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Review article

The role of ethology in animal welfare

Agata Kokocińska[1], Tadeusz Kaleta[2]

[1]Institute of Genetics and Animal Breeding of the Polish Academy of Sciences,
Jastrzębiec, ul. Postępu 36A, 05-552 Magdalenka; e-mail: a.kokocinska@ighz.pl
[2]Warsaw University of Life Sciences, Faculty of Animal Sciences,
Department of Genetics and Animal Breeding,
ul. Ciszewskiego 8, 02-786 Warsaw

Knowledge of the behaviour of a species makes it possible to ensure the well-being of animals raised in farm conditions, because when we know the behavioural standard we can guarantee that at least the animals' minimum needs will be met. Observation of animal behaviour is the first element in assessing their physical and psychological comfort. The main objective is to maximize production while at the same time maintaining animal welfare. However, this is often difficult and economic considerations come into conflict with the comfort and needs of the animals. The elements of knowledge of behaviour, in addition to ethology, i.e. the science dealing with animal behaviour, also include zoosemiotics and cognitive science, which explain of the occurrence of specific behaviours in terms of biology and physiology.

KEY WORDS: animal welfare / ethology / zoosemiotics / communication / behaviour

Economics and animal welfare are two essential elements accompanying animal production. Efforts are continually made to improve the quality of life of livestock animals, but on large-scale farms this is a major problem. Maximization of production is inversely proportional to the animals' quality of life. As the degree of intensification of farming increases, the decline in animal welfare becomes more severe. The key to success is to find a golden mean, i.e. to achieve maximum production while optimally meeting animal needs. The science of ethology enables understanding of animal behaviour, which in turn makes it possible to ensure suitable farming conditions and meet minimum needs. Knowledge of behaviour thus affects animal welfare (since the needs of a given species are known), but animals' behaviour is also an expression of their current living conditions. Observations of behavioural responses are the most reliable indicator of animal well-being.

The aim of the study is to present the role of ethology and related sciences in determining the welfare of animals—not only on large-scale farms, but also animals raised by amateurs and all other animals in captivity.

Historical outline and basic elements of ethology

The word 'ethology' derives from the Greek 'ethos', meaning habit or custom, and 'logos', i.e. 'word' or 'reason'; hence ethology is the science that deals with behaviour and all related aspects. The main areas included in its scope are inherited and acquired behaviour, adaptive aspects of behaviours, social behaviours, individual development, intraspecific interactions, and to a lesser degree, interspecific interactions. What is most important in ethology is that the behaviour of animals is studied in their natural environment, without human interference. The only research method here is observation, preferably in the natural environment, because only in nature are there no additional factors affecting the animal's behaviour [31]. Ethology was founded by the distinguished physician and zoologist Konrad Zacharias Lorenz, a pioneer in research and theories on animal behaviour [29, 30], and the zoologist Niko Tinbergen, whose book *The Study of Instinct* [44] was a breakthrough in the history of the science of animal behaviour and who laid the foundations for cognitive ethology [45]. In time, within general ethology a distinction was made between comparative ethology and cognitive ethology. Comparative ethology is the 'prototypical' ethology founded by Lorenz; this was even the name of the institute he co-founded and directed in 1949-1951 (Institute of Comparative Ethology at Altenberg) [26, 27]. It is based on comparison not only of the anatomical structure of animals, but also of their behavioural patterns, from which conclusions may sometimes be drawn regarding their evolution [29, 30]. Comparative ethology is an evolutionary, ecological and psychophysical analysis of animal minds. It focuses on animals' way of reasoning and on their sensations and emotions. It also investigates the existence of consciousness and self-awareness [1, 13, 14, 18, 21, 41]. Eibl-Eibesfeldt, who was interested in human behaviour, founded another branch called human ethology, which attempts to explain human attitudes and behaviour from a biological point of view [11].

Behaviour is the complex system of an animal's responses to signals reaching it from the external environment or from inside the body. If we consider the anatomical structure of the brain and the entire nervous system of vertebrates, it is clear that it is a specific correlation system which receives sensory information from the environment and links this response to appropriate schemata of motor responses. The sum of the organism's responses to a given factor constitutes behaviour. The autonomous nervous system of vertebrates and the closely associated somatic sensorimotor system, apart from controlling visceral functions and the endocrine system, also determines emotional and motivated behaviour, and for this reason the more developed the organism, the more complex behaviour it displays, which is linked to the evolution of the nervous system [27, 39].

Dethier and Stellar [7] distinguished several types of behaviour: stereotypic, instinctual and motivated. Behaviour originally consisted in a stimulus or series of stimuli

inducing a response; this type of behaviour is known as stereotypic. It is said to be innate, because it is dependent on innate characteristics of the nervous system of a given organism. Examples include the basic orienting response (preparation for fighting or fleeing) or spatial orientation, including taxes. This suggests that even the simplest organisms, such as protozoa, exhibit certain forms of behaviour, as at any moment they may react to an environmental factor and may develop diverse forms of adaptation. The more forms of adaptation they have, the more varied and less stereotypic the behaviour is. Another example of stereotypic behaviour is unconditional reflexes, which are the basis of the functioning of most organisms. These arise as a result of inherited traits of the nervous system, and thus are innate and immediate. The lower parts of the nervous system are responsible for them [7]. A more complex form, also consisting of reflexes, is instinctual (motivated) behaviour. To explain this form of behaviour in depth we must first analyse what instinct is. According to J. Chmurzyński, 'instinct (Latin *instinctus*—stimulus, impulse) is the innate, hereditary ability of animals (including humans) to execute a sequence of behaviours driven by impulses, triggered and controlled by corresponding external stimuli, leading to consequences necessary for the life of the individual or the preservation of the species' [4]. According to Tinbergen, it is a system of hierarchically organized nerve centres in the brain—drive centres, together with the associated 'releasing mechanisms' and 'effector mechanisms' (e.g. motor mechanisms), which are responsible for the manifestation of a chain of instinctual actions associated with one biological task [44].

One of the first Polish books dedicated to zoopsychology, *Psychologii zwierząt* [The psychology of animals] by Jan Dembowski, cites five points given by Ziegler which characterize instinctive behaviour:

'1. It is inherited, which means that the impulse to act and the ability to perform the action are innate traits of the animal.

2. It does not require prior learning by the animal.

3. It is fundamentally the same in all normal individuals of a species or breed.

4. It corresponds to the organization of the animal's body, i.e. the normal use of its organs.

5. It is adapted to the animal's natural living conditions, and often to temporary changes in these conditions, e.g. associated with seasons of the year' [6].

According to Dethier and Stellar, for behaviour to be called instinctive it must be

1) unlearned,

2) typical for the species, and

3) adaptive [7].

The modern definition by H. Korpikiewicz states that 'instinct is an inherited, unlearned ability (of animals and humans) to unconsciously, impulsively ('automatically') perform a sequence of behaviours triggered by external stimuli, serving the survival of the individual and the species' [25]. This is one of the more accurate definitions, but this concept should be used very cautiously. Dembowski notes that not all behaviours can be ascribed to instincts because there is a fine line between such behaviour and intelligent actions, and sometimes no line at all. Although the definitions cited have much in

common, complete clarity is still lacking. Modern ethologists stress that the concept of instinct must not be overused, because it is difficult to define the moment when instinctive behaviour begins to be intelligent, learned action. Instinctive behaviour is above all based on motivation. We know that a given stimulus or set of stimuli acting on a given organism may or may not cause a reaction in different situations. In order for the reaction to occur, we must observe a certain change called an 'intervening variable', i.e. a difference between two measurable parameters, in this case stimulation and response, and an effect on the relationship between them. Sometimes a very weak stimulus is sufficient to induce a response, while at other times a whole set of strong stimuli induces no response at all. It all depends on the motivation which directs a given organism to achieve a goal. Following this line of thought, we can distinguish three states of animal behaviour:

– the phase of searching for a defined goal
– behaviour directed towards the goal which has been identified
– the phase of calm following achievement of the goal [31].

A specific type of motivation is a drive, such as the sex drive or hunger. However, this is a difficult term to apply because a drive in itself is not measurable; only the responses to different types of stimuli can be measured. Motivated (instinctual) behaviour is thus a certain type of drive aimed at achieving the chosen goal, which leads to a state of satiety and calm. From a neurophysiological perspective, motivated behaviour is closely linked to the hypothalamus, because this is where the centres of stimulation and inhibition of motivated behaviour are located. The ventromedial hypothalamus is responsible for inhibition, so when this part is damaged inhibitory responses no longer function. In addition to the hypothalamus numerous other factors affect motivation, both internal (e.g. hormones) and external (experience) [31]. Instinctual behaviour can be considered to be between innate and acquired behaviour. Over the course of evolution animal behaviours become increasingly complex, and the influence of their environment, experience or observation begins to be visible. The type of behaviour which is modified by the learning process is called acquired behaviour. The word 'instinct' is often used as a synonym of 'innate behaviour'; both terms refer to innate, unlearned behaviours. Currently there is a tendency to move away from the use of the form 'instinct', and behaviour is limited to three forms: innate, acquired and complex [35].

To sum up, every animal displays a certain pattern of responses which is the basis for a description of its behaviour. Overall behaviour is the result of numerous factors, which should be taken into account during observations. Each species has its own behavioural pattern consisting of manifold forms of behaviour, which are assigned to a given category under investigation. This kind of structure enables us to create a basic 'data base' called an ethogram, which is the basic tool of an ethologist's work [17].

Zoosemiotics as an important element of ethology

The philosopher Ludwig Wittgenstein said that to imagine a language is to imagine a form of life. This is a very apt formulation, because when we learn a language we un-

derstand the desires and the message sent by another person or animal, and thus we can imagine the whole of a given form of life and the purpose of its existence.

Jakob von Uexküll was the first to draw attention to understanding of the animal world, and devised the theory of 'the animal as a receiver'. Every living creature has its own world, which is deserving of understanding. His theories formed the basis for the work of later ethologists and behaviourists, such as Thomas A. Sebeok, Gregory Bateson and Thure von Uexküll, Jakob's son, who improved on his father's theory and used it in research on psychosomatic medicine [37].

In 1963 the American linguist Thomas A. Sebeok observed that there was no word for the continually intertwining sciences associated with behaviour, i.e. ethology, zoology and semiotics, which are integrally linked to fields such as bioacoustics, physiology, linguistics, and comparative psychology. To refer to animal communication and all the sciences studying it he used the word 'zoosemiotics'. Thus zoosemiotics can be defined as the study of signals in the world of animals ('semiotics'—the study of signs and signals), both between and within species. All animals are social beings having their own characteristic way of communicating, which is the subject of this field of science [40].

According to Giuseppe Malacarne, zoosemiotics deals with the principles of animal communication by using information theory (e.g. mathematical analysis of signals) and communication theory. Apart from elements of traditional ethology and sociobiology, zoosemiotics deals with topics of particular meaning: 1) the nature of these individual communication channels in relation to the environment, 2) the meaning of a communication in relation to the context in which it is emitted, and 3) the species-specific ability of animals to create symbolic languages. On the other hand, Malacarne points out the similarity between zoosemiotics and cognitive ethology [37].

Three semiotic pillars can be distinguished: sign, code, and communication. The first phenomenon, signification, is understood as a sign where the recipient is only a subject taking part in semiosis (the process of using a sign in which its meaning is revealed), and there is no actual sender. In the second pillar, coding, only the sender is the subject of semiotics, who chooses the appropriate type of coding of the sign. In the third point, communication, we are dealing with both the sender and the recipient, where the encoded sign has a meaning imparted to it and is interpreted [33].

Zoosemiotics is essential for analysis of animal behaviour, because by learning the mechanisms of animal communication we are able to determine their intraspecific relations and correctly name their emotional states, which depending on the species may be manifested in very different ways.

Cognitivism as a 'tool' for studying animal behaviour

In order to thoroughly study and describe zoosemiotics, i.e. communication in the animal world, we should begin with an in-depth physiological analysis of the body, or more specifically, the brain. Communication and all factors associated with it (sound, movement, chemical, etc.) are regulated in the body's command centre (the brain) and are linked to the physiological processes taking place in it. The main focus here is on specific regions of the brain which are active during a given activity, process, or

consciousness itself. The science dealing with these aspects in connection with information processing and information theory is called cognitivism [17]. This is an area of study combining behavioural science, neurophysiology and information science, which makes it possible to scientifically prove theories about animal consciousness and their emotions or feelings. There are currently no studies that conclusively show what kind of nerve activity is necessary, for example, for consciousness. In 2005 an article by Francis Crick of the University of California in San Diego and Christof Koch of the Allen Institute for Brain Science appeared in *Philosophical Transactions of The Royal Society B*, describing the brain structure known as the claustrum as a kind of 'orchestra conductor' of the brain, responsible for consciousness [5]. Crick believed that it is the coordinator of brain function and brings together the functions of a variety of brain regions. It is the claustrum that integrates information (visual, auditory, tactile, pain, and millions of others) appearing in different parts of the brain to create the experience we call consciousness [5, 26, 43].

The cognitivist approach requires deeper analysis of the problem, e.g. division of the general concept of intelligence into attention, recognition, perception of differences, category creation, spatial memory, and assessment of size and quality. In this manner it has been demonstrated, for example, that animals are capable of creating what is known as cognitive maps [3]. The term was first used by Edward Tolman, an American psychologist and the creator of the idea of purposive behaviourism (neobehaviourism), who introduced the concept of latent learning [46, 47]. A cognitive map is an individual's knowledge of spatial and environmental relations and cognitive processes associated with coding and recalling the information making up this knowledge [8, 19, 20, 49]. Its goal is to model manifold thought processes as precisely as possible, especially in the context of imitating them later in creating artificial intelligence. In the 1990s mind maps were adapted for applications of fuzzy information. Maps of this type (fuzzy cognitive maps – FCM) are sometimes caused fuzzy decision maps – FDM) [34, 48].

On the basis of the similar anatomical structure of the brains of different groups of mammals, which have a central and peripheral nervous system, cognitive sciences not only study the human brain but also use animal models. For example, brain centres found in mice and rats are also present in the brains of humans, horses and whales. One example is spindle neurons, which in humpback whales, fin whales, killer whales and sperm whales are located in the same region of the brain as in humans. This region is linked to social organization, empathy, and intuition regarding the feelings of others, as well as rapid instinctual responses. Spindle neurons were once believed to be unique to humans and very important in generating emotions, but interestingly, whales have more of them than humans do [1]. Two hormones of the posterior pituitary, vasopressin and oxytocin, are also known to play a crucial role in the process of forming attachments in all mammals. They also play an important role in behaviour, and in particular in social memory, and thus in forming interpersonal bonds [1]. Thus animals can be ideal models in studies aimed at providing insight into humans.

Parameters of assessment of animal welfare

There are many definitions of welfare. According to Hughes it is a state of complete mental and physical health, where the animal is in harmony with its environment [16]. Duncan states that welfare is associated with what the animal feels [9]. Another definition presents welfare as a state of harmony between the animal and its environment, expressed as proper physiological and mental functioning, vitality, and a high quality of life [36]. According to these definitions we can distinguish four basic types of indicators of the level of welfare, relating to both the physical and mental state of animals:

– health indicators (absence of clinical disease symptoms)
– production indicators (e.g. a sudden reduction in milk yield)
– physiological indicators (e.g. stress hormones or immune indices)
– behavioural indicators (signs of pain, atypical or pathological behaviour, individual preferences)

Another division distinguishes five groups, adding 'zootechnical criteria', such as the condition of integuments, which according to the classification above are included among health indicators [22].

Health, physiological and production indicators can be assessed on the basis of specific parameters, including clinical and laboratory diagnostics or statistical analysis. Production indicators, such as milk yield or weight gain, and reproduction indicators (e.g. fertility and fecundity) are very sensitive markers of animal health (and thus their welfare) [12].

Particularly important among physiological parameters is the concentration of stress hormones such as cortisol, cortisone, corticosterone and aldosterone (in the blood, urine, faeces, feathers or hair). In livestock animals (pigs, cattle, horses, etc.) the main corticoids are cortisol, cortisone and aldosterone. In birds, the most important stress hormone is corticosterone, with a concentration 100 times greater than that of cortisol [32]. Health indicators include a wide range of diseases, and in particular the morbidity rate (the number of new cases in a given time period divided by the number of animals at risk) and prevalence (the number of infected animals divided by the number of animals at risk). This group of indicators is the most objective, but requires substantial labour input and expenditures. Behavioural indicators, on the other hand, may be the first symptom of both physical and mental pathologies. In this case the basic tools are observation and the ethogram describing the behaviour of the species in question. An important element of the ethogram is the time budget, based on which we are able to observe the first changes in behaviour which may be atypical or pathological.

The role of zoosemiotics in assessment of welfare

Zoosemiotics, as a science focusing on analysis of signals in the animal world, plays a key role in observation and the creation of ethograms, and thus becomes the basis for diagnosis with regard to behavioural indicators. Taking into account sensory channels such as sight, hearing, smell, taste, and touch (smell and taste can be treated jointly as the chemical channel), we are able to precisely study the behaviour of the species.

For example, domestic cattle, a well-known and well-described species, are characterized as follows [38]:

1. Very good eyesight, responsible for about 50% of all information received by the senses. The structure of the eye in cows may suggest that to some degree they can see and distinguish colours such as red, orange and yellow (while colours with short wavelengths, such as green, grey and blue, are difficult to distinguish). Cattle see better at short distances than long ones and have fairly poor accommodation capacity. Their visual acuity is 1/50 that of humans and is better at perceiving moving objects than still ones. Their field of vision is large, at about 330°, due to the location of the eyes at the sides of the head. Depth perception is limited to short distances, because the images from the two eyes only overlap to a small extent.

2. Good hearing, which is an important sense for cattle, although less so than vision. It is helpful in detecting dangers and plays a crucial role in intraspecific communication (e.g. warning signals), and interspecific communication as well. Optimum audibility for cattle is in the range of 1-8 kHz, as compared to 1-4 kHz for humans. The minimum frequency that can be registered by cattle is similar as in humans, i.e. 20-25 Hz, while the maximum is 20 kHz for humans and 35 kHz for cattle.

3. A highly developed chemical communication system, which helps to form social bonds between the mother and calf, as well as between adult individuals in the herd, and also affects reproductive behaviour, synchronization of oestrus, and even eating behaviour. Macrosmatic animals have two separate olfactory organs—the main and vomeronasal organ. The latter, also known as the Jacobson's organ, is responsible for detection of pheromones [24, 42, 51]. In terms of olfactory sensitivity, cattle can detect smells at much lower concentrations than humans. As regards taste, like other mammals cattle distinguish four basic tastes, enabling them to obtain information about certain properties of food.

4. The lips of cattle perform tactile functions similar to those of hands in humans. They are equally sensitive to tactile stimuli. The animals use them to investigate new, unfamiliar objects. The pain sensation mechanism in cattle is similar to that of humans, but the overt response to pain is smaller. A strong reaction to pain could attract the attention of predators.

Knowledge of the biological basis of behaviour and natural dispositions, which at one time, in natural conditions, had a role in the fight for survival, should be used to improve the welfare of animals, as well as their productivity [38]. By analysing the case of domestic cattle in terms of the significance of particular sensory channels, we can deduce what the basic needs of this species are. The knowledge that cattle use mechanisms associated with monocular vision and their memory of the size of objects to assess distances can be used to accustom the animals to a new place, or while driving the herd. Knowledge of the range of audibility of sounds for the species can be used to avoid problems in this area, as there are sounds inaudible to humans that can cause anxiety and behavioural changes in cattle. Knowing the animals' taste predispositions we can improve the palatability of fodder and thereby improve their feed intake. Knowing that

the animal receives pain stimuli in the same manner as human beings, we can attempt to limit these stimuli. It is possible that the capacity to process information flowing from nociceptors through the brain and to produce pain sensations is lower in cattle than in humans. This does not mean that they suffer less, but the psychological consequences of pain in cattle may be smaller than in humans [38]. Considering these aspects and analysing them in reference to the entire ethogram, we can draw conclusions about the needs of the species. Knowing that due to their body structure cattle mainly move well in a forward direction, primarily to obtain food and water, as well as to seek shelter, space, the company of other animals or a sexual partner, we should guarantee them the physical exercise necessary to keep them in good physical and mental condition. In natural conditions ruminants take in food by grazing on pastures, after which they digest it when they feel safe. This fact should be exploited so that the animal can better assimilate its food. Thus in addition to food intake, rest is crucial to cattle [38]. In view of the time budget and the fact that these animals spend their time mainly on taking in food and on rest, excessive activity or inappropriate time proportions may be a signal of a disturbance of mental or physical well-being.

For comparison, in poultry the main forms of behaviour are scratching the ground, standing, walking, fluttering the wings, vocalizing, clucking, sitting off the ground (on bushes or trees), and sand bathing. To ensure poultry at least a minimum opportunity to express their natural behaviour, even in cages variation is introduced in the form of perches or containers with sand. It is difficult to observe changes in the time budget of these animals, but other behavioural anomalies may occur. 'Redirected' behaviours often appear. These originally served other purposes, but in a stress situation (including inadequate welfare) the animal performs them towards an inappropriate object [22]. Caged chickens are often observed to peck out each other's feathers (in the absence of a substrate they can scratch), and calves given milk from buckets will often suck on various objects or body parts, as their need to suckle is not met [22]. For pigs, the most important element of behaviour is exploring and seeking food by rooting (as in wild boar). Piglets and fattening pigs kept on a hard surface with no opportunity to root, and also as a result of chronic stress, bite each other's tails and ears out of boredom.

Other examples of pathological behaviour are sterotypies, aggression, apathy, self--narcotization, and many other mental illnesses, such as obsessive-compulsive disorder (OCD). Stereotypies are repeated and purposeless behaviours which are a kind of defence system for the body. They are an adaptive mechanism protecting the animal against the appearance of psychosomatic disorders. They can, however, be self-destructive. Apathy is a response to chronic stress stimuli and expresses a state of depression and the animal's inability to adapt to the conditions of the rearing environment [22]. In the case of self-narcotization, the animal becomes dependent on the release of beta-endorphins [22].

The figure below presents the conflict between animal welfare and productivity [10]. From point B an increase in animal productivity is inversely proportional to their we-

lfare. Point E represents a state of balance between preservation of a suitable level of welfare and the animals' productivity.

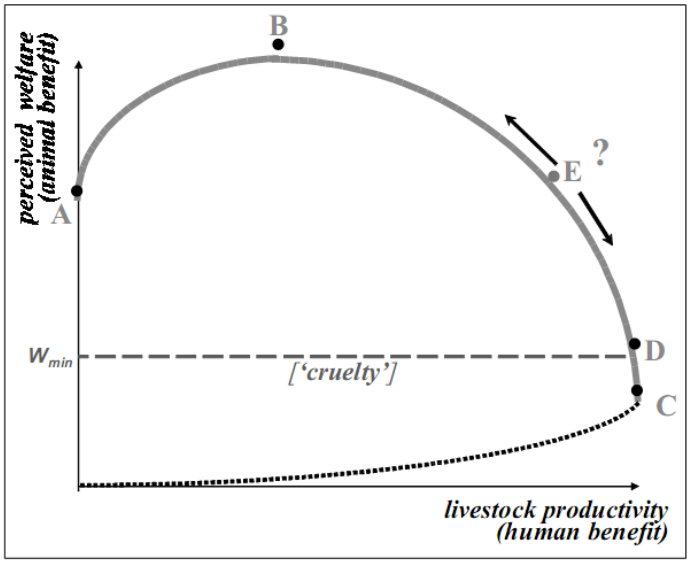

Fig. Conflicts and choices between animal welfare and productivity [10]

Intensive systems, which are the most profitable, are not able to guarantee the five freedoms developed by English specialists from the Farm Animal Welfare Council. However, when we study the behaviour of animals we know what they need and how to find the 'golden mean', designated in the figure by the letter E. It remains only to investigate the signals sent out by the animals [10]. Not only does intensification of production influence the quality of life of animals, but animal welfare also affects the economics of production. Thus these are two aspects strongly influencing one another.

The behaviour of the species during transport is highly significant. Transport is strictly regulated by law in order to protect animals from negative consequences and ensure their safety. Transport of animals can only be organized by entrepreneurs meeting statutory requirements, and the entire transport procedure is subject to control at the national and EU level [28]. During transport animals are subjected to severe stress associated with the change in their surroundings and the means of transport (loading and unloading methods and associated trauma), as well as to heat stress and fatigue

(during transport). Stocking density is also a significant factor (excessive density causes severe stress), as are the vehicle quality and the competence of the driver.

Another problem is slaughter of animals. The aim is to ensure that the procedure is as fast and painless as possible. The first, most important principle is that the animal should be put to death in a special facility intended for that purpose, so that other animals do not witness it. We know that animals [50], as well as humans [15], are able to detect the smell of emotions, especially those accompanying stress (fear or anxiety). Here a key problem arises, because in order for the animal not to feel frightened before death (for it to be unaware of what is about to happen), the 'smell of death' would have to be eliminated [52], which in a slaughterhouse is virtually impossible. Similarly, in the case of laboratories, in January 2016 a requirement came into force that animals must be sacrificed in a separate room with highly efficient ventilation. However, the problem of the scent of stress remains unsolved for macrosmatic animals (the facility would have to be very thoroughly disinfected). Another problem, much talked about lately, is that of ritual slaughter. In Poland there is no tradition of this kind, but shechita, i.e. ritual slaughter of animals in Judaism, performed by a highly-trained shochet, is a necessary condition for consumption of the meat. The Polish Constitutional Tribunal stated unequivocally that 'The lack of permission to subject animals to slaughter in a slaughterhouse in accordance with special methods prescribed by religious rites is inconsistent with the Constitution of the Republic of Poland. Criminal liability for subjecting animals to such slaughter is inconsistent with the Constitution' [23]. Because freedom of religion and conscience is guaranteed by the constitution, the Tribunal cannot prohibit ritual slaughter, as meat from an animal killed in any other way is not kosher.

Conclusions

Knowing the needs of a species we are able to create optimal living conditions for it. While the behaviour of livestock animals is fairly well known, wild animals, e.g. those kept in zoos or in vivarium conditions, have not yet been adequately described. The problem of animal welfare concerns not only livestock and zoo animals, but companion animals as well. When pet owners lack adequate knowledge of the behaviour of a given species, despite sincere intentions they fail to meet the animal's basic needs. This is why ethology is often the key to attaining a high or at least satisfactory level of welfare for animals, while later observations of their behaviour provide information as to whether their needs have actually been met. Thus learning a behavioural standard gives us guidelines for preparing a future living environment for animals that will meet their natural needs, and later observations provide information about their welfare.

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