CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Assessment of animal welfare of farmed and captive cervid

BACHELOR’S THESIS

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Declaration

I hereby declare that I have done this thesis entitled "*Assessment of animal welfare of farmed and captive cervid*" 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, 17th April 2024

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Vojtěch Novák

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Abstract

The global interest of utilization of Cervidae species products arose in the recent years. Cervid captivity represents welfare threads and concerns that need to be addressed in accordance with the latest scientific research. Research through many scientific databases was done to provide clear overview of the main threads and issues that are connected to cervid captivity. Issues of legal aspects both in European Union and Czech Republic, problems with evaluation and understanding of welfare, housing and handling, transportation, diseases, and pelt biting were examined. The natural biology and behaviour of cervids, an understanding of which is important for mitigating these problems, have been investigated.

Environmental enrichment has shown to be one of the best tools for alerting the stress-related responses. Other factors play key role however, namely facility design, as for example unsuitable fence design proved to be corelated with animal injuries. Smaller sized groups of cervids in captivity was seen in connection to less aggressive behaviour, therefore is good for welfare. Shade spots proved to be important as they help mitigate heat stress responses. Legal issues proved to be unspecific and had not covered many details about Cervidae species. However, there seem to be more and more legislation being created in the recent years covering welfare issues of animals.

Keywords: cervids, Cervidae, deer, welfare, enrichment, farmed, captivity.

Contents

1. Introduction

The global interest in utilization and production of non-traditional meat products arose in the recent years. Cervids can provide humans with meat, leather, milk, antler, and velvet (Putman 1989). It has been more and more recognized that we as humans have moral obligation towards other animals and it is our responsibility to develop more humane ways of treating them. Lately we as humans have also started to acknowledge the individual animal psychology and ethics of the farm breeding process. It is important to provide for the animal needs as well as secure the most ethical breeding conditions. Moreover, advances in ethology and behaviour sciences gave us insights into the emotional and cognitive capabilities. Animals can feel pain, suffering sadness or happiness and it is important to provide them with the most well-being as realistically and practically possible. The main problems and complications of deer welfare are associated with housing, breeding management, transport and killing of animals. There are several implications that can be established on captive cervid breeding farms such as welfare enhancement in form of environmental enrichment.

It is important that animal welfare is grounded by laws and regulations, to secure humane treatment and protection from harm. Legal frameworks need to be established to define basic standards of care, handling and treatment of animals. This should cover housing conditions, feeding, environmental enrichment, veterinary care, transport, and slaughter. These should be in accordance with latest scientific research and observations for animal needs, natural behaviour, and physiology. Ensuring highest possible level of animal welfare should ultimately be the priority. In European Union in the recent years, legislative focusing on well-being of animals in transport have been developed. Large part is dedicated to prevention of spreading diseases associated with Cervids. Farm to Fork is a strategy that focuses on sustainability and animal welfare issues. (EU 2019). Czech Republic’s legislative is covered by law 246/1992, the protection of animals against cruelty; 449/2001, hunting law; 166/1999, the veterinary law; and 154/2000, the breeding law. In Czech legislative there is a problem of clear definitions and specificity.

Global expansion of captive cervid breeding comes with some issues, however. Spread of captive cervid facilities can cause ecological, social, and political issues.

For instance, cervid captivity is associated with higher disease risk, especially chronic wasting disease. Risk is increased furthermore with transport and trade of animals or their products (Gerhold & Hickling 2016).

Acceptance of hunting by public is another issue. Hunting is socially acceptable only if the hunted species are culled for legitimate reasons. Confined shooting also does not help to get public support in oppose to situation when the animal is fair chased. As it is shown later, this view makes little sense as stalking is much preferable method of culling. Better communication with public and providing such information should therefore be in order. Wildlife professionals and managers of hunted species are also concerned with public's views of animal shooting as that can potentially lead to conflicts and misunderstandings.

In wild, many positive impacts on ecosystem have been recognized and these benefits could transfer into captivity as well. Ungulates regularly trample seeds into the land or disperse them by selective browsing. Faeces and hole making also have positive regeneration effect on pastures and swards. (Reimoser & Putman 2011).

2. Aim of the theses

The purpose of this Bachelor's thesis is to review the current knowledge on welfare of farmed and captive cervids and how it can potentially be improved.

The key point is understanding welfare goals based on Cervidae characteristics and ethology and finding the best ways to apply this knowledge to the farming environment. This involves the consideration of various aspects like cervid behaviour, psychology, natural environment, environmental enrichment, and animals´ adaptation abilities to farming conditions. Overall, the goal is to create new insights that can be used for the improvement of cervid welfare.

3. Methodology

Comprehensive search throughout many scientific and academic databases, journals or books was concluded. These databases included Google Scholar, Web of Science, PubMed, ScienceDirect and many others. The search included combination of keywords “cervids”, “Cervidae”, “deer”, “welfare”, “enrichment”, “farmed”, “captivity” and other relevant key points. Articles were mostly focused on assessment of welfare in farmed and captive cervids, although as knowledge of wild animal behaviour is useful in practical application, some of it was included as well. In terms of citation, the standardized form of the journal Conservation Biology was followed.

4. Literature review

4.1 General Definition of Welfare

The concept of welfare is continuously evolving, and its definition is continually refined over time. One of the initial approaches to welfare solely encompassed the physical aspects, such as food and shelter. The next step involved acknowledging various animal emotions, such as fear or frustration, and today, animal welfare includes mental aspects of animal well-being. The third perspective associated with this emotional view includes the idea that animals fare best when they live similarly or as closely as possible to their natural environment. Therefore, according to Hewson (2003), the most widely accepted definition of welfare is a combination of these three aspects, encompassing the body, mind, and the satisfaction of their natural tendencies.

Works such as "Animal Machines" (Harrison 1964) and "Animal Liberation" (Singer 1975) sparked societal questions regarding the ethics of animal treatment. This led to the formulation of the "Five Freedoms" by the Farm Animal Welfare Council during the 70s to 90s:

1. Freedom from thirst, hunger, and malnutrition – by providing easy access to fresh water and adequate nutrition to maintain health.
2. Freedom from discomfort – by offering suitable living conditions, including shelter and a comfortable resting place.
3. Freedom from pain, injury, and disease – through prevention or rapid diagnosis and treatment.
4. Freedom to express normal behaviour – by providing sufficient space, a suitable environment, and the company of animals of the same species.
5. Freedom from fear and distress – by ensuring conditions and treatment that eliminate mental suffering.

However, the freedoms have barely changed since their formulation in 1990s. It has been stated by the FAWC (2012) that the freedoms should be thought of more as an ideal state, rather than unbreakable standards which only makes sense, considering complete freedoms are not achievable. Webster (2005) argues that phrase “freedom from” should be replaced with phrase "as free as possible from”, as complete freedom is unachievable. It would go without saying, but many less informed people and even animal welfare NGOs adopted this literal interpretation of 5 freedoms even today (Mellor 2016).

4.2 Legal aspects

In European Union, European Commission adopted Farm to Fork strategy in 2020. This strategy is part of The European green deal, which covers emissions, economic growth, or COVID-19 pandemic with over €1.8 trillion in investments (EU 2019). Farm to Fork strategy focuses on redesigning today’s food systems, food security, food sustainability, how to reduce their environmental impact in terms of greenhouse gas emissions, or impact on biodiversity (EU 2019). Continuing in December 2023, the Commission adopted animal welfare proposal to improve rules on animal transport and better welfare. The current EU rules for transportation are over 20 years old and do not correspond with the newest scientific research on animal well-being. This new proposal focuses on reducing travel times of each transport, providing better conditions for animals that are being transported outside of EU, increasing space for animals in the transport, suggesting new rules for transport in high temperatures for different species, depending on their physiology and heat-stress response.

To transport species of Cervidae family withing the EU member states, there are requirements to be fulfilled. The animal must be older than 30 days, and not in contact with another cervid with lower health status. Animal coming from outside of EU into the Union state must be kept separate to prevent contact with other animals in that facility being transported into. Animals cannot be transported if there was infection of rabies virus within last 30 days and if there was infection with *Brucella abortus, Brucella melitensis, or Brucella suis* withing last 42 days. If the infection was caused by members of *Mycobacterium tuberculosis, M. bovis,* or *M. caprae,* this time period is 12 months (EU 2019). According to §8d 246/1992 protection against animal cruelty, cervids cannot be transported in period of antler regeneration in the Czech Republic.

In Czech Republic, animal welfare is covered within several laws including 246/1992, the protection of animals against cruelty; 449/2001, hunting law; 166/1999, the veterinary law; and 154/2000, the breeding law. It is submitted under the European community legislations, and it covers farm, laboratory, zoo, wild, and circus animals as well as pets.

The 449/2001, hunting low, covers conservation of wildlife species of Czech Republic. Czech Republic is bound with international agreements for protected animals, that cannot be hunted and those include mammal species of moose (*Alces alces*), Eurasian beaver (*Castor fiber*), European wildcat (*Felis silvestris*), brown bear (*Ursus arctos*), Eurasian lynx (*Lynx lynx*), steppe polecat (*Mustela eversmannii*), wolf (*Canis lupus*), and Eurasian otter (*Lutra lutra*). Other than that, there are other species of protected birds.

Cervidae species that can be hunted in Czech Republic include Fallow deer (*Dama dama*), Red deer (*Cervus elaphus*), White tailed deer (*Odocoileus virginianus*), European Roe deer (*Capreolus capreolus*), and two subspecies of Sika deer (*Cervus nippon dybowski*), and (*Cervus nippon nippon*).

There are three main options for cervid captivity in Czech Republic, depending on the intent of the captivity. For game hunting usage, hunting law 449/2001 applies, and they are captive in game reserves with minimum of 50 ha. They can be released into wild. Then farm breeding. This means with intent of breeding and production, not hunt itself. Such animals are considered livestock animals according to the veterinary law 166/1999. Then there is hobby breeding which is covered by ministry of agriculture and ministry of the environment. In this case, cervids are considered wild animals, cannot be released into the wild nor culled (Žbánek 2023).

In terms of breeding, there are only some general guidelines in the 449/2001 hunting law. Those include keeping the numbers of that species above certain minimum, so its population is not threatened and can safely reproduce. This certain minimum should correspond to the environmental quality as well as gender and age ratios and coefficient of expected population. Areas for breeding should be selected depending on suitable environment that fits the issued species. These areas cannot be harmful to its surrounding environment. These areas should be selected based on surrounding ecosystem, the result of controlled and comparative land, damages on agriculture and forestry caused by animals, results of animal census, and on the minimum and standardized animal census. No specifics are provided for cervid captivity and breeding.

Current crucial problem is with definition of term “wild animal” both in Czech and EU legislative. In czech “volně žijící živočich” is being translated in many different forms including “wildlife”, “wild animal”, “animal”, or “fauna”. Same unclear translation occurs when translating from English to Czech. It is problematic because it can create some confusions, especially when different laws use different definitions. The term should be differentiated from “zvíře” (“animal”) as for example, according to the 246/1992 protection against animal cruelty law, this includes only vertebrates and cephalopods. Similarly, the 89/2012 Civil code considers “animal” even invertebrates that do not feel pain or stress.

4.3 Evaluation of Welfare

In addition to determining individual aspects of welfare, the challenge lies in its assessment and consolidation into an overall evaluation. The European Union, including the Czech Republic, evaluates welfare based on stable measurements, prescribing what should be provided to animals.

Indicators of welfare levels include assessments based on animal production, such as growth rate or milk production. Other indicator is abnormal behaviour, meaning behaviour that was not observed in wild and is with no apparent biological function. This includes stereotypies, overgrooming, regurgitation, re-ingestion, and any form of self-harm (Mason & Rushen 2006). Concentration of hormones such as glucocorticoids can be a good indicator as they are associated with adrenal activity and therefore disturbance. Usually, they are measured from plasma samples, but that itself can cause more stress. Non-invasive methods are therefore recommended, meaning extracting the data out of excrete, saliva, hair, feather, milk, or eggs (Palme 2012).

Additionally, veterinary considerations are considered, encompassing respiratory diseases and a physiological approach that examines stress mechanisms, animal adaptation to stressors, and related functions such as metabolism, reproduction, immunity, and other physiological aspects like heart rate or cortisol levels. Lastly, evaluation is conducted based on animal behaviour, involving the observation of abnormal behaviours such as stereotypies, depression, aggression, and more (Pištěková 2014).

Although assessing and scientifically measuring such abstract thing as feelings can seem hard, there are few ways to do it. Feelings are linked to preferences and motivations. Fraser and Broom (1990) defined motivation as what changes in behaviour and psychology is brain controlling. Thus, two main approaches are used in assessing feelings. First approach is giving the animal control over its environment and then observing what decisions does it make with its freedom. The other observes, how is the animal behaving when its environment is limited and with less freedom (Kirkden & Pajor 2006).

Other way of assessing animal welfare can be done by preference tests. Giving the animals control over their environment and monitoring the choices and decisions they make, reveals their motivation, preferences, or frustration, deprivation, or distress. This displays the animal's tendency to perform or not perform the behaviour which can help address whether or not is the animal motivated to obtain a resource, whether or not it has preference between multiple resources, how strong the motivation to get that resource is, and whether or not are these factors affected by changes in its environment (Kirkden & Pajor 2006).

Another of the decision-making tests is cognitive bias test. Humans can have biases in the way of their thinking. Depressed or anxious people generally have tendencies, or biases to interpret different situations in more negative way than happy people. This can even lead to people creating their own subjective reality, that may differ from objective reality and thus leading to inaccurate judgement or some illogical thinking. Similarly, rats or mice implement the same biases (Willner 1997), but also so do dogs, starlings, and rhesus monkeys (Mendl et al. 2009). Animal's cognitive bias is associated with welfare state, meaning animals in better welfare make fewer negative judgements and more optimistic ones.

Although cognitive bias has been studied and tested many times in laboratories and in farming environment, more exotic animals in zoos have been left out. Cognitive bias has not been applied on Cervidae species, although NAWAC (2022) points out that improved quality of life and positive experiences in deer can be achieved by giving the animals the option to engage in activities that are reportedly rewarding. In zoo environment only bottlenose dolphin (*Tursiops truncates*), western lowland gorilla (*Gorilla gorilla gorilla*), and American black bear (*Ursus americanus*) have cognitive bias been tested (Clegg 2018).

Lastly, the welfare evaluation can be measured by quality of the environment, diet, structures provided for the animals in the paddock, for example if it includes hiding spot (when it comes to cervid species this includes dark and quiet place), and husbandry routines (Mellor & Beausoleil 2015).

4.4 Cervidae taxonomy & classification

The family Cervidae ranks among ruminant artiodactyls and the Cervidae taxon contains over 55 species living from the northern hemisphere through south America to southeast Asia (Gilbert et al. 2006).

Out of these species, two are considered extinct, one critically endangered, 8 endangered, 16 vulnerable, 17 are of low concern and for 10 species are not sufficient data. The main causes of threats include hunting, habitat loss and competition with domesticated and invasive animals (IUCN 2023). In addition, climate change has proven to be arising threat for cervids as it forces the wild animals to north and south, or into the higher altitudes. As an example, *Alces alces* is sensitive to heat (summer temperatures above 14 °C and winter temperatures above -5 °C leads to heat stress) which led to decline in their numbers in the recent years. Moreover, changes in climate can alter other species and vegetation which can than indirectly affect cervids (Rines 2014; Weiskopf et al. 2019).

Especially in North America, overhunting alongside environmental changes had devastating impact on wapiti (*Cervus canadensis*) (Mattioli 2011).

The only African deer is barbary red deer (*Cervus elaphus barbarous*), living in Tunisian-Algerian border and Morocco, currently with "endangered" classification (Zachos et al. 2010).

Family Cervidae consists of subfamilies Cervinae that includes Cervini and Muntiacini tribes, and Capreolinae that includes Capreolini, Alcenini and Odocoileinini tribes (Gilbert et al 2006).

The next is the list of today's known species of the family Cervidae divided by genera. UICN conservation status from extinct (EX), extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), nearly threatened (NT), conservation dependant (CD), least concern (LC), data deficient (DD), and not evaluated (NE) is added for each species (IUCN 2023):

1. Subfamily Cervinae
   1.1 Tribe Cervini

Genera Cervus

Red deer (*Cervus elaphus*) (LC)

Sika deer (*Cervus nippon*) (LC)

Wapiti (*Cervus canadensis*) (LC)

Tarim red deer (*Cervus hanglu*) (LC)

White-lipped deer (*Cervus albirostris*) (VU)

Genera Axis

Chital (*Axis axis*) (LC)

Calamian deer (*Axis calamianensis*) (EN)

Hog deer (*Axis porcinus*) (EN)

Bawean deer (*Axis kuhlii*) (CR)

Genera Dama

Common deer (*Dama dama*) (LC)

Persian fallow deer (*Dama mesopotamica*) (EN)

Genera Rucervus

Eld's deer (*Rucervus eldii*) (EN)

Barasingha (*Rucervus duvaucelii*) (VU)

Schomburgk's deer (*Rucervus schomburgki*) (EX)

Genera Muntiacus

Nothern red muntjac (*Muntiacus vaginalis*) (LC)

Reeves' Muntjac (*Muntiacus reevesi*) (LC)

Leaf Muntjac (*Muntiacus putaoensis*) (DD)

Fea's muntjac (*Muntiacus feae*) (DD)

Roosevelts' muntjac (*Muntiacus rooseveltorum*) (DD)

Gongshan muntjac (*Muntiacus gongshanensis*) (DD)

Black muntjac (*Muntiacus crinifrons*) (VU)

Large antlered muntjac (*Muntiacus vuquangensis*) (CR)

Annamite muntjac (*Muntiacus truongsonensis*) (DD)

Puhoat muntjac (*Muntiacus puhoatensis*) (DD)

Bornean yellow muntjac (*Muntiacus atherodes*) (NT)

Sumatran mountain muntjac (*Muntiacus montanus*) (DD)

Southern red muntjac (*Muntiacus muntjak*) (LC)

Genera Elaphurus

Père David's deer (*Elaphurus davidianus*) (EW)

Genera Elaphodus:

Tufted deer (*Elaphodus cephalophus*) (NT)

Genera Rusa

Javan deer (*Rusa timorensis*) (VU)

Philippine spotted deer (*Rusa alfredi*) (EN)

Philippine deer (*Rusa marianna*) (VU)

Sambar (*Rusa unicolor*) (VU)

2. Subfamily Capreolinae

2.1 Tribe Capreolini

Genera Capreolus

Siberian Roe deer (*Capreolus pyargus*) (LC)

European Roe deer (*Capreolus capreolus*) (LC)

Gerenra Hydropotes

Water deer (*Hydropotes inermis*) (VU)

2.2 Tribe Alcenini

Genera Alces

Moose (*Alces alces*) (LC)

2.3 Tribe Odocoileini

Genera Rangifer

Reindeer (*Rangifer tarandus*) (VU)

Genera Odocoileus

White tailed deer (*Odocoileus virginianus*) (LC)

Mule deer (*Odocoileus hemionus*) (LC)

Genera Blastocerus

Marsh deer (*Blastocerus dichotomus*) (VU)

Genera Hippocamelus

Taruca (*Hippocamelus antisensis*) (VU)

Patagonian Huemul (*Hippocamelus bisulcus*) (EN)

Genera Mazama

Central american red brocket (*Mazama temama*) (DD)

Gray brocket (*Mazama gouazoubira*) (LC)

Amazonian brown brocket (*Mazama nemorivaga*) (LC)

Small red brocket (*Mazama bororo*) (VU)

Yucatan brown brocket (*Mazama pandora*) (VU)

Brazilian dwarf brocket (*Mazama nana*) (VU)

Mérida brocket (*Mazama bricenii*) (VU)

Dwarf red brocket (*Mazama rufina*) (VU)

Peruvian dwarf brocket (*Mazama chunyi*) (VU)

Red brocket (*Mazama americana*) (DD)

Genera Ozotoceros

Pampas deer (*Ozotoceros bezoarticus*) (NT)

Genera Pudu

Southern pudu (*Pudu puda*) (NT)

Northern pudu (*Pudu mephistophiles*) (DD)

4.5 Biology of cervids

Basic biology of two different groups of species will be descripted to understand their natural behaviour. That is important in order to understand their needs in captivity and in applying of welfare. Cervids can be differentiated based on ecotypes where they live and in which they are adapted to. The first group lives mostly in open areas, grasslands, steppes. They are typically larger in size. This can include generas of Cervus, Dama, Rucervus, Elaphurus. The second group is found in dense vegetation cover such as temperature forests and dense tropical forests, or alpine meadows. This includes smaller genras such as Muntiacus, Axis, Capreolus, Mazama, or Elaphodus.

The red deer (*Cervus elaphus*) is one of the largest species of deer. Adult male stag size reaches up to 1.37 meters at shoulders and length up to 2.6 meters from nose to tail. Deer can weight ranges between 70 to 225 kg. The lifespan can vary. The record age for red deer observed was in Kiev Zoo, a 31-year-old female (Wildlife online 2024). Records for species *elaphus* are slightly above 21 years (Weigl 2005). These are the maximum ages recorded in captivity. In wild according to many sources the age lifespan ranges from 10 to 16 years with some exceptions living above 20 years (The Mammal Society 2024; Wildlife online 2024). However, it was observed by Hoffman and Valencak (2020) that there is not significant gap between the average lifespan between the wild and captive species of red deer (*Cervus elaphus*). Typical body temperature in red deer is 35 °C (HAGR 2020). The colour of coat changes depending on the season: reddish brown in summer months and greyish brown during winter months. Male stags also grow mane during winter.

Red deer antlers go through annual cycle of metabolic changes that typically begins at spring including shedding of antlers, regeneration, and calcification. These changes are regulated by secretion of testosterone. The regeneration of new antlers is associated with the period of lower activity of testicles. During the initial stages of growth, antlers are covered by a soft layer of skin called “velvet”. It serves as a supply of nutrients important for the growth of the antler through blood vessels and nerves. As the antlers mature and the cartilage tissue is replaced by bone tissue, there is higher concentration of testosterone.

Before mating season, the antlers are calcified, solid and fully cleaned of any remaining velvet. Deer keep their antlers from 3-9 months depending on their testosterone activity. Once the testosterone levels drop, males then shed their antlers and the whole cycle begins again. (Lincoln 1992). Female deer usually do not grow antlers. The only species of deer where female do grow antlers is reindeer (*Rangifer tarandus*) for food exposure in snow. Out of other species female antlers are relatively rare but can be observed mostly in red deer (*Cervus elaphus*), European roe deer (*Capreolus capreolus*) and white-tailed deer (*Odocoileus virginianus*) possibly due to high testosterone levels (Wislocki 1954).

The antlers are used by males during rut season to fight other males or for protection from harm of potential danger. Males and females live separately throughout most of the year, apart from the mating season.

Red deer are species commonly seen in more wide-opened areas such as glass lands, meadows, flood plains, river valleys, moorlands, parklands, and mixed woodlands. They tend to spend time close to water sources like rivers, lakes, or ponds, showing the importance of access to them in captivity. In summer, they can be found feeding in higher altitudes, for example Alps (Wildlife online 2024).

Species of genera Muntiacus can be found in southern China and southeast Asia. They body size ranges depending on the species but are typically smaller. The smallest group is from genera Pudu, ranging from 32 to 44 centimetres (SCE 2022). Body length can be up to 85 centimetres. Their weight ranges between 6.5 to 13.5 kg (Robidoux 2014). Water deer (*Hydropotes inermis*) is tall up to 50 centimetres and weighs from 11 to 19 kg. Reeves' muntjac deer (*Muntiacus reevesi*) grows up to 90 cm at shoulder, ranges 90 to 135 centimetres from nose to tail, and weighs 9 to 18 kg. Its lifespan can be up to 20 years in captivity. Their antlers are small and short appropriately to the body size. Females have small bony bulges instead of the antlers. Males also have 1-centimetre-long upper canines (Jackson 2002). Muntjacs change their coat annually. In captivity late coat change could be potential indicator of poor welfare. Because of their size and fast unpredictable movement, culling by stalking could prove to be difficult. Using feed such as apples or carrots as a bait could help avoiding this issue in terms of culling the individual animals.

These species prefer more closed areas with dense cover such as mixed woodlands, bushes, shrubby under growths, rainforests, and are increasingly more and more found in urban areas (The deer initiative 2008; SCE 2022). Genera Mazama is mostly found in South or Latin America forests and rainforests (IUCN 2023).

4.6 Domestication

Domestication began in the territory of today's Russia with a species of reindeer (*Rangifer tarandus*), and some authors claim that it happened shortly after the domestication of the dog (Bogoraz-Tan 1933). Reindeer farming provided a better return on resources than fishing, hunting or other forms of agriculture. In addition to meat, hides and milk, it also provided transportation in the early stages of domestication till present day.

Some species, for example red deer, sika deer, fallow deer, or reindeer, have been kept in semi captive conditions with the herders following the animals, but all species have retained specific characteristics to survive in nature without the help of humans, and they have not developed tameness, as in other fully domesticated species, therefore we consider deer as a semi-domesticated species (Zabrodin & Borozdin 1989). However, red deer and fallow deer could probably be considered domesticated species in most aspects (Mattiello 2009).

Red deer and European fallow deer are relatively recently domesticated species, and therefore certain complications with welfare may occur. For example, offspring of wild European deer is more susceptible to stress caused by intensive housing conditions than offspring of reared doe, which has been caused by a poorer immunological response to foreign antigens (Hanlon et al. 1994). Stress can lead to the death of the animal, or myopathy because of capture from the wild.

4.7 Role of zoos in cervid welfare

Today, zoos play increasingly more important role both in conservation and animal welfare. Many zoos take part in programs with an aim of securing endangered species genetic diversity in order to help prevent extinction of that species. This includes ex-situ conservation via breeding as well as in-situ, meaning helping the animals in their natural habitat. Zoos also help to raise awareness about conservation issues to the wider public and educate about species threats. Zoos also commonly cooperate with scientists to make records about animals' biology, behaviour and ecology which can help with conservation efforts.

The large antlered muntjac (*Muntiacus vuquangensis*) was uplifted from endangered to critically endagened in 2016. Threads to this species include development of urban areas, agriculture, hunting, energy production, mining, transport in form of road kills (UICN 2016). There was management area protection project for Nakai-Nam Theun National Park, funding many million dollars in 2015. Despite the large sums of donations, little progress has been made since. Strengthening and developing conservation management system in Nakai–Nam Theun NP, including skilled and motivated stuff, is key in this deer species' conservation.

Worldwide fund for nature is involved in large antlered muntjac conservation through MOSAIC project that includes working with locals and forest officials to implement appropriate conservation practices. This could also mean establishment of breeding centres for this species (WWF 2017).

Endangered Philippine spotted deer (*Rusa alfredi*) is under conservation among other places in Zoo Berlin. Reason for endangerment is destruction of habitat due to agriculture and human settlements. About 150 individual animals are currently under human care worldwide. That is large difference since 1980s when the species was believed to be extinct. Panay mountain National Park only recently started to reintroduce Philippine spotted deer back to the wild (Zoo Berlin 2024).

In zoo Prague, Finnish forest reindeer (*Rangifer tarandus fennicus*) can be seen. In Europe, it is the only wild subspecies of reindeer that is kept in captivity. Conservation of this species proved to be successful as calves were born (Prague Zoo 2023).

Père David's deer is yet another species that suffered habitat loss. Alongside with immense hunting that has led to their extinction in wild in early 1900s. Thankfully, zoological society of London's conservation programmes secured this species' survival and in cooperation with other zoos. According to UICN, it is still to this day considered as extinct in the wild (2023).

In UK's Whipsnade Zoo, in 2020, 14 new fawns have been born and in 2023, additional 13 fawns have been added to the herd making this an important conservation move (Whipsnade Zoo 2023).

Cervids are herbivore browsers meaning feeding on leaves, fruits, or shrub vegetation (Reimoser & Putman 2011). Zoos should provide foods that are related to this behaviour, promoting foraging, or browsing. Browsing is beneficial in terms of welfare because it supports the animal's activity and motivation to search for food. This can be achieved by distribution the food in smaller samples and spreading it all over the enclosure (Nielsen et al. 2016). Zoos regularly provide animals with toys or puzzles with foods. For cervids, some form of puzzle solving toys should be used to support antler usage. Other forms of environmental enrichment should be used as they help mitigate stress or boredom.

Enclosure design plays a key role in welfare. Visitor distance and visibility can negatively impact the animals in zoos to the extent of lowering the life expectancy. Enclosures should have retreat spots where can animals hide. Elevated platforms for visitors and natural masking or the whole enclosure should help mitigate these issues (Hartley & Wall 2017).

Zoos play key role in education and raising awareness of animal's threads and endangerments. This also indirectly impact the cervids welfare as zoos can help promote conservation campaigns or raise money for endangered species.

4.8 Seasonality and natural behaviour

Most female cervids are polyoestrous and polygynous (Asher 2011). Oestrous cycle is characterized by higher progesterone secretion and is triggered mostly by shorter photoperiod. Fawns are born at spring. Species of temperate or northern climate have their offspring in summer while species of more southern or tropical climate are often unseasonal (Lincoln 1985). Breeding tropical species such as chital deer (*Axis axis*) in northern climates therefore could be problematic in terms of welfare. For example, heavy rainfalls largely influenced the mating peaks between males and females in chital deer. Kelly et al. predicts that this might lead to increased variation in reproductive success of males (2022). Freedom to express natural behaviour should be provided, meaning that allowing them to breed all year round. This could be problematic, as there is potential risk in calf losses during the winter months.

The tropical species being mostly unseasonal and daylight not playing key part in their seasonality, it comes down to other factors, for example food availability, competition with other species or predation (Asher 2011).

The rut or rutting season is the period when deer mate. It ranges from mid-September to mid-October (Tajchman et al. 2022) but the onset of the period can be advanced in controlled environment by melatonin portions added into their feed (Clere et al. 1984). There are behaviour changes to be noticed in males in pre-rutting season, such as male fights, roaring, fighting vegetation or even detachment of velvet from the antlers (Tajchman et al. 2022). Antler growth, higher testosterone levels, volume, pH, concentration, and mobility of sperm are also recorded (Gizejewski 2004). Reduced ingestion of food has been recorded in males during rut season (Miquelle 1990).

There has been a long going debate concerning hypophagia in animals during the rut season, meaning there has been reduced ingestion of food observed. It applies for wild as well as captive animals (Schwartz et al. 1984). Miquelle (1990) observed significant reduction of forage intake of adult moose males roughly in the first two weeks of rut season, in mid-September. It might come as a surprise considering it is a time of most energy expenditure. At firsts, it was thought it is because of adult males typically spent considerable amount of time on social activities and behaviour. It does not fully explain the hypophagia as they also spent up to 45% of their active time idle; males were observed to have time to feed but did not do so. Other theory is that hypophagia is caused by physiological mechanisms. How does physiology affect the suppression of food intake is not understood (Miquelle 1990).

In captivity, it is therefore recommended to provide high nutrition feed after the end of rut season.

Red deer, as the only deer species, does not use his antlers for fighting other males, which is part of the reason why this species is fit for breed farming. Instead, males instead use vocalization to attract other females (Charlton et al. 2007). Seasonality observations help their welfare improvement in terms of knowing when to separate males, which hares to breed, or when a veterinary treatment is appropriate (Janiszewski et al. 2016). If possible, earlier mating and offspring birth is advantageous in breed environment as it leads to better growth and body weight (Tajchman et al. 2022).

4.9 Farm breeding

The worldwide meat consumption and demand for meat has increased by 15.3% between the years 2000 and 2019 globally (Whitton et al. 2021). The global interest in utilization and production of non-traditional meat products such as venison arose in the early 1970s (Drew 1985) and according to venison market report the trend continues growing (Business Research insights 2023).

Red deer (*Cervus elaphus*) and Fallow deer (*Dama dama*) are among the species most used for farm breeding (Fletcher 2002).

Today deer farms are found mainly in New Zealand, China, and Russia and then in Europe, North America, Australia and both intensive and extensive systems are used (Fletcher 2002). The estimated global number of captive cervids is around five million, with New Zealand accounting for the fifth of the whole mass and with Germany being the EU leader (Daszkiewicz 2015).

Deer provides humans with meat, skin, antlers, "antler velvet", and their breeding is especially useful in areas where the climate does not allow large-scale agriculture. For example, in the arctic polar zone, the caribou species is still used for sustenance and clothing. Today, however, most species are hunted for sport rather than necessity. Finally, they also play a role in ecotourism and are observed in their natural environment (Putman 1989). In 2015 the annual cervid production in Czech Republic was 3800 tons (1600 deer, 400 fallow deer, 1800 western roe deer) (Bureš at al. 2018).

4.10 Deer housing and handling

Experiments that housed adult deer indoors during the winter months showed that although such housing has a positive effect on gain, indoor conditions provoked aggression among deer leading to mutual skin damage (Pollard & Littlejohn 1998).
Higher numbers of individuals lead to increased aggression, as with more individuals' groups form and with higher density there is less space between nearest neighbours, which tends to lead to more aggressive interactions between individuals (Clutton-Brock et al. 1982) and the problem of intensive breeding arises. In the ideal case, it would be to form groups with a different arrangement of individuals, which would correspond to the natural one.

In terms of housing, a simple type of shelter to protect against extreme climates will suffice (Webster 2005). However, shade plays a key role during the early stage of life of the young, along with silence, due to their natural hiding behaviour. Shade also helps cervids to regulate their body temperature which is important as they are vulnerable to heat. Furthermore, shade has positive impact on shortness of breath, heart and respiratory rates, food conversion and body weight gain (Ramírez et al. 2021).

Access to a body of water is also important for hygiene and marking of their territories, so access to water is recommended in enclosures (Clutton-Brock et al. 1982).

Lastly, animal escapes from the facilities are unavoidable and happen regularly. The impact of mixing the genes with the wild individuals is not yet known. In breeding farms, goal in males is usually to grow unnaturally large antlers. The impact on other genetical traits is also still unknown and should be closely examined (Miller & Miller 2016).

When it comes to handling, the personnel must be able to maintain the animal's health, safety, and welfare. Handling the deer is different than in other domestic species such as cattle or sheep as cervids tend to be less tolerant and even fight if they feel the need to. The personnel therefore need to be trained to be able to recognize these behaviours which includes pelt biting, bullying and panting, that occur mostly as a consequence of stress (NAWAC 2022). Deer must never be handled by its tail, as pushing, or twisting it may lead to break of the tail bone and internal bleeding (DINZ 2015).

Unmanaged stress can lead to aggressive behaviour, pelt biting, bullying, cornering, teeth grinding, and pre orbital gland opening (Bartošová et al. 2012; DINZ 2018).

Adequate densities appropriate to the size of the facility is crucial. In more intensive environment, deer should be kept in small groups that correspond to the pen size. Isolation is not an option and not even for a short period of time as deer struggles to bear solitude (NAWAC 2022).

4.11 Structure and management of animals on farms

There should be a sufficient space in the corners of the enclosure to avoid risk of conflict among multiple animals in narrowed areas as they can lead to panic and even injuries. The boarders of the fences should be clearly visible to animals. It has been observed by Pollard and Littlejohn (1994) that moving the herd in and out of the enclosure is considerably easier at dusk, rather than in the dark and, in general, it is recommended to move in a direction from darkness towards light.

Special attention should be done on construction and design of fences, as they are likely to cause injury to animal. In a 1996 survey done on deer game farms in Michigan, injury was linked to 32% of all illnesses and 27% of all deaths. Same survey revealed that about one third of farms did not have veterinarian to provide his expertise. (Bruning-Fann et al. 1997).

Woven wire material is commonly used in cervid farms and although there is not many legislatives covering the proper attributes of the fence, some suggest minimum of 8 feet (2.4 meters). It should resist to commonly reoccurring weathers like winds, ice storms or flooding (West Virginia administrative 2015).

For one animal the minimum square feet should be 5000 (464 square meters), increased by 25% of the whole mass with each added animal. Mixing different species of cervids should be done only when the population density is at least 20.000 square feet per animal (West Virginia administrative 2015).

Allowing cervids to express their natural behaviour might be desired, although quite difficult or even impossible in commercial breeding farms. Cervids social behaviour includes grouping of animals or battling between the males. Forced separation instead of natural, gradual weaning is also common practice (Haigh & Hudson 1993).

4.12 Transportation

Transport of Cervidae species is one of the most challenging welfare concerns. Heart rate, cortisol levels, lactate and sodium all increase during the transport in much greater extend then in domesticated livestock (Waas et al. 1997). In many animals that had died during the transport, it has been found damaged tissues apparently caused by traumatic experiences (Selwyn & Hataway 1992).

To prevent stress associated with loading and unloading animals into the transport it is advised to use a less steep ramps (Smith & Dobson 1990). Furthermore, the animals should be in darkness and the ride should be careful and slow. A singular transport should not take more than 12 hours without water and should avoid stops on the way as unloading animals in unfamiliar territory increases the stress even more (DINZ 2015). Generally, it is considered better for the transport conditions to separate animals into the same groups of species, gender and age. Transport of males with velvet antlers must be avoided and solid antlers must be removed from males before transport. An exception could be if the transported male is singular; in such case antlers can be left intact.

The number of companies engaged with transport is reportedly decreasing, and new welfare regulations are being developed in New Zealand. Driver himself needs to be aware of these regulations and be able to recognize if an animal is not fit for the transport (DINZ 2018).

4.13 Culling

As an alternative to culling at a slaughterhouse, shooting in the paddock may be considered. Studies of Smith and Dobson (1990); Pollard et al. (2002) have highlighted significantly higher cortisol levels caused by capture, transportation, and the time before actual slaughter, as well as the negative impact on the pH of the meat of these animals. However, further research is needed to determine the impact of this method of slaughter on the rest of the herd.

The study in England compared post-mortal effects on red deer (*Cervus elaphus*) based on culling method. Welfare costs were compared when the deer were culled either by rifle (stalking) or were hunted by hounds (hunting). Hunting was associated with more stressors such as proximity of animals to humans, hounds, pursuit, noise or physical limitation. Measures of blood cell damage, muscle cell damage as well as psychological stress were significantly higher in hunted animals then in stalked ones. In terms of stalked animals, 11% of deer required two or more shoots to kill and 7% took 2-15 minutes to die. Overall, the study concludes the welfare costs are much higher with hunting then with stalking (Bradshaw & Bateson 2000).

Certain deer species need special considerations because of their biology. For example, muntjac deer in proportions is very small and displays ability to move very fast and unpredictably. When the muntjac suspects danger and is somehow disturbed he barks, circles around, runs and suddenly stops. Although muntjacs are not as susceptible to disturbance as larger species of deer, his size makes it more crucial that the stalker is not seen and gets to fire a clean shot. Sitting out, meaning setting up vantage points or high seats for the undisturbed stalking and it could be an option for muntjac species. In general, it is not recommended to stalk the same areas too often. Instead, setting several spots could prove useful culling method (The deer initiative 2008).

4.14 Velvet harvesting

This refers to the commercial procedure of removing antlers from an animal during their growth phase when they are still covered by the skin, known as "velvet." This usually means 50-55 days after shedding the old antlers and growing the new ones (Li at al. 2004). During this growth period, antlers have increased blood circulation, making them highly sensitive. The removal should be done under local anaesthetic drugs, and in dark and calm environment. The cut can by done with a help of a saw in 1-2 cm above the pedicle junction (Li at al. 2004).

These practices are mostly observed in New Zealand, primarily due to the demand for velvet antlers in East Asian countries such as China and Korea (DINZ 2018). In Europe countries and US these practices are not allowed.

4.15 Environmental Enrichment

Environmental enrichment could be defined in several ways. It can be modifications of the environment to enhance the quality of life for animals in farms, zoos, or laboratories, based on scientific knowledge with the goal of improving welfare (Young 2004). Any modifications that focus on physiological as well as psychological well-being in the certain environment of given animal (Newberry 1995, Baumans 2005). Engaging animals by means of environmental enrichment can reduce boredom, stress, or stereotypical behaviour patterns (Polanco at al. 2021).

There are several enrichment tools that can be used for welfare of cervids.

Feeding Enrichment

To simulate the natural foraging behaviour in the wild, food can be distributed in smaller portions and placed in variable locations throughout the enclosure or even in water sources. Wild animals often supplement their diet with minerals and proteins by consuming aquatic vegetation, so if possible, having access to water source can be also beneficial for them (Ceacero et al. 2014).

Providing mineral licks or salt blocks also has positive effects on micronutrients and overall nutrition intake. Different quantities of food, in combination with varied feeding times, have impact on animal activity and motivation in food-seeking behaviours.

The appetite and feed intake changes depending on the season (Asher 2020). The feed intakes are low during winter months and during the rut and higher during summer. Therefore, highlighting the importance of adding high quality nutrients into the feed after the rutting season. Type of feed includes perennial ryegrass, clover, herbs, and legumes such as plantain, chicory, red clover, brassicas, sainfoin, lucerne, turnip (Nicol & Barry 2002). Apricots, blueberries, grapes or mushrooms can also be used, as they simulate the feed most commonly found in wild. These alternative feeds have an advantage compared to grass feed, as they are mode digestible and provide higher dry matter intake. Herbs have positive impact on deer performance as well as on health and overall welfare (Stevens & Corson 2003).

Grains such as wheat, oats, maze, triticale can provide high energy source and good option for supplementary feed. Its usage is recommended mainly during winter and spring months. When changing the diet, gradual adaptation is recommended for lucerne and brassicas to be up to 10 days (DINZ 2022).

In some institutions like zoos, providing the animals with coniferous branches or trees can enrich the overall diet. Unused Christmas trees could be fitting, although many zoos, including the Prague Zoo does not accept usage of trees already used in households, as they can contain remains of ornaments.

Cognitive Enrichment

Wildlife photographer Jochen Langbein (2017) captured an image of a deer delicately removing bird feed using its antlers, showcasing precise and careful movements. This could serve as inspiration for cognitive enrichment in the form of puzzle-solving activities.

Social Enrichment

Inter-species associations exist not only among closely related species but also among animals of different orders. For instance, at Colchester Zoo, interactions were observed between the Indian Axis deer (*Axis axis*) and fruits dropped by the sacred langur monkey (*Semnopithecus entellus*). Mutual alarm calls between the groups were noted in response to danger, indicating a mutualistic relationship (Newton 2010).

Olfactory Enrichment

A group of four zoo-housed reindeers, Caribou (*Rangifer tarandus*) in Icelandic Reykjavik can be an example of usage of olfactory enrichment. Four essential oils (jasmine, lavender, lemon, peppermint, tea tree) were used and applied on wooden logs near the deer's enclosure. Five different spices (black pepper, chilli powder, cinnamon, garlic powder, oregano) were also used and applied in animals' foods. The study concludes that even though annual month matters in terms of deer time spent interacting with the olfactory object (suggesting July mean time is the longest), there was no significant difference between objects with and without essential oil or spice application (Katarzyna 2021).

Tactile enrichment

For tactile enrichment many objects can be used from branches or broom brushes to yoga ball. As for broom brushes there has been studies associating many positives for cows such as body cleanness and even improved milk yield (Mandel et al. 2016).

4.16 Pelt biting

Ungulates demonstrate a range of behaviour patterns to determine their social rank. These behaviours include vocalizations, distance changes, but also aggressive behaviours such as kicking, chasing, and biting many of which can lead to death of animals (Hall 1983; Volodin et al. 2019). One of the common behaviour interactions we can observe in cervids is pelt biting. This behaviour plays key role in terms of securing food, space, potential mating partners and overall rank in the social group (Pérez-Barbería et al. 2021).

Bites could serve as a stress indicator in a certain social group and could be important regarding assessment of animal welfare in these groups. The aggression of animals is affected by number of factors and conditions including group size, body weight, sex, age, or heat stress.

On captive Iberian red deer (*Cervus elaphus*), several tendencies have been observed: The higher the social rank of the deer, the lower the number of pelt bites this individual received. The more increased heat conditions in the environment, the more bites were received. The heavier the deer, the less bites he received. The bigger the group, the more bites their individual members received. Females received less bites, then males. Deer aging between 5-6 years suffered the greatest number of bites than other age groups. Doe giving birth earlier in the season received less bites than those giving birth later. (Pérez-Barbería et al. 2021).

Smaller sized groups have lower aggression rates because animal individuals do not have to fight over the resources. Heat has proven to be important stressor as it affects animal's aggression, comfort, or hormone levels and with predictions of increased global climate, it will become more and more pressing matter in the next few decades, especially in terms of animal welfare (Pérez-Barbería et al. 2020).

The simplest way for prevention of pelt biting in captive deer farms is to maximize the space each individual animal. This is not just to prevent pelt biting, but crowding animals in small space causes discomfort and should be avoided (Fernandes et al. 2021).

Aggression in captivity also increases at feeding points in farms so this should be considered when building space for the animals.

4.17 Diseases associated with cervid captivity

With expanding commercial demand for cervid breed farming and their products, issues concerning animal diseases, that arise in farming conditions, occur. With a lot of animals being kept at the same space with high density spacing, the increased risk of disease transmission between captive animals. With transportation of animals this risk of disease transmission is even more powerful. Pathogens can be also transmitted through fence from wild to captive deer and the other way around when the contact between two animals happens. Transmission from deer to human has not been historically recorded, although the cervid captivity as well as transportation can potentially lead to transmission of zoonotic disease agents (Gerhold & Hickling 2016).

The diseases that are observed in captive cervids include chronic wasting disease, agents of brucellosis (*Brucella abortus*), anaplasmosis (*Anaplasma marginale*) bovine tuberculosis (*Mycobacterium bovis*), hemorrhagic disease (*Orbivirus spp.*), bovine viral diarrhea (*Pestivirus spp.*), deer meningeal worm (*Parelaphostrongylus tenuis*), Johne's disease (*Mycobacterium avium paratuberculosis*), and other arthropod-borne diseases. Early detection is critical in eradication of most of these (Gerhold & Hickling 2016).

Problem with chronic wasting diseases is that there is no test available to determine whether the animal is infected, and so it can go unnoticed for months or even years. As such, it is impossible to know if the animal got infected before or after translocation (Keane et al. 2009). On top of that, agents of chronic wasting disease are very persistent and could have negative impact on cervid populations (Almberg et al. 2011).

Animal to animal transmission of chronic wasting disease was observed in mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and rocky mountain elk (*Cervus elaphus nelson*), so the translocation of these species has the potential to trigger the disease in new locations (Williams 2005).

Mitigation factors include on-farm containment of deer, implementation of tracking system of chronic wasting disease, including communication toolkit and necropsy of deaths. Experiments showed that animals such as mice, ferrets and dogs can detect avian influenza. Dogs can detect avian influenza in faecal samples, swabs, gastrointestinal tracts, and carcasses. Such usage could be potentially applied to chronic wasting disease, although further research is needed for the implementation (USDA 2021).

Mycobacterium bovis in cervids has become widespread in the 1980s with the rising interest in cervid farming and international trade in deer which then become problem in many countries in North America, Europe and New Zealand (Clifton-Hadley & Wilesmith, 1991).

M. bovis represents tread as it affects large number of animals, including domestic livestock, cervids and humans (O'Reilly & Daborn, 1995). Infection in wildlife has been spread from mixing infected livestock and wild cervids or when the cervid ate from the same feed as infected livestock (Miller & Sweeney 2013).

Tuberculosis can be detected by skin tests, skin damages, or veterinary suspicion. During winter, supplementary feeding in breeding farms could help with the maintenance of tuberculosis in the local population where the disease was discovered. Documentation of animal inventory records and animal on-farm containment is also beneficial for having the disease under control.

In the US and rarely in Canada, epizootic haemorrhagic disease is transmitted by culicoides midges (*Culicoides*). It affects variety of wild and domestic species, including white-tailed deer, mule deer, elk and lastly to lesser extent pronghorn, although the risk in domestic species is lower (WOAH 2019).

5. Conclusion

In conclusion, the welfare of captive cervids faces several issues and demands that need to be addressed in captive environment for the most possible well-being achievable.

Stress can occur on the regular basis due to cervid-human contact, improper housing conditions, or improper transport conditions and can lead to aggressive behaviour towards not only other members of the herd but towards humans as well. If remains untreated, it can lead to injuries or even deaths. Stereotypical behaviour or boredom point to improper welfare and can be addressed by environmental enrichment.

Facilities where the cervids are kept captive, need special considerations, especially in more closed areas and corners. Fences must be properly visible to the animals and safely designed as they pose a risk of injuries.

Aggressive behaviour caused by improper facility spaces, heat or any discomfort can take form of pelt biting, causing stress and injuries within the herd. This may even lead to death of the animals. Smaller sized groups, larger spaces for the animals as well as lowering the heat conditions in the environment should help mitigate these issues. Setting many appropriate shade spots within the captive area should prove helpful.

Legal issues are problematic because they are mostly too general and do not specialize on individual species. There also seem to be lot of recommendations or guidelines rather than strict laws.

Transportation can cause a lot of stress to the animals and therefore should be done with precision as cervids are more vulnerable to it then other domesticated species. Less steep ramps, darkness and careful rides that do not extend 12 hours are recommended. Special needs must be also pointed to a number and species that are being transported. Better and more proper legislative addressing these issues should also be created. Furthermore, with transportation, the risk of disease spread arises. Proper precautions of mitigation such as on-farm containment of deer or implementation of tracking system of chronic wasting disease are in order.

Culling of cervids poses welfare issues and if done improperly can cause a lot of unnecessary stress. Studies showed that stalking is much preferable method of culling, but that itself might no be enough as it requires experienced and precise stalkers. Proper stalking places need to be set up also to make it work and legislative should cover this.

Not enough veterinarians with proper specialization on cervid physiology was also reported and remains an issue.

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