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Sustainable game management as one of the determinants of the welfare of hunting animals

Zrównoważona gospodarka łowiecka jako jeden z czynników zachowania dobrostanu zwierząt łownych

Summary. There are groups of species among game animals demonstrating varied life strategies, demographic conditions and protective status. Therefore, a specific approach to managing the particular populations is needed. Game animals are more dependent on the natural environment because they are inseparable from it and any change in their natural habitat immediately affects the populations they create. The purpose of breeding wild animals in their natural habitat is primarily to preserve populations of different species in their natural biotopes, in the optimum biocenotic densities, species structure, as well as age and sex of the population. The work has attempted to point out elements in the hunting management that maintain welfare of the game animals. The described biochemical and physiological indicators of the organism, which reflect the internal equilibrium in an organism are influenced by various external environmental factors. In addition, attention was paid to other parameters describing the animal condition, e.g. energy reserves in the form of adipose tissue, antler weight, and population density and structure.

Key words: hunting management, game animals, density, stress

INTRODUCTION

Hunting has been practiced since the beginning of humankind when man hunted to get meat and cater for the family/group without any interference with the existence of wild animals. The concept of farming wild animals at large has been introduced relatively recently. Especially in the socialist countries, this was meant to be a model of agriculture and a fully controlled economy [Szukiel 1994]. The aim of all research and practical measures undertaken for livestock welfare is to select such rearing and breeding methods that will combine increased profitability with fulfilment of all biological needs and, hence, good development of animals, but will not be associated with ruthless exploitation of animals [Janiszewski *et al.* 2016]. However, application of methods developed for rearing and breeding of domestic animals in the wild animal breeding is impossible and cannot succeed for many reasons [Szukiel 1994].

In Poland, hunting animals are regarded as national wealth and are owned by the State Treasury [Ustawa... 1997]. In comparison to livestock, hunting animals are more dependent on the natural environment [Szukiel 1994] as its inseparable part; therefore, any changes in their natural habitats exert an immediate impact on their populations. The best of the many definitions of hunting animal welfare [Broom 1991, Hewson 2003, Dawkins 2006] determines the physical and mental health of an organism in balance with the environment in which it lives. The property of the State Treasury comprises all wild hunting animals [Goettel 2013], both animals under species protection [Ustawa... 2004] and hunting animals [Ustawa... 1995]. The program of species protection is developed by the Minister of the Environment and relevant nature protection authorities [Ustawa... 2004]. As regards game species, protection and management of such animals are regulated by the Ustawa… [1995]. It defines hunting management as protection of game animals and management of the resources in accordance with the principles of ecology and rational farming, forestry, and fishing. In this approach, hunting management and all related practices mean a guarantee of the welfare of hunting animals. The most important objectives of hunting management include species protection, preservation of diversity, rational management of hunting animal populations (preservation of game animals as an integral part of the forest environment), protection and modelling of the natural environment to improve the living conditions of game animals (improvement of natural feeding and shelter conditions), maintenance of an appropriate population size of hunting animal species by regulation of the number of animals and maintenance of environmental balance (mainly by minimisation of damage to forest, coppice, and agricultural crops), fulfilment of social needs in terms of hunting, fostering hunting traditions, and promotion of hunting ethics and culture.

The indicators of failure to provide an adequate level of hunting animal welfare reported in the literature [Broom 1988, Kołacz and Bodak 1999] include reduced adaptability to stressful situations, diminished growth and reproduction performance, diseases, behavioural pathologies, body damage, and limited manifestation of natural behavioural responses.

PARAMETERS OF THE STRESS LEVEL IN HUNTING ANIMALS

Environmental living conditions have a direct influence on the physical status of animals, i.e. their ontogenetic quality; therefore, body weight, which reflects the fitness to survive and achieve a reproductive success, is the basic criterion of assessment of the condition of hunting animals. However, this is not an ideal and only indicator of ontogenetic quality [Sheriff *et al.* 2011]. Other parameters describing the animal condition are used, e.g. energy reserves in the form of adipose tissue, antler weight, and population density and structure. Assessment of welfare can also be based on biochemical and physiological indicators of the organism, which reflect the internal equilibrium in an organism influenced by various external environmental factors [Poljičak-Milas *et al.* 2004, Czyżowski *et al.* 2013].

Haematological and biochemical blood parameters are an important tool for monitoring of the welfare of many species from the Cervidae family; however, they can undergo modifications induced by stress related to the capture and/or blood sampling procedures [Sems *et al.* 1993]. Determination of the stress level in Cervidae is associated with many technical problems and can sometimes pose a threat to the animals themselves. Moreover, it is difficult to "create" conditions in which a uniform level of stress is achieved in all specimens examined [Bubenik *et al.* 1999]. In many deer species, endocrinologic examinations are often impractical and even dangerous due to the excessive stress associated with the necessity of capturing and keeping the animals [Pereira *et al.* 2005].

A good method for non-invasive monitoring of steroid metabolites in Cervidae is the examination of their faeces and urine [Pereira *et al.* 2005]. Faecal glucocorticoids are easy to acquire, even without the need to observe animals; they can provide information about changes in blood cortisol levels over the previous 24–48 hours of life [Huber *et al.* 2003]. Secretion of glucocorticoids (frequently regarded as a stress indicator) increases the metabolic rate, which may expose animals to unnecessary losses, especially during periods of limited food availability (severe winters) [Janicki *et al.* 2006]. High levels of stress exert an impact on the reproductive performance of animals. Stress leads to secretion of ACTH, which initiates the release of glucocorticoids. In deer, the corticotropin concentration may rise in stress situations, which is reflected in an increased level of blood cortisol. Cortisol, in turn, suppresses the gonadoliberin-induced secretion of lutropin and testosterone [Bubenik *et al.* 1999]. The different Cervidae species exhibit different stress tolerance. The white-tailed deer (*Odocoileus virginianus*) tolerates very high population density without showing signs of stress [Seal *et al.* 1982]. This species is thought to exhibit a high level of environmental stress tolerance. In turn, the red deer (*Cervus elaphus*) cannot cope with stress so efficiently, which may cause an increase in the level of adrenocortical hormones contributing to disorders in the antler shedding cycle [Bubenik *et al.* 1999]. Investigations conducted by Huber *et al.* [2003] demonstrated the highest concentration of cortisol in the faeces of some Cervidae representatives between December and January. It was also found that low temperature and snow had the most important effect on the level of cortisol in the faeces. However, certain species exhibit an elevated blood cortisol level in the summer months when the temperatures reach high values; this may be associated with thermal stress [Bubenik *et al.* 1999]. These discrepancies may be caused by the differences between species or the different climatic conditions in which the animals live [Huber *et al.* 2003].

Cervidae representatives are easily excitable species, which is reflected in their haematological indices. The level of white and red blood cells in an excited deer is substantially higher than that in a non-agitated animal [Boes 2010]. Stress can cause splenic contraction, thereby increasing the count of circulating red blood cells. The level of other haematological indices may change as well due to the dynamic storage of blood in the spleen [Arnemo *et al.* 1994]. In stressed animals, haematocrit and lactate concentrations increase as well. Very severe stress can lead to homeostatic imbalance of the level of proteins and release of proteins from the liver and other organs to the bloodstream. It has been shown that severe stress experienced by the white-tailed deer can result in a 13% rise in the albumin and globulin fractions [Sems *et al.* 1993]. Strong stress can also affect the level of NEFA (non-esterified fatty acids) in blood. The level of NEFA in stressed animals increases, which is probably caused by a rise in the level of lipolysis-stimulating cortisol. Acute adrenal stimulation and muscle injuries may elevate the concentration of creatinine kinase (CPK) [Giudice *et al.* 1990]. Severe stress combined with a long-term effort and exhaustion can lead to a number of physiological disorders, including lactic acidosis, initiate myositis and necrosis, debilitate the immune system, and cause death in extreme cases. Capturing wild ungulates can induce myopathy, i.e. one of the most serious consequences of stress in these animals. Myopathy can be caused by chasing, capture, and transport of animals. It is characterised by clinical depression, muscle stiffness, incoordination of movement, muscle paralysis, acidosis, and death in the final stage [Montané *et al.* 2003]. Exercise myopathy is physiologically similar to malignant hyperthermia, i.e. hypermetabolic skeletal muscle disorders associated with an abnormal concentration of calcium ions after exposure to some anaesthetic agents [Antognini *et al.* 1996].

Another biochemical parameter used in evaluation of the ontogenic quality in Cervidae is the level of creatinine in urine or blood serum. As a derivative of creatine, creatinine is formed during metabolic transformations in the muscles. It is present in both blood and urine. Besides urea, creatinine is one of the main nitrogen compounds excreted from the body. Its increased blood levels indicate renal impairment. In turn, elevated levels of serum creatinine in healthy individuals are associated with greater muscle weight and enhanced physical activity, which indicates good cardiac efficiency and high fitness of the animal [Czyżowski *et al.* 2013].

With age, the animal body weight increases, but the growth rate declines over years. In the case of fallow deer, the body weight increases until the age of 7–10 years [Chapman and Chapman 1975]. The highest mean body weight has been reported for 7-year-old individuals. One of the many determinants of the body weight is the seasonal variability in the quantity and quality of food, which is related to reduction in the volume of fat and muscle tissues in winter [Weber and Thompson 1998]. The body weight in Cervidae decreases by even 31% between October and March, and these changes are greater in wild living than farmed animals [Parker *et al.* 1993]. As demonstrated by Del Guidice *et al.* [1990], the mean body weight of the white-tailed deer (*Odocoileus virginianus*) dropped by 22% between February and May and increased by 45% between May and October. Weight loss during the winter period was also noted in farmed fallow deer [Janiszewski *et al.* 2008]. This is confirmed by the results obtained by other authors [Guidice *et al.* 1992], who reported a decline in the creatinine level in wintertime and its increase in the summer period in wild ungulates.

The creatinine level in the blood of fallow deer is influenced by stress induced by transport of these animals [Montane *et al.* 2003]. However, investigations conducted by Poljičak-Milas *et al.* [2004] did not show differences in the level of this compound between red deer culled in a grange and animals slaughtered after transport. Similarly, there was no effect of blood sampling-related stress on the level of serum creatinine in Cervidae [Marco and Lavin 1999, Topal *et al.* 2010]. In turn, a significant impact of the sex has been shown, as the mean creatinine level in males was by approx. 18%

higher than in females [Vengušt and Bidovec 2002]. In fallow deer, the serum creatinine level was shown to increase with age, which may be associated with the greater muscle weight in adults.

The creatinine level in Cervidae depends on the annual cycle, i.e. periods of antler growth and shedding [Eiben and Fischer 1984]. It declines during the antler development, since males exhibit limited activity during this period and the decline in muscle activity leads to a decrease in creatinine production. The creatinine level increases rapidly after fraying the antlers, which is associated with an increase in physical activity during the mating season. As reported by the authors cited above, the average level of serum creatinine throughout the annual cycle was 1.8 mg/dl.

In winter, the animal ontogenic quality declines and the level of creatinine in blood serum is substantially reduced due to reduction of muscle weight and lower physical activity of animals in the winter period. Available results indicate that the decrease in the serum creatinine level in healthy animals (not related to renal impairment) can be used for assessment of the welfare of hunting animals as an indicator of the decline in their ontogenic quality.

HUNTING IN PRACTICE AND THE WELFARE OF GAME ANIMALS

The primary goal of breeding hunting animals in their natural habitats (forest, field) is to preserve the populations of their different species in natural living biotopes with optimal (from the biocoenotic point of view) density and species, age, and sex structure of specimens in the population [Szukiel 1994].

Many types of unusual behaviour, which can be classified as certain abnormalities (cannibalism, pterophagy, cribbing, "weaving", sexual aggression), have not been fully studies so far; nevertheless, many researchers believe that excessive density of individuals in a group and discomfort (e.g. due to poor diversity of environmental stimuli) can stimulate emotional centres and cause behavioural deviations. It is assumed that domesticated species with a higher level of intelligence exhibit greater intensity and variety of atypical forms of behaviour [Szukiel 1994].

Population density is a measure that should relate to specific conditions and specific time. The density of the game species population is typically expressed by the number of individuals per 100 ha (1 km^2) of the hunting ground (hare, roe deer) or per 1000 ha (10 km^2) area (red deer, elk, wild boar). It exerts a considerable impact on such population processes as reproduction and survival. The effect of this factor on the population function can be generally formulated as the so-called Allee's law [Allee *et al.* 1958], according to which life processes reach their optimum at specified population densities. All deviations, i.e. either excessive or insufficient density, substantially reduce the reproduction rate and induce stress. This information is highly important in planning optimal hunting of game animals [Krupka 1989].

In the seventies of the last century, the notion of the so-called capacity of hunting complexes was introduced in the management of Cervidae populations. It denoted the maximum number of game animals per unit area where they can feed without causing excessive damage to the forest. In life sciences, the term has been replaced by "proper density" of animals. In the hunting practice, a conversion unit was adopted for calculation of the proper density, i.e. a deer unit (1 d.u.) = 1 red deer = 0,3 elk = 2 fallow deer = 4 roe deer. The proper animal density was defined as an economically acceptable number of animals of a given species per area of land that can inhabit a hunting complex, with the provision that the damage caused by these animals will be economically tolerable. An attempt could be made to determine proper animal densities based on the size of damage caused by game to agricultural crops. However, this parameter is quite controversial, as crops will always be easily accessible and tempting for game animals [Krupka 1989].

For several years, there has been a steady increase in the size of game species populations and it can be assumed that the so-called annual stocktaking of game animals, i.e. determination of the number of game animals in hunting grounds, can be burdened by a large error. It has been reported from a majority of hunting grounds that the stocktaking is based on all-year observations of animals. The lack of methods for these observations suggests that the estimates provided by hunters are subjective and only sporadically reflect the size of game animal populations. Such hunting management has led to an increase in the number of red deer, roe deer, and wild boars at a seemingly appropriate culling policy. Constant stress as well as a shortage of food and proper shelters results in deterioration of immunity, increased prevalence of diseases, weakness, and mortality (in winter). New appetitive (e.g. imitative, consummatory) behaviour influencing the health status appears in overpopulated herds with excessive numbers of females and juvenile animals. Overpopulation in the case of large ungulates exerts a negative effect on the function of forest ecosystems and causes local damage to forest crop cultivation aggravating the economic problem of hunting-induced damage [Szukiel 1994].

The increase in the number of animals is best reflected by the number of wild boars in Poland, which has increased by 160% while culling rates have increased by 139% (1991–2008). In the spring of 2007, the wild boar population across the country was estimated at 179 thousand animals [Kamieniarz and Panek 2008].

As shown by the documentation of the Regional Directorate of State Forests in Lublin [unpublished data], the population size of this species in Poland has increased by 1101% over the last 76 years. Concurrently, the forest area has increased merely by 6%. Such a large rise in the wild boar population was promoted by the change in the crop structure (greater area of maize and wheat cultivation) and milder winters. This species can thrive in areas that are strongly influenced by human economic activity and, especially, in areas of intensive farming.

Another problem is the extreme decline in the number of small animals, in particular hares and partridges. In previous times, the density of hares was 56 animals per 100 ha, whereas the present number is only 5 individuals per 100 ha. The current size of partridge populations is even more disturbing: it is estimated at approx. 2.6 individuals per km^2, i.e. 1 pair per km^2, in the Lublin region, which may be an indication of the necessity of all-year protection of the species. This is associated with the high density of foxes, which has exceeded 22 individuals per 1000 ha in some hunting complexes, whereas the optimal number is 1–3 animals per 1000 ha. The population size of this species in large areas should be reduced substantially, while the existing habitats for partridges and hares should be improved and new ones should be created [Regional Directorate of State Forests in Lublin 2017].

Such factors as density, habitat quality, genetic structure, climate, etc. are regarded as important predictors of the body size in even-toed ungulates. Osteometric measurements are very helpful in classification of animal forms and determination of their phylogenetic development line. An especially interesting object of investigations is the skull, and craniometry, i.e. the technique for measuring skulls, is a more objective method than descriptive approaches. Parts of the skeleton are often used as retrospective indices describing the size and height of the body as well as the resistance of the organism to seasonal changes in the availability of food resources. The size of the skeleton and, consequently, the animal's body size are important features in population and ecological studies. It reflects the relationship between the body size and living conditions, which is highly important for managers of the nature, hunting complex capacity, and game culling size. A particularly important indicator in many deer species is the length of the mandible. It has been found that animals living in better conditions are characterised by larger mandibles [Tajchman 2017].

The mandible is one of the first bones that finish growing. It has been evidenced that this bone exhibits a high growth rate until the age of five. The greatest increase in the mandible length is observed between birth and the first year of life, and then its length increases by approx. 1 cm per year over another four years. This information suggests that the living conditions ensured to a young animal have an enormous impact on its final size and fitness [Zannese *et al.* 2006].

This parameter has also been found to correlate with other apparently unrelated processes, e.g. fertility. Better-nourished and larger animals begin the reproductive period earlier. For instance, the probability of ovulation increases to over 0.95 in one-year-old red deer females with a mandible length of 130 mm. Additionally, increased fertility of one-year-old females, close to that noted in adult individuals, has been noted in areas characterised by better feed conditions. In deer females aged 1–7 years, such parameters as age, body weight, and mandible length were found to be essential for fertility. However, the most important variable in correlation with the fertility of animals was the length of the mandible [Zannese *et al.* 2006].

In the area of Belluno (Italy), roe deer were culled in 1990–2001 and their mandibles were measured (from the zygomatic arch to the incisor roots) in 11 590 animals. The analyses revealed differences in the mandible length between animals from the northern and southern parts of Belluno. The length of the mandible of a doe living in the south was 128.8 mm in 1990–1995 and 127.7 mm in 1996–2001; these values in the north were 123.6 mm and 123.9 mm, respectively. The average length of the mandible in one-year-old fawns was 153.3 mm in the south and 150.0 mm in the north. This parameter was also analysed in two-year-old males: 157.4 mm in the south and 154.0 mm in the north, and in females of the same age: 156.1 mm in the south and 153.0 mm in the north. The differences in the length of the mandible indicate that the conditions prevailing in the south of the analysed area characterised by milder climate and better feeding resources are more favourable than in the north [Zannese *et al.* 2006].

This feature was also compared with the density of roe deer in these areas, which was noted to decrease from the north (0.44 animals/km^2) southwards (0.33). This has evidenced the great importance of animal density on their fitness. In the southern part of Belluno, animal culling gradually decreased throughout the research period, which contributed to an increased density and a slight decline in the length of the mandible of young roe deer. In the north, the same culling rate was maintained and the length of this bone in young animals was constant or increased minimally [Zannese *et al.* 2006].

Another approach to evaluate the ontogenic quality is to employ biometric methods, which are successfully used in the case of livestock [Salako 2006, Alonso *et al.* 2007]. However, biometric measurements of hunting animals are more difficult to perform with intravital methods; therefore, they are carried out *post mortem* [Fruziński *et al.* 1982, Szczepański *et al.* 2006]. Such measurements are used for calculation of selection indices showing, depending on the measurement type, the degree of development of the musculoskeletal, respiratory, and cardiovascular systems as well as the growth rate and somatic type of the animal [Drozd *et al.* 2006, Karpiński and Czyżowski 2006].

Investigations of *Cervidae* in breeding conditions have revealed that direct indicators based on observations of animal behaviour are a better method for determination of the welfare of hunting animals. Reactions evoked by stress, the impact of fear, and changes in social behaviour, e.g. excessive aggression, changes in the herd structure, isolation etc., modifications of feeding activity, excessive vocalisation, and changes in mothers' behaviour can be indicators of absence of welfare. Additionally, any signs of pervious injuries can serve as this type of indicators [Mattiello 2009].

CONCLUSIONS

Assessing the level of animal welfare is not an easy task. It can be conducted based on biochemical and physiological indicators of the organism, which reflect the internal equilibrium in an organism influenced by various external environmental factors. However, this is not practical for this group of animals. Man does not have much direct influence and control over game, however, by observing their behavior, health, mortality or changes in the functioning of the game's population, one can determine its level of welfare. Man shaping the right living space of animals, the right ratio of sex and age in populations by regulating their densities reduces the stress caused by these factors. Activities that have been undertaken for many years also include the improvement of stocktaking methods adapted to the biology and behavior of individual species. The variability of the population dynamics in a given area should be considered on a local scale and culling plans should not be made for strictly defined administrative boundaries of hunting grounds; instead, the diversity of forest ecosystems, the presence and density of developments, and the microclimate, etc. should be taken into account. Spatial variability and heterogeneity of the environment should be included in the culling schemes.

An attempt to improve the management of game animal populations was to group hunting district into hunting complexes in 1997. A principle that hunting complexes should allow free migration of large mammals within larger forest complexes was adopted. Unfortunately, the hunting complexes were created within the boundaries of the Regional Directorate of State Forests. A mistake was the disregard for the designed investments of expressways and motorways. Currently, most areas of the hunting complexes are divided by the road infrastructure as well as the expansion of cities and suburbs. In most cases, the construction of animal crossings or undertaking other mitigation measures cannot keep up with these changes. Additionally, the network of ecological corridors has not been legally settled and is often ignored by planners [Gorczyca and Mikoś 2015]. Therefore, it is necessary to revise the boundaries of the hunting complexes and hunting grounds. Their external borders should run along anthropogenic barriers, e.g. expressways, or along natural geographical and environmental boundaries.

Currently, an uncontrolled increase in the number of foxes and raccoon dogs accompanied by a drastic decline in the number of small game animals (in particular partridge and hare) can be observed. Unfortunately, the stocktaking errors have led to an uncontrolled increase in the population size of red deer, roe deer, and wild boars, as described above for the Lublin region. These errors should be corrected and new methods for calculation of the population size should be introduced. The reconstruction of the populations of small game animals should mainly be carried out through reduction of the excessive numbers of predators (foxes, raccoon dogs, etc.) and improvement of the natural habitats of small game.

Cooperation between forestry and hunting managements should be the basic principle to guarantee forest functioning in equilibrium with hunting animals, thereby ensuring animal welfare without major damage and maintenance of species diversity.

According to the five principles developed by the Farm Animals Welfare Council [FAWC 2014], rational hunting management can ensure the welfare of hunting animals through:

– regulation of animal density to be optimal for a given habitat, thereby preventing stress induced by overpopulation: changes in the behaviour and phenotypic structure of animals; ensuring food resources sufficient for animal growth and development and elimination of discomfort by providing optimal living space and social composition in groups;

– maintenance of species diversity through attempts to restore species with drastically low population sizes, creation of natural living habitats, and reduction of natural enemies;

– rapid prevention, prophylaxis, diagnostics, and treatment through continuous veterinary monitoring at selection and sanitary culling;

– minimisation of stress factors – hunting animals living in the natural environment will always be exposed to stress associated with climatic conditions or the natural presence of predators. Man can only minimise the stress by resignation from collective hunts and undertaking individual hunts, which are the most appropriate form of ensuring optimal levels of the animal population size, as well as by improvement of existing and creation of new game habitats.

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Streszczenie. Wśród zwierząt łownych znajdują się grupy gatunków o różnych strategiach życiowych, charakteryzujące się odmienną sytuacją demograficzną i zróżnicowanym statusem ochronnym. Wobec tego niezbędne jest specyficzne podejście do zarządzania populacjami przedstawiciel każdej z tych grup. Zwierzęta łowne są bardziej uzależnione od środowiska przyrodniczego, gdyż stanowią z nim nierozerwalną całość i wszelkie zmiany w ich naturalnych siedliskach natychmiast wywierają wpływ na populacje, które tworzą. Celem hodowli zwierząt dzikich w naturalnym środowisku ich bytowania jest przede wszystkim zachowanie populacji różnych gatunków w naturalnych biotopach, w optymalnym z biocenotycznego punktu widzenia zagęszczeniu, odpowiedniej strukturze gatunkowej oraz wiekowej i płciowej osobników w populacji. W pracy podjęto próbę wskazania w gospodarce łowieckiej elementów warunkujących dobrostan zwierząt łownych. Wymieniono i opisano kryteria uwzględniające wskaźniki biochemiczne i fizjologiczne organizmu, które pozwalają na ocenę stanu wewnętrznej równowagi organizmu będącego pod wpływem różnych czynników środowiska zewnętrznego. Ponadto zwrócono uwagę na inne parametry opisujące stan osobnika, np. zapasy energetyczne w postaci tkanki tłuszczowej, jakość trofeów myśliwskich, a także wskaźniki dotyczące populacji, jak jej zagęszczenie czy struktura.

Słowa kluczowe: gospodarka łowiecka, zwierzęta łowne, zagęszczenie, stres

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