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Unconventional uses of pigs

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Abstract: *Unconventional uses of pigs*. The study presents the possibilities of pigs' sensory organs and their sensitivity to odor stimuli (i.e. to search for truffles and drugs by pigs), as well as their role in the animal adaptation processes. We use the knowledge about the senses to more effectively enrich farming environment and in this way to improve the animal welfare. The pigs' ability to distinguish and remember sounds and the appropriate associated reaction can be used to create the desired behavior, improve welfare of pigs and their production results. Similarly, the pigs' ability to distinguish colors and their color preferences also enable to influence the behavior, welfare, and production effects of pigs. Miniature pigs are used as companion animals and in rehabilitation. The similarity in the anatomical structure of the pig and human organs, and the course of physiological and metabolic processes are used in medical research and creates hope for their use in so-called xenotransplantation. Transgenic pigs create new horizons in the unconventional use of pigs.

Key words: pigs, senses, animal welfare, medical tests, transgenic pigs

INTRODUCTION

Swine are the main source of meat both in the world (about 40%) and in Poland (almost 60% of meat and meat products consumed). This dominance will likely persist for a long time, given the growing demand for meat products, the undoubted advantages of this species of animal and culinary traditions, which usually do not change quickly. Only a small percentage of the large pig population is used by humans for other purposes. Centuries ago, pigs were a source of meat and fat for humans, but they also loosened soil through rooting, aided in hunting and accompanied people in their everyday life. Also, human needs nowadays suggest the wide variety of pigs' qualities should be taken advantage of (Kaleta 1996, Grabowska 2014).

SENSE OF SMELL AND TASTE

Swine are animals with an extremely sensitive sense of smell that is necessary for their survival. Newborn piglets must recognize olfactory signals such as the smell of the mother, which makes it easier to reach the udder. Adult pigs use "information" encoded in smells to recognize the opposite sex and to locate potential breeding partners. Free-living wild boars and pigs also use their sensitive sense of smell to search for food, detect predators, and recognize own territory boundaries.

Sensitivity of pigs to scent-based stimuli, especially during mating season,

has found practical applications and prompted the production of synthetic substances stimulating the reproductive system to more strongly display oestrus symptoms, what is conducive to optimal introduction of semen and fertilization of females of this species (Adamczyk et al. 2015).

Highly sensitive sense of smell makes it easy for omnivorous pigs to find substances that are suitable for eating. Among the wide menu of wild boars and pigs there are also treats that man considers a luxury, such as truffles.

Well-developed olfactory system and instinct to use the nose to search for food means that swine are naturally predisposed to finding delicacies such as truffles, i.e. fungi from the ascomycete group, producing subterranean fruiting bodies. They have the shape of a tuber, surrounded by rough skin. Most often they grow in symbiosis with the roots of deciduous trees – oaks, limes, poplars and willows. Of the more than 150 species of truffles, of high culinary value are considered mainly: the black truffle *(Tuber melanosporum*), the white truffle (*Tuber magnatum*), the black summer truffle (*Tuber aestavium*), and the whitish truffle (*Tuber borchii*) (Gerhardt 2006). The main attraction of these fungi is the seductive taste and aroma, which depends on the type of tree they associate with. In addition, it is believed that the truffle has a similar scent as male wild boar pheromones, which makes pigs even more effective in their search – they can sniff out truffles even three feet underground.

Thanks to the sensitive sense of smell, unconventional uses of pigs are not limited to truffle search only. In recent years, they have also become the terror of drug smugglers. In this new role, pigs do better than many trained dogs, checking the luggage of passengers of some airports for psychoactive substances and explosives, thus ensuring the safety of passengers and airport employees.

The case of a pig named Luisa "serving" in the Hanover police was widely publicized. Commissioner Werner Franke acquired Luisa as a young piglet from an animal shelter and trained her to search for cocaine and marijuana. For five years, Luisa made the life of smugglers a misery, achieving better results than many dogs. She eventually ended her service simultaneously with her retiring caretaker, as she turned out to be loyal at work only to the person who looked after her. Relationships between people and animals take on a variety of shapes.

It should also be made clear that animals of this species spend most of their lives in pig houses, the atmosphere of which contains certain amounts of harmful gases (mainly ammonia and hydrogen sulfide) adversely affecting mucous membranes of their upper respiratory tract (Mihina et al. 2012).

There is no doubt that the sense of smell plays a significant role in pig adaptation (Perry 1992, Kristensen et al. 2001, Jensen 2002, Nowicki and Klocek 2012). Swine use their nose not only to find food, but also for social purposes (Mendl et al. 2002). On the other hand, there are many reports that pigs do not have a particularly well-developed sense of sight (Hutson et al. 1993, Lomas et al. 1998, Tanaka et al. 1998, Zonderland et al. 2008). In commercial farming, the selection of environment enrichments for

pig pens is still often arbitrary (with the exception of bedding) (Szewczyk 2011). Behavioral needs of pigs are not taken into consideration. The consequence of this method of environment enrichment in pig farming is that animals very quickly lose interest in such objects (Day et al. 2002). In addition, elements placed on the floor of the pen can be very easily contaminated with faeces and swine – as animals with a very sensitive sense of smell – quickly scorn them (Blackshaw et al. 1997).

Therefore, suspended objects seem to be better able to maintain interest of pigs. Also, in memorization processes of these animals, smell plays a more important role than appearance of a given object (Croney 2003). Research on other animals, such as rodents and chickens, suggests that a previously known smell is attractive in a new environment, and its presence reduces fear (Jones and Gentle 1985).

Effective improvement of piglets' welfare level after weaning should result from the synergistic effect of the interesting smell of an enrichment object and the opportunities for its deformation, biting, chewing and, as a result, destruction. The latter features are mentioned in the literature as decisive for effectively maintaining interest of animals in such an object, and actually causing a reduction in aggression (Studnitz et al. 2007, Van de Weerd and Day 2009). Until recently, however, aromatization of environment enrichments in pig breeding was not associated with the above-mentioned benefits. An enrichment object integrating the sense of smell was constructed only in 2012 (Nowicki and Klocek 2012). An aromatic chew toy was made of fabric strips attached to a metal frame, with a perforated container for vanilla aroma. The choice of scent was based on previous, unpublished, own pilot experiments. Subsequently, three years later an aromatic toy with option to switch scents was proposed, which ensured the possibility of long-term interest of pigs in such an enrichment. The preferences of pigs in relation to natural and synthetic fragrances were also determined (Nowicki et al. 2015).

SENSE OF HEARING

In the wild, the sensitive sense of hearing of wild boars and pigs allows them to pick out sounds that signal approaching danger. The crunch of dry leaves or cracking of breaking branches might mean a threat from a predator or hunter. The sooner these signals are located, the more likely the animal is to escape. In farming environments, in the pig pens, sound signals seem to be of secondary importance. However, the sharp sense of hearing still receives various sounds from the environment, produced by the animals themselves (vocalizations), as well as the sounds of various devices that are part of the piggery equipment: fans, heaters, feeders, automatic feeders, drinkers. These noises may cause chronic stress, often unnoticeable, but resulting in deterioration of animals' well-being, certain reactions of the endocrine system, worsening production performance indicators (weight gain, use of feed, delayed occurrence or intensity of oestrus symptoms) (Otten et al. 2004).

The response of individual animals to sound stimuli referred to as noise is highly varied – in more sensitive animals

they can cause depressive symptoms leading to atypical behaviors, known as behavioral stereotypies. The Swiss studies (Klocek et al. 2017) show that fan noise above 85 dB prolonged the finishing period by 14 days. More intense noise (95–110 dB) caused anxiety, increased heart rate. More spectacular may be reactions to sudden unusual noises of high intensity (loudness), leading to disruption of the farrowing process. In such a situation, the sow may delay the start of delivery or stop in the middle of farrowing, with all its consequences. The problem of excessive noise in pig rearing was reflected in legal acts specifying the acceptable noise levels. The ordinance of the Minister of Agriculture and Rural Development on minimum housing conditions for various farm animal species stipulates that "noise in pig pens: should not be constant or caused suddenly, and its intensity should not exceed 85 dB".

The source of sound in animal farming environments are also people caring for the animals: their too loud conversations, commands given, shouting, whistling, singing as well as radio programs or music played. Such activities are intended to make the work of people caring for the animals more pleasant. The sounds make it easier for animals to identify individual caretakers or signal situations that are to take place: pen cleaning, changing out of the bedding, feeding or periodically performed treatments. These signals are also received by animals, which can react differently depending on the type of sound. If the sounds are repeated, they can create specific associations in the animals, both positive and negative. A particular type of music or song associated with a given person or activity can have different consequences. Such associations, usually created spontaneously, can also be triggered by man in a conscious way to achieve a specific purpose.

Information on diverse reactions of swine to various types of sounds, including various musical compositions moved researchers to undertake more detailed research, both with cognitive and practical profiles.

Animal ability to distinguish and remember sounds and the appropriate associated reaction can be used for practical purposes. Jonge De et al. (2008) showed that playing music to piglets when they were given the opportunity to leave the pen freely builds positive associations between the mentioned stimuli. After weaning, replaying of the music track associated with this substitute for freedom was conductive to greater mobility, willingness to play and reduced aggression, which resulted in better health and greater daily increases. In our own research (Petrynka et al. 2015) on weaned piglets, an attempt was made to create positive associations between music and access to fruit in the animals. Music was played twice a day for 15 minutes. Piglet behavior and production indicators were monitored, and pulse rate was measured using a heart rate monitor. In groups of experimental pigs, an increase in exploratory behaviors, extended duration of food and water intake, and longer time spent on games and sham fighting were observed.

The referenced research results indicate the possibility of practical use of pig sense of hearing to improve both their welfare and production indicators.

SENSE OF SIGHT

Light is important for many animal life processes, including in the case of pigs (Anderson 2000, Canaday 2014). Vision makes it easier to reconnoiter and penetrate the surrounding environment, search for food, and identify other individuals. Light is involved in stimulating reproductive processes, it accelerates sexual maturation, promotes earlier onset and stronger manifestation of oestrus symptoms after weaning of piglets, promotes an increase in the number of ovulated eggs and reduction of embryo mortality in the preimplantation period, and also increases vitality and development rate of piglets. Therefore for swine, especially those used for breeding, access to light, preferably natural, is very important.

From a practical point of view, it is important how pigs see and whether they distinguish colors. A pig's eye is very similar to the human eye in terms of dimensions and anatomical structure. Pigs can see in the panoramic range of 310 degrees, with binocular vision of 35–50 degrees. It is believed that the pig's eye has only a limited accommodation (ability to sharpen and focus the image). Many researchers believe that the anatomical structure of the pig's eye allows these animals to distinguish between blue and green wavelengths. With these premises in mind, interiors of most piggeries are dominated by various shades of gray – walls, floors, partitions, equipment items such as feeder pipes, supports, feeders, fans are usually finished in grey tones. Less often, some pieces of equipment are made out in green (usually cold dark green) or blue. Coloured accents in pig pens are most often feed bowls or waterers for piglets, sometimes chew toys made of red or yellow plastic (Klocek and Mielczarek 2008). This chromatic range certainly does not promote an optimistic mood in pig caretakers; we also don't know much about how such world looks like from the pig's point of view.

Japanese scientists (Tanida et al. 1991) found – using the differential conditioning method – that piglets are probably not able to perceive the full range of light wavelengths, and of the three primary colors probably only perceive blue. The results of research on possibility of distinguishing colors by Asian wild boars indicate that these animals are able to discern blue from gray very well, green from gray to a lesser degree, and are unable to distinguish red from gray. In an extended experiment, the same authors proved that wild boars clearly distinguished different shades of blue from gray (Eguchi et al. 1997).

Deligeorgis et al. (2005) observed in their studies on piglets a higher intake of water from red and blue drinkers than from green ones. The profile of piglets using waterers of different colors depended on their sex. Females preferred blue drinkers and used them more often than male animals, which in turn tended to use red waterers with greater intensity. The authors referenced the known fact that color preference varies depending on gender in rats, primates, and also in humans.

The results of research by Poznański et al. (2004) suggest that piglets' preferences for specific colors change with age.

In our own research (Klocek et al. 2016) we attempted to determine the pref-

erences of piglets regarding the colors: blue, red and yellow. Piglets were showing more interest in blue and red feeders as opposed to yellow ones. Pigs took the most feed from blue feeders and the least – from yellow feeders. Similar ratios were observed also as concerned number of approaches to feeders and time spent by the feeders of different colors.

Currently, it is increasingly often emphasized that keeping animals in pens made out in colors they perceive positively may have a positive effect on their behavior and level of well-being and, as a result, on the achieved production indicators. Painting certain elements in pig pens in accordance with pigs' color preferences can make them easier to find and encourage (or discourage) their use.

Among many stimuli, visual stimuli can also be used by animals to recognize people (Hemsworth et al. 1994). Koba and Tanida (1999) showed that in distinguishing people swine use differences in color and/or brightness of overalls worn rather than dimensions and shapes. In later studies (2001) carried out on miniature Goetian pigs by these authors, it was observed that these animals could discriminate between people wearing overalls in the same or different colors. In addition to colors of protective clothing, pigs were also able to use characteristic scents and visual signals, such as caretakers' face and body size for identification (Tanida et al. 1995).

ANIMAL ASSISTED INTERVENTION WITH PIGS

Physiotherapists in one of the Dutch rehabilitation and revalidation centers came up with the unconventional idea of using pigs as co-therapists. Interested in the benefits of introducing animals into the process of treatment and therapy (Odendaal 2000, Nimer and Lundahl 2007), they decided to involve not dogs or cats, but pigs. Their goal was to improve fitness and activity levels of the elderly, and emotional sensitization of young people participating in the conducted sessions. The element of surprise brought by miniature pigs led to patients participating in therapy with much greater energy and willingness. The appearance of such special guests was always bringing joy to those taking part in therapy sessions. The speed and willingness of pigs to learn new tricks meant that it was swine (Marino and Colvin 2015) that were a hit in therapy rooms, and not dogs, nowadays more and more commonly used for this purpose. In fact, the success of using miniature pigs was so great that other centers decided to include these charming, oinking animals as co-therapists in their programs. In the US, the cradle of animal therapy, some decided to go even a step further – organizations such as American Mini Pig Education promote the thought of using pigs as therapeutic animals.

It is quite a common practice in the United States to use pigs not only as pets, but also as emotional support, i.e. as Emotional Support Animals (ESA). Commonly known as "prescription animals", they are intended for people struggling with mental problems and illnesses. They allow their owners to feel safer and more comfortable in everyday situations, as well as when traveling by air (they can travel with a passenger onboard an aircraft). Emotional Support Animals aid in the treatment process and minimize the risk of relapse.

It seems that such behavior has become a prologue to the next, unprecedented type of work that man entrusts to pigs. The well-recognized – by both people and science – fact that contact with animals has a peaceful, calming influence (Tsai et al. 2010) was taken advantage of in a rather unprecedented form at the San Francisco airport. In addition to dogs and cats, the task of soothing the troubled nerves of travelers afraid of air travel was entrusted to a miniature pig named LiLou. This idea was received with great approval, to the extent that the quadruped now has social media accounts, with thousands of followers on an ongoing basis. The popularity gained by the pig has prompted her caretakers to keep the animal's work schedule confidential so as not to create additional problems with airport capacity.

SWINE IN BIOMEDICAL RESEARCH

Significant similarity of the anatomical structure of pig and human organs, as well as similarity of physiological and metabolic processes of the two species have long been used in medical research. Hence the great demand for miniature pigs used in medical research (cardiological, pharmacological, toxicological, oncological, surgical, microbiological and many others). The mentioned similarity in structure and dimensions of various human and pig organs creates hope for their use in so-called xenografts (interspecies organ transplants) (Schoeckel et al. 1998, Diamond 2001). Although the discovery of HIV genes in pig genotype has significantly slowed down such work, the development of biotechnology is likely to aid us in overcoming these difficulties as well. The use of animal organs and tissues often raises ethical resistance. And, as often happens, procedures that in many developed countries arouse controversy from an ethical or moral point of view find no barrier to being carried out in China.

Widely bred pig species grow quickly to large sizes, so their maintenance is relatively costly and care can be burdensome. That is why miniature pigs were bred for laboratory test purposes – they reach the body weight of about 40 kg after two years. This slower growth rate allows for long-term research that would not be possible to implement for standard-sized pigs that grow much faster (Hager and Rekiel 2016). Thus miniature pigs have been and are used:

- in research into the role of bacteria and other microorganisms in digestion, metabolism, and the importance of vitamins and mineral salts in the body;
- for research in pharmacology and toxicology of various chemicals and drugs;
- in microbiology, virology, immunology and allergology as well as dermatological research;
- for experimental surgeries; in bone, vascular, skin and organ grafts;
- in procedures on the brain, in open heart and gastrointestinal surgeries, in experimental fetal and plastic surgery;
- as well as in research in the field of radiobiology and radiation oncology – in the search for mechanisms of oncogenic action of ionizing rays (Klocek et Kalinowska 2002).

New perspectives for unconventional uses of pigs have opened up thanks to the progress of biotechnology in recent years,

especially the possibilities of genetic modification of animals – obtaining the so-called transgenic animals (individuals having in their genome certain genes from another species).

Another area of use for transgenic pigs are tissue and organ transplants between individuals belonging to different species, known as xenotransplants (Smorąg et al 2011). The development of xenotransplantation brings the hope of solving the problem of finding the sufficient number of organ donors for human transplant recipients. Medical data indicate that of the thousands of people whose lives can be saved only by transplantation of appropriate tissues or organs, only half have a chance of finding the right donor. The hope for others lies only in the possibility of using, at least temporarily, mechanical devices (e.g. artificial kidneys or heart valves) or obtaining suitable organs from animals. Also, pigs commonly used for fattening are used in medicine. Such pigs are a good substrate for research into the development and treatment possibilities of so-called lifestyle diseases: obesity, diabetes and a number of others. Swine, as it turns out, can be a model organism in research on formation, prevention and treatment of the so-called human metabolic syndrome (Szczerbal et al. 2009). And this is most likely not yet the limit to unconventional uses of animals of this species.

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Streszczenie: *Niekonwencjonalne użytkowanie świń*. W opracowaniu przedstawiono możliwości praktycznego wykorzystania zmysłów świń. Szczególna wrażliwość na bodźce zapachowe pomaga w wyszukiwaniu trufli i narkotyków oraz w bardziej efektywnym wzbogacaniu środowiska chowu i poprawie dobrostanu. Możliwość rozróżniania i zapamiętywania dźwięków przez świnie i odpowiedniej skojarzonej reakcji można wykorzystać praktycznie do tworzenia wywoływania pożądanych zachowań, poprawy dobrostanu oraz wyników produkcyjnych. Podobnie możliwości rozróżniania barw przez świnie oraz ewentualne preferencje także wskazują na możliwość wpływu na ich zachowanie, poziom dobrostanu, oraz efekty produkcyjne. Świnie miniaturowe wykorzystywane są jako zwierzęta towarzyszące oraz w rehabilitacji. Podobieństwo budowy anatomicznej narządów świni i człowieka oraz przebiegu procesów fizjologicznych i metabolicznych wykorzystywana jest w badaniach medycznych, oraz stwarza nadzieję na wykorzystanie ich w tzw. ksenotransplantacjach. Nowe horyzonty w niekonwencjonalnym użytkowaniem świń stwarzają świnie transgeniczne.

Słowa kluczowe: świnie, zmysły, dobrostan, badania medyczne, świnie transgeniczne

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Beef cattle breeds in Poland

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Abstract: *Beef cattle breeds in Poland:* Various of beef cattle breeds offer many different paths of breeding for Polish breeders. Understanding their predisposition is the key to effective and profitable production. The current level of beef consumption in Poland barely exceed 3 kg per person per year, what is lower result than in the past when it amounted nearly to 18 kg per person per year. It is strongly connected to lack of beef cattle production and consumption tradition. The rapid development of poultry and pork production results in prices drop of those products and deepen marginalization of the culinary beef. To repopularize beef on the Polish market, it is necessary to increase its quality in order to meet the current requirements of customers and become attractive for them. According to many authors, the key element is the promotion of knowledge in this field among farmers to produce better quality beef. Quality is a key due to the increase in nutritional value and improvement of its taste and appearance which is crucial during making a choice. The difficult market situation forces breeders to make a deliberate decision and apply new solutions in breeding. The mentioned and described breeds are present on Polish farms, however their populations differ significantly despite the diverse potential they have.

Key words: breeds, cattle, breeds in Poland

INTRODUCTION

The availability of different breeds on the market is the first choice of breeders. The variety of breeds determine many possibilities of using the genetic potential of beef cattle. Depending on the farm profile of and the availability of meadows and pastures, Polish breeders face a complex and difficult choice of the appropriate breed (Grodzki et al. 2005). The dominant production profile of cattle is dairy use, where calves are fattening or sold (Grodzki and Przysucha 2010). In Polish farms beef cattle is more frequent than before, what indicate its growing popularity (Małkowski et al. 2013). According to the Polish Association of Cattle Breeders and Producers (PZHiPBM) data, the dominant position in the Polish beef cattle herds is occupied by the Limousine breed, what affects in to the highest availability of calves of this breed. However, this is not the only breed that can be used to create a new herd or replace the previous one. Basis of the

literature review, a list of meat cattle breeds was made. Polish Association of Cattle Breeders and Producers evaluate and characterize animals on the basis of its production results and potential use in Polish farms. The popularization of beef cattle production is currently an important element for the consumer due to the low availability of high quality culinary beef (Jasiorowski 2011), and for the producers to increase their income. Poland do not have tradition of beef consumption and consumers do not know how to cook beef properly and how to recognize high quality meat. Those aspects are very important in beef promotion planning. Predominate on Polish market beef came from dairy cows. Its quality is significantly lower than from the breeds predisposed to fattening and its negatively affect on consumer demand due to its lower quality and flavor (Jasiorowski 2010). The current level of beef consumption in Poland barely exceed 3 kg per person per year, what is lower result than in the past when it amounted nearly to 18 kg per person per year (Pisula et al. 2007). The rapid development of poultry and pork production results in prices drop of those products and deepen marginalization of the culinary beef (Bąk-Filipek 2014). To re-popularize beef on the Polish market, it is necessary to increase its quality in order to meet the current requirements of customers and become attractive for them. According to many authors (Bąk-Filipek and Parlińska 2011, Domaradzki et al. 2016), the key element is the promotion of knowledge in this field among farmers to produce better quality beef. Quality is a key due to the increase in nutritional value and improvement of its taste and appearance which is crucial during making a choice (Damon et al. 1960, Połczyńska and Górska 1997).

REVIEW OF BREED

Angus

This breed split on two breeds Angus Red and Angus Black. It is one of two most popular beef cattle breeds worldwide. Easy adaptation to difficult environmental conditions, good use of feed and very good fertility are the reasons of current range of occurrence include almost all continents. The Angus Black breed originates from the Scotland shires Aberdeen, Banff, Kincardine and Angus. This breed derived from unhorned cattle from those regions. Originally small cattle has been changed to medium size with good parameters of body mass growth and meat carcasses content (Reverter et al. 2000). The history of Angus Red starts in 1878 year in United States when they start to import Angus Black. They perpetuated the red coat trait which is determined by recessive gene. They also provided body size increase (Grodzki et al. 2009, Cruz et al. 2010). The breeding program in Poland maintain the present breed traits as a current body mass, easy calving and strong mother instinct. Adult cows should have 550–600 kg of body mass and 125 cm height at the withers and bulls 800–1000 kg and 130 cm, respectively. Breed pattern indicate that the coat should be uniformly black or red with short or medium length hair. Skin, muzzle, mucous membranes white or red pigmented. Head should be short and well-muscled. Long torso with straight

wide back and deep chest. The abdominal line parallel to the backline. Sternum clearly marked and extended forward. Croup and loin well-muscled and wide. Strong limbs proportional to the body.

Early maturing allows first calving in 24 months old. Average birth body mass for heifers is 32.2 kg and 35.2 kg for bulls. It is important trait which allow easy calving. Following to PZHiPBM (2015) data, 210 days old Angus Black breed achieved 231.7 kg in heifers group and 244.1 kg for bulls with daily gains 933.5 g/day and 934.2 g/day, respectively. Crossbreeding with dairy cows maintain good daily gains and quality of meat (Nadarajah et al. 1984). Crossbreed heifers in first 210 days achieved 931.6 g/day mass growth and bulls 1020 g/day. Better growth results are observed in Angus Red group. This breed was created in United States and is characterized by higher growth speed. PZHiPBM data showed the average daily gain for heifers was 1020.9 g/day and bulls 1142.3 g/day. Results in crossbreed groups with dairy cows were 913.7 g/day and 1014.6 g/day, respectively. Data collected in Poland showed, that cows can provide even 12 lactations, what is very good result. Angus breed is characterized by many positive traits as good slaughter yield, good marbling, soft, tender and juicy meat with small fibers (Chambaz et al. 2003, Muchenje et al. 2009). Grodzki et al. (2009) indicated 70% of slaughter yield for bulls with small content of bones, significant amount of fat in carcasses. Red Angus have also good quality of the meat (Tatum et al. 1990). Breed is mostly kept on pastures rich in herbs, what provide excellent quality of meat (Jasiorowski and Przysucha 2005, Jasiorowski 2011). Population of Angus Black cows under evaluation slowly increasing in last 10 years from 328 heads in 2009 to 527 in 2018 and from (PZHiPBM 2018) but Angus Red cows population is decreasing from 412 in 2009 to 213 in 2018. The main reason of that is domination of French breeds on Polish farms, which are mainly focused on dairy production. Crossbreeding with Angus breeds, gives less profits than other breeds, which can provide higher speed of growth and less fat content in meat, what is not desirable by European customers.

Blonde d'Aquitaine

This breed came from south-west France. Three local breeds were crossed: Garonnais, Quercy and Blonde des Pyrenees and achieve new breed with very high body mass, high daily gains and impressive genetic potential, which can be used in cross with dairy cows. Grodzki et al. (2009) indicated 30 countries where this breed appeared. Many positive traits of this big breed, like good muscles carcasses content, easy calving and early maturing provided growing popularity. Easy calving is important aspect of Polish production which is mainly focused on dairy sector (Keane et al. 2010). The breeding program focuses maintain current parameters. High in withers 142 cm and 600 kg of body mass for cows and 145 cm and 1100 kg for bulls. Polish breed pattern indicate the coat colors from a wheat to slightly red. Hair should be soft and sort, but never wavy. Any color patches are not allowed. Older animals coat is changing to brighter, especially on abdomen and sides. Skin is flexible and soft, medium-thick, pink without pigmentation. Head

is medium-long, rather narrow. Forehead and muzzle are wide. The horns grow horizontally and then bend downwards. The neck is quite short and muscular with a single bulge. Long and wide torso with visible muscles. Wither is well connected and wide. The back is straight and wide. Chest deep and well filled. Loin wide and long. Croup rump with a very well developed musculature, with thick rounded quarters. Abdomen strongly suspended with parallel line to the backline. Limbs are firmly set.

This breed achieved breeding maturity at 15 months old. Fertility and calving are specific trait compared to other large breeds. Keane et al. (1989) indicated that Blonde d'Aquitaine have high growth potential. It stays in agreement with results of this breed documented by PZHiPBM. Heifers and bulls 210 days old achieved very good daily gains 1078 g/day and 1183 g/day, respectively. Those results requires good feed and care of welfare (Grodzki et al. 2009, Listrat et al. 2001). Comparatively big birth body mass is not affecting on difficult calving. New born calves weight 37 kg in heifers group and 40.9 kg in bulls group. Those traits make this breed popular in crossing with dairy cows. Its result also high birth body mass 38.3 kg for heifers and 39.6 kg for bulls and high daily gains 1100.3 g/day and 1138.3 g/day, respectively. Calving problems are rare issue in this breed, what is result of very wide hips of mothers and calves narrow head (Phocast and Sapa 2004). Data collected in Poland showed the best cows has been used eight lactations. Blonde d'Aquitaine is heavy breed characterized by high slaughtering yield, which can exceed 65% and even 1500 g of daily gains (Jasiorowski 1996, Grodzki et al. 2009). Body mass of bulls is around 1200 kg. Listrat et al. (2001) indicated good quality of meat, what is result of good valorization of forage. Jasiorowski and Przysucha (2005) pointed that this breed need intensive feeding and good environment conditions. Meat is tender, with moderate fat content what makes this breed valuable in crossing with dairy cows (Grodzki 2007). Population of this breed is systematically growing up in many countries as a France, where estimated number of heads is about 100,000 cows under evaluation. Polish population of Blonde D'Aquitaine cows under evaluation increased form eight heads in 2009 to 274 heads in 2018 (PZHiPBM 2018).

Charolaise

Charolaise is a beef cattle breed from central France. It is heavy breed from Saone et Loire region. This is the heaviest France breed, which origin is working cattle from Charolaise in Burgundy. This breed was crossed with other breeds, including Shorthorn, Hereford and Angus (Grodzki et al. 2009). This breed is present in 92 countries around the world. Charolaise breed need intensive feeding and care. This docility cattle have high growth potential, adult bulls can growth to 1300 kg and 150 cm high at the withers. Cows can achieve 700–900 kg of body mass and 140 cm high at the withers. Excellent feed and care can provide daily gains at 1300–1400 g. Polish breed program is mainly focusing on increasing weight growth, maintain good milk yield and reject sires with high birth weight trait.

Charolaise breed pattern obtained that the coat should be white, cream and creamy white, other colors are not

allowed. Hairs should be medium length and soft. Allowed is hairy look, skin of medium thickness, clear, without pigment, same as mucous membranes, hatchet, hooves and horns. The head should be short and wide. Mandible should be strongly marked, dark eyes and wide muzzle. Horns of the horned animals should grow sideways from the inter-landscape, than turn forward and rise upwards. Neck have clearly marked muscles especially in adult bulls. The trunk is long, deep, even with a backline and perfectly arched ribs. Shape of pelvis have moderate length and inclination. Thighs fully muscled and rounded with a very well arched back. Limbs rather long with strong bones.

Age at puberty is about 18–24 months old. This late maturing cattle have fertility problems and average ease of calving, recommended is supervising (Przysucha et al. 2018). Average birth body mass in heifers group was 40.2 kg and 43.3 kg for bulls. Following to PZHiPBM (2015) data 210 days old Charolaise breed achieved 266.3 kg in heifers group and 290.2 kg for bulls with daily gains 1084.9 g/day and 1177.3 g/day, respectively. Crossbreed heifers in first 210 days achieved 1073.2 g/day mass growth and bulls 1116.3 g/day. Grodzki et al. (2010) research obtained difficult calving percentage in Charolaise (CH) and Black and White (BW) crossing. Three groups of BW cows with higher Body Condition Score than recommended were crossed with French breed bulls of Limousine (LM), Charolaise (CH) and Blonde d'Aquitaine (BA). Results showed that the lowest percentage of difficult delivers were in CH×BW cross (20%), followed by LM×BW (26.7%) and much worse BA×BW (100%).

Charolaise is a popular breed with excellent meat quality what provide its popularity in Europe. Chambaz et al. (2003) reported that meat is characterized by low fat content, juiciness and tenderness what stays in agreement with Bartoň et al. (2006). This breed is also rich in high value cuts (Fahmy and Lalande 1975). Slaughtering yield can exceed 65% and daily gains 1500 g (Jasiorowski and Przysucha 2005, Nowaczyk 2008, Jasiorowski 1996). Following to PZHiPBM (2018) data, population of Charolaise cows under evaluation in Poland was 1570 heads but constantly decreasing from 2417 heads in 2009. Iwanowska and Pospiech (2010) indicated the reason of this is replacing Charolaise breed by Limousine cattle. However, this is still second most popular breed of beef cattle in Poland.

Hereford

Story of this breed starts in the Hereford shire in west England. Created by crossbreeding local red work cattle with white-head Flander cattle. Benjamin Tomkin started the work on new breed by use a whitehead bull named Silver. Originally small size cattle has been changed to medium size due to USA breeding programs. This is the most worldwide popular beef cattle breed. Hereford was also used to create unhorned Polled Hereford, Braford, Beefmaster, Kazakh breeds and few more mostly in Asia. The reasons of its role in beef production are early maturing, good fertility, easy calving, docility, high daily gains and excellent meat quality (Peripolli et al. 2016, Pesonen et al. 2017, Pogorzelska

et al. 2018). This breed is also characterized by easy adaptation to difficult environment and good forage conversion (Bradley et al. 1966, Rozwadowska 2007, Nowaczyk 2008, Huuskonen et al. 2010). Breeding program focuses on maintain the present easy calving, great mother instinct and early maturing. Adult cows should have 550–600 kg of body weight and 130 cm height of withers and bulls 900–1000 kg and 135 cm. Head, neck, dewlap, belly, part of the tail and ankles should be white. Rest of the coat should be red. Horned animals should have bright horns. Dark colors are undesirable. Dark pigmentation around the eyes occurs often. Skin should be soft and flexible with thick hair. The head quite long, note too wide with slightly prominent keen eyes. Horned animals has a characteristic arrangement of horns descend in arcuately downwards. Neck is quite long, shoulders strong. Sternum is strongly connected and not too wide. Chest straight and well filled. Rounded ribs, wide back and loins. Back and belly line should be parallel. Long and rectangular croup with marked wide muscles. Stem of the tail should be on same height as backline. Thighs wide and muscular, hooves strong and healthy. Hereford age at puberty is 15–18 months old. Mating animals is allowed at this age and results of calving are very satisfying. Average birth body mass for heifer was 31.8 kg and 35 for bulls. Groups 210 days old achieved 246.7 kg and 269.2 kg respectively. Przysucha et. al. (2019) indicated that purebred and also crossbred calves are characterized by relatively high daily gains and it stays in agreement with PZHiPBM (2015) data. Daily gains were 1001.9 g/day for heifers and 1104 g/day for bulls. Crossbreed with dairy cows in Poland result 35.9 kg of birth body weight, 241.5 kg at 210 days old and 952.3 g/day of daily gains for heifers. In bulls group calves achieved 38.2 kg, 264.5 kg and 1029.9 g/day respectively (Papaleo et al. 2016). Hereford meat is characterized by intensive marbling, juiciness and tenderness due its high ground fat and intramuscular fat content (Berg and Butterfield 1966, Miciński et al. 2005, Muir et al. 2010). This popular breed is predisposed to extensive system with good fattening results which can exceed 1000 g of daily gains (Jasiorowski and Przysucha 2005, Muizniece and Kairisa 2017). Carcass important traits are high fat, moderate meat and low bones content and slaughter yield value can be even more than 65% (Guilbert and Gregory 1952, Grodzki et al. 2009). This most worldwide popular breed is not so know in Poland. Polish population of Hereford cows under evaluation was not stable in last 10 years but 1052 heads in 2018 was close to 1042 heads from 2009 (PZHiPBM 2018).

Limousine

Limousine cattle came from Limousine and Marche in central France. Hard environment created many positive features of this breed like good health, condition and adaptability. Those animals are strong and massive what allowed to use them in work. Nowadays it is one of the most worldwide popular breeds. High daily gains and excellent quality of meat guarantee to this breed important position in French cuisine. Characteristic trait of those animals is sustainable development of meat and skeletal development. This is the reason of good bones and meat ratio

in even early slaughtering. This breed is not so polite as others. Cows can react nervously during supervising (Grodzki et al. 2009). Breeding program focuses on maintain the present slaughter performance, body weight, easy calving and milk yield improve. Adult cow should have 600 kg of body weight and 135 cm height of withers and bulls should have 1100 kg and 145 cm. The coat is uniformly red with various shades from light yellow to dark cherry with lighter borders around the eyes and muzzle. Medium thickness, loose and soft skin with soft hair and devoid of pigmentation. Spots and other pigmentation are unacceptable. Small and short head with wide forehead, orbital arches slightly convex. Arched forehead with straight profile, keen, bright eyes and wide muzzle with thick lips. Horned animals have horizontally spread horns at the stem, bending forward at the middle and slightly upward at the end. The neck is short and the withers are not very clearly marked. Long torso, straight backline, deep chest with rounded ribs. Strongly muscular croup with rounded buttocks. Belly with a line almost parallel to the backline. Limbs firmly set and properly proportioned, strong and durable hooves. Limousine cattle is characterized by easy calving, low percentage of calves delivery problems and good daily gains of calves (Comeford et al. 1987). Following the PZHiPBM (2015) data average body birth mass heifers achieved 35.1 kg and bulls 38.3 kg. Body weight of 210 days old was 250.7 kg and 1010.3 g/day for heifers and 272 kg and 1096.6 g/day for bulls. Moreover good results are noticed for crossbreed Limousine and dairy cows. Average birth body mass was 36,4 kg for heifers and 38.4 kg for bulls. Animals 210 days old achieved 246.5 kg and 989.6 g/day for heifers and 266.9 kg and 1078 g/day for bulls. This breed is also good to use in crossbreeding because of semen with muscles hypertrophy trait. Polish cattle sector is mainly focused on dairy production and Limousine is good fathers lane to produce beef from crossbred calves (Nogalski et al. 2016). This breed is characterized by high content of meat, low content of fat in and low content of bones carcasses. Those traits provide good results in EUROPE classification (Wajda et al. 2004, Miciński et al. 2005) and excellent quality of meat (Keane et al. 1989, Alberti et al. 2008). Daily gains can exceed 1300 g and 67.5% slaughter yield. Grodzki (2008) reported that meat content in carcasses can achieve 75%. This breed shows muscles hypertrophy trait (Grodzki et al. 2009). Following to PZHiPBM (2018) data Limousine is most popular breed and count 13 893 cows under evaluation. Popularity of this breed in Poland can be observed in population changes. From 2009 to 2018 we could observed that population constantly increasing from 9995 heads to current 13,893 heads.

Simental

Simmental cattle is Switzerland old breed. Name of this breed comes from the Simme river in Canton of Bern. First information's about this breed came from XIII century. Good climate conditions, landform and working use determinate many positive traits in this breed. It is characterized by good wholesomeness, easy adaptation to difficult conditions, good feed conversion and three profiles of use. This cattle split on dairy use

profile, beef production and mixed. This is one of the most popular breeds on the world. Currently they are on five continents in the number of more than 40 million heads. This breed was also used to improve other breeds and create some new like Simbrah or Simbrasil (Choroszy and Choroszy 2006, Lukic et al. 2017). Breeding program indicate to develop growth and muscular features. Cows should keep their maternal characteristic and milk yields on currently level. Adult animals should have 750 kg of body mass and 143 cm height at the hip as a cow and 1300 kg and 150 cm as a bull. The coat is yellow-brown to cherry in various shades in combination with white spots. Head, dewlap, sternum, abdomen, lower parts of the limbs and tail end usually white, the ability to change the proportion of white patches, especially behind the shoulder blades and on the sides. The continuity of colored surfaces is desirable without being divided in to small patches or spots. Soft hair, light and elastic skin with medium thickness. The muzzle, tongue, palate and hooves are pale pink. The horned variety has white or yellowish corners, darker on the ends. Construction is rather longhead with a straight profile with a wide forehead and a wide, non-pigmented muzzle. Eyes large, keen with a bright border. Horns in the variety of horned cows at the base, the flattened deflects outwardly towards the front, and the ends facing upwards, horizontal and thick in bulls. Moderate muscled neck with medium length, deeply developed reaching up to the sternum, especially in bulls. Loosely bound strong shoulders, leaning slightly at the withers. Withers broad, medium tall, well-muscled long and straight. The back is wide, straight and well-muscled. Loins are medium wide, straight and long. Chest deep with well arched ribs. Mid-wide pelvis, slightly tilted back. Croup slightly rise Towards the rear. Tail of medium length, acceptable tall and thick steam. Limbs Strong and tough. Simmental is late maturing breed. Big body birth mass can determine calving problems. Following the PZHiPBM (2015) data average body birth mass heifers achieved 30.6 kg and bulls 32 kg. Body weight of 210 days old animals was 276.1 kg and 1200.8 g/day for heifers and 320.2 kg and 1380 g/day for bulls. Those results were highest of all breeds. It showed how big genetic potential have this breed. Moreover good results were achieved in crossbreeding with dairy cows. Birth body mass in this group was 31.6 kg in heifers group and 32 kg for bulls. 210 days old animals achieved 241 kg and 982.7 g/day for heifers and 279 kg and 1197.9 g/day for bulls. Slaughter yield for this breed can exceed 60% with 1400 g of daily gains. Carcass consist of moderate amount of bones and fat and high content of meat (Jasiorowski et al. 1996, Jasiorowski and Przysucha 2005, Choroszy and Choroszy 2008). Adult bulls weight can be 1200 kg and its require intensive feeding. Meat is flavorful and like meat from other breed with more intensive marbling (Mandell et al. 1997, Mandell et al. 1998, Sami et al. 2004, Bel'kov and Panin 2011). Following to PZHiPBM (2018) data cows under evaluation was 368. Dairy profile production of this breed is more popular in Europe what explains population decline in this profile. Wajda et al. (2006) indicated positive results from crossbreeding with dairy cows what provide profitability for breeders.

Belgian Blue

The father of this breed was the bull named Gédéon du Vieux-Château de Maurenne. Muscles hypertrophy was spread in Belgian cattle population and result in very well-muscled beef cattle breed named Belgian Blue. Nowadays Belgian Blue breed is popular in many countries around the world. Easy adaptation to new environment, good growth potential and good feed conversion allowed to this breed become a popular in crossbreeding with dairy cows (Grodzki et al. 2010). Breeding program focuses on fertility increase and easier calving, decreasing of calves birth body weight and increasing of their health. Body mass of mature cows should be 700–900 kg and 138–145 cm height of the withers. For bulls 1100–1200 kg and 145–150 cm respectively. The coat can be white, blue and black. Combination of these colors is acceptable. Head and body is wide and massive with very well muscles. Muscles hypertrophy is characteristic for this breed (Biagini and Lazzaroni 2005). Posture is strong and look impressive. Belgian Blue is late maturing breed. First calving is recommended in 32 months old cows. Calves characterized by high birth body mass are delivered mostly by cesarean section. Grodzki (2009) indicated 44 kg of birth body mass for heifers and 48 kg for bulls. Pure bred animals can achieve 1300–1500 g of daily gains. This breed is often used in crossbreeding with dairy cows. PZHiPBM (2015) reported that crossbred calves achieved 41.6 kg for heifers and 51.8 kg for bulls. 210 days old animals weight was 291.6 kg with 1164.0 g/day of daily gains for heifers and 350.0 kg with 1184 g/day for bulls respectively. These were the highest results of all records for crossbred calves in Poland reported in that year. Belgian-Blue is one of the newest breeds. In Poland its mostly used in crossing with dairy cows to improve quality of meat and carcass values. Good feed conversion, low content of bones and fat in carcasses and excellent slaughter yield makes this breed very efficient to mating dairy cows (Grodzki et al. 2009). Daily gains can exceed 1500 g/day and 70% of slaughter yield (Nowaczyk 2007). Biagini and Lazzaroni (2005) indicated characteristic body conformation in this breed as good shape of carcasses, high body weight and well-muscled hind-quarter. This breed have also high EUROP classification ratio. In 2018 there was no cow under evaluation (PZHiPBM 2018). This breed is not popular in Poland due of calving problems in purebred breeding. Semen is imported to Poland and use to cross with dairy breeds.

Galloway

Is the oldest cattle kept in Great Britain and it has been bred in Scotland for centuries. Nowadays its popularity decreased and its replaced by others breed with better parameters of growth speed and feed conversion. This small size cattle is genetically unhorned. Docility, good fertility and tolerance for difficult environment makes this breed easy to breeding. (Szewczyk 2008). This breed is predisposed to good feed conversion even with low quality of feed with no barn or shed (Grodzki 2009). Breeding program focuses on maintain good fertility, easy calving and good health of calves before weaning. Cows should have 420–680 kg of body mass and 125 cm height of withers and bulls 750–

−1050 kg and 130 cm. This medium size cattle should have compact body structure and good musculation. The coat is uniformly black, dark red, brown, dark yellow. This breed have no horns, medium length hair which become downy in winter season. Head is small, medium length with wide forehead, pigmented muzzle and small eyes. The neck is short and well-muscled. Back is wide and parallel to abdominal. Loins are wide, croup medium long and well-muscled. Limbs are strong, proportional to the logs. Healthy and though hooves. Wide white belt behind ribs is allowed. Age at puberty is 15 months and it is good moment to first mating. Easy calving, good fertility and good calves wholesomeness reduce owner supervising to minimum. Following to PZHiPBM (2015) data birth body mass of calves was 29.2 kg for heifers group and 30 kg for bulls. Low body mass of calves provide very easy calving. 210 days old records showed 237.8 kg of body mass in heifers and 248.5 kg for bulls. Daily gains were 1004.7 g/day and 1087.3 g/day respectively. Crossbreeding data was not completed. White et al. (1934) research showed that the crossed Holstein and Galloway cattle achieved 41.3 kg of weight in bulls group and 38.6 kg in heifers group. Galloway is small size breed predisposed to extensive breeding systems what provide high quality of meat. Grodzki et al. (2009) indicated 57% of slaughter yield and 1000 g of daily gains for this breed. Ground fat and bones content in carcasses are low however intramuscular fat content is high and its guarantee good marbling, juiciness and tenderness and have good PUFA n-3/n-6 ratio (Dransfield et al. 1984, Nürnberg et al. 1999). PZHiPBM (2018) inform about 22 cows under evaluation what is slightly higher value than 3 heads in 2009. Grodzki et al. (2009) indicated 13 countries where it is currently present and the total population is about 40,000 heads.

Highland

Highland is one of the oldest currently using cattle breed. From many centuries this docility animals were grazing on north and west Scotland mostly in Perth, Inverness and Ayrshire shires and Hebrides Islands. This small size breed characterized by long hair and impressive horns very popular attraction in Polish Agritourism Farms. Docility, attractive look and low feed storage requirements makes Highland more and more popular in this sector and live with other animal species in same place. Difficult conditions Scotland make this breed flexible in adaptation what allows them to live in low temperatures without feed intake decrease and with no difficult calving. All of those traits determined the presence of this breed in North and South Americas, Europe and Australia (Śmiełowski 2007, Nowaczyk 2008, Grodzki et al. 2009). Breed program focuses on maintain good fertility, easy calving and great health. Body mass of cows is 400–500 kg and 105 cm height of withers and 650–800 kg and 125 cm in bulls. The coat of this breed have many variations from light brown, red, black to white and silver color. Long horns can achieve 1.5 m of length. Double hair coat is long and thick on outer and soft and fluffy inner. On the head hair cover eyes and even muzzle what is characteristic to this breed. Skin is elastic and soft.

Head proportional to body size, wide forehead and hide dark eyes under wide and long forelock. Muzzle is wide and pigmented. Bull horns are massive and horizontally extended from the head than turning forward and downwards. Cow horns protrude more or less horizontally beyond the head and raised. Posture and body structure is wide and looks massive. Limbs are broadly spaced with a fairly thick bone. Hooves are strong and large. It is the result of long breeding work started at XVIII century. This is early maturing breed and first mating are allowed at 15 month old. This breed is characterized by docility and strong mother instinct. Cows are very caring and calves wholesomeness allows to calving even at –25°C degree. Following to PZHiPBM (2015) data birth body mass for heifers group was 25.4 kg and 26.6 kg for bulls. 210 days old animals achieved 158.6 kg of body mass for heifers and 166.5 kg for bulls. Daily gains were 637 g/day and 644.7 g/day respectively. Crossbreeding with dairy cows results in 26.8 kg of birth body mass in heifers group and 28.2 kg in bulls group. In 210 days old groups heifers achieved 177.8 kg of body mass and 174 kg for bulls. Daily gains were 684.3 g/day and 698.8 g/day respectively. Those results make this breed not attractive in crossbreeding with dairy cows. This small size breed is characterized by excellent quality meat what has been appreciated by royal British family. Fattening period can be twice longer than other breeds because of low daily gains and it can be even 36 months. Ground fat content is low but marbling is significant what provide tenderness, juiciness and tastiness. Average daily gains are 800 g/day. Bones and ground fat content in carcasses are small but the meat content is high. Slaughter yield is about 60% (Jasiorowski et al. 1996, Jasiorowski and Przysucha 2005, Nowaczyk 2008, Grodzki et al. 2009). PZHiPBM (2018) data informed about 156 cows under evaluation in Poland.

Piemontese

This is old Italian breed from Lombardia and Ligurii regions. To achieve good results from cattle grazing cattle should be strong and have not many feed requirements. This part of Italy is characterized by hot and dry summers and difficult winters. In breeding was used zebu from Pakistan. Those factors and breeding programs determined medium size and well-muscled Piemontese cattle.

Almost whole population have muscles hypertrophy what is exposed on hindquarters. Part of cows population use to milking. Milk have specific composition what is used to produce parmesan cheese (Rogala 2008). Breeding program focuses on maintain current parameters. Cow high of hip should be 140 cm and bulls 145 cm. Body mass 600 kg for cows and 1100 kg for bulls. Bulls coat should have gray or salmon color with black hair on head, neck, shoulders, limbs and sometimes on sides. Cows coat is white or bright salmon. Gray discoloration is allowed. Young calves have strong salmon color hair. Dark pigmentation occurs on mucous membrane, tongue, palate, cheeks, ears, eyelashes, eyelids, foreskin, scrotum, labia and hooves. Horns are black until 20 months of age. Skin is soft and elastic. Bulls head is shorter and wider than cows. Forehead is flat and a bit recess between eyes. Ears are not big, big black

eyes and wide nose. Bulls have wide and well-muscled neck. Body structure is massive and wide. Limbs are strong and hooves are clenched and though. First mating is allowed at 16–18 months old. Big problems in this breed are high percentage of calving with human assist and not good wholesomeness of calves. Due to those issues this breed is not good in extensive systems. Intensive production allow to achieve good production results and calving supervising. Cows mostly produce more milk than calves need so it is also use in dairy production for famous Parmesan cheese. Following the PZHiPBM (2015) data average body birth mass heifers achieved 35.1 kg and bulls 36.6 kg. Body weight of 210 days old was 224.4 kg and 891.3 g/day for heifers and 240.9 kg and 1001 g/day for bulls. Piemontese cattle is also use in crossbreeding with dairy cows. Average birth body mass was 35 kg for heifers and 42.5 kg for bulls. 210 days old animals achieved 251.45 kg and 1025.1 g/day for heifers and 266.7 kg and 1158,3 g/day for bulls. Piemontese is characterized by high daily gains (1000 g/day), excellent laughter yield (70%) and low fat and bones content in carcasses (Tatum et al. 1990, Jasiorowski et al. 1996, Grodzki et al 2009). Meat is tender even with low marbling (Davies et al. 1992). Other important aspect is low cholesterol content what is important for consumers. This breed also occurs muscles hypertrophy (Jasiorowski and Przysucha 2005). Following to PZHiPBM (2018) data 19 cows were under evaluation.

Salers

This breed came from south region of France where its population is mainly concentrate. This big size cattle is characterized by low feed requirements and environment resistance. Moreover, docility, strong mother instinct, easy calving and good milk yield makes this breed good as mother line in crossbreeding with big beef cattle breeds. Breeding program focuses on achieving 600–650 kg body mass and 135–140 cm hip height of mature cows and 950–1050 kg and 145–150 cm for bulls respectively. The coat should be uniformly mahogany red. Thick skin should have brown pigmentation with brighten eye round and muzzle. Dark coat and skin pigmentation is acceptable. Head should be narrow with triangular shape. Horned animals have lyre shape, un horned individuals are acceptable Neck is long and massive, back wide and flat. Lumbar region massive and muscled. Chest convex especially in bulls. Back and stomach lanes almost parallel. Limbs muscled and strong. Salers cattle is late maturing, long-live breed with good fertility and easy calving. Grodzki et al. (2009) indicate that less than 5% of calving require human assistance. Following the PZHiPBM (2015) data average body birth mass heifers achieved 29.1 kg and bulls 31.1 kg. Body weight of 210 days old was 249.2 kg and 1103.3 g/day for heifers and 274.6 kg and 1214.8 g/day for bulls. Salers cattle is also use in crossbreeding with beef cattle bulls. Crossbreeding with dairy cows is not popular. Birth body mass in this group was 42.5 kg for bulls. Animals 210 days old achieved 244 kg and 972 g/day for heifers and 265 kg and 1036.3 g/day for bulls. Salers meat is characterized by juiciness and tenderness due to high content of intramuscular fat and ground fat. Intensive

marbling provide flavorful product for customers (Nowaczyk 2008). Slaughter yield is 57% and daily gains can achieve 1300 g (Jasiorowski and Przysucha 2005, Jurie et al. 2007). Adult bulls weight can be 1200 kg (Grodzki et al. 2009). Following to PZHiPBM (2018) data cows under evaluation was 132.

Welsh Black

Welsh Black breed is came from Wales region. This medium size cattle is characterized by good health, easy calving and docility. Easy adaptation to difficult environment. Breeding program indicate adults cows body mass around 500 kg and 130 cm height of withers. Very good maternal instinct should be kept. The coat should be black, only small amount of white hairs are allowed on udder of scrotum. Other white hairs are not allowed. During winter the coat can change his color on dark born especially in calves. Skin and muzzle are black. Horns are bright yellow and dark on tips. Head is quite light, short and wide, well-muscled. Back line is straight, ribs strongly arched, deep chest. Abdomen is large and deep. Loins and croup are long and wide. Following the PZHiPBM (2015) data average body birth mass of heifers achieved 31.4 kg and bulls 36.5 kg. Body weight of 210 days old animals was 230.5 kg and 870 g/day for heifers and 235.3 kg and 874.6 g/day for bulls. Birth body mass in crossbreed groups were 31.1 kg in heifers group and 34.7 kg for bulls. Animals 210 days old achieved 216.7 kg and 848.8 g/day for heifers and 241 kg and 931 g/day for bulls. Welsh black not require high quality forage and buildings and its mostly grazing. Good feed conversion makes meat very juicy and flavorful due to intensive marbling and high fat content. Carcass consist of moderate bones and meat content, high fat content. Daily gains can achieve 1000 g and body mass of adult bulls can exceed 1000 kg (Szewczyk 2008, Grodzki et al. 2009). Following to PZHiPBM (2018) data in Poland was 31 cows under evaluation. Low popularity of this breed is connected to dairy profile of farms where cross breeding with Welsh Black did not provided satisfying results.

SUMMARY

The breed is an important factor in the production of beef cattle due to its connection with the profitability of production and the quality of raw material. Individual breeds are characterized by better or worse conversion of feed, various living requirements, increments, slaughter efficiency, fatness and fertility. The gradual development of meat cattle production has a positive impact on the quality of the available raw material. The breeds described in the article offer a wide range of applications from intensive to extensive breeding and crossbreeds with dairy cattle.

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Streszczenie:
Rasy bydła mięsnego w Polsce: Zróżnicowanie w obrębie ras bydła mięsnego dostępnego obecnie dla hodowców daje możliwość osiągnięcia pożądanych celów hodowlanych i efektywnego wykorzystania dostępnych w gospodarstwie zasobów paszowych. Poziom spożycia wołowiny w Polsce obecnie oscyluje na poziomie ledwie przekraczającym trzy kg na osobę rocznie. Dawniej spożycie wynosiło blisko 18 kg na osobę rocznie. Jednym z powodów tak drastycznego spadku spożycia wołowiny był gwałtowny rozwój produkcji trzody chlewnej oraz drobiu, co spowodowało spadek ich cen i marginalizację udziału mięsa wołowego w diecie Polaków. W celu zwiększenia rodzimej produkcji należy poprawić jakość mięsa dostępnego w sklepach oraz promować wiedzę pośród konsumentów dotyczącą licznych wartości odżywczych wołowiny. Trudna sytuacja na rynku zmusza hodowców do nowych kierunków rozwoju. Omówione rasy mogą znaleźć zastosowanie w wielu Polskich gospodarstwach, a ich popularyzacja może korzystnie wpłynąć na jakość mięsa dostępnego w sklepach oraz efektywniejsze wykorzystanie zasobów paszowych.

Słowa kluczowe: bydło, rasy, bydło w Polsce

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Using Corine Land Cover to predict habitats occupied by moose *Alces alces*

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Abstract: *Using Corine Land Cover to predict habitats occupied by moose Alces alces.* The aim of the study is to assess the possibility of predicting the habitats occupied by moose on the basis of Corine Land Cover. The second aim was to assess whether the impact of the structure of land cover on the population density of moose can change over time with an increase in population numbers. The data for analysis was the number of moose in 293 hunting districts assessed each year in spring in Podlaskie Voivodship. The data covered ten years from 2010 to 2019. The boundaries of each hunting district were compared to the Corine Land Cover layer, and the share of each type of coverage was calculated. The impact of cover types on moose numbers was analyzed in generalized linear models. The moose population showed a distinct increase of population numbers over the last 10 years in the Podlaskie Voivodship. In all the analyzed years, four cover types explained the distribution of moose. The numbers of moose decreased along with the increasing share of arable lands, but was positively related to the presence of inland marshes and share of deciduous forest. In 2010 and 2011, additionally two cover types explained the distribution of moose in the models, similarly in 2019. Obtained results show that the current range of moose in the Podlasie Voivodeship allows the reliable prediction of its numbers on the basis of Corine Land Cover. Impact of some cover types has changed with time.

Key words: *Alces alces*, density, cover types, Corine Land Cover, hunting districts

INTRODUCTION

The size of the moose population is highly variable over last 200 years due to the fact that this species is exploited, but then it recovers. By the mid-nineteenth century, this species was extinct throughout Central and Western Europe; in Poland, it remained only in the forests near Rajgrod (Raczyński and Ratkiewicz, 2011). According to Dzięciołowski and Pielowski (1993), the size of the moose population increased several times during the interwar period, but then there was a drastic decline during World War II (Raczyński 2006). In 1952, this species was under protection, which brought an increase in population numbers (Świsłocka 2014); since 1967, it has been included again in the list of game species. Another decline in the population size resulted in the introduction of a moratorium on the hunting of moose in 2001. Since then, a significant increase in the population size of this species has been recorded, especially in the northeastern part of Poland (including the Biebrza Valley) (Raczyński 2006, Ratkiewicz 2011, Wawrzyniak 2016), which is home to

70% of the Polish population (Świsłocka 2014). At present, the western border of the moose range runs through Poland (Ważna et al. 2014).

The increase in the moose population is associated with its impact on the environment and the human economy. In the area of the Regional Directorate of State Forests in Białystok, moose was responsible for about 30% of significant damage to forests in 2011, and 36% in 2015. In young forest stands, moose browse trees and cause around 60% of all significant damage to them (Ratkiewicz 2011, Wawrzyniak 2016). Animals of this species chew pine shoots on plantations, which affects the trees' growth and shape. In older stands, moose strip bark off trees. Despite the use of various forest-protection measures (including chemical and mechanical protection of trees), the amount of damage is constantly increasing. Moreover, according to Wawrzyniak (2016) the natural forest protection measures used so far are no longer effective. In 2015, in four Regional Directorates of State Forests (Białystok, Olsztyn, Lublin, Warsaw), the value of the damage caused by this species amounted to EUR 3.4 million (Wawrzyniak 2016).

The effect of the increasing number of moose is that they move to new habitats that are not always optimal for this species; nevertheless, the distribution of moose on a regional scale varies, even in the main moose refuge in the Podlaskie Voivodship (Wawrzyniak 2016). Understanding the colonizing mechanisms and factors that limit the presence of moose is necessary for the proper management of this species and to determine optimal population size. The aim of the study is to assess the possibility of predicting the habitats occupied of moose on the basis of Corine Land Cover (https://land.copernicus.eu). The second aim was to assess whether the impact of the structure of land cover on the population density of moose can change over time with an increase in population numbers.

MATERIAL AND METHODS

The data for analysis was provided by the Polish Hunting Association Research Station in Czempiń. The number of animals in each hunting district was assessed each year in spring by counting the moose population in hunting districts in Podlaskie Voivodship on the area of. The analyzed area covered 20,187 km^2 (http://www.gios.gov.pl). The data covered four years: 2010–2011 and 2018–2019. Moose numbers in each hunting district were combined with the boundaries of the districts in shapefile format. In total, we analyzed data from 293 hunting districts (Fig. 1).

The boundaries of each hunting district were compared to the Corine Land Cover layer, and the percentage share of each type of coverage was calculated. For the further analysis, we used cover types that occurred in at least 10% of the districts. Cover types that occurred in less than 30% of the districts were transformed to a grouping (categorical) variable (with the presence or absence of this cover type) to avoid zero-inflated variables. Two cover types were transformed into categorical variables: "Industrial or commercial units" and "Inland marshes". In total, we analyzed 12 cover types: 1) broad-leaved

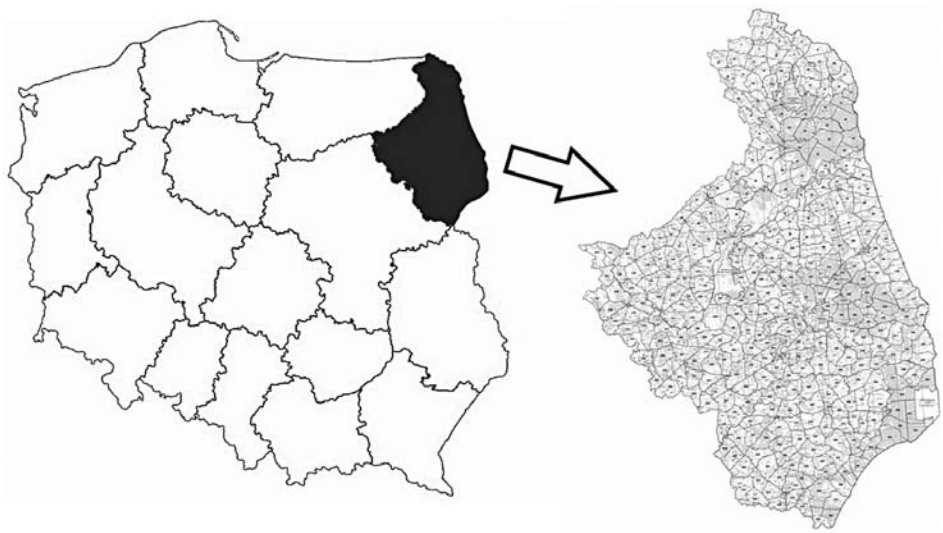

FIG. 1. Study area with marked hunting districts
Source: https://fotoomnia.pl and http://www.gminalomza.pl

forest, 2) complex cultivation patterns, 3) coniferous forest, 4) discontinuous urban fabric, 5) industrial or commercial units, 6) inland marshes, 7) land principally occupied by agriculture, with significant areas of natural vegetation, 8) mixed forest, 9) non-irrigated arable land, 10) pastures; 11) transitional woodland-shrubs; 12) water bodies.

The impact of cover types on moose numbers was analyzed in generalized linear models because the dependent variable (moose numbers in each hunting district) was not normally distributed. Using Akaike criterion information (AIC), we compared various distributions to find the best-fitting model. Finally, we used tweedy distribution with the log link function. To select set of variables in each model we compared various model types and a null model to achieve the best-fit model using AIC in a backward elimination procedure. In this procedure, we started by including all 12 variables in the model and evaluated the change of the AIC value after removing the variables. The model with the lowest AIC value was selected. We also used a pairwise comparison with Bonferroni adjustment of groups in factors that were statistically significant in the model.

RESULTS AND DISCUSSION

The moose population showed a distinct increase of population numbers over the last 10 years (2010–2019) in the Podlaskie Voivodship. The population was estimated to be 2,277 individuals in 2010. Since then the population has more than doubled and there were 5,047 individuals in 2019 (Fig. 2). At the same time, the proportion of hunting districts occupied by moose increased from 76% to around 95% (Fig. 3).

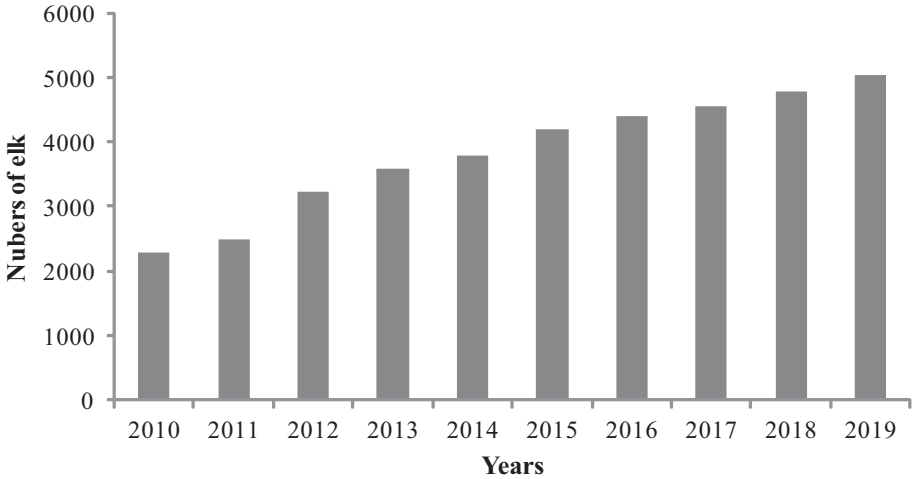

FIG. 2. Moose population numbers in 2010–2019 in Podlaskie Voivodeship (analyzed hunting districts)
Source: Polish Hunting Association Research Station in Czempiń.

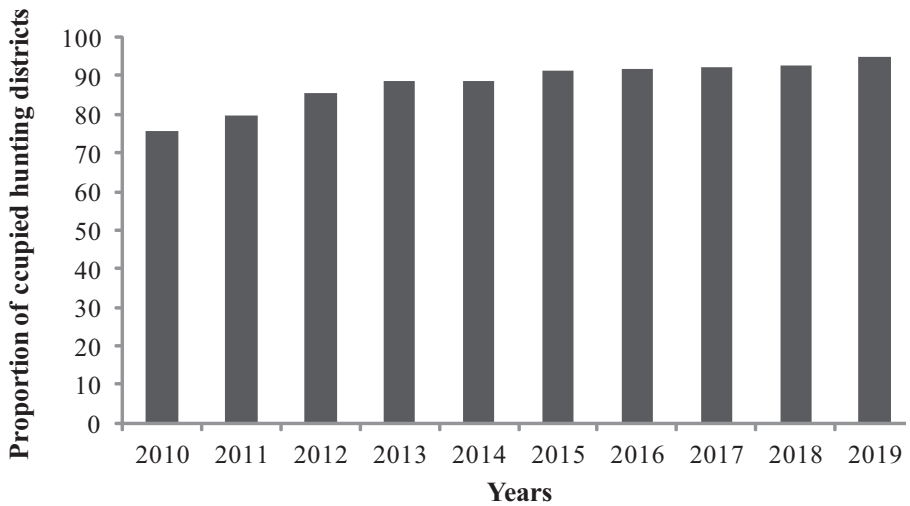

FIG. 3. Proportion of hunting districts occupied by moose in 2010–2019 in Podlaskie Voivodeship (analyzed hunting districts)

Source: Polish Hunting Association Research Station in Czempiń.

In all the analyzed years, four cover types explained the distribution of moose (Table 1). Moose numbers were positively related to the presence of inland marshes (negative B-value to the lack of Inland marshes; F_Inland marshes = 0). The numbers of this species also decreased along with the increasing share of arable lands expressed by two cover types: "land principally occupied by agriculture, with significant areas of natural veg-

TABLE 1. Effects of generalized linear models of moose numbers and land cover (from Corinne Land Cover) in years, 2010–11 and 2018-2019; *B*-values of each cover type are shown in the table. Each row presents model effects for one year; * = statistically significant.

Source	2010	2011	2018	2019
[F_Industrial or commercial units = 0]				0.334*
[F_Inland marshes = 0]	–0.445*	–0.487*	–0.410*	–0.433*
Broad-leaved forest	5.464*	4.411*	2.830*	2.521*
Land principally occupied by agriculture, with significant areas of natural vegetation	–3.131*	–3.649*	–2.111*	–1.476
Non-irrigated arable land	–2.605*	–2.547*	–1.797*	–1.803*
Pastures	1.217*	1.104*	0.730	
Transitional woodland-shrubs	–7.203*			
Complex cultivation patterns				–3.879*
Water bodies				
model statistics				
$\chi 2$	149.46	158.47	133.14	136.60
df	6	6	5	6
p	<0.001*	<0.001*	<0.001*	<0.001*

etation" and "non-irrigated arable land" (negative B-values in all cases). Moose numbers were positively related to the share of broad-leaved forest (positive B values in all cases). B coefficient of other forest types were not statistically significant and variables were excluded during the backward elimination procedure. In 2010 and 2011, two cover types were significant in the models: moose numbers were positively related to the share of "pastures" (B = 1.217 for 2010 and B = 1.104 for 2011) and negatively to "transitional woodland shrubs"(B = –7.203 for 2010 and B = –5.239 for 2011); however, B coefficient of these cover types were not significant in the following years. In 2019, which was the last year of analysis, moose numbers were negatively related to the presence of "industrial or commercial units" (positive B value to the lack of Industrial or commercial units; F_ Industrial or commercial units = 0) and "complex cultivation patterns" (B = –3.879).

The obtained results show that Corine Land Cover can predict habitats occupied by moose in specific hunting districts. The presence of moose was positively related to the presence of inland marshes and the proportion of deciduous forests in all the studied years. Moose mainly prefers swamps, vast forests, peat bogs and willow-birch thickets (Gębczyńska and Raczyński 1984, Heikkilä et al. 1996, Raczyński 2006, Sokół 2009, Ratkiewicz 2011). Its diet consists of deciduous trees such as birch, which are browsed all year round, but also willow and aspen (Morow 1976, Hjeljord et al. 1990, Heikkilä et al. 1996). Poole and Stuart-Smith, 2005). These tree species are characteristic of swampy deciduous forests and explain the positive relation between the occurrence of moose and the higher proportion of deciduous for-

ests. In the Biebrza National Park (the main moose refuge), as much as 30% of the area is covered by alder stands, and 29% mixed boggy forest (https://www.biebrza.org.pl/47,lasy).

In winter, after the first frost and snowfall, moose usually move to pine forests, mainly the younger age classes (Gębczyńska and Raczyński 1984, Gębczyńska and Raczyński 1997). However, coniferous forests did not represent a significant variable in any of the models, even though pine needles and shoots are one of the main components of the moose diet in winter (Morow 1976, Heikkilä and Härkönen 1993, Sokół 2009, Ratkiewicz 2011). In our opinion, this was an effect of the common presence of this cover type. Coniferous forest is dominant in the study area and does not limit the numbers of moose.

The moose makes long migrations, often to areas that were not previously inhabited by this species, thus resulting in the gradual extension of its range (Raczyński 2006). This may be the reason for the decrease in the negative relation between moose numbers and arable land (for non irrigated arable land: B= –2.605, B= –2.547 for 2010 and 2011 respectively, and B = –1.797, B = –1.803). Moose use arable land because it offers easy access to high-energy food (Flis 2018, Dziki-Michalska et al. 2019). In our results, however, moose avoided arable lands with and without a significant share of natural vegetation. Over the studied years, a negative relation was demonstrated between moose numbers and the proportion of two types of cover that represent arable lands: "land principally occupied by agriculture, with significant areas of natural vegetation" and "non-irrigated arable land". In the last year of the study, the "complex cultivation patterns" cover type also limited the occurrence of moose. However, forest is the main habitat for moose, and arable lands offer only supplementary food. A hunting district with a significant share of this type of coverage will therefore have less habitat capacity for this species. However, the lower B-values in 2018 and 2019 indicate overpopulation of moos in this region and occupation of suboptimal habitats.

In 2010–2011, moose numbers were positively impacted by the presence of pastures and negatively by "transitional woodland shrubs". Moose was not as widespread during the given years and reached the highest density in the Biebrza valley (Ratkiewicz 2011, Świsłocka 2014). Domestic livestock pastures are concentrated mainly around Biebrza National Park, even in the hunting districts. Hence, the greater importance of this cover type was the result of a clear predominance of moose in this region. Successional plant communities, represented here by "transitional woodland shrubs", are the food base for moose, particularly in the early stages of growth (Morow 1976, Gębczyńska and Raczyński 1984, Raczyński 2006). However, unlike pastures, the "transitional woodland shrubs" cover type was dispersed in other regions, and its share in the vicinity of the main moose refuge was insignificant. In 2019, industrial or commercial units had a negative impact on the number of moose. The results, therefore, indicate that the moose spread extends to suburban areas where this type of coverage usually occurs. This also indicates that moose tend to occupy

suboptimal habitats as result of the overpopulation.

CONCLUSIONS

It can be concluded that the current range of moose in the Podlasie Voivodeship allows the reliable prediction habitats occupied by moose on the basis of Corine Land Cover. As shown, analysis of moose occurrence in 2010–2011 could lead to erroneous assessments of the importance of individual habitats due to the concentration of the population around the main refuge. We have shown 1) a positive relation between numbers of moose and inland marshes or deciduous forests, and 2) a negative relation between numbers of moose and arable lands or industrial commercial units. However the significance of the last group indicate that moose tend to occupy suboptimal habitats as result of the overpopulation in Podlasie Voivodeship.

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Streszczenie: *Wykorzystanie Corine Land Cover* do przewidywania środowisk zasiedlanych przez łosia *Alces alces*. Celem pracy była ocena możliwości przewidywania środowisk zasiedlanych przez łosia na podstawie Corine Land Cover. Drugim celem była ocena, czy wpływ struktury pokrycia terenu na zagęszczenie populacji łosia może zmieniać się w czasie wraz ze wzrostem liczebności tego gatunku. Materiał do analizy stanowiły dane o wiosennej liczebności łosi w obwodach łowieckich województwa podlaskiego. Dane obejmowały 10 lat od 2010 do 2019 roku. Granice każdego obwodu łowieckiego porównano z warstwą Corine Land Cover i obliczono procentowy udział każdego rodzaju pokrycia terenu. Wpływ rodzajów pokrycia terenu na liczebność łosi przeanalizowano w uogólnionych modelach liniowych. Populacja łosi wykazała wyraźny wzrost liczebności w ciągu ostatnich 10 lat w województwie podlaskim. We wszystkich analizowanych latach cztery typy pokrycia terenu objaśniały rozmieszczenie łosia. Liczebność łosi malała wraz z udziałem pól uprawnych, ale była pozytywnie powiązana z obecnością bagien i mokradeł śródlądowych oraz udziałem lasów liściastych. W latach 2010-2011 dwa inne typy pokrycia objaśniały występowanie łosia, podobnie w roku 2019. Uzyskane wyniki pokazują, że obecne występowanie łosi w województwie podlaskim pozwala na wiarygodne prognozowanie jego liczby na podstawie Corine Land Cover. Wpływ niektórych typów pokrycia uległ zmianie w czasie.

Słowa kluczowe: *Alces alces*, zagęszczenie, typ pokrycia, Corine Land Cover, obwody łowieckie

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Hematological Parameters of the ovine breed of Rembi in Tiaret, Algeria

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Abstract: *Hematological Parameters of the ovine breed of Rembi in Tiaret, Algeria.* The aim of this study was determine the influence of short and long days, age, sex, and phase of pregnancy status on hematological parameters in the ovin breed of the Rembi raised in Tiaret, Algeria. One hundred seventy two (172) cross-breed Rembi sheep (104 females and 68 males), from 2018 to 2019, aged between three months and four years old were used sheep were sampled in the short and long days. The age, sex, and phase of the pregnancy status were noted. Jugular blood samples were collected via vacutainer tubes with (EDTA) early in the morning and brought to the laboratory within two hours for analysis. In all samples, the number of white blood cells (WBC), red blood cell (RBC), packed cell volume (PCV), haemoglobin (Hb), mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration(MCHC), Lymphocytes, Monocytes, and polynuclears were determined. In our study, the sex had a significant effect ($P < 0.05$) on monocytes with 1067.29 ±1223.33 for males and 422.08 ±272.78 for females but in the yearling male and female we haven't a significant effect, the phase of pregnancy had a significant effect ($P < 0.05$) on WBC, MCH, MCHC , Polynuclears and Lymphocytes with 6738 ±1949.84(/ml), 14.71 ±4.13 pg, 37.39 ±9.99 g/dl, 1592.01 ±486.37/mm^3 and 4702.76 ±1837.53/mm^3 in the early pregnancy and 7046.36 ±3576.76/ml, 13.22 ±2.48 pg, 33.21 ±5.40 g/dl, 2282.05 ±1145.00 / / mm^3 and 4057.34 ±3425.06/mm^3 in the late pregnancy respectively. The short and long days had a significant effect ($P < 0.05$) on RBC, Hb, PCV, plynucears and monocytes with 6.57 ±1.30 × × 10^6/L, 9.17 ±1.06 g/dL, 25.87 ±5.16, 2799%, 92 ±1714.17/mm^3, and 486.2 ±395.41/mm^3 in the short days, and 7.18 ±1.85 × 10^6/L, 9.75 ±1.31 g/ /dL, 28.57 ±6.96% 2343.27 ±1088.69/mm^3, and 1662.07 ±1224.38/mm^3, in the long days respectively. For the different stage of age between three months for 72 months we had a significant effect on RBC, Hb, MCV, MCH, polynuclears, lymphocytes and monocytes. this work showed that age, season, sex, phase of pregnancy affected significantly haematological parameters in cross bred Rembi sheep raised in western Algeria.

Key words: sheep, hematological, blood, sample, analysis

INTRODUCTION

In Algeria, sheep dominate and spread throughout the northern part of the country, with a higher concentration in the steppe and semi-arid high cereal plains, it occupies an important place in the national economy (Bencharif 2011). The sheep's population is consisted of main dominant race (Ouled Djellal, Hamra, Rembi) and secondary breeds such as Berber, Barbarine, D'men and Sidahou. (Chellig 1992).

The sheep can be considered as living bank against various natural calamities such as crop failure, drought, and flood. The consumption of the meat of sheep is high, leading to an increase in its price due to rapid urbanization (Rekik 2018). Blood is an important index of physiological and pathological changes in an organism (Mitruka and Rawnshey 1977). The primary function of the blood is to transport oxygen from respiratory organs to body cells (Duke 1975), thereby maintaining homeostasis of the internal environment (Bentrick 1974). Currently, a lot of information on hematological characterizations of sheep in the word are available (Hernandez Trevino 2017).

Soch et al. (2011) determined that the sampling in blood is an important diagnosis tool, to help identifing the physiological responses of an animal; through the clinical analysis can be known about health, well being and nutritional status. The hematological parameters influence the productive and reproductive capability of animals (Abdelfattah 2013), while variation are associated with several internal and external factors including age, sex, breed, season, race and physiological status of animal (Oramari et al. 2014).

Ramirez et al. (1998) considers that the parameters of concentration of erythrocytes, packed cell volume and hemoglobin concentration are important criteria to calculate the absolute hematimetric indices or indexes Wintrobe, which are used for the morphological classification of anemia's and are of great importance in veterinary medicine. The intensity of the immune response is linked to productive parameters, such as the reproductive efficiency, the shearing of the sheep and the milk (Azab and Abdel-Makssoud 1999).

The present work aimed to determine the hematological parameters standards values in Rembi breed sheep raised in Tiaret a semi-arid region at the west of Algeria.

MATERIALS AND METHODS

For this study, 172 apparently healthy Rembi sheep (68 males and 104 females) were used between October 2018 and August 2019. Animals were aged between three months and four years. Animals were raised in different farms across the Tiaret region. The age, sex, and phase of the pregnancy status were noted.

Jugular blood samples were collected via vacutainer tubes with (EDTA) early in the morning and brought to the laboratory within two hours for analysis. In all samples, the number of white blood cells (WBC), red blood cell (RBC), packed cell volume (PCV), haemoglobin (Hb), mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC), Lymphocytes, Monocytes, and polynuclears were determined.

RESULTS AND DISCUSSION

It was reported that hematological and biochemical parameters of animals may vary based on factors like breed, age, and sex (Njidda et al. 2013). The parameters values, recorded in our work, were similar to those reported by authors (Naseir and Harith, 2014, Hernandez-trevino and al. 2016).

In our study sex had a significant influence ($P < 0, 05$) on monocytes values (Table1). The mean value of the monocytes for males reported in our

study was 1067.29 ±1223.33/mm^3, significantly higher ($P < 0.05$) than females with 422.08 ±272.78/mm^3, the pregnancy stage had also a significant influence ($P < 0.05$) on the mean value of the monocyts while the WBC was significantly higher ($P < 0.05$) in late pregnancy with 7046.36 ±3576.76/mm^3 than in early pregnancy with 6738.00 ±1949.84/ /mm^3. For the MCH mean values were significantly higher ($P < 0.05$) in early pregnancy with 14.71 ±4.13 pg than in late pregnancy with 13.22±2.48 pg. The MCHC mean values were significantly higher ($P < 0.05$) in early pregnancy with 37.39 ±9.99g/dl than the late pregnancy with 33.21 ±5.40 g/dl. The polynuclears levels were significantly lower in early pregnancy with 1592.01 ±486.37/mm^3 than in late pregnancy with 2282.05 ±1145.00/mm^3. The lymphocyte mean value was significantly lower in early pregnancy with 4702.76 ±1837.53/ /mm^3 than late pregnancy with 4057.34 ±3425.06/mm^3.

The mean value of the monocytes for non-pregnant females were significantly lower ($P < 0, 05$) with 422.08 ±272.78/mm^3 than the yearling females with 1628.80 ±954.61/mm^3.

In our work, the highest value of RBC's count was 7.09 ±1.94 × 10^6/L for yearling males and the lowest value for yearling females was 5.99 ±1.79 × × 10^6/mm^3. In addition, the lowest mean MCHC value was observed in yearling females with 37.55 ±12.16 g/dl against 40.13 ±13.28 g/dl in yearling males without significant difference ($p > 0.05$).

The highest polynuclears mean value was 2000.15 ±1127.02/mm^3 in yearling females while the lowest value was recorded in yearling male with 1815.85 ±1023.36/mm^3. The highest value of lymphocytes mean value was 8551.72 ±2047.59/mm^3 in yearling females than the yearling males with 6480.78 ±1466.10/mm^3. The WBC mean value was higher for non-pregnant females with 17,238.67 ±29871.78/mm^3 than the females in post-partum with 7952.67 ±1907.81/mm^3. The highest value of lymphocytes was reported for the non-pregnant females with 6748.67 ±1685.54/mm^3 than the post-partum females with 4550.48 ±1005.62/mm^3. The highest WBC's mean value was 17,238.67 ±29,871.78/mm^3 in females, while the lowest value was recorded in males with 9726.84 ±3176.09/mm^3.

WBC value was lower than those reported for Iraqi Awassi sheep with 9518.6 ±314/ml for males and 10,375 ±22/ml for females (Naseir and Harith 2014). The lowest platelets value was recorded in females with 423,733.33 ±108,746.4/ /ml than 389,789.47 ±170,628.85/ml for males which is similar to 312,200 ±16,600/ml reported for Iraqi Awassi sheep's males and 270,800 ±10,200/ml for females (Naseir and Harith, 2014).

In this study the day period had a significant influence ($P < 0.05$) on the measured parameters (Table2). The RBC, Hb, PCV and monocytes values were significantly ($P < 0.05$) higher in long day with 7.18 ±1.85 × 10^6/L, 9.75 t ±1.31 g/dL, 28.57 ±6.96%, 1662.07 ±1224.38/ /mm^3 than the short day with 6.57 ±1,30 × × 10^6/L, 9.17 ±1.06 g/dL, 25.87 ±5.16%, 486,20 ±395.41/mm^3 respectively. In contrast, the polynuclears mean value was significantly higher ($P < 0.05$) in the short day with 2799.92 ±1714.17/ml than the long day with 2343.27 ±1088.69/ml.

Table 1: Mean ±*SD* values of haematological parameters in sheep.

Statut	**Nonpregnant (15)**	**Males (57)**	**Early Pregnancy (15)**	**Late Pregnancy (44)**	**Post-partum (15)**	**Yearling females (15)**	**Yearling males (11)**	**Total (172)**
WBC (/ml)	17238.67 ±29871.78	9726.84 ±3176.09	6738.00 ±1949.84*	7046.36 ±3576.76	7952.67 ±1907.81	12180.67 ±2961.71	9733.64 ±1389.74	9495.29 ±9452.47
RBC (x106/L)	6.10 ±1.47	7.07 ±1.71	6.54 ±1.49	7.16 ±1.50	6.85 ±1.14	7.09 ±1.94	5.99 ±1.79	6.88 ±1.62
Hb (g/dL)	9.63 ±0.66	9.72 ±1.02	9.09 ±1.05	9.23 ±1.54	9.03 ±0.86	9.97 ±1.24	9.19 ±1.58	9.46 ±1.22
PCV (%)	24.31 ±5.14	27.70 ±6.28	25.63 ±5.81	28.32 ±6.13	27.24 ±5.09	28.62 ±7.83	24.57 ±6.89	27.22 ±6.26
MCV (fl)	40.27 ±2.12	39.47 ±2.07	39.40 ±1.12	39.84 ±4.03	39.87 ±2.00	40.60 ±1.76	41.45 ±2.77	39.89 ±2.70
MCH (pg)	16.79 ±4.54	14.64 ±4.29	14.71 ±4.13	13.22 ±2.48*	13.51 ±2.65	15.25 ±5.22	16.56 ±5.66	14.55 ±4.08
MCHC (g/dl)	41.40 ±9.56	36.95 ±9.57	37.39 ±9.99	33.21 ±5.40*	34.04 ±6.57	37.55 ±12.16	40.13 ±13.28	36.42 ±9.24
Platelettes (/ml)	423733.33 ±108746.41	389789.47 ±170628.85	283866.67 ±123441.06	338568.18 ±165269.53	412200.00 ±159553.04	358333.33 ±96502.90	317909.09 ±104986.15	365023.26 ±154001.52
Polynuclears (/mm^3)	2570.00 ±1123.72	3183.13 ±1767.22	1592.01 ±486.37*	2282.05 ±1145.00	2824.16 ±839.79	2000.15 ±1127.02	1815.85 ±1023.36	2556.00 ±1428.59
Lymphocytes (/mm3)	6748.67 ±1685.54	5582.42 ±2690.59	4702.76 ±1837.53	4057.34 ±3425.06*	4550.48 ±1005.62	8551.72 ±2047.59	6480.78 ±1466.10	5493.80 ±2803.72
Monocytes (/mm3)	422.08 ±272.78*	1067.29 ±1223.33	443.23 ±597.62	1529.17 ±1243.12	644.75 ±498.91	1628.80 ±954.61	1437.00 ±695.68	1095.38 ±1092.90

In the present study the age had a significant influence ($p < 0.05$) on the measured parameters (Table 3). The RBC's and Hb mean value were significantly ($p < 0.05$) lower in sheep aged 5 months than the other ages with 5.71 ±1.63 × × 10^6/L and 8.00 ±1.57 g/dL respectively. However, the higher value for the Hb and RBC's mean values were recorded at the 10-month age respectively with 10.88 ±0.88 × 10^6/L and 9.04 ±0.68 g/dL. The MCV and lymphocytes mean values were significantly ($P < 0.05$) lower in sheep aged 6 months with 36.50 ±2.43 fl, 1654.18 ±1777.08/ml than the other age categories. The polynuclears and monocytes mean values were significantly ($P < 0.05$) lower in sheep aged 20 months with 2007.09 ±514.81/mm^3, 524.25 ±466.69/mm^3.

In our study, the lower mean value of WBC was recorded in animals aged 12 months with 12,775.43 ±17,148.92/ /mm^3. Firas and Wathiq (2017) reported WBC value of 8300 ±470 for animals aged less than 12 months. The Hb mean value was significantly ($P < 0.05$) higher for 10 month age with 10.88 ±0.72 g/dL however, Firas and Wathiq (2017) reported the value of 8.24 ±0.19 g/dL. For the animals between 1 and 2.5 months, Firas and Wathiq (2017) reported a value of Hb with 8.42 ±0.16 g/dL which is higher than our results with 9.74 ±0.57g/dL for the sheep aged 20 months.

Table 2: Mean ±*SD* values for haematological parameters a variation within days lightning duration.

Days Lightning duration	Short (86)	Long (86)	Total (172)
WBC (/ml)	9,458.26 ±13,069.35	9,532.33 ±2,989.76	9,495.29 ±9,452.47
RBC (×10^6/L)	6.57 ±1.30	7.18 ±1.85*	6.88 ±1.62
Hb (g/dL)	9.17 ±1.06	9.75 ±1.31*	9.46 ±1.22
PCV (%)	25.87 ±5.16	28.57 ±6.96*	27.22 ±6.26
MCV (fl)	39.51 ±2.07	40.27 ±3.18	39.89 ±2.70
MCH (pg)	14.55 ±3.74	14.55 ±4.41	14.55 ±4.08
MCHC (g/dl)	36.73 ±8.32	36.11 ±10.12	36.42 ±9.24
Platelettes (/ml)	366,883.72 ±140,078.50	363,162.79 ±167,579.72	365,023.26 ±154,001.52
Polynuclears(/mm^3)	2,799.92 ±1714.17*	2,343.27 ±1,088.69	2,556.00 ±1,428.59
Lymphocytes (/mm^3)	5,457.79 ±2,101.26	5,527.29 ±3,339.65	5,493.80 ±2,803.72
Monocytes (/mm^3)	486.20 ±395.41	1,662.07 ±1,224.38*	1,095.38 ±1,092.90

*Refers to a significant difference in the same line ($P < 0.05$)

Table 3: Mean± *SD* values for haematological parameters in sheep within age.

Age (Month)	*N*	WBC (/ml)	RBC (x106/L)	Hb (g/dL)	PCV (%)	MCV (fl)	MCH (pg)	MCHC (g/dl)	Platelettes (/ml)	Polynuclears (/mm3)	Lymphocytes (/mm3)	Monocytes (/mm3)
3	**6**	10,225.00 ±2,514.84	7.02 ±2.05	9.77 ±1.00	28.72 ±8.55	41.17 ±1.72	14.80 ±3.66	36.10 ±8.63	356,833.33 ±81,959.54	1,454.60 ±902.82	7679.13 ±1,894.70	1,091.27 ±590.25
4	16	12,000.00 ±2645.07	6.71 ±1.98	10.00 ±1.29	27.04 ±7.78	40.63 ±2.13	16.41 ±5.97	40.26 ±13.58	356,687.50 ±108,761.34	2,096.88 ±1,066.34	8,153.12 ±2,098.83	1,750.00 ±836.37
5	4	9,107.50 ±1,841.24	5.71 ±1.63*	8.00 ±1.57*	23.65 ±5.80	42.00 ±3.46	14.90 ±5.65	35.98 ±14.45	256,000.0 0 ±43,235.79	1,924.74 ±1,358.78	5,759.91 ±1,298.07	1,422.85 ±1,099.88
6	46	12,775.43 ±17148.92	6.36 ±1.62	9.52 ±0.88	25.34 ±5.99	40.15 ±1.89	16.08 ±4.84	39.81 ±10.67	412,456.52 ±137,730.45	2,984.00 ±1,725.28	6,859.42 ±1,946.45	619.37 ±580.42
10	6	6,913.33 ±2,286.20	9.04 ±0.68	10.88 ±0.72	32.98 ±3.42	36.50 ±2.43*	12.05 ±0.37*	33.22 ±2.91	401,833.33 ±269,186.49	2,518.18 ±1,829.19	1,654.18 ±1,777.08*	2,740.98 ±2,237.35
12	21	9,841.43 ±2,228.83	7.08 ±1.75	9.94 ±0.89	28.05 ±6.68	39.81 ±1.54	14.91 ±4.04	37.30 ±9.02	287,904.76 ±172,384.72	2,496.54 ±916.72	5,845.07 ±2,258.16	1,499.69 ±1,156.07
19	15	7,952.67 ±1,907.81	6.85 ±1.14	9.03 ±0.86	27.24 ±5.09	39.87 ±2.00	13.51 ±2.65	34.04 ±6.57	412,200.00 ±159,553.04	2,824.16 ±839.79	4,550.48 ±1,005.62	644.75 ±498.91
20	5	6,564.00 ±791.32	7.47 ±0.61	9.74 ±0.57	29.04 ±3.05	39.00 ±1.00	13.06 ±0.69	33.70 ±2.27	316,200.00 ±93,207.83	2,007.09 ±514.81*	4,023.66 ±980.78	524.25 ±466.69*
24	1	4,950.00	9.15	10.10	33.70	37.00	11.00	30.00	575,000.00	2,376.00	1,188.00	1,386.00
36	11	6,808.18 ±2,287.57	7.76 ±1.33	9.65 ±1.46	31.45 ±6.06	40.36 ±2.16	12.54 ±0.96	31.07 ±3.29	466,454.55 ±147,256.49	3,021.63 ±1,393.85	2,323.63 ±1,655.56	2,280.30 ±1,277.83
48	12	4,273.33 ±1,555.54	6.64 ±0.71	8.33 ±1.10	25.25 ±3.31	38.00 ±2.00	12.53 ±0.68	33.03 ±1.81	283,416.67 ±119,633.12	980.14 ±764.41	3,468.45 ±829.85	248.32 ±112.14
60	22	7,414.09 ±2,701.17	7.10 ±1.50	9.38 ±1.09	27.84 ±6.15	39.27 ±2.16	13.83 ±3.59	35.30 ±8.75	314,318.18 ±168,449.90	2,713.27 ±1,618.30	3,633.51 ±2582.91	1,252.90 ±1,243.71
72	7	8,750.00 ±6,327.60	6.30 ±2.05	8.20 ±2.28	25.83 ±7.22	42.86 ±8.23	13.51 ±1.99	31.70 ±1.77	385,142.86 ±8,1495.25	2,728.66 ±1524.36	7,122.78 ±5,629.33	361.54 ±152.85
Total	172	9,495.29 ±9,452.47	6.88 ±1.62	9.46 ±1.22	27.22 ±6.26	39.89 ±2.70	14.55 ±4.08	36.42 ±9.24	365,023.26 ±154,001.52	2,556.00 ±1,428.59	5,493.80 ±2,803.72	1,095.38 ±1,092.90

*Refers to a significant difference in the same line ($P < 0.05$)

CONCLUSION

This work showed that age, season, sex, and the stage of pregnancy affected significantly hematological parameters in cross bred Rembi of sheep raised in western Algeria and it must be taken in consideration when hematological analysis was done in order to investigate pathologies in sheep.

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Streszczenie: *Parametry hematologiczne owczej rasy Rembi w Tiaret, Algieria.* Celem badania było określenie wpływu długości dnia świetlnego, wieku, płci i fazy ciąży na parametry hematologiczne u owcy rasy Rembi hodowanej w Tiaret w Algierii. Dane pochodziły od 172 owiec Rembi (104 samice i 68 samców), w wieku od trzech miesięcy do czterech lat. Próbki krwi pobierano z żyły szyjnej za pomocą probówek próżniowych z (EDTA) wcześnie rano i dostarczano do analizy w ciągu dwóch godzin. We wszystkich próbkach oznaczano liczbę limfocytów (WBC), erytrocytów (RBC), hematokryt (PCV), hemoglobinę (Hb), średnią objętość erytrocytów (MCV), średnią zawartość hemoglobiny (MCH), średnie stężenie hemoglobiny komórkowej (MCHC), monocyty

i wielojądrzaste granulocyty. Płeć miała znaczący wpływ ($P < 0,05$) na liczbę monocytów (1067,29 ±1223,33 tryki i 422,08 ±272,78 maciorki) u starszych zwierząt, zaś u rocznych nie zaobserwowano różnic. Faza ciąży miała znaczący wpływ ($P < 0,05$) na WBC, MCH, MCHC, wielojądrowe i limfocyty (6738 ±1949, 84/ ml, 14,71 ±4,13 pg, 37, 39 ±9,99g/dl, 1592,01 ±486,37/mm^3 i 4702,76 ±1837,53/mm^3 we wczesnej ciąży i 7046,36 ±3576,76/ml, 13,22 ±2,48 pg, 33,21 ±5,40g/dl, 2282,05 ±1145,00/mm^3 i 4057,34 ±3425,06/mm^3 odpowiednio w późnej ciąży). Krótkie i długie dni wpłynęły ($P < 0,05$) na RBC, Hb, PCV, plynuceary i monocyty (6,57 ±1,30 × 106/L, 9,17 ±1,06 g/dL, 25,87 ±5,16, 2799%, 92 ±17 144,17/ /mm3 i 486,2 ±395,41/mm^3 w krótkich dniach oraz 7,18 ±1,85 × 106/l, 9,75 ±1,31 g/dL, odpowiednio 28,57 ± 6,96%, 2343,27 ±1088,69/mm^3 i 1662,07 ±1224,38/mm^3, odpowiednio w długie dni). W wieku od trazech do 72 miesięcy obserwowano znaczący wpływ na RBC, Hb, MCV, MCH, wielojądrowe, limfocyty i monocyty. Praca ta wykazała, że wiek, pora roku, płeć, faza ciąży miały znaczący wpływ na parametry hematologiczne owiec Rembi hodowanych w zachodniej Algierii

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