide cattle according to sex, age and usage. The first time a male is born, it is called a bull calf. If it is left intact (not castrated), he becomes a bull. If he gets castrated, he becomes a steer and during the next 2 to 3 years he grows into an ox, but generally we can call them bullocks. When a female is born, the animal is called a heifer calf. It remains a heifer until it gives birth to its first calf – after that, we call it a cow. Cattle used for meat human consumption are called beef cattle, and they are usually castrated to make them more docile. Cattle used for milk human consumption are called dairy cattle and cattle used for drafting purposes are oxen. Drafting animals are usually also castrated to make them more tractable during work (The Editors of Encyclopaedia Britannica 1999).

4.3.1. Cattle behaviour

Cattle belong to the group of highly social animals. Since they are, as herbivores, prey animals, they have learned to be vigilant in every situation due to their evolutionary history, so forming a large herd is not only beneficial for their mental health and keeping them calm, but also for protection against predators and provides them with learning from each other. They form strong social bonds and see isolation as aversive (Jensen 2018). Their behaviour is determined by experience, sensory perception and instinct. Sensory behaviour refers to something that was seen, heard, or felt. Together with experience learning it may include letting down the milk during milking, staying calm inside a parlour or being afraid of an electrical fence. Instinct is something all of us, cows included, have inside and instinctual behaviour refers to actions the cow is naturally motivated to do. Instinctual behaviour has many forms, from standing up the first time after being born to the most automatic ones, like breathing or defecation (Moran & Doyle 2015). Cattle are a type of animals that are afraid of new things and environments but easily gets used to them. They remember when one treats them gently, but even when one treats them rudely. If cattle become frightened, it can take 20 minutes for them to calm down (Moran & Doyle 2015). Therefore, that is the reason they should be handled with care during transports or milking. To improve their wellbeing, there are some things owners can improve – provide non-slippery floors, raising and breeding them in a sanitary comfortable environment with enough social contact, handling them gently by trained people and/or eliminating the "punishments", such as electric fences, shouting or beating.

What is the difference in herd composition between domestic and wild cattle? In the case of wild cattle, the organization appears to be groups of mothers with young, along with groups of grazing bulls. This grouping is related to dominance and therefore, they are called socially dominant groups. Dominant bulls join the female herd only during the female oestrus cycle, in other words, the fertile cycle. Unlike wild cattle, the domestic cattle also have females with young, but the bulls are almost completely isolated. These different ways of organizing the group can cause tension between the bulls and can also cause danger in their handling, danger to owner and animal as well. At this moment, castration is offered as a solution that can suppress their aggressive behaviour (Moran & Doyle 2015).

4.3.1.1. Daily behaviour

Besides some specific behaviour, an important part of their routine is their daily behaviour, like grazing, ruminating, resting or bonding with other cows. Cattle prefer routine activities and doing the same activities each day at a regular rhythm increases their welfare. They need to have their day budgeted correctly with hours in the day allocated to certain activities to be the most productive (Regusci 2017). A lot of studies were made about their daily behaviour and how much time they spend doing certain activities. A study by Albright & Grant (2000) came up with a simplified ethogram, a time budget spent on various activities (Table 3). An important mention is that this study aimed at lactating dairy cow living in a freestall barn, but it can serve us as a rough overview of cow's behaviour.

Table 3: Average daily time budget for lactating dairy cow (Source: Albright & Grant 2000).

Activity	Time devoted to activity per day
Eating	3 to 5 h (9 to 14 meals/d)
Lying/resting	12 to 14 h
Social interactions	2 to 3 h
Ruminating	7 to 10 h
Drinking	30 min
Outside pen (milking, travel time)	2.5 to 3.5 h

Grazing occupies a large amount of time in cows. Grazing behaviour is affected by many factors, including environmental conditions and plant species. To graze, cattle usually stand or slowly move across the pasture with mouth close to the ground, biting and tearing off the grass without much chewing.

Cows prefer to ruminate while laying down (OMAFRA 2021) and they usually spent a whole third of their day ruminating. Rumination is an important process, and if for any reason is done incorrectly, it can ultimately result in lower milk production. They eat very fast with minimal chewing. Studies have shown that up to 90% of rumination can happen in stalls, so the availability of comfortable stall is critical for optimizing the whole process (OMAFRA 2021). One purpose of rumination is to make saliva (up to 190 litres of saliva), which helps with decreasing the acidity inside of the rumen. Another purpose is to decrease particle size and increase the surface area of the feed. The result is an increased digestion rate and decreased lag time earlier to fermentation. If the cow is not ruminating enough, the fibrous particles will stay in the rumen longer causing the rumen to feel fuller. This will reduce the cow's total intake of food and negatively impact milk production (Ondarza 2000).

As seen in Table 3, most of their time (as much as half of the day) is dedicated to lying or resting. Munksgaard et al. (2004) proved that cattle have a strong motivation to rest. This motivation is increasing in case the cows are suffering from resting or sleeping deprivation. Resting behaviour has a high priority and, even after a relatively short time of resting or sleeping deprivation, cows are willing to give up some of their feeding time to rest. But feeding and resting behaviour are linked in the case of dairy cattle.

Since cattle are highly social animals, they profess many kinds of social interactions. Grooming, grooming each other, playing, mounting, showing territoriality or being aggressive (Arawe & Albright 1980). They also have their own ways of individual recognition. Individual recognition occurs when one organism identifies another one according to its unique distinctive characteristics (Tibbbetts & Dale 2007). Recognition is an important part of the social life of all animals and people too. To maintain the coherence of groups, animals need to process social information efficiently (Coulon et al. 2009). Cattle use many ways how to recognize each other, for example their fur, colour marks and patterns on the skin, musk or odour (Coulon et al. 2009). This being said, the most important sense for the cow's communication is sight. With sight, they can determine aggression, fear, cold or threats. An aggressive bull will lower his head down, incline his horns towards the opponent and paw the ground to show his readiness to start. A fearful cow will hide its tail under its body. An irritated cow will be wagging its tail to the sides, which is also a sign of it being ready to kick (Moran & Doyle 2015).

4.3.1.2. Abnormal behaviour

There are many problematic behaviours connected to domestication. They evolve when an animal is not able to behave naturally and can contribute to reduced productivity. Many of these traits have been developed from the artificial environment made by humans, because these behaviours are absent in extensive breeding. When cattle are feeling discomfort, some abnormal or stereotypical behaviours can occur (Moran & Doyle 2015). To those may belong tongue rolling, aggression, food throwing, reluctance to enter the milking parlour, excessive licking, biting or urine licking (Landsberg & Denenberg 2014). All of them are connected to poor management in different forms. For example, animals that were tethered for a long time may be practising bar biting because they were restricted from free movement, which can be solved with daily exercise. On the other hand, tongue rolling may be caused by the intensification of housing, therefore cows do not spend so much time on pasture ruminating. The solution for this may be adding extra hay to chew on (Moran & Doyle 2015).

4.3.2. Domestication

Domestication is a process that begun in distant history. It is a gradual purposeful transformation of wild species (animals and plants) into domesticated species, suitable for human care, i.e. breeding, and use. It is a long process that consists of permanent genetic modification of the species, and subsequent selection of individuals with modified traits by humans, which leads to adaptation to humans. Man takes care of the organism, has a significant effect on its reproduction and obtains the necessary raw materials. In terms of cattle we talk about milk, meat, skins or a drafting force (Melletti 2016).

All theories about domestication agree on one point – domestication is a two-way relationship between human and targeted species. However, these scientific assumptions diverge on the question of who benefits more from the relationship. Man, or the wild species we are domesticating? Some believe that man is the dominant half in this process and has become superior to animals, a "master", and can control animal’s every movement, reproduction or feeding. On the other hand, some believe that domestication is an element of mutualism and both parties benefit from this relationship. Some even claim that domesticated animals use us. The theory is that domesticated animals manipulated unconscious humans and created relationships that gave them a great evolutionary advantage at the expense of human abilities (Zeder 2012).

Genetic data show that cattle were firstly domesticated from wild aurochs (*Bos primigenius*) approximately 10,500 years ago. Aurochs have roamed across Europe and Asia, originated in India, spreading into China, the Middle East, and eventually northern Africa and Europe. There were two major areas where domestication started: first in the Near East, specifically Western Iran, and second in the area of actual Pakistan (McTavish et al. 2013).

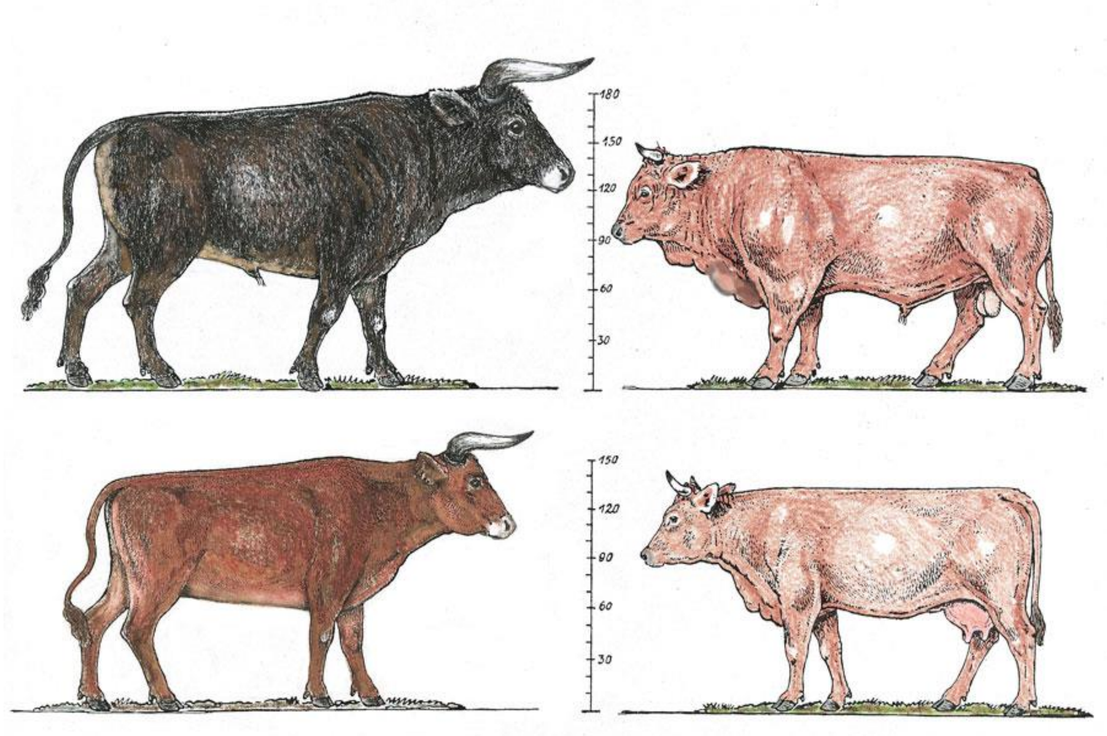

Figure 5: Bos primigenius (left) and Bos taurus (right) comparison (Source: Van Vuure T.).

During domestication, not only the behaviour had changed, but also the phenotype (the observable characteristics) had changed, mainly regarding horns and size (Figure 5). The first domestic cattle had long horns, which is still common in some breeds, especially in French, British or African breeds. The first short-horned cattle appeared about 3000 BC in former Mesopotamia (actual Iraq, Turkey, Syria and Kuwait), because of suitability to the environment (Melletti 2016). These short-horned cattle became the most common type in Europe from about 1000 years BC (Lenstra et al. 2014). Several ecotypes (breed adapted to local conditions) and adaptations have been developed due to the distribution throughout different locations (Lenstra et al. 2014). Following these events, by breeding itself humans have been able to create breeds differentiating in colour, horns or tameness.

And when dairy production started around 7000 BC, cattle have developed for example larger udders (Melletti 2016).

One of the more important behavioural changes accompanying the domestication process is a reduction in responsiveness to changes in the animal's environment (Price 1984), and the core of it all is in the “downsizing” of not only the cattle phenotypic traits but also the non-observable traits, including their brain. It is proven that the brain size of domesticated animals is much smaller than the brain size of their wild animals. Usually, brain size is narrowly connected with body size, but even if we compare dog and wolf of the same size, the wolf has a bigger brain. Pigs’ brain has shrunk down by 35% (Weiner 2017). When we want to think about a comparison of brain size, we have to identify which specific parts of the brain are now smaller. Studies have shown that part of the brain called the amygdala is significantly smaller. Amygdala is responsible for responsiveness to changes in the environment and for aggressive behaviour, therefore it is responsible for antipredation behaviour and mostly the flight or fight response (Fang et al. 2016). This is the result of artificial selection where animals are in close contact with human on daily basis (Kruska 1988). People are always looking for the easiest animal to handle, and that means finding the tamest one. By breeding tame animals, another tame animal will appear. Domesticated animals can be therefore less responsive to predators and their antipredation behaviour may be suppressed due to intensive breeding system in contrast with wild animals, where their behaviour may be purer and rawer since there is a higher possibility of encountering a predator. However, domestication is a long and difficult process, which is probably still ongoing, so there is no guarantee that this is the final form of domesticated animals.

4.4. Findings from other acoustic experiments on large herbivores

To understand and evaluate my results better, an overview from other practical studies focused on acoustic experiments with large herbivores is necessary. Taking into consideration that every study has different technical or environmental conditions to begin with, their results should still be based on a similar basis. Here is a small overview of different studies focused on related topics.

A study from Hettena, Munoz & Blumstein (2014) focused on reactions of mule deer (*Odocoileus hemionus*) to acoustic stimuli of sympatric and allopatric sounds. It was found that mule deer have kept their ability to distinguish a sympatric predator, specifically with a wolf (*Canis lupus*), even though they have been extinct from the area for almost a century. The other types of responses were dependent on the human habituation of the area. Where human residencies were nearby, deer did not allocate as much time to being vigilant as with the deer that lived closer to human residencies. Therefore, human contact which is an inherent part of domestication is a major factor in animals' antipredation behaviour.

A study conducted by Klimšová (2011), was focused on interspecies communication – do Roe deer (*Capreolus capreolus*) and European hare (*Lepus europaeus*) react to the alarm calls of Eurasian jay (*Garrulus glandarius*)? Findings were positive. Both species responded to alarm calls of Eurasian jay, causing them to be more vigilant, and therefore confirming the interspecies communication theory. This study is also suggesting that wild animals may be more responsive than the animals in human captivity. Interestingly enough, Roe deer reactions were influenced by the hunting season. Since the experiment was conducted by people, one of the biggest deer's predators was present. The results so suggest that the hunting pressure has been sufficient for maintaining Roe deer's ability to recognize the jay's alarm calls because no other natural predators were present in the area (Klimšová 2011).

Kluever et al. (2009) studied how sounds of predators (wolf [*Canis lupus*] and mountain lion [*Puma concolor*]) and heterospecific (mule deer [*Odocoileus hemionus]*) affect cattle's behaviour. They studied 4 main behavioural changes – (1) vigilance, (2) foraging rates, (3) giving up density of high-quality foods and (4) time spent in high- quality forage locations. Wolf stimuli have expectedly increased their vigilance and decreased foraging rates. Lion's stimuli did not affect cattle's behaviour. Mule deer affected cattle in a positive way, where cattle have increased their foraging rates. This study shows that cattle are not only responsive, but they can differentiate between two different predators, or they simply do not react to the sounds they do not know. And their antipredatory behaviour may decrease when in presence of heterospecific.

A study by van der Meer, Pays & Fritz (2012) examined the effects of a simulated predator, African wild dog (*Lycaon pictus*), on its two main prey species, kudu (*Tragelaphus strepsiceros*) and impala (*Aepyceros melampus*). Examiners have spread predator's faeces around and played its sounds at different intervals to mimic two types of predator presences – immediate and non-immediate. Simulated presence of African wild dog had only negligible effect on antipredatory behaviour of their prey. When immediate predation risk was mimicked, only kudu demonstrated a heightened vigilance, whereas impala showed no response.

The results of these studies are different, but we can see a pattern. studies are not confirming known hypotheses completely, but there are similarities within the hypotheses and results. The conclusion is that wild animals should be more vigilant than animals used to being in contact with human,

5. Results – Practical part

When cows were played playback experiments, we have measured 4 main variables (seen in Table 4). With 88 samples, we found out that the intensity of response was fluctuating between number 1 and number 2, meaning that there were either no reactions at all, or they were not as significant, like head movements or ear movements. The vigilance latency was on average 10.5 seconds (SE±0.8), which tells us that the cows did take some time to acknowledge the sounds played. Vigilance frequency was measured in numbers of reactions demonstrated. The number ranged between 3 and 4 but did not differ among the type of herds or type of calls. And the vigilant duration was 19 seconds (SE±5.7), which points to us that once the cow was vigilant, they stayed alert for quite some time.

Table 4: Overview of basic values of dependent variables.

Variable	Valid N	Mean	Median	Std.Dev.	Std.Err.
Intensity of response	88	1.693	1	0.849	0.091
Vigilance latency	88	10.477	16	5.988	0.838
Vigilance frequency	88	3.864	3	1.648	0.176
Vigilance duration	88	19.159	16	5.665	0.0604

5.1. Relationships among cattle behaviour responses

All the measured variables reporting on vigilance were mutually correlated (Table 5). There was a significant positive correlation between the ordinal variable, the intensity of response, and all other vigilance parameters – latency, frequency and duration. However, as seen in Table 5, the coefficient of the correlation between the intensity of response and latency is strongly negative, which shows us that if the intensity of response increases, the time of acknowledging the sound, vigilance latency, decreases, i.e. the longer it took the cow to notice the sound, the weaker response they demonstrated (Figure 6).

The relationship between proper vigilance parameters was a significantly negative correlation, with again one exception – the frequency and duration were correlated positively. The coefficient of correlation is positive. When the vigilance frequency increases, the vigilance duration increases as well. Therefore, if the cow demonstrated for example 4 vigilant behaviours, the duration of them was longer in total (Figure 7).

Table 5: Correlations between parameters of vigilant responses.

Pair of Variables	Valid N	Spearmen R	t (N-2)	p-value
Intensity of response + v. latency	111	-0.833901	-15.7745	< 0.01
Intensity of response + v. frequency	111	0.635382	8.5905	< 0.01
Intensity of response + v. duration	111	0.591971	7.6683	< 0.01
v. latency + v. frequency	111	-0.61155	-8.0697	< 0.01
v. latency + v. duration	111	-0.642717	-8.7588	< 0.01
v. frequency + v. duration	111	0.740494	11.5034	< 0.01

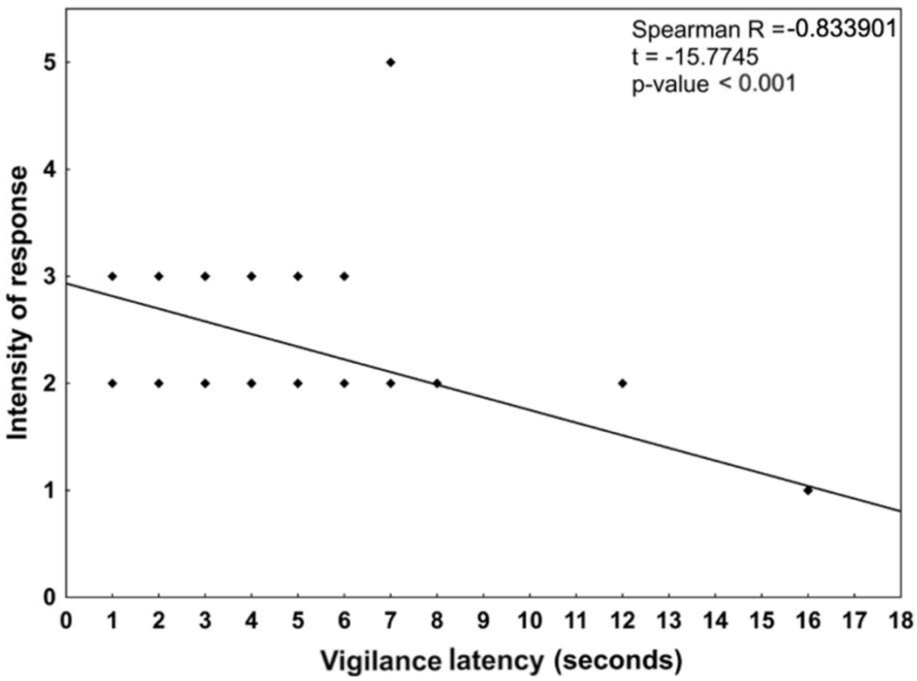

Figure 6: Correlation between the intensity of vigilant response and vigilance latency.

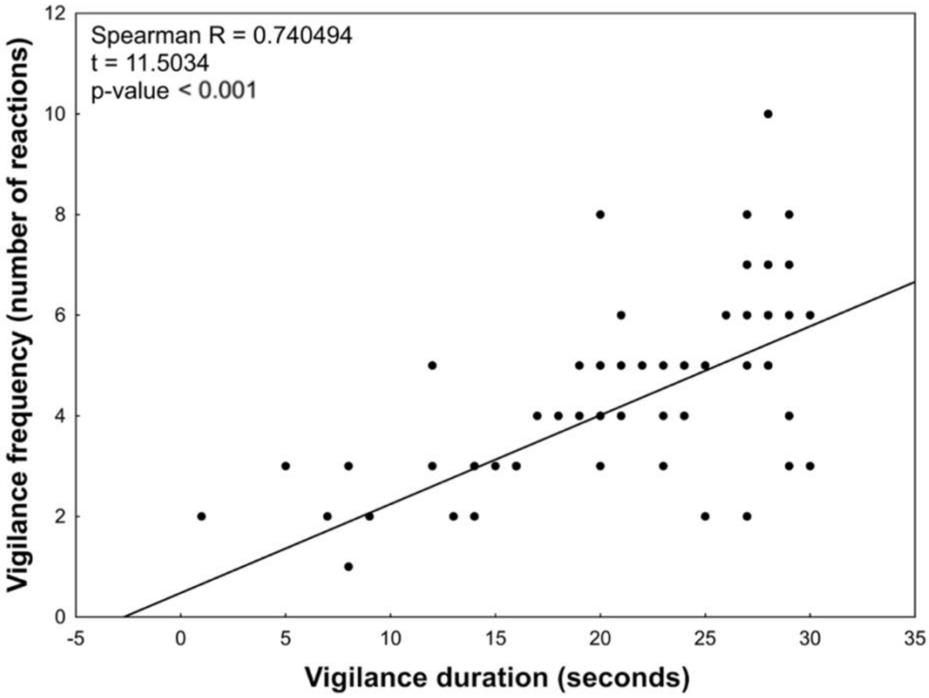

Figure 7: Correlation between vigilance frequency and vigilance duration.

5.2. Cattle responses to predator sounds

The results of the experiment showed that differences between cattle's reactions depending on the type of herd and type of call are statistically negligible, therefore, cows did not demonstrate any behaviours that would suggest they can distinguish between predators (Figure 8, Figure 9, Figure 10). However, when testing the vigilance frequency to the type of herd and call (Figure 9), there was a deviation when the sound of a chaffinch was played. Namely, herds of steers have reacted on average more times than herds of suckler cows and variability among their reactions was much higher. These differences were slight and very tight, and they occurred with chaffinch sound, which was used as a control, therefore those deviations in reactions appear not biologically meaningful.

Among the most frequent reactions the cows demonstrated were movements of ears by which the animals were locating the sound, then head movements and interruption of previous activities. During the grazing and resting periods, the cows reacted the least and almost ignored the sound. This may indicate the importance and time and attention investment that they place on their daily activities.

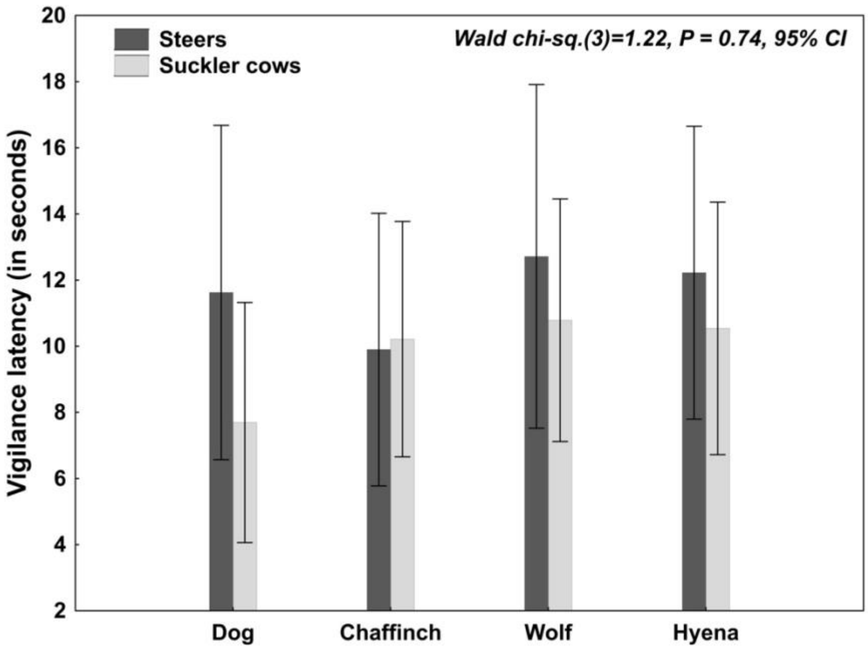

Figure 8: The mean vigilance latency (±SE indicated by error bars) of cattle in two types of herds responding to predator and control sounds.

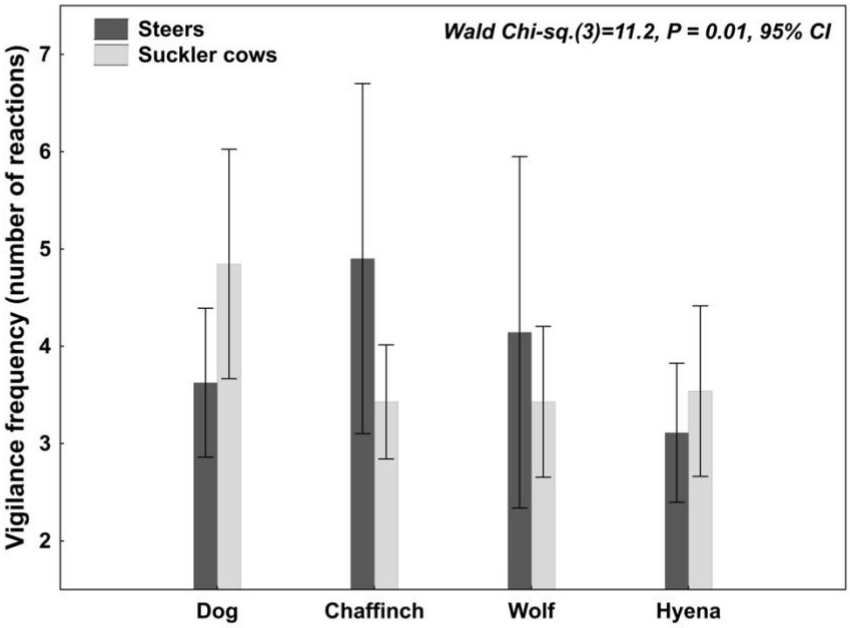

Figure 9: The mean vigilance frequency (±SE indicated by error bars) of cattle in two types of herds responding to predator and control sounds.

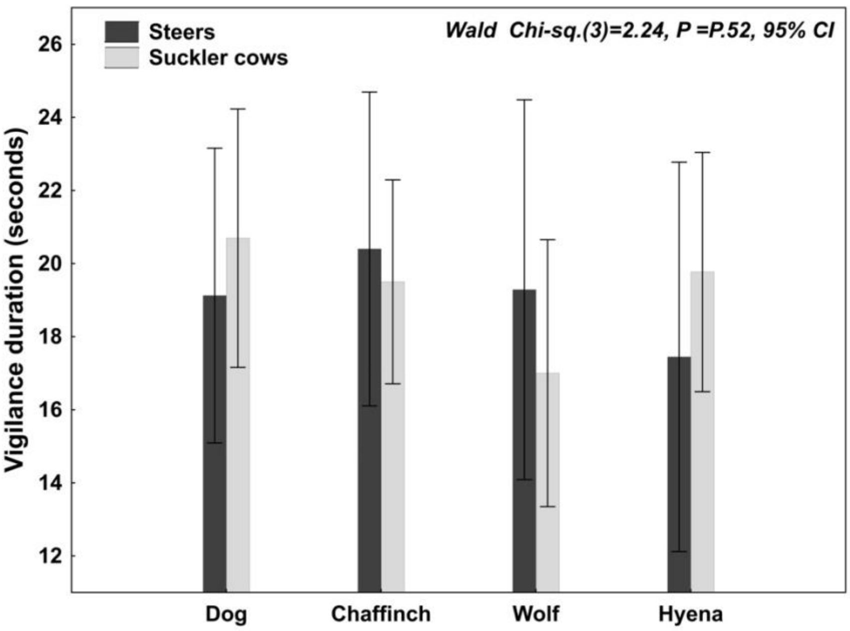

Figure 10: The mean vigilance latency (±SE indicated by error bars) of cattle in two types of herds responding to predator and control sounds.

6. Discussion

Several studies have suggested that ungulates should be able to differentiate between predator sounds and should be responsive. On the other hand, domesticated ungulates could be possibly less responsive to acoustic stimuli, which is supported by Kluever et al. (2009) study of how predators alter cattle' behaviour.

In this experiment, when cows were exposed to different predator sounds and one control sound, there were no deviations in their reactions. They did not demonstrate any behaviour that would suggest their ability to distinguish between predators. There were also no differences in reactions of suckler cows and steers, nor even differences in reactions while demonstrating different activities like grazing, resting or being social. According to my literature review, frequent human contact and domestication may have a major impact on the behaviour of animals, so it might be an explanation of this phenomena.

This fact is also corresponding with the study conducted by van der Meer, Pays & Fritz (2012) examining the effects of a simulated predator on its two main prey species, kudu and impala, where their reactions were very weak. There is also a little correlation with Hettena, Munoz & Blumstein (2014) study focused on reactions of two groups of mule deer to acoustic stimuli of sympatric and allopatric sounds. Even though one group showed the ability to distinguish predator calls, the second group, living near human residences, had their reactions suppressed. This is concluding that as stated in my literature review, domestication plays a crucial role in animals' antipredation behaviour. This ties with Fang et al. (2016) and Kruska (1988) studies, where they are discussing the effects of domestication. Due to domestication, animals' brains are getting smaller, including thw amygdala, part of the brain responsible for responsiveness to changes in the environment. Since the cows from my experiment are from an intensive breeding system, where contact with human is usual, this could be the reason for their low responsiveness. But there have been many studies conducted on this topic, and some of them are contradictory to my results.

There is also a high possibility of selective loss of natural behaviour. There are many breeds of cattle with different purposes. Some are bred as drafting animals, some are for high production of meat or milk. Cattle bred for high production, like Limousin cattle, are in strong and frequent contact with human, where all of the cattle's activities, including breeding and feeding, are dependent on human. Therefore animals' behaviour might change due to a completely different environment than they experience in the wild. Those changes may be as serious that they cause the loss of their most important behaviour – the antipredatory behaviour that helps them survive. On the other hand, animals bred in extensive breeding systems may have kept most of their natural behaviours, since they are not subject to frequent contact with human. An example may be Scottish Highland cattle, used to living in harsh wild-like conditions. I would also like to point out one of the findings from my experiment. During the analyses I found out that, although Moran & Doyle (2015) claim otherwise, cows were good at locating the sounds.

The reliability of my analysis is impacted by few factors that were not perfected during or after the experiment. Firstly, there was not much data "to waste", which could be improved by taking more samples. It is often during experiments that the data recorded are somehow not usable or damaged, this is why we should always take more samples than is needed. I had a sufficient amount of data to conduct an analysis, but there were few which were not perfectly suitable. It was not always possible to use a cover due to environmental conditions, resulting in few cases where cows were not in a relaxed state and they were already looking at the people conducting the experiment. This situation makes it harder to establish whether they were vigilant because of the sounds played, or because they have spotted people. Therefore, I would also suggest being prepared to have some type of artificial cover at every time. And afterwards to make sure that all necessary information are somewhere noted for future use.

For future research when doing a similar experiment, I would suggest taking more samples for obtaining more accurate data. Having a cover is also an important part that may affect the results. My results are proving the theory that domesticated cattle are less reactive, but to be more precise, I would also like to prove my results by another, similarly based experiment, focused maybe on already mentioned extensive breeds. Therefore, more research should be done.

7. Conclusion

By using playback sounds I have found out that cattle present in the experiment have suppressed ability to distinguish between predators. There were also no differences in terms of different type of herds (steers x suckler cows) or type of playback. Based on my results, possible reason for these reactions might be domestication. All species have the self-preservation instinct – the purpose of all species is to survive and thrive even in future generations. This purpose may have been diminished by human impact. But there might be the possibility of selective loss. Some cattle breeds are high production breeds and they can be found in intensive breeding systems with frequent contact with human. Other breeds, however, are part of an extensive breeding system, where contact with human is not as often. Intensive breeding might affect the animal's behaviour in such ways as losing their natural behaviour. Even the most important survival strategy, the antipredation strategies, may be partially or completely lost, which makes it impossible for the species to survive in the wild again.

Domestication is an ongoing process that may not be finished yet. It has a major impact on animals' lives and behaviour, therefore we should keep researching it in the future.

8. References

Abrams PA. 2000. The Evolution of Predator-Prey Interactions: Theory and Evidence. Annual Review of Ecology and Systematics **31**: 79-105.

Albright JL, Grant RJ. 2000. Effect of Animal Grouping on Feeding Behavior and Intake of Dairy Cattle. Journal of Dairy Science **84**: 156-163.

Arawe CW, Albright JL. 1980. Cattle behavior. Journal of Dairy Science **64**: 1318-1329.

BD Editors. 2019. Difference between Allopatric and Sympatric Speciation. Biology Dictionary. Available from www.biologydictionary.net (accessed April 2019).

Blowey RW. 2016. The Veterinary Book for Dairy Farmers (4th ed.). 5M Publishing, Bristol.

Brown JS, Vincent TL. 1992. Organization of Predator-Prey Communities as an Evolutionary Game. Evolution **46**:1269-1283.

Cheetah conservation Fund. 2011. Why are predators important? Cheetah News. Available from www.cheetahupdates.blogspot.com (accessed May 2011).

Cherry K. 2020. When and Why Does Habituation Occur? Verywell Mind. Available from www.verywellmind.com (accessed December 2020).

Coulon M, Deputte BL, Heyman Y, Baudoin C. 2009. Individual Recognition in Domestic Cattle (*Bos taurus*): Evidence from 2D-Images of Heads from Different Breeds. PLoS One 4 (e4441) DOI: 10.1371/journal.pone.0004441.

Davies NB, Krebs JR. 2008. An Introduction to Behavioural Ecology (3rd ed.). Blackwell Scientific Publications, Oxford.

de Ondarza MB. 2000. The stomach of the dairy cow. Milkproduction. Available from www.milkproduction.com (accessed October 2000).

Doebeli M, Dieckmann U. 2000. Evolutionary Branching and Sympatric Speciation Caused by Different Types of Ecological Interactions. The American Naturalist **156**: 77-101.

Elgar MA. 1989. Predator vigilance and group size in mammals and birds: the criticial review of emprical evidence. Biological reviews of the Cambridge Philosphical Society **64**: 13-33.

Fang Z, Li H, Chen G, Yang J. (2016). Unconscious processing of negative animals and objects: Role of the amygdala revealed by fMRI. Frontiers in Human Neuroscience **10**: 1-12.

Geere D. 2012. Cattle DNA traced back to single herd of wild ox. Wired. Available from www.wired.co.uk (accessed March 2012).

Hackmann TJ, Spain JN. 2009. Invited review: Ruminant ecology and evolution: Perspectives useful to ruminant livestock research and production. Journal of Dairy Science **93**: 1320-1334.

Hall JB, Silver S. 2005. Nutrition and Feeding of the Cow-Calf Herd: Digestive System of the Cow.

Hettena A, Munoz N, Blumstein DT. 2014. Prey Responses to Predator's Sounds: A Review and Empirical Study. Ethology **120**: 427-452.

Hoogesteijn A, Hoogesteijn R. 2014. Antipredation strategies for cattle ranching in Latin America: A guide. Eckograf Soluções Impressas Ltda., Campo Grande.

Hunter LT, Skinner JD. 1998. Vigilance Behaviour in African Ungulates: The Role of Predation Pressure. Behaviour **135**: 195-211.

Jensen MB. 2018. The role of social behavior in cattle welfare. Pages 123-155 in Tucker CB, editor. Advances in Cattle Welfare. Woodhead Publishing, Aarhaus.

Kitchen DM, Bergman TJ, Cheney DL, Nicholson JR, Seyfarth RM. 2010. Comparing responses of four ungulate species to playbacks of baboon alarm calls. Animal Cognition **13**: 861-870.

Klimšová V. 2011. Responses of animals to interspecies alarm calls [MSc. Thesis]. Czech University of Life Sciences Prague, Prague.

Kluever BM, Breck SL, Howery LD, Krausman PL, Bergman DL. 2008. Vigilance in Cattle: The Influence of Predation, Social Interactions, and Environmental Factors. Rangeland Ecology and Management **61**: 321-328.

Kluever BM, Howery LD, Breck SW, Bergman DL. 2009. Predator and heterospecific stimuli alter behaviour in cattle. Behavioural processes **81**: 85-91.

Kruska D. 1988. Effects of domestication on brain structure and behavior in mammals. Human Evolution 3: 473-485.

Landsberg GM, Denenberg S. 2014. Behavioral Problems of Cattle. MSD Veterinary Manual. Available from www.msdvetmanual.com (accessed May 2014).

Laporte I, Muhly TB, Pitt JA, Alexander M, Musiani M. 2010. Effects of wolves on elk and cattle behaviours: Implications for livestock production and wolf conservation. PLOS One 5 (e11954) DOI: 10.1371/journal.pone.0011954.

Lenstra JA, Theunissen B, Felius M. 2014. Domestic Cattle and Buffaloes. Pages 30-38 in Melletti M, Burton J, editors. Ecology, Evolution and Behaviour of Wild Cattle. Implications for Conservation. Cambridge University Press, Cambridge.

Limousin Editors. 2017. Breed History. Limousin. Available from www.limousin.co.uk (accessed March 2021).

Lung MA, Childress MJ. 2006. The influence of conspecifics and predation risk on the vigilance of elk (Cervus elaphus) in Yellowstone National Park. Behavioural Ecology **18**: 12-20.

McTavish E J, Decker JE, Schnabel RD, Taylor JF, Hills DM. 2013. New World cattle show ancestry from multipleindependent domestication events. Proceeding of the National Academy of Sciences of the United States of America **110**: 1398-1406.

Macmillan Education India. 2020. Digestion in Grass Eating Animals. Youtube. Available from www.youtube.com (accessed March 2020).

Marrow P, Law R, Cannings C. 1992. The coevolution of predator—prey interactions : ESSS and Red Queen dynamics. Royal Society **250**: 133-141.

Melletti M. 2016. Cattle Domestication: from Aurochs to Cow. Cambridge Blog. Available from www.cambridgeblog.org (accessed February 2016)

Ministry of Agriculture, food and rural affairs. 2020. Ruminations on Rumination. Ministry of Agriculture, food and rural affairs, Ontario. Available from www..omafra.gov.on.ca (accessed 2020).

Moran G. 2010. Vigilance Behaviour and Alarm Calls in a Captive Group of Meerkats, Suricata suricatta. Ethology **65**: 228-240.

Moran J, Doyle R. 2015. Cattle behaviour. Pages 37-68 in Moran J, Doyle R, editors. Cow Talk: Understanding Dairy Cow Behaviour to Improve Their Welfare on Asian Farms. Csiro Publishing, Clayton.

Moran J, Doyle R. 2015. The implications of cattle domestication. Pages 25-36 in Moran J, Doyle R, editors. Cow Talk: Understanding Dairy Cow Behaviour to Improve Their Welfare on Asian Farms. Csiro Publishing, Clayton.

Mougi A. 2010. Coevolution in a One Predator–Two Prey System. PLoS ONE 5 (e1388) DOI: 10.1371/journal.pone.0013887.

Munksgaard L, Jensen MB, Pedersen LJ, Hansen SW, Matthews L. 2004. Quantifying behavioural priorities—effects of time constraints on behaviour of dairy cows, *Bos taurus*. Applied Animal Behaviour Science **92**: 3-14.

Parsons MH, Lamont BB, Kovacs BR, Davies SJ. 2007. Effects of Novel and Historic Predator Urines on Semi-Wild Western Grey Kangaroos. Journal of Wildlife Management **71***:* 1225-1228.

Périquet S, Loveridge AJ, Macdonald D, Fritz H, Valeix M, Madzikanda H. 2010. Individual vigilance of African herbivores while drinking: the role of immediate predation risk and context. Animal Behaviour **79**: 655-67.

Price EO. 1984. Behavioral Aspects of Animal Domestication. The Quarterly Review of Biology **59**: 1-32.

Quenette PY. 1990. Functions of vigilance behavior in mammals: a review. International Journal of Ecology **11**: 801-818.

Randler C. 2006. Red Squirrels (Sciurus vulgaris) Respond to Alarm Calls of Eurasian Jays (Garrulus glandarius). Ethology **112**: 411-416.

Regusci E. 2017. A cow's daily schedule. Hoard's dairyman. Available from www.hoards.com (accessed July 2017).

Shahbandeh M. 2020. Number of cattle worldwide from 2012 to 2020 (in million head)*. Statista. Available from www.statista.com (accessed May 2020).

The Editors of Encyclopaedia Britannica. 1999. Cattle. Britanicca. Available from www.britannica.com (accessed May 1999).

Tibbbetts EA, Dale J. 2007. Individual recognition: it is good to be different. Trends in Ecology & Evolution **22**: 529-537.

Treves A. 2000. Theory and method in studies of vigilance and aggregation. Animal behaviour **60**: 711-722.

Valeix M, Loveridge AJ, Chamaillé-Jammes S, Davidson Z, Murindagomo F, Fritz H, Macdonald DW. 2009. Behavioral Adjustments Of African Herbivores To Predation Risk By Lions: Spatiotemporal Variations Influence Habitat Use. Ecology **90**: 23-30.

van der Meer E, Pays O, Fritz H. 2012. The Effect of Simulated African Wild Dog Presence on Anti- predator Behaviour of Kudu and Impala. Ethology **118**: 1018-1027.

Weiner S. 2017. Why Do Domesticated Animals Have Tiny Brains? Popular Mechanics. Available from www.popularmechanics.com (accessed December 2017).

Zeder M. 2012. Pathways to Animal Domestication. Pages 227-259 in Gepts P, Famula TR, Bettinger RL, editors. Biodiversity in Agriculture: Domestication, Evolution and Sustainability. Cambridge University Press, Cambridge.

Zu J, Wang J, Huang G. 2016. Evolutionary Diversification of Prey and Predator Species Facilitated by Asymmetric Interactions. PLOS One 11 (e0163753) DOI: 10.1371/journal.pone.0163753.

Appendices

List of the Appendices:

Appendix 1: Cattle's reactions to acoustic stimuli

Sex	Lying/standing	Activity	Type of call	Call ID	ensity of respor	Vig (l + 1)	Vig (f + 3)	Vig (d + 16)
male	standing	grazing	predator	dog	1	16	3	16
male	lying	resting	control	chaffinch	2	12	4	20
male	lying	resting	predator	wolf	2	5	7	27
male	lying	watching	predator	hyena	3	5	5	20
female	lying	ruminating	predator	hyena	2	8	4	20
female	lying	ruminating	control	chaffinch	2	5	3	15
female	lying	ruminating	predator	wolf	1	16	2	14
female	standing	grazing	control	chaffinch	1	16	3	16
female	standing	grazing	predator	wolf	2	7	5	24
female	standing	ruminating	predator	dog	3	1	8	20
female	standing	social	predator	hyena	1	16	2	27
male	standing	social/grazing	control	chaffinch	2	3	3	12
male	standing	standing	predator	hyena	5	7	3	16
male	standing	ooking into cam	predator	wolf	4	5	5	12
male	standing	ooking into cam	predator	dog	3	3	3	23
female	lying	resting, head up	predator	wolf	2	4	3	5
female	lying	resting, head up	predator	hyena	2	3	3	14
female	lying	resting	control	chaffinch	1	16	3	16
female	standing	grazing	control	chaffinch	1	16	3	16
female	standing	social	predator	dog	1	16	3	16
female	standing	watching	predator	wolf	2	4	2	14
female	standing	ruminating	predator	wolf	2	2	5	20
female	standing	ruminating	control	chaffinch	2	1	6	28
female	standing	razing/watchin	predator	hyena	2	3	4	19
female	standing	razing/watchin	predator	dog	1	16	2	9
female	standing	ooking into cam	control	chaffinch	1	16	2	1
female	standing	ooking into cam	predator	hyena	2	2	4	29
female	standing	ooking into cam	predator	dog	3	3	5	19
female	standing	ooking into cam	predator	wolf	3	15	3	14
male	standing	watching	predator	dog	2	2	6	21
male	standing	watching	predator	wolf	3	5	7	27

male	standing	ooking into cam	control	chaffinch	3	2	2	27
male	standing	watching	predator	hyena	1	16	3	16
male	standing	ooking into cam	predator	wolf	2	1	4	29
male	standing	grazing	predator	dog	3	5	5	25
male	standing	grazing	control	chaffinch	3	5	8	27
male	standing	grazing	predator	hyena	1	16	2	13
male	standing	grazing	predator	hyena	1	16	3	16
male	standing	ruminating	control	chaffinch	1	16	3	16
male	standing	grazing	predator	wolf	1	16	3	16
male	standing	grazing	predator	dog	1	16	3	16
male	lying	ruminating	control	chaffinch	2	6	6	26
male	lying	ruminating	predator	hyena	1	16	2	7
male	lying	ruminating	predator	wolf	1	16	3	16
male	lying	ruminating	predator	dog	1	16	3	16
male	lying	watching	predator	wolf	2	1	5	23
male	standing	g into cam/rumi	predator	dog	2	10	5	22
female	standing	grazing	predator	wolf	1	16	3	16
female	standing	grazing	predator	dog	1	16	3	16
female	standing	walks away	predator	hyena	1	16	3	16
female	standing	grazing	control	chaffinch	1	16	3	16
female	lying	ruminating	predator	hyena	1	16	3	16
female	lying	ruminating	predator	wolf	1	16	3	16
female	lying	ruminating	control	chaffinch	2	8	4	24
female	lying	ruminating	predator	dog	1	16	3	16
male	standing	urinating/social	predator	dog	1	16	3	16
male	standing	social	control	chaffinch	1	16	3	16
male	standing	atching/groomi	predator	wolf	2	2	6	30
male	lying	resting	predator	hyena	2	3	4	29
female	lying	resting	control	chaffinch	3	4	2	25
female	lying	ruminating	predator	dog	3	4	5	20
female	standing	grazing	predator	wolf	3	2	5	27
female	standing	ating, looking in	predator	wolf	2	4	6	28

female	standing	ating, looking in	control	chaffinch	3	1	3	30
female	standing	ating, looking in	predator	dog	2	11	4	21
male	standing	ooking into cam	predator	dog	1	16	2	13
male	standing	ooking into cam	predator	wolf	2	3	4	17
male	standing	ooking into cam	predator	hyena	2	1	4	18
female	lying	ruminating	predator	hyena	1	16	3	16
female	lying	ruminating	predator	dog	2	8	4	24
female	lying	ruminating	predator	wolf	1	16	3	16
female	lying	ruminating	control	chaffinch	2	4	4	21
female	standing	grazing	predator	wolf	1	16	3	16
female	standing	social	predator	hyena	1	16	3	16
female	standing	social	predator	dog	2	3	5	21
male	standing	grazing	predator	hyena	1	16	3	16
male	standing	grazing	control	chaffinch	1	16	3	16
male	standing	social	predator	wolf	1	16	3	16
female	standing	grazing	predator	dog	3	6	5	24
female	standing	grazing	predator	wolf	1	16	3	16
female	standing	grazing	predator	hyena	3	6	4	23
female	standing	grazing	control	chaffinch	1	16	3	16
male	standing	social	predator	dog	3	4	5	28
male	standing	grazing	predator	hyena	3	4	5	28
male	standing	ruminating	control	chaffinch	2	4	10	28
male	standing	ooking into cam	predator	wolf	2	13	3	8
male	standing	grazing	predator	wolf	1	16	3	16
male	standing	grazing	predator	dog	2	4	4	20
male	standing	grazing	predator	hyena	1	16	3	16
male	lying	resting	predator	wolf	2	4	7	28
male	standing	walking	predator	dog	1	16	3	16
male	standing	grazing	control	chaffinch	2	5	6	27
female	standing	grazing	predator	hyena	1	16	3	16
female	standing	ruminating	predator	dog	3	3	7	29
female	standing	walking	control	chaffinch	1	16	3	16

female	standing	grazing	predator	wolf	1	16	3	16
female	lying	ruminating	predator	wolf	2	4	1	8
female	lying	ruminating	predator	dog	3	3	4	18
female	standing	grazing	predator	hyena	1	16	3	16
female	standing	grazing	control	chaffinch	1	16	3	16
female	standing	grazing	predator	dog	3	5	8	27
female	standing	grazing	predator	wolf	1	16	3	16
female	lying	resting	control	chaffinch	2	4	5	28
female	lying	resting	predator	hyena	2	2	3	29
male	lying	ruminating	predator	wolf	1	16	3	16
male	standing	grazing	predator	hyena	1	16	3	16
male	standing	grazing	control	chaffinch	1	16	3	16
male	standing	grazing	predator	dog	1	16	3	16
female	lying	resting	predator	hyena	3	3	8	29
female	lying	resting	predator	wolf	2	4	6	28
female	lying	resting	predator	dog	3	3	6	29
female	lying	resting	control	chaffinch	3	5	3	20