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Adaptation of Scottish Highland cattle to wet and swampy lowland areas in Poland as an example of welfare

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Summary

Over the last 10 to 20 years, Highland cattle have gained popularity in Poland and around the World. Farmers appreciate the breed's high resistance to unfavourable environmental conditions and certain diseases, as well as their low demands, which make it easy to maintain profitable production. Unfortunately, because cattle of this breed were originally bred under different environmental conditions, they had to adapt to new conditions in Eastern Europe, including Poland, which could have adversely affected their welfare as well as production parameters. Observations of Highland cattle conducted over a three-month period, together with information obtained from farmers covering a period of five years, were used to assess the behaviour of cattle during grazing and the maternal instinct of cows. Certain production parameters were assessed as well, such as cases of mastitis, lameness, length of gestation, birth weight of calves, the number of culled individuals, stillborn calves and calves that died after birth, average milk yield and colostrum quality. The parameters confirm that Highland cattle were well adapted to the temperate climate conditions characteristic of south-eastern Poland.

Keywords: Highland cattle, beef cattle, welfare

Scottish Highland cattle are one of the oldest domesticated breeds, also referred to as ancient breeds, having developed as a result of centuries of natural and breeding selection in the harsh climate of northern and western Scotland. The breed is descended from the ancestors of cattle living in the mountains and islands of western Scotland, probably since Celtic times. The original domesticated Celtic shorthorn cattle, introduced about 5000 years ago, became the breed called Kyloe – small, hardy cattle, mainly with a dark or black coat, which were the precursor of today's Highland cattle (9). Highland cattle are one of the oldest registered cattle breeds, with a set of traits developed as a result of centuries of adaptation to a cold, mountainous environment. They were originally divided into two classes: West Highlands (Kyloe) and Highlander. Currently, all individuals bear the name Highland cattle (www.thecattlesite.com). The first herd book was published in 1885 and contained a breed standard, which confirms that it was not 'created suddenly', but developed gradually through local breeding and selection in the Scottish climate (www.highlandcattle-society.com). Although Highland cattle originated in Scotland, the breed's numerous advantages led to its spread within Europe (Denmark, Finland, Sweden, the Netherlands, Poland, Romania, France, Switzerland,

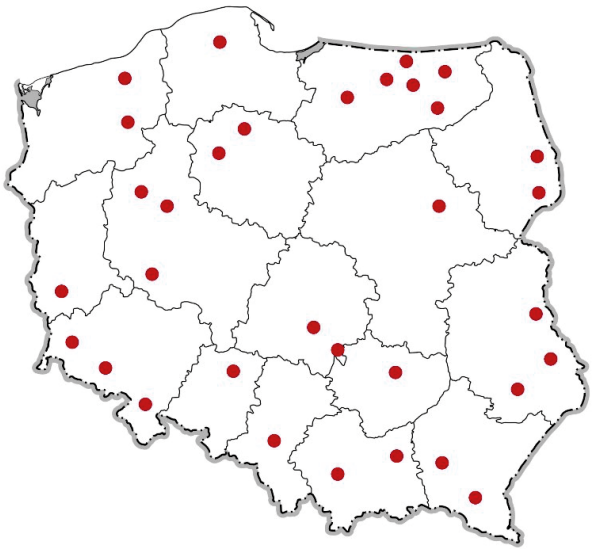

Fig. 1. Locations of Scottish Highland cattle farms in Poland

and Hungary), in North America (the United States and Canada), and in Oceania (Australia and New Zealand) (2, 11, 15, 17, 32, 33).

In Poland, the farmed population of this breed numbered about 500 head in 2010. Highland cattle farming has become much more popular over the last 15 years, resulting in a significant increase in the population, currently estimated at over 3000 head (8). According to the latest data (8), the most farms keeping Scottish Highland cattle are located in the Masovian, Lublin, and Pomeranian Voivodeships, as well as in the Greater Poland and Podlaskie Voivodeships (Fig. 1). One of the largest herds is located in the Świętokrzyskie Voivodeship and numbers about 140 head, of which more than 50 are cows and the rest are calves and feedlot cattle. Highland cattle farming is concentrated in these parts of Poland because of the presence of large areas of marshes and grasslands, which allows the animals to move about freely and provides an unlimited amount of food in the form of plants growing on wet forest meadows, as well as some shrubs on forest edges. Six basic solid coat colours are predominant in the breed: black, red, dun, brindle, silver, yellow and white (2, 34) (Fig. 2). A characteristic feature of the head are the long, wide horns which grow throughout the animal's lifetime. In females, the horns usually bend upwards and have a finer texture than those of males, but they grow faster and are longer (2) (Fig. 3). In bulls, the horns grow horizontally from the head and are bent slightly forwards and upwards (www.highlandcattlesociety.com, Fig. 3).

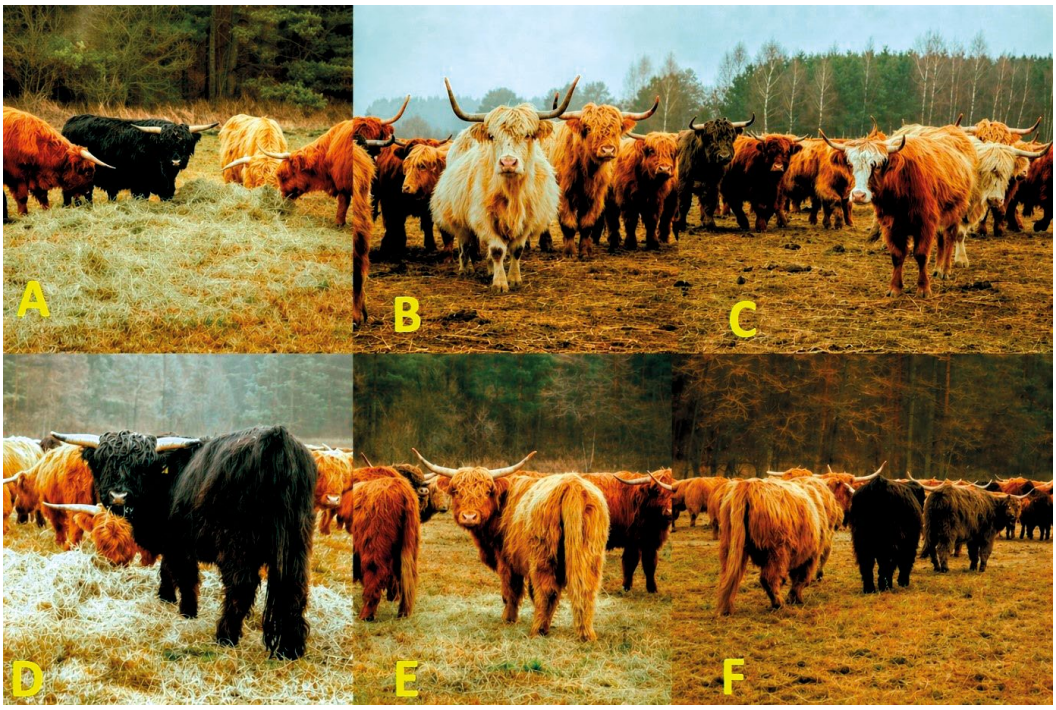

Fig. 2. Basic coat colours of Scottish Highland cattle: A – left to right: red, black, yellow, red; B – white; C – brindle; D – black; E – dun; F – left to right: dun, black, silver

Fig. 3. Differences in horns between male (A) and female (B)

The Scottish Highland breed, as the most primitive one, is one of the breeds most distinctive and resistant to harsh winter conditions, especially lower temperatures and winds. This is due to their long, thick hair coat, which persists through nearly the entire year, reducing its volume slightly in late June and early July (20). Highland cattle are relatively small, but with a robust build. According to available data, the males attain a weight of 800-1000 kg, while females can reach 400-500 kg (17, 31). Cows are distinguished by high fertility, easy calving, and a very strong maternal instinct (31). Cows give birth on pastures without assistance, despite low temperatures and unfavourable atmospheric conditions. The reproductive period in females can last up to 18 years, during which the cow is able to produce up to 15 calves (www.thecattlesite.com). The milk has high fat content, ensuring good calf viability and growth during rearing. The average birthweight ranges from 21 to 35 kg (31). Due to their good reproductive attributes, Highland males and females are used to create crosses with other breeds, such as Limousin, Charolais and Blonde D'Aquitaine (www.highlandcattlesociety.com). The meat of this breed has lower cholesterol and fat content, but higher protein content, than other cattle breeds (2). This is confirmed

Tab. 1. Comparison of selected physicochemical parameters of meat (5)

Parameter	Highland	Limousin	Commercial Beef
Fat (g/100 g)	10.99	9.38	n/a
Cholesterol (mg/100 g)	51.50	53.70	64.3
Protein (g/100 g)	21.49	19.99	18.6
Iron (mg/100 g)	2.33	1.96	2.0

by the results of other studies (5) indicating that beef from Highland cows has not only higher protein content, but also nearly 16% higher iron content than beef from the comparable Limousin breed (Tab. 1).

Highland cows are an important subject of scientific research with practical applications in agriculture and environmental protection. They combine high environmental resistance, good adaptation to extensive systems and a positive impact on the landscape and biodiversity. For these reasons, they are increasingly used not only in agricultural production, but also in environmental protection and sustainable agriculture projects (10, 26). Studies on herd structure and social relationships have shown that Highland cattle form relatively stable bonds in the herd. Observations of three varied Highland cattle herds suggest that the social structure of these cattle is strongly dependent on the size and composition of the group. Larger herds varied by age and sex form more stable communities, while the presence of calves and mature individuals – particularly those with long standing in the herd – reduces aggression and conflict behaviours, which helps stabilize the hierarchy. By maintaining the hierarchy, the Highland breed preserves natural social patterns, also in semi-wild conditions, which is beneficial for the animals' welfare. From a practical point of view, minimizing frequent changes in the herd can reduce stress and improve animal welfare (33). Neave et al. (24) presented similar conclusions in their study on Highland cattle, confirming the link between a specific social structure and the size and composition of the group. The study showed that greater variation in production groups is associated with high herd stability, and the presence of older females and calves reduces the frequency of aggressive behaviour. However, analyses of changes in group composition, e.g. those due to movement of individuals between herds, indicate that excessive interference can increase the frequency of stress responses in animals, which can adversely affect their welfare, e.g. by reducing the quality of feed conversion or disturbing the maternal instinct (20, 24). As Highland cattle are raised for high-quality meat, these actions are significant for farmers trying to ensure a high level of animal welfare in order to obtain high production results. Other research, carried out in France (33), which analysed the behaviour of Highland cows from four herds following the transfer of a few individuals between herds, demonstrated a significant effect on behaviour between individuals. Reorganization of the social structure of the herd due to the introduction or removal of individuals was confirmed to lead to social stress and stress associated with the adaptation of new individuals in the herd, thereby negatively affecting the animals' welfare. Cows were also observed to form strong relationships based on similarity of age and position in the hierarchy, which translates into herd stability. Transfer to new herds proved to be particularly stressful for young individuals, which was manifested in their isolation on the outskirts of the group. Older individuals, on the other hand, demonstrated a higher position in the social structure and greater adaptability to changes in the composition of the herd. The researchers suggest that, in order to minimize stress, cattle should be transferred between herds within groups of acquainted individuals, preferably young animals together with adults. Social relationships in cattle are an important element of herd welfare and functioning, and a stable group composition fosters the maintenance of lasting bonds. It has been suggested that understanding the dynamics of the social relationships of Highland cattle is helpful in planning their translocation in a way that favours the welfare and productivity of the herd (37). Scottish Highland cattle not only form relatively stable bonds, but also have a calm temperament. In a study analysing the reactions of cows to their surroundings, Highland cows responded more gently and calmly to the presence of humans than 'wilder' animals of the Tauros or Wisent breeds. Highland cattle are well-adapted to areas where contact between humans and animals is more frequent, as they react more calmly and less intensely than semi-wild forms of cattle. For this reason they are considered a relatively safe choice in extensive grazing and landscape protection projects (15).

Another study (27) assessed the influence of various Highland cattle rearing systems, such as high mountain pasture, lowland pasture, or free-stall barn with deep litter or a concrete floor, on the appearance and health of the hooves. The results indicated that environmental conditions have a significant effect on the hooves. Compared with free-stall housing, natural pasture conditions help maintain a correct hoof structure and reduce the risk of pathological changes. The hooves were larger during periods of grazing in pastures, with a long dorsal surface and heels, and were also more symmetrical. The hoof horn was hard and well-formed, and the natural structure of the sole was preserved, so that the hooves did not require correction. In contrast, cattle reared in the barn had shorter toes and a steeper hoof wall angle. The animals also suffered more frequently from hoof damage, such as white line degradation, heel horn erosion and abrasion of the weight-bearing edges. Abnormalities in the hoof horn of Highland cattle resulting from a semi-indoor system necessitate hoof correction because of reduced natural abrasion of their hooves (27).

Sorg et al. (36) showed that Highland cattle also have a genetically determined increased immunity to mastitis. The study involved a comparative analysis of the innate immune response of the mammary gland, in the context of resistance to mastitis, in ancient cattle breeds – Highland cattle and White Park cattle – and the modern Brown Swiss and Red Holstein dairy breeds. The study was carried out using primary mammary gland epithelial cells, which were isolated from milk and then stimulated in *in vitro* cultures with inactivated *Escherichia coli* and *Staphylococcus aureus* pathogens, considered to be the most common causes of mastitis in cows. The study revealed a markedly higher expression of genes responsible for the production of immune proteins in the Highland and White Park breeds. All cattle breeds tested in the study differed from one another in gene expression and protein production. In the Highland and White Park breeds, however, the basic level of expression of immune genes was significantly higher, including genes encoding receptors TLR2 and TLR4, which recognize pathogens, and mediators of the immune response, such as caspase-8 and IL-8 (36). In contrast, in the Brown Swiss and Red Holstein dairy breeds, stimulation with the above-mentioned pathogens induced a greater change in the expression of many immune genes, complement component C3, cytokines IL8 and TGFβ, as well as other chemokines, e.g. those responsible for activating immune cells (monocytes, macrophages and T lymphocytes) at sites affected by inflammation. In effect, the immune response in modern breeds was more dynamic, but also more reactive. The authors suggest that this mechanism may partly explain the greater natural resistance of both the Highland and White Park breeds to mastitis in comparison with the intensively selected dairy breeds (36). Unfortunately, because Highland cattle were originally kept in different conditions, the change in the living environment of animals kept in various parts of Europe may significantly limit their ability to express their natural behaviours, which adversely affects their welfare and production parameters. In addition, their thick, long coat may pose a threat in the warmer climate of Poland, increasing the risk of overheating in the summer or invasion with insects, such as lice and ticks. Scientific reports (20) indicate that the thick double coat makes Highland cattle unsuitable for life in a hot climate because they are highly susceptible to overheating, which can lead to reproductive disorders, the birth of weak calves and increased mortality (16, 35). Therefore, in the face of global warming and hot, dry periods in the spring and summer, which also occur in Poland, it seems useful to conduct research to assess selected welfare parameters in Highland cattle as potential indicators of their adaptation to changing living conditions.

The aim of the study was to assess the level of adaptation of Highland cattle to living conditions in Poland as one of the main criteria of their welfare.

Material and methods

The study assessed the level of adaptation of Highland cattle to living conditions in the marshy areas of the Bug and Pilica river basins in south-eastern Poland. The study was carried out in two herds of Highland cattle, together numbering about 200 head. The evaluation included cows and bulls aged between 1 and 8 years. The observations were conducted for a period of three months from March to June 2024. The cattle were kept year-round in a pasture system. Herd 1, numbering 140 head, used a pasture with an area of 100 ha, while herd 2, numbering about 60 head, was kept on a pasture measuring about 20 ha. The area where the animals were kept was partially forested, and the pastures had highly diverse species of meadow plants and shrubs (Fig. 4).

Fig. 4. Maintenance conditions of one of the assessed herds of Scottish Highland cattle

Selected physiological and behavioural parameters were assessed in the herds, including behaviour during grazing, physical activity (movement from place to place), the desire to lie down and the occurrence of disorders of the maternal instinct in cows after calving.

The animals were observed while they grazed and during increased activity in order to check for lameness. In addition, the study evaluated parameters affecting reproduction in the herd, such as gestation length, calving percentage, number of stillborn and live-born calves, birth weight of calves and their growth in the first few days of life and the percentage of cows that did not become pregnant.

In addition, information was obtained from farmers regarding the reproductive period and the average milk yield over the previous five years, and colostrum quality was tested with an optical refractometer (Kerbl®, Germany).

Results and discussion

The analysis of indicators of adaptation of Highland cattle showed no differences in the length of time

Fig. 5. Examples of maternal instinct expression towards calves

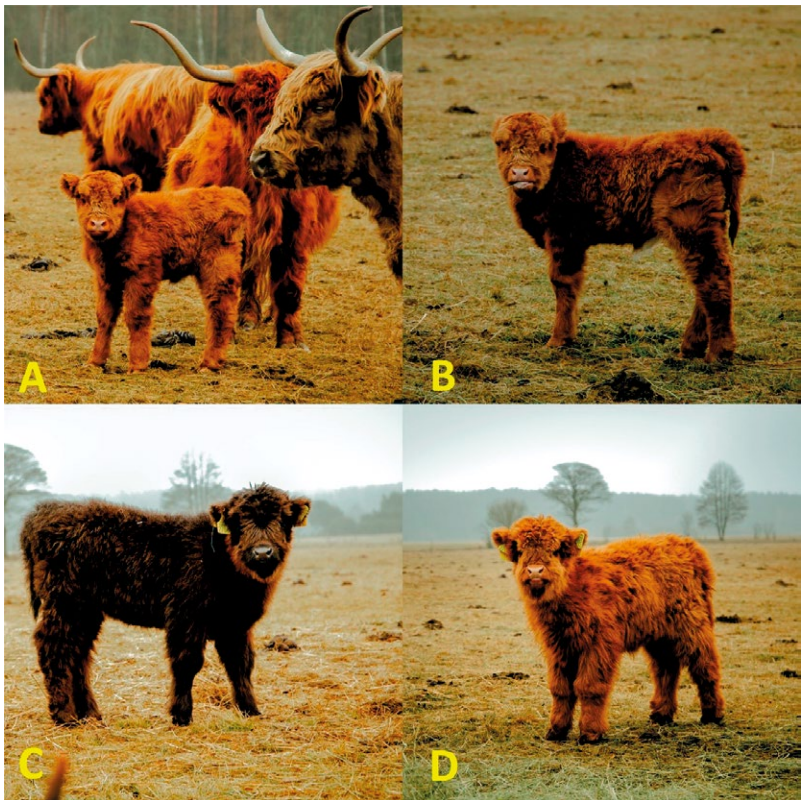

Fig. 6. Scottish Highland calves on the 4th day after birth (A and B) and in the second week of life (C and D)

spent in the pasture, desire to use the pasture, the length of time spent in a recumbent position or the desire to move during the day. Symptoms of lameness were observed in three cows: the left pelvic limb was affected in one case and the right pelvic limb in the other two. No problems with expression of maternal behaviour were observed in cows with calves. Cows readily looked after their newborn calves and were very protective of them, which in some cases even took the form of aggression towards other individuals that approached the offspring too closely (Fig. 5). Calving did not require veterinary intervention, as the calves were born without serious problems, irrespective of the time of the year or atmospheric conditions. Calves were viable after birth; they attempted to stand within 15-20 minutes and took their first portion of colostrum about 40 minutes after birth. An interesting phenomenon observed in suckling calves was their tendency to hide in the bushes and tall grass during the first few days of life. This behaviour may be explained by the fact that the Highland breed is a primitive breed, so the calves instinctively hide from predators. All cows exhibited normal maternal behaviour and were able to find their newborn calves before each feeding time. The percentage of stillborn calves was very low, at just 0.5% (one dead calf per 200 born in the five years preceding the study), while maximum calf mortality in the first year of life was 2% – on average one death per 50 calves over the previous two years (according to herd book data obtained from farmers). The average birth weight was about 25 kg, which is a very good result, given that the farmers did not carefully control food intake by pregnant cows (Fig. 6). The quality of the colostrum allowed the calves to effectively develop immunity against infections, as the average content of immunoglobulins in the samples ranged from 115 to 125 g/l. The cows' annual milk yield was 750-900 litres, and lactation lasted eight months on average. Mastitis was very rare, affecting only 0.5% of lactating cows. These results were relatively low in comparison to beef breeds, such as Limousin, in which comparable parameters were higher, in part because their milk production was more than three times as high (Tab. 2).

It should also be noted that Highland cows had fully adapted to the climatic conditions of the temperate zone, changing their reproductive physiology and displaying signs of oestrus throughout the year. A measurable effect of these adaptations was an increase in the frequency of conception and the birth of calves year-round. According to their physiology, Highland calves are born from the start of February to the end of March or early April.

The results confirm the animals' ability to adapt to the wet conditions in the temperate climate zone in Poland. A measurable result of their very rapid adaptation is the increase in the population of this breed in the country since 2010. Highland cows are a breed with a unique biological profile combining high environmental resistance, stable behavioural traits and ecological elasticity. Highland cattle farming is also economically profitable, because the breed does not have special living requirements, respiratory disease

Tab. 2. Comparison of selected physiological parameters of Highland cows and selected beef breeds

Parameter	Scottish Highland cattle assessed in the study	Limousin	Charolais
Behaviour during grazing	Animals were willing to move around the pasture. Resting and lying down were observed mainly in the early morning and late afternoon. Mock fights were frequently observed in adult cattle (Fig. 7).	Cattle thrive in year-round grazing, even in low temperatures. They also adapt quickly to the terrain they inhabit (42).	Younger cows are more aggressive towards humans, while older ones (more than 4 years old) are calmer. Aggression-linked genes are hereditary (12).
Maternal instincts	Maternal behaviour was expressed towards every newborn calf, as well as during the first months of rearing.	Maternal instincts are strong and increase up to the third calving. Mothers are very protective of their calves (14). Calves accompany their mothers until weaning (42).	Cows are very protective of their calves; they find their newborn calves hidden in the grass, and their maternal instinct significantly contributes to calf survival (41).
Mastitis (%)	0.5	4.52 (3)	33.1-53% (1)
Culled females (%)	1	10.1 (3)	20 (19)
Lameness (%)	2	7.56 (3)	68-94 (23)
Length of pregnancy (days)	270 ± 5	282 ± 0.81 (3)	286-289 (4)
Stillborn calves (%)	0.5	2.35 (3)	6.98 (7)
Birth weight (kg)	25 ± 3	42 (13)	40-46 kg (39)
Calf deaths during the first year of rearing (%)	2	6.53 (22)	1.5-3.8 (41)
Average annual milk yield (litres)	750-900	1 884.8-2002.4 (30)	~850-900 (19)
Average colostrum quality – IgG (g/l)	> 115	95.9 ± 36.2 (40)	50-84 (21)

and diarrhoea occur sporadically, and calving nearly always takes place without complications, so the need for veterinary intervention is negligible. Importantly, the present study also found only sporadic occurrence of common ailments, such as lameness (2%) and mastitis (0.5%) (Tab. 2). This is an important advantage, as hoof diseases are a common problem in both dairy and beef cattle. British scientists analysed nearly 750 cases of lameness in beef cattle, including breeds such as Angus, Brangus, Simmental and Hereford, as well as commercial crossbreds. The results indicate that the vast majority (85%) of problems associated with lameness in beef cattle affect the outer surface of the hooves in the pelvic limbs. In the aetiopathogenesis of lameness, non-infectious factors were shown to predominate: screw claw (25.6%) and vertical fissure (21.2%). Among infectious foot diseases, the most commonly diagnosed were digital dermatitis and heel erosion, which occurred in nearly 6% of cases (25).

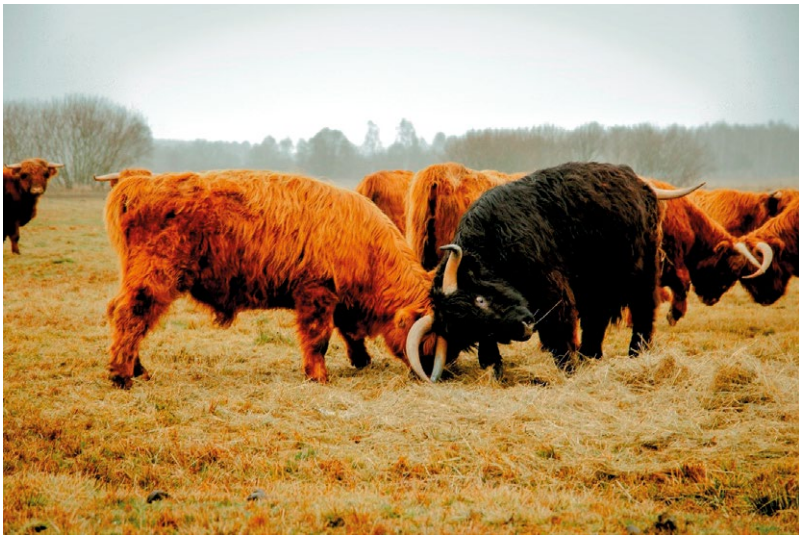

Fig. 7. Example of mock fights between cows

The problem of mammary gland disorders is most common in herds of highly productive dairy cattle, whereas mastitis is much rarer in beef cattle, with an incidence of about 4.5% (29). Nevertheless, mastitis in beef cattle can affect production efficiency by adversely affecting the health of cows and reducing the amount of milk for calves and can indirectly affect their weight gain. In beef cattle, in contrast to dairy cows, subclinical infections predominate (29).

Research on the behaviour of Highland cows while grazing also occupies an important place in the literature. A study by Pauler et al. (28) analysed the relationships between the anatomy, movement and foraging behaviour of three cattle breeds differing in productivity: Highland cattle – a low-production breed, Original Braunvieh – a dual-purpose (beef and dairy) breed, and a highly productive Angus × Holstein crossbreed. The study demonstrated that highly productive breeds have greater body weight with relatively small hooves, which increases pressure on the ground and is harmful to the soil and vegetation. These animals move in a highly selective manner, choosing only high-quality

forage, whereas the less demanding Highland cattle adapt much better to difficult mountain conditions, exhibiting less forage selectivity, which helps to preserve biodiversity in Alpine ecosystems. Similar conclusions regarding high feeding elasticity were reported in the previously cited study by Nota et al. (26). Highland cattle are able to make efficient use of both herbaceous and woody plants, which makes them a valuable tool in landscape protection and management of semi-natural areas. In a sylvo-pastoral (forest and pasture) system, this breed incorporates from 15% to 46% of woody and shrubby vegetation in its diet. Grazing of Highland cattle can be an effective tool in preventing shrubs from overgrowing mountain pastures. This strategy helps restore biodiversity in areas abandoned by agriculture and affected by climate change. From an ecological perspective, their grazing helps to maintain biodiversity (10, 26, 28). Research carried out using Highland cattle in the Swiss Grande Cariçaie nature reserve, an example of a typical wetland environment, confirmed that these cattle avoided excessively wet places where the ground was muddy, showing a preference for transitional zones between dry and wet areas and using areas where green plants were more accessible (11). Similar conclusions regarding adaptability to wet pastures were presented following observations of Highland cows on a pasture west of Rotterdam (6). Another study, by Ranta and Mălinaş (32), aimed to test two cattle breeds, Galloway and Scottish Highland, in the temperate Eastern European climate and to assess their potential in sustainable and climate-resilient farming. The researchers focused on evaluating average daily weight gains in calves fed low- and medium-quality forage, which is of key importance for sustainable agriculture. The authors' conclusions indicate that both breeds are suitable for sustainable meat production in a temperate climate and mountainous conditions. Highland cattle showed a slower growth rate than Galloway, but greater resilience to difficult conditions and exceptionally low grazing selectivity, as well as the ability to use low-quality vegetation.

The type of fodder consumed has a significant influence not only on the animals' health, but also on meat quality. Extensive grazing, which is typical of the Highland breed, makes it possible to obtain better quality meat with less fat in comparison with intensive systems (38). Meat from Highland cattle is appreciated by consumers all over the world for both its flavour attributes and its health benefits. The low content of subcutaneous fat is linked to the specific thermoregulatory conditions resulting from the presence of a double hair coat – an undercoat and a thick outer layer (www.thecattlesite.com/breeds/beef/40/highland/). This results in a greater amount of intramuscular fat and thus to marbling of the meat, which improves its palatability. Another characteristic feature of this type of beef is its lower cholesterol content (5). Physicochemical analyses of meat samples from Highland cattle confirmed that they had a higher content of protein and iron than commercial beef ('All Beef') and Limousin beef (5) (Tab. 1).

From a veterinary perspective, Scottish Highland cattle are described as a breed with increased environmental resistance, but not without certain health risks. The findings of the present study indicate that for anti-parasitic prophylaxis it is sufficient to deworm the herd twice, in early spring and late autumn. Young calves do not need to be dewormed in summer. However, articles on parasitology have described cases of parasite infection in which Highland cattle were hosts for parasites locating in the liver – the giant liver fluke (*Fascioloides magna*) and the common liver fluke (*Fasciola hepatica*). In the case of *Fascioloides magna* in cattle, including Highland cows, the parasite does not fully mature or lay eggs because cattle are a nonspecific host for it. This means that in most cows

Tab. 3. Advantages and disadvantages of farming Highland cattle based on our own observations and those presented in the literature

Advantages of Highland cattle	Disadvantages of Highland cattle
Exceptional hardiness and low demands regarding living conditions. Rapid and easy adaptation to new environments. Good adaptability to difficult, cold and wet climate conditions. Ability to survive on low-quality fodder, so they can be kept on low-class land.	Slow growth rate, which prolongs the fattening period and the time needed to achieve slaughter weight. Increased sensitivity to heat stress due to the thick double hair coat. Poor adaptation to a hot, wet climate. Increased predisposition to infection with external parasites, such as lice and ticks. Regular grooming is necessary.
Easy calving due to the small size of calves. Excellent maternal instinct.	
Calm, mild temperament, friendly and easy to lead. Meat for consumption is of very good quality – lean, rich in protein and iron, low in fat and cholesterol.	High meat prices in comparison to traditional beef cattle. Small final individual size, which translates into less meat. Higher purchasing price of individuals for herd rebuilding and fattening, because it is a niche breed. Need for greater space to prevent injuries due to the long, wide horns.
High viability and fertility. Cows can give birth for even 18 years.	
Farming is environmentally friendly, because the animals are not selective in foraging, which improves pasture quality, clears brush, and promotes biodiversity.	

the parasite does not reach sexual maturity, and its life cycle is interrupted in the body (18). Infection with the giant liver fluke is rare; infection with the common liver fluke, for which cattle are the definitive host, occurs more frequently (18).

Unfortunately, analysis of the literature indicates that there have been few long-term studies on the health of Highland cattle populations in the context of climate change and intensification of land use. This suggests the need for further interdisciplinary research combining veterinary, ecological and genetic approaches.

In summary, Highland cattle, like any other breed, have advantages and disadvantages, the most important of which are presented in Table 3.

References

1. *Abegewi U. A., Esemu S. N., Ndip R. N., Ndip L. M.*: Prevalence and risk factors of coliform-associated mastitis and antibiotic resistance of coliforms from lactating dairy cows in North West Cameroon. PLoS One 2022, 17 (7):e0268247.
2. *Asmussen G.*: 2025 https://www.agriculture.com/family/living-the-country-life/benefits-of-raising-highland-cattle
3. *Basiel B. L., Barragan A. A., Felix T. L., Dechow C. D.*: The impact of beef sire breed on dystocia, stillbirth, gestation length, health, and lactation performance of cows that carry beef × dairy calves. J. Dairy Sci. 2024, 107 (4), 2241-2252.
4. *Blanc F., Agabriel J.*: Modelling the reproductive efficiency in a beef cow herd: Effect of calving date, bull exposure and body condition at calving on the calving-conception interval and calving distribution. J. Agric. Sci. 2008, 146 (02), 143-161.
5. *Bruce C. J.*: An investigation into the health and tenderness benefits present within Highland cattle beef compared to a Commercial breed SAC University of Glasgow, May 2011.
6. *Caspers C. J. M.*: Habitat use of feral Highland cattle and Konik horses on Landtong Rozenburg, the Netherlands, 2015, master's thesis. https://studenttheses.uu.nl/handle/20.500.12932/21197.
7. *Čítek J., Kasna E., Rehout V., Hanusová L.*: Obstetrical problems and stillbirth in beef cattle. Anim. Sci. Pap. Rep. 2011, 29 (2), 109-118.
8. Data from the Polish Association of Beef Cattle Breeders and Producers supplemented with data obtained directly from breeders not affiliated with the Association.
9. *Dennis R.*: The importance of traditional cattle for woodland biodiversity in the Scottish Highlands 1998. https://scottishhighlandcattle.com.au/docs/Importance_of_traditional_cattle_for_woodland_biodiversity_in_Scottish%20Highlands%20.pdf.
10. *Dumont B., Farruggia A., Garel J. P.*: Grazing behaviour of hardy cattle breeds and implications for biodiversity conservation. Appl. Anim. Behav. Sci. 2017, 196, 44-53.
11. *Gander A., Rockmann A., Strehler C., Gusewell S.*: Habitat use by Scottish Highland cattle in a lakeshore wetland, Bull. Geobot. Inst. ETH 2003, 69, 3-16.
12. *Garza-Brenner E., Sifuentes-Rincón A. M., Randel R. D., Paredes-Sánchez F. A., Parra-Bracamonte G. M., Arellano V. W., Rodríguez Almeida F. A., Segura Cabrera A.*: Association of SNPs in dopamine and serotonin pathway genes and their interacting genes with temperament traits in Charolais cows. J. Appl. Genet. 2017, 58 (3), 363-371.
13. *Hristov M., Markov N., Dimitova T., Mondeshka L., Stoycheva S.*: Limousin Breed – creation, approval, specifications and challenges. Review. Sci. Papers Ser. D, Anim. Sci. 2023, LXVI (2), 308-315.
14. *Karamfilov S.*: Study on the maternal instinct of Limousin cows. Bulg. J. Anim. Husb. 2025, 62 (2), 3-10.
15. *Kessel J. A. M. van.*: Bovine and recreation interactions under semi-wild conditions: Behavioural reaction of Tauros, European bison, Galloway and Scottish Highland cattle to three types of recreational visitors. Utrecht University, Faculty of Geosciences, 2014, p. 56.
16. *Kim W. S., Nejad J. G., Park K. K., Lee H. G.*: Heat stress effects on physiological and blood parameters, and behavior in early fattening stage of beef steers. Animals (Basel) 2023, 13 (7), 1130.
17. *Kosztolányiné S., Zandoki A. V., Janos R. T., Stefler J.*: Role and importance of Scottish Highland Cattle in the world. AWETH 2021,17 (2), 99-124.
18. *Leontovyč R., Košťáková M., Siegelová V., Melounová K., Pankrác J., Vrbová K., Horák P., Kašný M.*: Highland cattle and Radix labiata, the hosts of Fascioloides magna. BMC Vet. Res. 2014,10, 41.
19. *Liénard G., Lherm M., Pizaine M., Marcheal L., Boussange J., Barlet D., Bouchy R.*: Productivité de trois races bovines françaises, Limousine, Charolaise et Salers. Bilan de 10 ans d'observations en exploitations. INRAE prod. anim., 2002, 15 (4), 293-312.
20. *Lindsey M.*: Choosing a breed of cattle: 5 needs and 40 breeds for selecting cattle that fit your purpose (Practical Country Living). Homestead on the Range 2019, p. 144.
21. *Martin P., Vinet A., Denis C., Grohs C., Chanteloup L., Dozias D., Maupetit D., Sapa J., Renand G., Blanc F.*: Determination of immunoglobulin concentrations and genetic parameters for colostrum and calf serum in Charolais animals. J. Dairy Sci. 2021, 104, 3, 3240-3249.
22. *Monuaix B., Roussel P., Assie S.*: The mortality of calves in French beef cattle farms: a national review; EAAP/Institut de l'Élevage https://docs.eaap.org/2013/S33p_03.pdf.
23. *Morrone S., Scanu A., Gerolamo M., Crovace A. M., Romeo S. M. T., Saderi L., Sotgiu G., Columbano N.*: Retrospective study of lameness in beef cattle in northeastern Sardinia, Italy. PLoS One 2023, 18 (5), e0285840.
24. *Neave H. W., Weary D. M., Keyserlingk M. A. G.*: Impact of group management and transfer on individual sociality in Highland cattle (Bos taurus). Front. Vet. Sci. 2019, 6, 193.
25. *Newcomer B. W., Chamorro M. F.*: Distribution of lameness lesions in beef cattle: A retrospective analysis of 745 cases. Can. Vet. J. 2016, 57 (4), 401-406.
26. *Nota G., Svensk M., Barberis D., Frund D., Pagani R., Pittarello M., Probo M., Ravetto S., Lonati M., Lombardi G.*: Foraging behavior of Highland cattle in silvopastoral systems in the Alps. Agrofor Syst. 2024, 98 (2), 491-505.
27. *Nuss K., Kolp E., Braun U., Weidmann E., Hässig M.*: Klauengrösse von Schottischen Hochland-Kühen nach Weide- und Laufstallhaltung. Schweiz. Arch. Tierh. 2014, 156 (9), 433-440.
28. *Pauler C. M., Isselstein J., Berard J., Braunbeck T., Schneider M. K.*: Grazing allometry: Anatomy, movement, and foraging behavior of three cattle breeds of different productivity. Front. Vet. Sci. 2020, 7, 494.
29. *Persson Waller K., Persson Y., Nyman A. K., Stengärde L.*: Udder health in beef cows and its association with calf growth. Acta Vet. Scand. 2014, 56 (1), 9.
30. *Przysucha T., Gołębiewski M., Grodzki H., Wnęk K., Slósarz J., Kunowska-Slószarz M., Tokarski P.*: Analysis of Limousine beef cattle recording results in Poland. Department of Animal Breeding and Production, Ann. Wars. Univ. Life Sci.-SGGW, Anim. Sci. 2015, 54 (1), 83-94.
31. *Przysucha T., Grodzki H., Gołębiewski M., Slósarz J., Piotrowski T.*: Evaluation of the performance of Scottish Highland beef cattle in Poland. Med. Weter. 2013, 69 (4), 252-254.
32. *Ranta M., Mălinaș A.*: Contributions to more sustainable and climate-resilient cattle production: Study of performance of Galloway and Highland Breeds in Transylvania, Romania. Animals 2024, 14 (24), 3686.
33. *Robic F., Keller B., Pelé M., Sueur C.*: Etude de l'influence de la démographie de groupe sur la structure sociale chez les Highland Cattle (Bos taurus). 2015, master's thesis. 10.13140/RG.2.1.1228.0482.
34. *Schmutz S. M., Dreger D. L.*: Interaction of MC1R and PMEL alleles on solid coat colors in Highland cattle. Anim. Genet. 2013, 44 (1), 9-13.
35. *Shephard R. W., Maloney S. K.*: A review of thermal stress in cattle. Aust. Vet. J. 2023, 101, 417-429.
36. *Sorg D., Fandrey E., Frölich K., Meyer H. H. D., Kliem H.*: Mammary immunity of White Park and Highland cattle compared with Brown Swiss and Red Holstein. AnGR 2013, 52, 91-104.
37. *Sosa S. O., Pelé M., Debergue É., Kuntz C., Keller B., Robic F., Siegwalt-Baudin F., Richer C., Ramos A., Sueur C.*: Impact of Group Management and Transfer on Individual Sociality in Highland Cattle (Bos taurus). Front. Vet. Sci. 2019, 6, 183.
38. *Szarek J., Nawrocki L.*: Żywienie pastwiskowe bydła mięsnego. Byd. Mięs. 2023, 3 (42), 52-56.
39. *Šlyžienė B., Mečionytė I., Žilaitis V., Butkienė E., Anskienė L., Šlyžius E., Palubinskas G.*: The Association between Charolais Cows' age at first calving, parity, breeding seasonality, and calf growing performance. Animals (Basel) 2023, 13 (18), 2901.
40. *Vandeputte S., Detilleux J., Rollin F.*: Investigation of colostrum quality in beef cattle by radial immunodiffusion and brix refractometry. Vet. Rec. 2014, 175, (14), 353.
41. *Vinet A., Leclerc H., Marquis F., Phocas F.*: Genetic analysis of calf health in Charolais beef cattle. J. Anim. Sci. 2018, 96 (4), 1246-1258.
42. *Wiśniewski K., Świątek M., Król J., Kuczyńska B.*: The nutritional value of beef from Polish Red and Limousin cattle breeds maintained by an extensive production system. Arch. Anim. Breed. 2024, 67, 259269.

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