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Importance of living environment for the welfare of captive animals: behaviours and enrichment

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Abstract

Animal welfare can be defined on the principle that a captive animal must present no prolonged negative emotional states thanks to physical and social environments that allow it to express its full behavioural repertoire and maintain its homeostasis. For several years, livestock breeders and zoos have been working to increase the welfare of their animals by applying ergonomic principles otherwise known as environmental "enrichments". These enrichments must allow the animal to enjoy daily activity that satisfies its physical, physiological and cognitive needs, which in concrete terms is shown by

(1) an increase in behavioural diversity,

(2) a reduction in the frequency of abnormal behaviours (stereotypies for example), and finally

(3) an increase in the positive and full use of the captive environment.

This of course requires specific knowledge of the animal's behavioural repertoire in its natural environment, but also of its ecology and biology in general. Five enrichment categories can be defined: physical, social, dietary, sensory and cognitive. Much progress has been made in terms of physical enrichment: size of pen or presence of structures and accessories are now seen as a priority, particularly at zoos. But there is room for other improvements, particularly for social enrichment: the important presence of animals of the same species is often overlooked. In terms of food, major problems are often noted for the particular class of social carnivores but in general there is very little diversity in the composition of food or its spatial or temporal distribution. Once again, such improvements can only be made if there is an understanding in the biology and ethology of the species held in captivity but also by incorporating the principle of animal welfare at all levels of society.

Introduction to enrichment

1. Definitions

Environmental enrichment is a concept which describes how the environments of captive animals can be changed for the benefit of the inhabitants, thus enhancing their welfare (Hill & Broom 2009). Animal welfare is defined as the absence of suffering and the respect of animals' needs, not only imperative and nutritional – which would mean good treatment – but also behavioural. There are many behavioural needs, such as living space, sociality and the capacity to move, flee, hide or hunt (Vilanova & Smith 2014).

An analysis of animals' needs allows us to better define what would be their ideal environment. These needs are assessed by studying an animal's physiology, movements and posture. Obvious signs can be used to understand whether an animal, whatever its species, is suffering or in a state of unease. These signs increase in rate and amplitude based on the intensity of the constraint imposed

or suffering felt. The latter will first impact behaviour (presence of stereotypies, self-mutilation, aggression), physiology (increase in cortisol indicating high levels of stress, ulcers, decrease in noradrenaline), neurology (decrease in brain cell density, decrease in cerebral plasticity, memory), then production (absence of milk, impact on growth, absence of reproduction) and finally the animal's health (decrease in immune response, weight loss and illness)(Veissier & Boissy 2009).

Principles of ergonomics are therefore applied to animals, seen as agents that carry out certain tasks: feeding, resting and moving. The ergonomic approach can reduce injury and increase the animal's comfort by creating suitable facilities, and is itself called "enrichment".

2. The different historical approaches

Differing notions of welfare, which more or less take into consideration the different needs and wants of animals, have led to the development of three approaches to improving animal welfare: the naturalist approach, the adaptive approach and the mental approach (Young 2003).

The naturalist approach considers that an animal must be able to live its natural life (Rolin, 1993), namely perform its species' full behavioural repertoire. By applying this approach, the aim is therefore to favour environments that are similar to the species' ecological niche, in other terms recreate the animal's natural environment. There are pitfalls with this approach however, because animals have continued to demonstrate abnormal behaviour in captive environments that visually look like the animal's natural environment. This is because the similarity was artificial and based on the structural aspect of the environment (shape of trees and rocks, landscape, terrain) instead of the ecological aspect (presence of real plant and animal species with which the animal can interact). The idea above all is that the animal can interact with its environment.

The behavioural approach is based on the principle that all individuals have mechanisms to adapt to their environment to achieve a state of homeostasis (behavioural stability). But if the gap between the animal's actual environment and optimum environment persists, it will tire itself out trying to adapt. This approach therefore consists in ensuring that the animal exhibits its full behavioural repertoire even if the captive environment is not visually similar to its wild environment. In this approach, the animal interacts with objects or structures in its environment, even if they are not visually similar to elements that it would encounter in its natural habitat.

Finally, the mental approach draws on the very notion of welfare itself: the animal's captive environment must be designed in such a manner that the animal’s resulting state is free of prolonged negative emotions (fear, pain, frustration). This state is subjective and unique to each individual depending on the way it perceives its environment and this mental approach therefore includes the notion of sentience. However, fulfilling the criteria of this approach means fulfilling the same needs as the two approaches mentioned above. The three approaches are complementary and all require knowledge of the animal's environment and behavioural repertoire in its natural environment. The animal's captive environment must more or less resemble that of its natural environment (naturalist approach) but the animal must be able to interact as much as possible with elements of this environment (behavioural approach) in order to decrease its stress as much as possible (mental approach).

3. Objectives

In short, enrichment can be used to achieve four objectives. The first objective is to increase behavioural diversity, namely increase the number of behaviours shown by the animal, whether these behaviours are natural or non-natural but leading to a better level of welfare. Adding straw bedding for pigs instead of leaving them on bare concrete allows them to root and dig as they would in their natural habitat. This also decreases diseases caused by direct contact of hooves with concrete. The element itself (straw) is not natural, meaning that pigs naturally root earth or grass

rather than straw, but adding straw helps the animal express this natural behaviour (Guy & al. 2002; Morrison & al. 2007). It is also possible to provide an animal with a non-natural element that will result in a non-natural behaviour, and therefore increase its behavioural diversity but not its abnormal behaviours. For example, a chimpanzee feels a certain sense of well-being by holding and using a pen or painting on paper with its finger, even if chimpanzees do not paint in their natural environment (Watanabe 2012).

The second goal is to reduce the frequency of abnormal behaviours that are defined as frenetic behaviour towards abnormal objects (chewing on an iron bar instead of natural elements) or an absence of objects (chewing on nothing in the absence of even an iron bar), or stereotypies (static, repeated or apparently aimless activity such as head-shaking or pacing in cages). Pigs frequently chew on elements in their environment, whether to feed or not, elements that are usually present in a captive environment. The presence of substitute elements allows the animal to produce these rooting behaviours. However, the absence of these elements can lead to abnormal behaviour such as repeated biting of pen-mates' tails (hence the practice of tail docking in piglets on farms) or stereotypies (Collectif & Chemineau 2013).

The third objective consists of increasing the number of natural behaviours by enrichment, often for purpose of species conservation. Finally, it is not necessarily useful to increase the number of natural behaviours for animals raised as livestock, it is simply necessary that their welfare is respected. However, it is very important that natural behaviours are expressed along with the full behavioural repertoire of animals reared to be released into the wild or reared to produce offspring that will be released. In this case it mainly concerns flight or predatory behaviour (Guy & al. 2014).

The fourth objective is to increase the positive and full use of the captive environment. For a zoo or farm, space has a cost. The non-use of space by animals can have a significant economic impact and it is important that we understand why animals are not fully using their enclosure. This could be due to an element in the environment that keeps the animals away from part of the enclosure (other species if a mixed group, external factor such as a nearby road, etc.), or the animals are not drawn to this part of the enclosure and the enrichment would be to add structures that attract them there.

A user can enrich the enclosure to fulfil one or all of these objectives based on its use by the animal or the reason for which it is being reared. However, the objective to reduce the number of abnormal behaviours must be achieved for all animals held in captivity. Many arguments have been made against the use of enrichments; these can be mostly defined and summarised as follows:

- Enrichment increases maintenance costs for captive animals. This is false. Most often, any cost, as little as it may be, put into enriching an enclosure, will be gained elsewhere on animal care costs and the fact that it will be less likely to destroy its environment by looking to increase and diversify its activity.
- Enrichment creates extra work for animal keepers. This is partly true and partly false. Work to enrich the animal's environment can lead to less destruction of this environment. Where animal keepers loose time, they gain it elsewhere. Moreover, involving animal keepers and having them understand the value of enrichment, playing on entertainment rather than obligation, generally leads to better psychological welfare of the animal keepers, meaning they are more effective in their work and therefore saving time and money (Young 2003).
- Enrichment leads to a riskier environment for the animal. This is false if we know the animal's habits and behaviours in its environment and the enrichments are suited to the species' ethology. It is obvious that a three-dimensional environment is riskier than an environment without structures (branches, trees) but the animal's distress is such that it is riskier to leave it in poor conditions rather than improve its enclosure with physical enrichments.

- Enrichment increases inter-individual variability in test protocols. This is false if the same enrichments are given to the tested subjects. A PVC or paper roll in a mouse's cage will not increase this variability in relation to an environment without any enrichment. Inter-individual variability is, in any case and intrinsically, already great enough between individuals and this personality trait is very seldom tested during research protocols or product tests. Moreover, giving a poor environment to subjects leading to a chronic increase in their stress levels is not a solution for verifying the effectiveness of substances and renders scientific results invalid and non-transposable to the target subjects.
- There is no scientific evidence that shows the effect of enrichment on animal welfare. This is false. Many examples showing its effectiveness are published every month in specialised peer reviews.

The various types of enrichment

There are various types of enrichment that we can group into five main (non-exclusive) categories. When an animal's environment needs to be rich and diverse, adding a specific enrichment must respond to a specific need of that animal (social, locomotive). For example, if an animal exhibits stereotypic "pacing" behaviour, the size of its enclosure needs to be increased; adding a social partner as an enrichment would not resolve the stereotypic problem. If the animal has a behavioural problem, the first step is to:

(1) identify the problem, then

(2) identify its cause or causes,

(3) treat these by a suitable enrichment, and

(4) verify the effectiveness of the enrichment on the problem in question.

Therefore, generally speaking, when the environment of one or several animals must be enriched, several questions should be asked. These questions will make it possible to provide the most appropriate enrichment for the captive animals. These questions are varied and cover the sociality of the animal, its diet, activity, the time it spends per day satisfying its needs (time budget), *etc.* For example:

- How social is the species (solitary, gregarious, social)?
- How many dimensions does the animal move in (two or three)?
- What distance does each animal cover each day and for how long?
- What is the animal's diet? What is its dietary diversity?
- Is the animal a prey or a predator? Does it hunt in groups?
- How many times is it fed a day and for how long?
- What sense does the animal use to find its food?
- How does the animal extract its food? What parts of its body are used to do that?
- How do the answers to the questions above vary depending on the type of food the animal eats?

The list of enrichments for improving captive animals' welfare that we have provided here is far from exhaustive. Other examples are given in the numerous references. We strongly recommend the book *Environmental enrichment for captive animals* by Robert J. Young (2003) and the website "The Shape of Enrichment", which has a very extensive video library on the topic.

1. Physical enrichment

The enclosure of an animal or group must suit its species in terms of enrichment. The personalities of captive animals and interactions between individuals will determine how the enclosure will be used (Clark 2011; Gartner & Weiss 2013; Tkaczynski & al.). The size of a zoo

enclosure, livestock pen or medical research cage must first and foremost allow animals to express their natural behaviours, particularly locomotive ones. The size of the cages must be defined on the principle that a rabbit must be able to jump and a chicken must be able to spread its wings (see Decree of 1 February 2013 implementing the conditions for the agreeableness, structure or function of an establishment of a breeder, supplier or user of animals used for scientific purposes and their controls NOR: AGRG1238753A). Herbivores must also be given enough space for the grass that they graze to be able to grow back or be given a hay supplement (Ramos & al. 2016).

The animal's social aspect must also be taken into account. When animals are placed in groups in an enclosure or cage – where this is preferable for the expression of their social behaviours – it is vital that the space is big enough for individuals to stand apart or escape their pen-mates. The suitability of the space for the species can easily be noted by observing the animal's health. One or several individuals regularly presenting numerous injuries is firstly a sign of (1) a feeding problem: the quantity of food must be increased and placed in various areas. If the problem persists, it means that (2) there is a spatial problem: the size of the enclosure (or cage) is too small and needs to be increased. A persistent problem even with a larger enclosure suggests that there is (3) a social problem in which several individuals are not socially compatible. This requires an ethological study of their social relations (Sueur & Pelé 2015).

A new way of thinking about space in zoos, fields and nature reserves is to remove barriers. In these conditions, certain animals that live in groups or herds are given GPS collars and a negative conditioning system (electric shock that is no greater than that of the existing electric fences already used in many enclosure systems) (Sikka & al. 2004; Butler 2006). This creates a virtual barrier so that when an animal wearing a collar crosses over the line, it receives a shock, which conditions it to turn around and stay within the predefined space. The benefit of this system is that not all members of the group need to be equipped – which would be difficult to implement due to economic and health considerations (need to anaesthetise the animals). The few individuals that are given a collar are chosen because they are known to be "leaders" (Ramos & al. 2015).

The complexity of the enclosure can also be enhanced by non-linear division into more or less isolated areas. In some zoos, the enclosures are built so that species can be easily switched between compartments using a system of hatches. With this system, the animals' enclosure can be changed and the animals temporarily blocked off from certain compartments, which also constitutes an enrichment.

Permanent structures must be presented in the enclosure. These structures can be rocks placed so that the animals can overlook their enclosure and beyond, bask in the sun or on the contrary, find shade or shelter from the rain. For arboreal and semi-arboreal mammals and birds, it is important that they are given structures such as beams and perches on which they can move across several levels. Herbaceous, shrubby or arboreal plants can also be placed in the enclosure. If the enclosure is outside, other non-captive species may be attracted to these and mix with the captive animals. However, checks must be done to ensure that the plants placed with the animals do not cause any health issues for the captive species. Enclosure platforms often allow individuals in a group species to stand apart. However, it is important to check how many platforms to install as they can often be monopolised by certain individuals, stopping other members of the group from accessing these elements. The same applies to swamps or mud puddles that limit the number of individuals they can contain due to their size. It is therefore important to check that the number of permanent structures can be accessed by as many individuals as possible. The brown bear enclosure at the Sainte-Croix Animal Park (Rhodes, France) was entirely redesigned in 2014. With a strong resemblance to the natural environment of brown bears (*Ursus arctos*), the two-hectare enclosure offers its four inhabitants a range of areas: a damp area with reeds that allow the bears to hide, a tree-lined area, various reliefs and several ponds.

Temporary structures may also be installed. They are temporary because they deteriorate much faster than the permanent structures and are precisely designed to be "damaged" and used by the animals. These could be tree trunks or branches that the animals will gnaw on, plastic barrels or iron sheets that the animals can climb, or cardboard boxes which they can hide or lie in. The latter are in fact a typical example of temporary enrichment used for felines: cats, lions, panthers, tigers and others love playing in cardboard boxes or sleeping inside them. This infatuation is mostly likely due to the fact that felines hide to hunt and rest, and particularly during parturition. The benefit of these temporary structures is that they are often recycled objects and cost nothing for the keeper regardless of how they will be used.

With regard to animal research, it is possible to provide mice and rats with permanent structures (tubes, exercise wheels, nests, etc.) as well as temporary structures (cardboard rolls, cotton, etc.). There are several suppliers of enrichment products that are specifically packaged (sterilised, suitable for autoclave treatment) for laboratory animals.

2. Social enrichment

Many species live in social groups or flocks. Social animals need to interact with members of their own species. An animal's social interactions and structures, whatever its degree of sociality, has a huge impact on its health, welfare, ability to reproduce and longevity (Price & Stoinski 2007; Silk & al. 2003; Stanton & Mann 2012). It has been demonstrated in several species that investment in the development of long-lasting stable relationships has a positive effect on the animal's quality of life and reduces their stress levels (Archie & al. 2014; Fürtbauer & al. 2014). It is therefore important that social animals are in contact with members of their own species. In its natural environment, an animal also interacts with animals of other species. Social enrichment and the contacts on which it is based can thus take various forms.

It is vital for social animals to live in groups. Research on baboons in their natural environment showed that the stability of social relationships had a positive impact on their health and welfare (Silk & al. 2009). It is therefore important that stable, long-lasting relationships are favoured in order to ensure the welfare of the individuals. This does not entirely fit in with conservation and reproduction programmes that result in animals being exchanged between zoos to prevent inbreeding. The stability of social relationships also depends on the sociability of the individuals in the group, another aspect of personality (Wolf & Weissing 2012). Certain species that are solitary in their natural environment may be held in groups in their captive state. In zoos, brown bears (*Ursus arctos*) often share their enclosure with members of the same species although they are solitary in their natural environment outside of breeding season. These bears must develop social contact with the individuals with which they share their enclosure; if the enclosure is big enough, this can be an advantage for their welfare compared to being alone. In agriculture, chickens (*Gallus gallus domesticus*) are held in groups that are more or less dense whereas in the wild, their ancestral species lives alone or in very small groups. Recent studies have shown that domestic chickens can interact and even develop positive relationships with those nearest to them (Abeyesinghe & al. 2013; Koene & Ipema 2014). The social relationships of a social group must therefore be known, and the inter-individual hierarchy must be noted and monitored from one year to the next in order to prevent any social problems from arising within the group.

In other cases, animal welfare can be improved by the creation of multi-species groups (Chapman & Chapman 2000; Buchanan-Smith *et al.* 2013). Individuals from different species will either simply share the space without developing any particular relationship, as is the case of hoofed 'Savannah' animals (zebras and antelopes) or European fauna (bison, deer, ibex), or share the same space but also develop social and relationships and groom each other (Pearson *et al.* 2010). For example, this is present in various species of lemurs, but is also frequent in gibbons and

orang-utans. For example, it was shown that these mixed groups led to a decrease in vigilance in impala antelopes (*Aepyceros melampus*) (Pays *et al.* 2014). This also allows them to intensify their search for food in their natural environment (Farine *et al.* 2015). It is however important that the species kept in contact maintain positive or even neutral relationships, but above all not negative ones. A species can be relatively aggressive, due to territorial behaviour for example, and this can lead to attacks that cause injuries or even the death of an animal. Contact with humans can also be important if it is the only contact possible. However, it is important that the animals can extract themselves from this contact when they feel like it in order to avoid stress.

When it is unfortunately not possible for an animal to be in contact with other animals of the same species or another species due to health reasons or a test protocol, solutions exist to socially stimulate the animal. First of all, animals held in separate cages must be able to see each other. This visual contact is vital for social animals (Bayne *et al.* 1993). Under such conditions, contact with humans is also very important: animal handlers must interact with the animals whatever the species, and this is even more vital for species that have advanced cognitive capacities, such as monkeys. As a last resort, the animal can be stimulated by a sensory enrichment such as radio or television. If possible, the animal must be able to turn the device on or off by itself, so as be calm or stimulated when it wishes. Finally, it has been shown that animals quickly get used to this type of stimulus, as they soon cease to pay attention to it. Therefore it is a temporary solution because it clearly falls short on meeting the minimum conditions of welfare. As a result, it is important to check the animal's psychological state and assess whether it has fallen into a state similar to depression.

3. Cognitive enrichment

Cognitive enrichment consists in stimulating animals' cognitive capacities. For many species, looking for and extracting food in the natural environment takes up a large part of the day (up to 95% of the day, excluding rest). For example, chimpanzees may use sticks as tools to look for ants or termites in collectively built tunnels; they also break nuts open using selected stones called hammers or anvils (McGrew 1974). With cognitive enrichment, we are trying to recreate this foraging time by making food access more complicated. The idea is not to make all food difficult to access but for some more appetising food items to be integrated into these distribution systems. For primates, biscuits may be freely available but fruit or grains may be more difficult to access. This enrichment is not only possible for species with high cognitive capacities but can be adapted to any species. For example, piles of tubes or tunnels can be made to house ants or other insects that can be hunted as food. The enrichment can also be a system that makes it difficult to access a piece of meat for a carnivore, either because the meat is hidden, up high or on a moving structure.

The first type of cognitive enrichment can be puzzles or artificial fruit. Puzzles are labyrinth systems where food is placed at one end beyond the animal's reach. The animal must use its fingers or a tool to extract the food through an opening at the other end. These devices are used mainly for primates but are beginning to be developed for other species. Artificial fruit are boxes in which food is placed (Dindo *et al.* 2008; van de Waal *et al.* 2012). The animal must handle the box (turn it over or around, or use a lever) to access the food. Although initially developed for zoo or laboratory animals, these enrichments have been made available for pets. For example, no fewer than eight bowls using the same concept have been developed for cats (the Trixie Tunnel feeder, Aïkiou's Stimulo, Chat Perché's Temple à croquettes, Cat it's LabyrintheSense, and others). None of these are electronic but more sophisticated systems have been developed, such as CleverPet's game console for dogs. This interactive learning and entertainment device has coloured keys that light up which the animal must touch to receive a food reward. These devices prevent the pet from getting bored when their owner is not present. They can also be used to maintain a certain level of cognitive activity in older animals. Over the past decade, similar systems have been developed for

primates that use touch screens on which the monkey must resolve more or less complex cognitive problems to be able to access an appetising food item (again in addition to its unlimited food). These systems allow the animal to replace their natural food foraging time and reduce their levels of stress. New Kinect-type interfaces (without levers or screens) are also being developed by Melbourne Zoo in Australia with orang-utans. Interaction with humans, whether for entertainment such as a show, but above all as part of behavioural experiments, such as in comparative psychology and ethology, also provide animals with stimuli. These tests are regularly renewed and test advanced cognitive capacities such as recognising numbers, colours and symbols, opening enticing boxes using tools or the capacity to exchange elements of different values (Tomasello & Call 1997; Pelé *et al.* 2009). The Wolfgang Köhler Primate Research Center invites visitors at the Leipzig Zoo in Germany to attend behavioural tests with great apes. Neither should we underestimate the importance of human presence and contact with isolated animals. Bayne *et al.* (1993) have shown that only six minutes per week of human presence significantly decreases stereotypic behaviour in individually housed rhesus macaques (*Macaca mulatta*).

4. Sensory enrichment

Sensory enrichment, as its name suggests, will stimulate one or several of the animal's senses: sight, hearing, touch, taste and smell, with the latter two generally combined.

Visual sensory enrichment consists of giving the animal the possibility of observing a changing environment. In zoos and farms, this enrichment can first be done by creating an enclosure that allows the animal to see outside, or even have an overlooking view and/or be able to see the horizon. Animals are stimulated by seeing visitors and/or other animals. Access to television or a computer can also elicit behavioural reactions from animals. For example, in China, videos of coupling pandas (*Ailuropoda melanoleuca*) increased the breeding success rate of captive pandas ("Panda Pornography", Wikipedia, 2016). In birds, if a quail has two containers, one red and one blue, and is shown a video of a Japanese quail (*Coturnix japonica*) only eating from a blue recipient, this will increase the probability that the quail having seen the video will also eat from the blue recipient (Akins *et al.* 2002). A mirror can also be used to enrich an animal's environment but has different effects on animals' behaviour depending on their cognitive capacities (Gallup Jr *et al.* 2002). For example, for species that do not recognise themselves in the mirror (no self-awareness), the mirror creates the illusion of there being more individuals in the pen, which can increase the individual's welfare and reproduction, as has been shown with flamingos (O'Connel & Rodwell 2004) and rabbits (Jones *et al.* 2005). However, great apes, which are able to recognise themselves in a mirror, will spend time using it to inspect parts of their bodies that they usually cannot see (behind, inside mouth). Nevertheless, it is not advisable to place a mirror in front of gorillas (*Gorilla sp*) because this species sees direct eye-to-eye contact as aggressive behaviour. Direct visual contact is also a threat for many monkey species.

Auditory sensory enrichment consists of playing sound (natural, music, radio) to animals that have no open environment or have been temporarily isolated. Sound can also be played when an animal must enter an unfamiliar enclosure or area. Music is also increasingly used in dog shelters to calm and sooth new arrivals (Wells *et al.* 2002). As with television, these sounds must not be played continuously but only for several minutes a day or week. For species whose vocal repertoire includes song (gibbons, passerines) or which simply communicate through vocalisation (wolf howl, deer bellow), playing sound recordings can stimulate the animals. As music can have a positive effect on animal welfare, it also affects their production. It has been shown that cows produce more milk when music, especially classical, is played (Albright & Arave, 1997). Many species are also able to recognise a beat and enjoy rhythm, such as seals (Cook *et al.* 2013) or parrots (Patel *et al.* 2009). The Washington National Zoological Park in the United States has even given Asian otters access to a synthesiser; the animals were able to play with the keys and produce sounds. Behavioural

research has also shown that a chimpanzee hitting or beating a barrel followed a rhythm similar to rhythms produced by humans (Dufour *et al.* 2015).

Tactile sensory enrichment consists of giving an animal various substrates (with different textures or grains) with which it may interact or on which it can move. These enrichments may be permanent or temporary. By simply knowing how a species interacts with elements in its natural environment, it is possible to know which substrate to introduce to its captive environment: sand or straw for animals that look for food on the ground, such as chickens and pigs; mud for animals that like to cover themselves with it; access to water (river or pond) for animals that like to bathe. Pinnipeds (seals, sea lions, etc.) whose vibrissae are innervated and contain a blood supply, are able to detect by touch shapes that are 3 mm thick and 2 mm wide, meaning they are able to search through sand and look for decapods (lobster, crayfish, etc.) and shellfish. The walrus (*Odobenus rosmarus*) tank at the Nagoya aquarium in Japan has a plastic mat along the bottom dotted with bumps and gaps to stimulate the animal's sense of touch. Tactile enrichment can also consist of installing showers that the animals can activate at will or automatic water misters. Another activity is to place items (food or other things) in ice. Ice is also given to animals during heatwaves to cool them down. This consists in giving animals blocks of ice that contain food (fish for bears, seeds for granivores, meat for felines, fruit and vegetables for primates, and others).

Finally, sensory enrichment by smell consists in stimulating the animals by using natural or chemical odours that the animals are not used to. This could just be branches or trees cut for clearing but placed in the enclosure instead of being thrown away, or items specifically purchased for their smell (odours of other predatory, prey or neutral species; various spices). For example, Seattle Zoo in the United States recycles its coffee grounds by giving them to grizzly bears (*Ursus arctos horribilis*) because the smell of coffee stimulates them: they roll in it and rub it on their fur.

5. Dietary enrichment

Animals in their natural environment spend most of their time looking for food, namely 80 to 95% of their time when not resting or sleeping. However, this time depends on the animal's diet. Each animal species has developed a specific diet that depends on its natural habitat, namely what food is available, the way in which it is provided and the presence of rival species. These ecological pressures have shaped animals' food foraging behaviour. A species' natural food types must be respected for the welfare of animals held in captivity (Newberry 1995; Young 1997). Very often, captive animals are given a very rich diet that greatly reduces their foraging behaviour and can lead to weight problems. It seems vital that there is a similar level of difficulty to that which an animal encounters in its natural environment when extracting food or catching prey. For certain species, it is therefore necessary to provide systems that complicate access to their food. This can be spatial (the food is placed in several areas around the enclosure) and temporal (food is distributed throughout the day or at random times).

Placing food in various areas, changing these areas every day or scattering food allows a frugivore or carnivore to find food when alone. Placing food in a specific location rather than more or less randomly around the enclosure can increase food competition within a social group and prevent subordinate or peripheral individuals from accessing this food (Barton *et al.* 1996; King *et al.* 2011). Keeping a log of aggressive behaviour can also help understand the group's hierarchy and reduce conflicts. Before setting up a food distribution system (which areas and how often), it can be interesting to understand the sub-groups or groupings present and determine the number of food distribution locations based on these affiliations. This will prevent aggressive encounters and reduce overall stress levels (Buchanan-Smith *et al.* 2013).

Temporal food distribution involves two factors: frequency and food distribution order. In their natural environment, animals do not have permanent access to vast amounts of food. It is

therefore necessary that food or certain types of food are provided intermittently. Unlimited supplies of some food may be given (biscuits or hay) while more appealing food is given two or three times a day. Other less frequent foods in their diet can also be given once a week or month. Food distribution systems can be made very easily by drilling holes in tubes that let the food out intermittently. For insectivores, crickets or larvae can be put into tubes placed high up; as they move the insects will gradually fall to the ground, increasing the animal's foraging behaviour. These same tubes placed freely or attached to the ground and filled with seeds will also increase the animal's dietary activity.

Dietary enrichment also consists in playing on the novelty of the food provided. Animals are often given pumpkins for Halloween, whatever their normal diet. The value of this food is not necessarily nutritive but rather gustative and tactile. The animal can play at destroying the pumpkin and more or less eat it. Many zoos use pumpkins for a wide range of species: carnivores, primates, elephants, monitor lizards, etc.

For captive animals in zoos, the ideal situation would be to present predatory species with live prey to stimulate their senses, cognitive capacities and motor capacities. This is already sometimes done for animals that will be released into the wild to increase population numbers for the purposes of preserving the species (People Le Ruyet *et al.* 1993; Young 1997; Bashaw *et al.* 2003). This enrichment raises several issues. The first is that we must ensure that the predator kills the prey "quickly and cleanly" so as to limit its stress and pain. Health risks must also be removed. Another important issue is how zoo visitors might react; they will certainly not react in the same manner to a cricket being eaten by a bat as to a rabbit being suffocated by a snake (Ings *et al.* 1997). This emotional reaction from visitors, which entirely depends on the type of prey and its reaction to the predator, could be called speciesism; but there is also the variable aspect of nociception (set of phenomena that allow a central nervous system to integrate a painful stimulus by activating nociceptors (pain receptors) found in the skin, muscle tissue and joints) to be taken into account. As prey, a mammal or bird will not have the same cognitive (suffering) or emotional (pain) integration of nociception as an insect or bivalve mollusc. These scientific and ethical concerns should be taken into account when wanting to provide this type of enrichment. Finally, more or less complex systems can be put into place to simulate the characteristics of prey and approximate the difficulty a predator faces when hunting. For example, lure coursing is used in some zoos to encourage cheetahs (*Acinonyx jubatus*) to run.

Current issues

Much progress has been made in understanding animal welfare. However, there is much more to be done first, in terms of understanding different species' biology but also applying welfare approaches to different domains. We have chosen to discuss three main issues here.

1. Species-specific needs

As indicated in paragraph 2.5. on dietary enrichment, natural ecological pressures have shaped animal behaviour and respecting the natural diet of each species appears to be vital for improving animal welfare. Herbivores, as well as most hoofed animals, spend little time looking for and extracting food but a long time foraging. On average, a giraffe (*Giraffa camelopardalis*) eats 66kg of plant matter a day. This foraging activity takes up nearly all of the animal's time budget (excluding rest or chewing time) due to the low nutritional value of their diet. The animals therefore need to be able to graze all day long. Whether giraffes live next to other species (savannahs) or not (zoos), any other enrichment would be almost superfluous.

On the other hand, frugivorous species, such as many primates or parrots, eat more high-energy food (fresh fruit or nuts) but these foods take a great amount of time to find and extract.

Therefore, these animals should be given puzzles or artificial fruit as outlined in paragraph 2.3. on cognitive enrichment, to keep them busy.

Finally, carnivores in their natural state only eat every two to three days, and have a long resting period (up to 20 hours per day for felids). However, they spend a large amount of time and cover great distances finding their prey. These species should be given a large amount of space to avoid stereotypic behaviour. With pets, it is most often the owner's lack of knowledge that causes human-animal relationship problems and distress to the animal. A good understanding of the species, in terms of its physiology, ecology and ethology, is essential for the welfare of captive animals, whether they are zoo animals, livestock or pets.

2. A multi-factorial approach

Only animal welfare should be taken into account when introducing an enrichment. However, this is far from what is done in reality and the approach to enrichment is often multi-factorial. There are three inseparable factors to take into account: (1) animal welfare, which is the purpose of the enrichment, (2) "consumer" satisfaction, and (3) the keeper. By "consumer", we mean owners, whether they are professionals or individuals, zoo and aquarium visitors, laboratory animal handlers and buyers of agricultural products. So a consumer and a keeper are often one and the same person. Of course, a zoo or pet shop manager must not decrease the welfare of their animals to benefit the consumer or animal care staff, but the right balance must be found in order to maintain an ethically and economically viable system. Enrichment, notably size, vegetation and other structures, can prevent visitors from seeing the animals. The failure to satisfy visitors who are keen to see the animal can lead to lower attendance rates with a varying impact on the zoo's budget. But this enrichment also allows the animal to not be seen. Continuing to think of zoo enclosures as they have been made until now creates a conflict between animal welfare and visitor satisfaction: an increase in one decreases the other. Why not look at new ways to design enclosures? They do not need to be polygons that visitors stand around but can be spaces which visitors are able to "enter" through a system of footbridges, tunnels or paths that take them closer to the animals, without being seen. Protected vehicle systems (bicycles or electric cars) could also be made. The Bjarke Ingles Group architecture firm drew on this new approach to create Zootopia, a zoo soon to be built in Denmark (Quintal 2014). Finally, the animal care team, whether for a zoo, laboratory or farm, must also be trained in animal welfare and the needs of each species. If animal technicians are trained and involved in decisions made for the welfare of the animals that they tend to, they will be more willing to spend part of their working time carrying out these activities.

3. Double standards depending on the sector and use of the animals

Much progress has been made in animal welfare over the past 20 years, though not in all fields in which animals are involved. Zoos have developed facilities and introduced enrichments to improve animal welfare as a result of pressure from two sources: (1) visitor opinion and (2) the need to implement conservation plans that respect the behavioural integrity of animals. However, circuses, which also have an entertainment aspect, have not progressed in the same way as the pressure they receive is not the same. Nevertheless, in the past few years, there has been some public interest in protecting circus animal welfare, an interest to which the circuses themselves pay very little attention. As a result, several towns and countries have banned circuses that use wild animals.

The most common pets are cats and dogs but rabbits, ferrets, rodents and other new pets (*nouveaux animaux de compagnie* - NAC) are being seen in increasing numbers in French households. A certificate is required to obtain and keep some NACs, such as snakes. However, any French citizen has the right to acquire a dog, cat, rabbit, rodent, etc. in France without having to

certify that they understand the animal's physiological or ethological needs. This is not the case in Switzerland, where since 2008, owning a dog has required a licence. Owning an animal is not a trivial thing, especially when the latter is kept in an apartment. Many people own dogs that only have access to the outside a few minutes a day and cats that never have access to the outside. This only causes a few complications for some breeds but is clearly problematic for others. For the latter, their behaviour needs to be closely monitored and they need to be given many enrichments. With regard to NACs, as things stand, there are only recommendations as to what conditions the animals are to be kept in. As a result, rabbits often live their entire life in cages that are too small and are unable to express their natural behaviours such as running and jumping. Much progress remains to be made in terms of prevention and education about pet ownership.

The same can be said for livestock reared for agricultural products or meat. This activity concerns the use of the greatest number of animals and yet it is here that the worst animal welfare conditions have been observed. This is largely due to societal and economic demands that have led to more intensive farming practices. Most livestock are reared in individual cages that are too small for them to express natural behaviours (spreading their wings or lying down, for example). The space given to groups is also small, which leads to significant attacks. Lastly, there is almost no enrichment of their environment. However, in recent years a collective awareness seems to have appeared, both in terms of what conditions are unsuitable for animal welfare, the economic stakes that animal welfare involves (consumer impression, better productivity, better immune system, etc.). As a result, some livestock breeders leave their animals in groups with access to the outside, and provide them with enrichments such as bedding, ground mats, perches, music or pivoting brushes to sooth cows. On 1 January 2012, the European Union banned the use of conventional battery cages (cages with 550 square centimetres of space per hen) for laying hens. There is also a strong trend towards the consumption of free-range chicken, particularly in Germany and Austria.

Finally, animal testing for scientific research is often problematic in terms of animal welfare, even if the conditions for using animals has never been so controlled as they are today, and compared to other fields that use animals. Without mentioning the constraints placed on animals in test protocols, the breeding processes used for laboratory animals often do not meet the minimum conditions to ensure those animals' welfare. Cage size, use of enrichments or the number of pen-mates are often limited. These conditions are maintained for the purpose of decreasing the number of variables that could influence the test results and are often standardised as a result. But could such conditions - the minimum for respecting good treatment - not cause the opposite effect? The animal could be in such a state of stress that it could invalidate the scientific test and its findings. It is therefore important that the species' biology is respected by providing it with conditions that ensure its welfare. Other than valid scientific results, an animal such as a macaque (*Macaca sp.*) should not ethically be held in a 1.5 cubic metre cage without contact with other members of its species, in light of its need for social interaction. Mounting pressure from citizens on this aspect of animal use is starting to make itself felt and there is an interest in taking this into account so that research can continue calmly.

Outlook

Respecting animal welfare is an ethical issue – as humans, do we have the right to impose poor captive conditions on the animals that we use? – but also has an economic impact: for a zoo, a distressed animal does not attract visitors and depending on the species, produces little or no offspring; for farmers, a distressed animal grows less, produces less, cannot breed or falls ill; for an individual, a distressed pet is synonymous with chaotic co-habitation and a difficult relationship. It is therefore important that animal welfare is improved but also that this approach is multi-factorial, one that simultaneously includes animal welfare, the ethics of the target audience

(livestock, entertainment, research) and understanding of the regulations in place. As such, an animal needs to be looked at from three angles to ensure its welfare: 1) biology, namely its ethology, physiology and ecology; (2) the law, namely any regulations pertaining to its use, and (3) ethics, namely what is moral to do or not. These three disciplines appear inseparable. However, in France very few universities offer courses that combine these three complementary fields. To date, a university degree in equine law is offered by the *Institut de droit équin* (equine law institute) and an animal law degree is offered by Limoges University. The VetAgro Sup veterinary school in Lyon also has a course entitled "Animal protection: from science to law", created in partnership with the French *Fondation Droit Animal, Ethique et Sciences*. Strasbourg University offers a Master's in Ethics and Societies with a major in animal ethics that includes lessons in ethology, animal ethics and animal law. The same university also offers a continued learning course on animal law for professionals as well as public lectures on animal ethics. We encourage the spread of these types of course in France so that all animal keepers or owners can learn the basics for ensuring their welfare.

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