Cattle behaviour and the human-animal relationship:

Variation factors

and consequences in breeding.

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Summary

Photos:
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I. - Introduction

Let us begin with the essentials: cattles are indeed herbivores, but they are also gregarious and social animals. Naturally, they live in groups and thus behave in a manner associated with this way of life. Each member of the group develops affinities and maintains competitive relationships; to do so, they must communicate between themselves. Thus the group is structured and communication is made according to the sensory characteristics of the animals.
Although cattle have a pre domestication history, today they are entirely governed by humans and wild herds hardly exist anymore.
Breeding and the practices involved therein impose a relatively close relationship between man and his herd and often-restrictive conditions for the animals. Throughout their history as a 'preyed-upon' species, cattle have considered man has a potential predator if they are not accustomed to his presence: they react to his approach and to the constraints of breeding. This results in situations that are dangerous for both the handler and the animals. To predict their reactions and reduce the risks, it seems essential that we humans understand cattle sensory perception, behavioural characteristics and their mechanisms for adapting to changes in environment. Thus, they too (the cattle) can understand us better.

II. - Sensory perceptions and communication

In order to safely control, manage and manipulate his herd, the stock breeder must first of all, understand how the animal perceives his environment. The sensory universe of a cattle, i.e. the functioning of its senses and environmental perception, effectively conditions a large part of the animal's reactions. Awareness of cattle modes of perception is therefore essential in understanding and predicting the animals' reactions. Experimental research in this field is still rare, but it is often corroborated by biology and the practical observations of those who work with animals.

1.1. Sight and visual communication

Sight plays an essential role in comprehending an environment and detecting danger, but also in the recognition of one's kind and communication between animals (UETAKE and KUDO, 1994; LOMAS et al. 1998). Along with hearing, sensory perception is the most studied element of cattle, these studies have produced some convincing results.

The cattle eye is composed -like they eye of all mammals- of two types of photoreceptor: rods and cones (SZEL et al, 1988; HAMILTON and HURLEY, 1990). The rods are responsible for the eye's sensibility to light; they are generally associated with nocturnal vision. The cones are responsible for visual acuity and contain photo-pigments that determine the vision of colours; they are generally associated with diurnal vision.

DIMBERTON (1999) proposes a detailed anatomical description of the cattle eye and its main functional characteristics. He discusses both the high proportion of rods and also the form of the crystalline lens, which gives cattle good visual sensibility (strong perception of light stimulus), but reduced acuity (weak perception of details). Their long sight, however, is very clear (BALDWIN, 1981) but long to focus.

Cattle can distinguish several geometric forms as well their orientation (BALDWIN, 1981; REHKÄMPER et al, 2000). However, the anatomy of their eye engenders a differing visual acuity for immobile and mobile objects (ENTSU et al, 1992; REHKÄMPER and GÖRLACH, 1997 and 1998): in particular, the perception of dynamic movement is more detailed than human vision and the vision of movement is distorted (figure 1). This characteristic would explain the animals' fear when faced with rapid movements and the necessity for the breeder to move slowly and frequently.

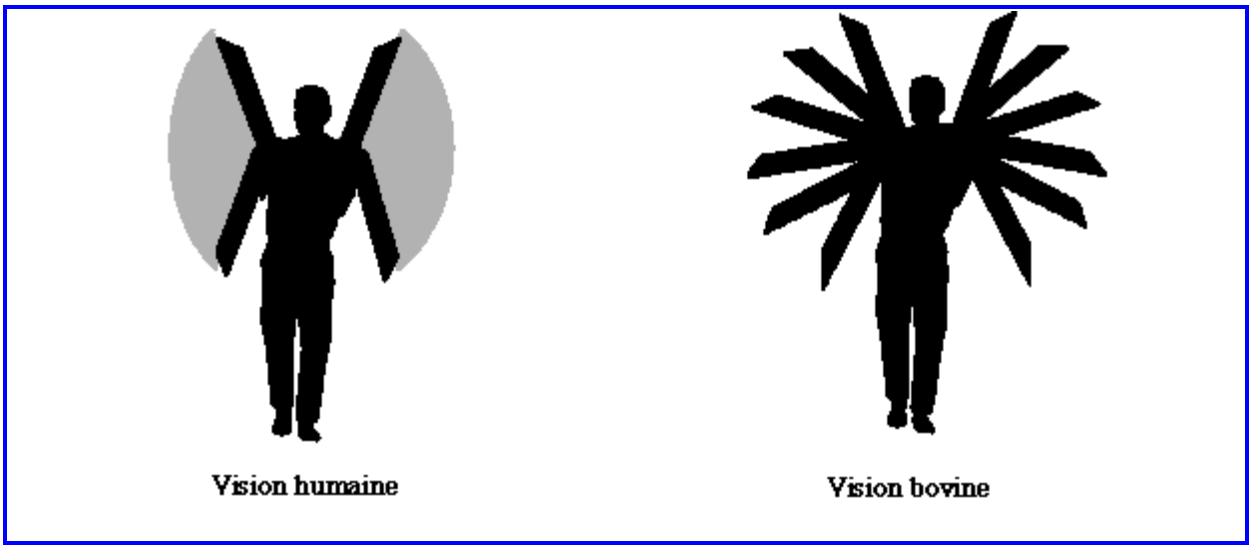


Figure 1: Perception of movements in humans and cattle.
(DIMBERTON, 1999)

The cattle eye's strong sensibility to light is a result of their 'crepuscular' way of life. This means that they are dazzled when confronted with intense light (that would not bother a human) thus engendering a 'fear' of contrasting light. Hence, cattle may be stopped in its tracks by the square of light projected on the floor from a window or colour changes on the ground. Therefore, it is necessary to ensure the uniform lighting of buildings and to avoid vibrant or reflective colours.
Changes in luminosity require an adjustment of the pupils' diameter and of the number of photo-pigments: the latter are eliminated when passing from a shaded to a brighter area and synthesized conversely. The synthesis of visual pigments is longer than their elimination: taking up to 3 minutes in cattle (DIMBERTON, 1999). Therefore, the passage from a bright area to a shaded one requires an adjustment period of a few minutes, which the breeder should take in to account when he intends to move the animals. The converse adjustment is quicker: cattle are attracted by the light when it is not dazzling.

The lateral position of the eyes and the rectangular form of the pupils enable a wider field of vision (up to 330°), which is essentially monocular: without moving the head,

cattle can see practically everything happening around them, excluding a narrow zone located behind them (figure 2). However, the binocular (frontal) zone of vision includes a blind spot where the lines of sight cannot converge owing to the lateral position of the eyes. Cattle handlers observe an increase in the span of this blind spot when the animal is frightened or stressed.

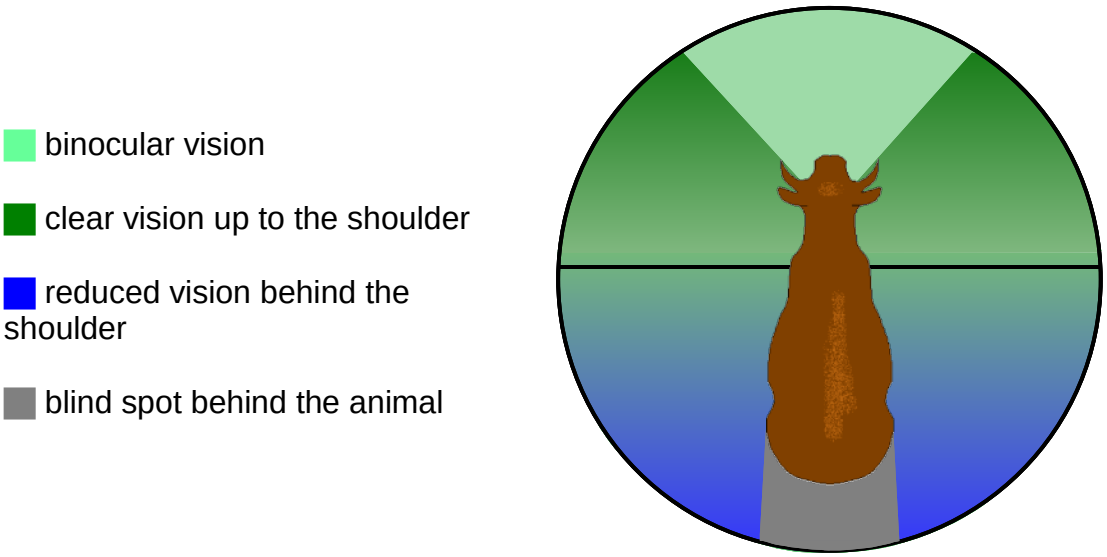


Figure 2: The panoramic field of vision of cattle.

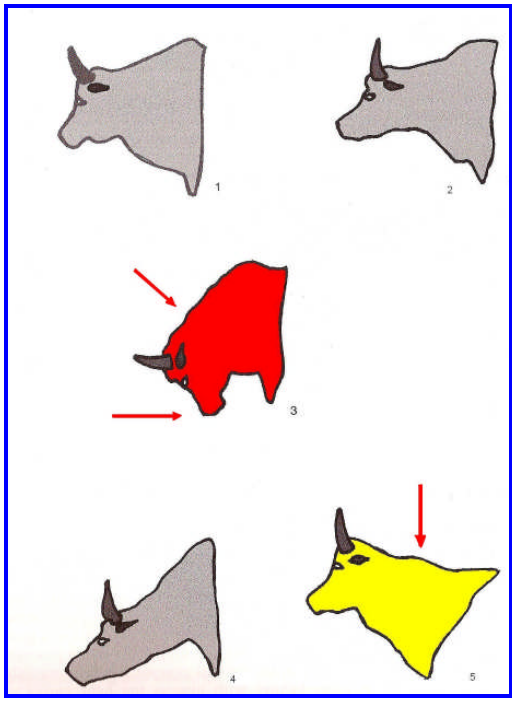
Moreover, use of the field of vision varies according to the animal's stress level (REHKÄMPER and GÖRLACH, 1997): cattle that sense some insecurity will use its lateral field of vision more intensively.

One must not forget that these visual characteristics are linked to the eating habits of herbivores: contrary to predators, they need good short sight in order to detect and select their food and a wider field of vision to detect predators on the move.

Numerous studies confirm the colour vision of cattle (review in LOMAS et al, 1998). The optic properties of the eye, in particular, the distribution of cones and photo-pigments contained within, determine the range of colours perceived. (JACOBS et al, 1998). Several studies based on conditioned behavioural experiments (GILBERT and ARAVE, 1986; RIOL et al, 1989) describe the ability of cattle to distinguish 'warm' colours (red, yellow, orange: medium and long wave lengths). Luminosity appears to be the best-perceived characteristic (PHILLIPS and LOMAS, 2001). Nevertheless, cattle adapt quickly to the colours of their environment (the breeder's clothing, colours of cars, buildings and equipment).

Cattle often employ visual modes of communication, particularly to inform other members of their group during altercations. The facial muscles of cattle are not very mobile: facial expressions, therefore, are minimal. Visual communication is essentially made via significant postures of the head (SCHLOETH, 1956; HALL, 2002) or the tail (ALBRIGHT and ARAVE, 1997), or by bodily movements (KONDO and HURNIK, 1988; PHILLIPS, 1993). These different postures have often been described, sometimes with differing interpretations. They indicate the attentiveness,

excitement, or aggressiveness of the animal. The position of the muffle and the inclination of the neck are identifiable elements (figure 3).



1 : neutral position

2 : confident approach

3 : aggressive posture

4 : submissive approach

5 : warning position preceding flight

Figure 3: The main postures of the head and their significance. (from SCHLOETH, 1961).

Visual communication between cattle is also made by a rocking motion of the head. (KONDO and HURNIK, 1988). This non-physical intimidating behaviour serves to establish or re-affirm the hierarchy (KONDO et al, 1989) in large groups (RIND and PHILLIPS, 1999). They delay and prevent confrontation. Differences in the intensity of these movements can be observed between males and females (PHILLIPS, 1993). Other intimidating behaviour may also be observed: scraping the ground with the hooves or the horns, rubbing the flanks or neck against a bush or hedge. During the rutting period, these movements are particularly frequent and constitute ostentatious behaviour. Moreover, they are associated with mating behaviour, including homosexual behaviour, and expectations of copulation. Although rubbing the ground with the neck is more of an olfactory form of communication because it enables the animal to impregnate the ground with pheromones (PHILLIPS, 1993).

Cattle require visual contact with their kind. When isolated, the installation of a mirror will, without fail, induce a decrease in cardiac rhythm and the cattle' agitation (PILLER et al, 1999).

<u>Cattle' visual perception of humans.</u>

The most studied aspects of cattle' perceptions of humans are visual and auditory; they also present the most convincing results in terms of their approach and use. Observations made in dairy farms have shown how breeder's movements and gestures are influential. The speed of the breeder's movements during the journey from the pasture to the milking room (i.e. if the breeder waves his arms, runs etc.) is

positively correlated to the animals' agitation during milking (BREUER et al, 2000). In other words, the more agitated the breeder is when accompanying the cows, the more they appear nervous during milking (often moving, kicking etc.). On her website (www.wcds.afns.ualberta.ca), American scientist, Temple GRANDIN, who is very reputed in the field of cattle handling, gives advice on cattle herding: the breeder should act using slow movements, refrain from running to ensure a minimum stress level to avoid jostling and agitation. Where large ranching herds are concerned, she compares the breeder to a predator: it is less stressful for the animals if the breeder behaves like a calm predator that begins by herding the group together, than to behave as a predator that surges forth by running and attacking.

1.2. Smell and olfactory forms of communication

Smell completes visual information and contributes to the personal recognition of individuals, to the construction of the cow-calf relationship and influences the social organisation of the group. The perception of scents actively participates in reproduction. Scents constitute a means of communication between the members of the group. However, these functions only operate in association with the other sensory perceptions.

Odours are detected by sensory cells (chemo-receptors) located in the epithelium of the nostrils. However, cattle also possess a second olfactory organ: the Jacobson organ or *organum vomeronasale* (vomeronasal organ), which is used in communication between individuals. This organ is located in the mouth in the upper palate. Its use is closely linked to the characteristic behaviour known as the 'Flehmen behaviour' whereby the animal lifts its nose with the mouth slightly open, the upper lip curled up and the tongue lying flat to enable the air to pass into the Jacobson organ (figure 4). The two olfactory systems (mucous membrane of the nose and sinus and *organum vomeronasale*) very likely have complementary functions but their chemical characterisation has not been proven (PHILLIPS, 1993). The sensitivity of these two organs varies according to the natural concentration of the odour and its biological significance (BOISSY et al, 1998). The fact that cattle have numerous odoriferous glands confirms the use of odours in communication between individuals. (BOUISSOU et al, 2001).

Figure 4: Flehmen behaviour

Cattle perception of odour is, therefore, more acute than human perception (ALBRIGHT and ARAVE, 1997). Olfactory communication between individuals is

made via pheromones. These are chemical molecules emitted by an animal that engender a specific response in the animal that detects (perceives) them (CHEAL, 1975). These molecules, present in all animal secretions (perspiration, urine, faeces, oestrus and vaginal secretions), are of a varied chemical nature but are mainly composed of aromatic alkenes (PHILLIPS, 1993). The Jacobson organ appears more sensitive to pheromones than the mucous membrane of the nose.

Olfactory communication between cattle is made and recognised essentially via pheromones (SCHLOETH, 1956, SIGNORET et al, 1997). Thus, the presence of a stressed cattle or the odour of its urine will modify the behavioural reactions of its fellow creatures. (BOISSY et al, 1998). One can also observe a slower learning capacity in heifers when they are exposed to the odour of a stressed fellow animal. (BOUISSOU et al, 2001). Thus, pheromones constitute a warning signal from the animal in danger to its fellows. Olfactory communication is more than often associated with one or several other modes of communication (postures or calls).

Not only does acute olfactory perception enable the animal's individual recognition of its fellows (review in SIGNORET et al, 1997, SCHLOETH, 1956, MÜLLER-SCHWARTZE, 1974) and in particular maternal recognition (WILLIAMS et al, 2001), it also enables the animals to recognise social rank within the herd: even blinded, cattle maintain group hierarchy (BOUISSOU, 1985). Moreover, hierarchy is maintained after removal of the olfactory bulb (MANSARD and BOUISSOU, 1980) but it is affected by the cauterization of the Jacobson organ (ALBRIGHT and ARAVE, 1997).

The handler must take these olfactory particularities into account when leading and handling his herd or choosing pasture areas. The stress of one animal due to violent handling or conduct is very likely to disturb the behaviour of its fellows: indeed the excretion of urine or dung is often a behavioural reaction to the fear they detect in another. The presence of chemical signals in faeces constitutes a warning signal for the other members of the herd and may lead to reactions of refusal and avoidance.

Smell also plays a role in the reproduction of cattle (review in SIGNORET et al, 1997). Vaginal secretions transmit odorous molecules. The bull detects the scent of the female's vaginal secretions (KLEMM et al, 1987) but will not intervene if the scent emanates from a dummy. (HALE, 1966, WALLACH and PRICE, 1988). However, sexual behaviour has been successfully stimulated by using the vaginal mucus of females in heat (ALBRIGHT and ARAVE, 1997).

The role of urine in stimulating sexual behaviour is recognised and corroborated by its chemical composition: specific composites can be detected in the urine of cows that are in heat (KURMA et al, 2000). The cow's urine acts as a chemical signal to entice the male via pheromones, but its exact role is not defined (REKVOT et al, 2001).

Similarly, perception of olfactory molecules influences sexual development. Thus, the presence of a male accelerates puberty in heifers (IZARD et VANDENBERGH, 1982) and conversely, the presence of cows stimulates testicular development and the production of testosterone in bulls. (KATONGOLE et al., 1971).

The Jacobson organ is essential for sexual behaviour stimulation (KLEMM et al, 1987) and is often associated with the Flehmen behaviour (ALBRIGHT and ARAVE, 1997). In addition, removal of the olfactory bulb does not impede the reproductive behaviour of cattle. (MANSARD and BOUISSOU, 1980).

Finally, cattle use odours along with colours and taste to identify and choose their food (BAILEY et al, 1996). The characteristics of food, odour included, condition the animal's appetite (BAUMONT, 1996). Thus, adding aromas to grass ensilage may increase the quantity consumed. Moreover, the odour of manure has a lasting dissuasive effect on pasture; the animals refuse to graze in contaminated zones for a month after (DOHI et al, 1991).

Cattle perception of human scent

There are no studies that explore the importance of odour in the human-animal relationship: RYBARCZYK et al, in 2001 and 2003, failed to prove that cows discriminate through smell. In their studies, only one calf succeeded in identifying the 'right' handler if the human-stimuli presented for tests wore overalls of the same colour. That is why they concluded that cattle principally use visual keys to differentiate humans but that nevertheless, they can use other determining factors.

Cattle handlers observe that a stock breeder who regularly lets his animals sniff him gives the impression of being 'recognised' by them (figure 5). Conversely, they affirm that an outsider will be recognised by his 'strange' or even by his 'parasitic' scent, such as that of medication in the case of a veterinarian.

Figure 5: Sense of smell: a disputed method of recognition in humans

1.3. Sense of hearing and vocal communication

The sense of hearing is much more sensitive in cattle than in humans: they perceive a more extensive range of frequencies (from 23 to 37,000 Hz) and their sensitivity to

high and low frequencies are much higher, with a maximal sensitivity of 8,000 Hz (HEFFNER, 1998, figure 6). Hence, cattle can hear sounds that are inaudible to the human ear: for example, cows react to the ultra sound cries of vampire bats (DELPIETRO, 1989). Their range of frequencies is vast to enable them to detect predators at great distances and to locate the noise source (HEFFNER and HEFFNER, 1992). Cattle' sense of hearing also enables them to hear and identify their own kind. In particular, a calf is capable of recognising its mother's calls. (HEFFNER, 1998).

It is a reflex for cattle to listen constantly: they prick up their ears and remain vigilant. They localise the noise source via the auricle: this ability is particularly effective when the noise comes from in front of the animal and is reduced to an angle of 25° on the sides of the head (PHILLIPS, 1993). The animal must turn its head to identify the noise source. A connection should be made between the weak precision of their ability to localise sound, their herbivore diet and their status as prey: an approximate localisation of the predator is sufficient to know in which direction to flee.

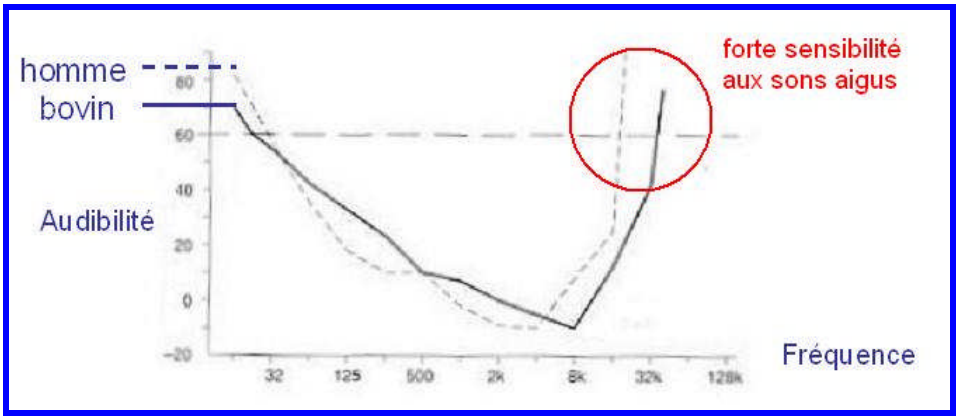


Figure 6: Cattle audiograms are different from those of humans.

The characteristics of cattle' sense of hearing condition their behaviour on the farm. Noise-induced stress has been observed in slaughterhouses (GRANDIN ,1996). Sound levels in the cattle-shed may rise to 70 or 80 db around the animals and up to 90 db in the milking rooms or under the ventilators (ALGERS et al, 1978). This background noise is due to the equipment but also to various noises produced by the animal (mastication, mooing, drinking of water, the sound of chains etc.). However, cattle do get used to familiar noises, even if they are intense.

Cattle sensitivity to noise varies with age: heifers and the bull-calves react quicker to new sounds than cows and bulls (LANIER et al, 2000), but the animal's temperament is an important variation factor. Furthermore, cattle adapt quickly to their usual sound environment: they identify and adjust to the daily noises of the farm (milking room, tractor, radio) and only new or unexpected noises lead to fearful reactions, high-pitched sounds (high frequencies) in particular. Low-pitched sounds (low frequencies) tend to soothe the animal (ARAVE, 1996).

Cattle may memorize sounds and associate them with a prior experience. Thus, the sound of the tractor may be associated with the arrival of food or water, whereas the metallic sound of the cattle crush may remind the animal of a painful experience. Therefore, the same noise may have different consequences according to the animals' prior experiences: The sound of a vehicle's horn will frighten animals grazing in a rural zone (ARAVE et al, 1985, 1991), whereas it will have no particular effect on cows that graze near to a motorway (GRANDIN, 1997). Noise may also exacerbate an already stressful situation: noises during transport, metallic noises during a painful intervention.

Cattle use their voices to communicate between themselves. The sounds emitted are varied: mooing, grunting, and bellowing and they are associated with distinct meanings (SCHLOETH, 1961, KILEY, 1972, HALL, 2002): warnings, threats, a call to fight, a provocation to fight, the call of the herd, cries of anguish or cries that signify a gathering. The average frequency of cattle vocal communication is 8,000 Hz, which is the maximal frequency they can detect: on these frequency even very weak sounds (10 dB) are heard by cattle (PHILLIPS, 1993).

Identification and interpretations of the calls and cries are disputed (see reviews in PHILLIPS, 1993, ALBRIGHT and ARAVE, 1997, BOUISSOU et al, 2001). The audiograms differ according to sex, (HINCH et al, 1982) and age (HALL et al, 1988, KOENE, 1997). These writers describe the superior vocal activity of the males. The vocal communication of cows appears to play a part in sexual behaviour: it enables the males to recognise a female in heat and triggers competition between the males. FRASER and BROOM, 1990).

Analysing the cries of cattle has proved to be effective in evaluating stress and pain levels in the slaughterhouse (GRANDIN, 1998) or during marking operations (WATTS and STOOKEY, 1999). However, these methods are only pertinent when measuring intense levels of stress, and should be considered in terms of a group response and not and individual one.

Calves identify and recognise the calls of their mothers (WATTS and STOOKEY, 2000); including recorded samples of their mothers' call (BARFIELD et al, 1994). This has not been proven conversely (mothers do not recognise their calves' calls), but the recorded calls of calves do stimulate lactation in cows (POLLOCK and HURNIK 1978, McGOWAN et al 2002). Modulations have been observed in the cries of young calves after separation from the mother, this may be due to stress and frustration (WEARY and CHUA, 2000).

Cattle auditory perception of humans.

Cattle are sensitive to the human voice and can identify it. Inflections in the voice and recognition (or not) of the person calling lead to behavioural changes (WAYNERT et al, 1999). Thus, a human cry may prompt more agitation and acceleration of the cardiac rhythm than a metallic sound. WAIBLINGER et al (2006) underline the importance of the auditory factor: humans may give off soothing signals or, on the contrary, signals that announce danger, which may provoke fear in the animals, give an impression of aggression or make them feel uneasy. For example, a study showed that cows prefer a human that speaks softly to one that shouts. Furthermore,

they seem to dislike shouting more than being beaten (PAJOR et al, 2003). Communication with the animal is possible via the human voice. Hence, the calves are capable of responding to their name when they are told to suckle their mothers or to leave the group of calves. (MURPHEY and DOUARTE, 1983).

1.4. Touch and tactile communication

Touch refers to the tactile sensation felt by the animal when it is in contact with the physical environment, a fellow creature or a human. Touch is the sense of proximity: it informs the animal about its immediate environment.

Tactile sensitivity is the result of several types of sensory receptors (anatomical review in DIMBERTON, 1999) that engender tactile perception (mechanoreceptors), thermal perception (thermo-receptors), and also perception of pain (noci-receptors). Tactile perception occurs via the mechanic deformation of the skin under the effect of contact and through the hairs. Thermal perception is conditioned by the temperature of the animal and the thermal conductivity of the object with which it comes into contact (a metal object seems colder than a wooden object because it transmits its temperature better to the skin). Finally, the perception of pain refers to a superior intensity than the aforementioned perceptions and their simultaneous stimulation.

The sensory receptors are evenly disposed across the cattle's body and they also have 'sensitive' zones. Hence, it is well known that persistent contact on the tufts has a calming and/or immobilising effect on the animal and facilitates handling (figure 7). The various handling and restraining methods (buccal halter, dorsal attachment system, chest restrainers, touching the palatine ridge, and insisting on the point of balance) are designed having taken the sensitive zones into consideration.

Figure 7: A hand on the tufts and contact with the flanks facilitates handling.

Direct contact between cattle occurs during mating, calving and the attention the calf receives after its birth, and during social grooming behaviour (ALBRIGHT and ARAVE, 1997). The purpose of fighting behaviour is to establish hierarchy in the group (BOUISSOU et al, 2001).

Social grooming is performed by another animal licking the area around the head and neck (figure 8), and is sometimes accompanied by rubbing and scratching. This behaviour is a major part of cattle life, in the natural environment as on the farm (BROWNLEE, 1950). Social grooming occurs between animals of equivalent social rank, or between a subordinate and dominant member of the group (SATO et al, 1993, PHILLIPS, 1993), but essentially between animals of the same herd. (SATO et al, 1991 and 1993). The duration of grooming is longer between animals of the same rank but there is often no apparent link with hierarchy. (ALBRIGHT and ARAVE, 1997). The introduction of a new animal to a group often causes grooming behaviour to cease entirely and to recommence only when the social rank of the newcomer has been established (ALBRIGHT and ARAVE, 1997). More often, grooming is the result of a request and is focused on the parts of the body that are inaccessible to the animal on its own: the head and the neck (SATO et al, 1991) Thus, it ensures a cleaning role (FRASER and BROOM, 1990, REINHARDT, 1980a). When grooming is not requested, it is concentrated on the back and rump of the animal. The role of grooming in the social integration of newcomers has been described (REINHARDT and REINHARDT, 1981). Hence, grooming behaviour appears to have a functional significance in establishing, stabilising and reinforcing social links. It also helps to strengthen the links between animals and to soothe them after they have been disturbed or deprived of food (FRASER and BROOM, 1990). This calming effect is confirmed by the deceleration of the cardiac rhythm observed in both animals during grooming (SATO and KURODA, 1993). Also, a connection between the amount of grooming received and the amount of weight gained by the animal (SATO, 1984), as well as an increase in the amount of milk produced (ORIHUELA, 1990) can sometimes be made.

Tactile interaction with humans

Tactile sensitivity is primordial in cattle handling: touching, brushing an animal (especially when outside of animal's field of vision) are actions that may entail unforeseeable reactions in a surprised animal. According to the experiences of hardened handlers, it is better to establish a straightforward contact like that of the animals themselves. (COLLECTION INRAP, 1988, COQUILLET et al, 2005).

Contact with the animals often includes -among other means of stimulation- tactile interaction (RUSHEN et al, 1999, BREUER et al, 2003, PAJOR et al, 2000 et 2003, GRIGNARD, 2001, LENSINK et al, 2000 and 2001, KROHN et al, 2001, RYBARCZYK et al, 2001 and 2003, BOIVIN et al, 2003, RAUSSI et al, 2003, WAIBLINGER et al, 2003, 2004, 2006, DE PASSILLÉ and RUSHEN, 2005, MÜLLER and SCHRADER, 2005 to cite only the most recent literature). The impact of human contact on cattle and their behaviour has been experimentally tested according to three areas:

- **Tactile contact qualified as 'negative':** In literature, this is described as disagreeable, stressful or painful for the animals (for example beating, pushing or giving them an electric charge) (for review, BOIVIN et al, 2003). The studies have shown that disagreeable tactile interaction, that may seem moderate from our point of view, is an important factor in the development of fear of humans in cattle (BREUER et al, 2000, HEMSWORTH et al, 2000). Through experiments, it has been possible to define the actions that cows perceive as negative, by

using choice tests with a Y[1] maze: according to the results, twisting their tails is less negative than beating them, an electric charge being the treatment they fear the most. It should be noted that twisting the tail, which would appear disagreeable, doesn't seem to upset the cows as long as the movement doesn't lead to injury. (PAJOR et al, 2000 and 2003).

Tactile contact qualified as 'positive'. This is described as agreeable, gentle or soothing for the cows (such as rewarding the animal with food, flattering and stroking the animal). This positive contact with the animals helps to decrease their fear of humans (lower cardiac rhythm and lower concentration of cortisol for example). LENSINK et al. showed this in veal calves: the calves that had received additional positive contact during feeding (sucking of fingers, stroking) were less prone to fleeing when humans approached and more prone to approaching compared with calves that had received no additional treatment. Thus, such contact could improve the human-animal relationship (LENSINK et al, 2000 and 2001, KROHN et al, 2003). However, although the beneficial effects of stroking are widely known, they have not been scientifically proven. In the calves of brood cows and in milk calves, BOIVIN et al (1998) and JAGO et al (1999) show that beneficial effects do not come from stroking alone. Cows and heifers seem to be more averse to stroking than receiving no treatment at all and they prefer to be fed. (PAJOR et al, 2000). Conversely, the studies of RUSHEN et al (2001) or WAIBLINGER et al (2004) suggest that a human who strokes dairy cows when they are isolated or during a sanitary operation may succeed in lowering their cardiac rhythm and level of agitation. But these studies do not disassociate the effects of stroking from the effects of human presence. Recently, SCHMIED et al (2004) have observed that adult dairy cows react to being stroked (lowered ears, lengthened neck, lowered cardiac rhythm) on certain parts of the body (parts of the neck, notably ventral) in the same manner as during intra specific licking (figure 8). The results of this experiment suggest that stroking may be soothing for cattle that are already used to the presence and contact of humans, but the beneficial nature of stroking for the human-animal relationship has not yet been proven. The differences observed between the studies may be due to the fact that an animal may perceive an interaction as positive, neutral or negative depending on the relationship it has with the humans; i.e. based on prior interactions (DE PASSILLÉ et al, 1996).

[1] During these tests, the two arms of Y propose two different situations: the animals must choose the situation or method of handling they prefer.

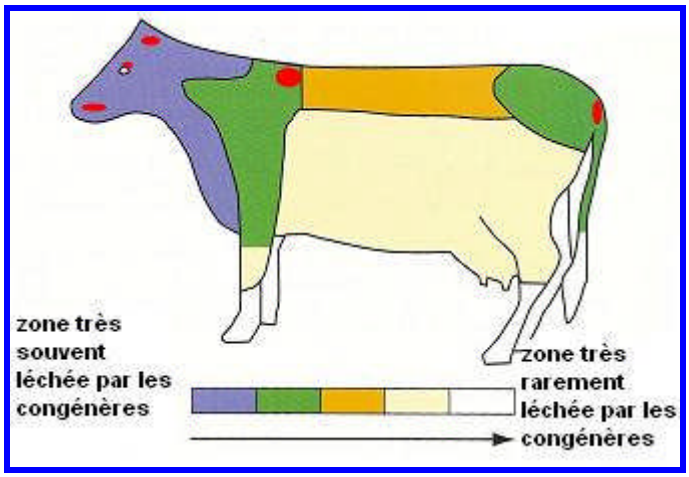


Figure 8: Areas licked by fellow animals (SAMBRAUS, 1969).

1.5. Taste

Taste corresponds to the perception of sugary, salty, acidic and bitter sensations. These sensations are associated with the essential physiological needs of mammals: a supply of nutrients in the case of sugar, a balance of electrolytes in the case of salt, toxin detection in the case of acidity and pH regulation in the case of bitterness. (PHILLIPS, 1993). The perception of taste is ensured by the receptors that are stimulated by chemical molecules. Food choice is linked to taste and taste is linked with the other sensory perceptions (ARAVE, 1996, BAUMONT, 1996). Sensitivity to taste varies with age (PHILLIPS, 1993), but also with endocrinal factors. Nutritional, maternal and social apprenticeships have been observed.

Taste receptors are located near the buccal mucous membrane of the palate and the tongue where they are regrouped into taste buds. The form and distribution of the taste buds across the cattle's tongue define their perception of different tastes: the sides for bitter and salty tastes, the base of the tongue for acidic and sugary tastes and the tip of the tongue for salty tastes (HARD et al, 1989, anatomic description in DIMBERTON, 1999). There is a connection to be made between the preferential use of the interior part of the tongue in taste detection and the fact that herbivores retain their food in the mouth for longer (PHILLIPS, 1993). Cattle do not possess hydration receptors, but the mechano-receptors located at the base of the tongue transmit the modifications in pressure linked to the passage of water. Equally, the lingual thermo-receptors inform the animal of extremes in temperature inside the mouth. Therefore, water stress is perceived but in an indirect manner (PHILLIPS, 1993).

Using greed to 'tame' cattle.

Cattle have a different perception of taste than humans: they appreciate sugary tastes (beetroot, molasses and corn silage), salty tastes (salt stone, minerals) and milky, vanilla and grilled almond tastes. Hardened handlers recommend using the animals' greed to encourage them to approach or gather in the pasture. Equally, they will get used to the scent of humans if the handler gives the cows salt directly from his hand. It is also possible to guide the animals using a bucket of pellets, although

the scent of the human is not as easily perceived thus. Finally, it is possible to use their greed to 'reward' them after handling: the animals are thus conditioned to associate handling with the taste of a food they like.

III. – The social behaviour of cattle

Above all, cattle are gregarious: they live in herds and their behaviour is closely linked with the structure of the group. Knowledge and consideration of cattle' social behaviour are essential when organising the herds. Hence, the handler must be aware of the animals' modes of communication between themselves and the rules of behaviour that govern them in order to evaluate and control the risks of a given handling situation. Moreover, accurate comprehension of these rules will enable the handler to optimise management by improving the human-animal relationship on the one hand and the well being of the animal on the other.

The herd is defined by its social organisation (BOUISSOU et al, 2001) no matter the size. The number of individuals constituting farm herds may vary in direct correlation with the country's level of economic development (NANGING, 1989) or local practices. Cattle herds living in the wild are rare (review in BOUISSOU et al, 2001) and the majority of behaviour observed in cattle is conditioned by farming.

Wild herds are generally made up of males and females linked by groups that are structured according to a matriarchal model: mothers and youngsters together, the bulls apart (DAYCARD, 1990) except during the reproductive season. The same spatial segregation of the sexes is observed in herds that have been moved back to a wild state (LAZO, 1992). The composition of these groups (members, sex ratio) varies depending on the availability of resources and the risk of predation (LAZO, 1994).

In most farms the sexes are separated. Cattle do not present any territorial behaviour. However, within their given space and notably in the pasture, they dispose themselves in a structured manner. As is the case in wild herds, the group serves as a refuge from predators. Competition for the various resources (food, space, and reproduction) may, however, be accentuated since the farmer controls their access.

The **social behaviour of cattle** has been described since 1941 by WOODBURY, and by SCHEIN and FORHMAN in 1955. The social relationships between the individual members of a herd have led to several concepts being termed: the animal's personal space, affinities between the animals, but also the hierarchy of the group and the underlying notions of dominance and subordination. The definition of these concepts and the descriptions of their associated behaviour are very documented and disputed: they often vary in relation to the experimental situation and the tools of evaluation used (BERSTEIN 1981, BEILHARZ, 1983, HAND, 1986, WIERENGA 1990).

The notion of the **animal's 'personal' space**, that is to say the space that is required by and which is sufficient for the animal, is an essential concept in understanding the

social behaviour of animals. This space is generally described as a ‘bubble’ within which the animal avoids interference with another animal or a human (BOUISSOU, 1980). Intrusion within this space provokes a reaction and the flight zone may be defined as the level of proximity that the animal will tolerate before fleeing or displaying aggressive behaviour. Personal space and the flight zone vary according to many factors: farming conditions, physiological state of the animal and its social rank, but also the individual variability of character. The flight zone will increase when the animal is in a state of excitement (GRANDIN, 1989) stress (PHILLIPS, 1993).

Affinities between cattle correspond to the preferential relationships existing within a group (BOUISSOU et al, 2001). They are reflected by very close spatial proximity, close contact, more frequent contact (licking, figure 9) and few antagonistic interactions. Very close affinities are established early on: between birth and six months, and they are thus more intense in animals that have been reared together from an early age. Then, they are stable and endure throughout the herd’s lifecycle (HALL, 2002). The affinities are very important because they ensure group cohesion and reduce the impact of competitive situations by increasing the animals’ tolerance of each other (BOUISSOU, 1965).

Figure 9: Licking reflects affinities between cattle.

The **hierarchy** of a group of cattle describes the relationships of domination and subordination between the members of the group. It determines which member has priority of access to a given resource. (HAFEZ and BOUISSOU 1975). Its organization may be simple or complex (figure 10).

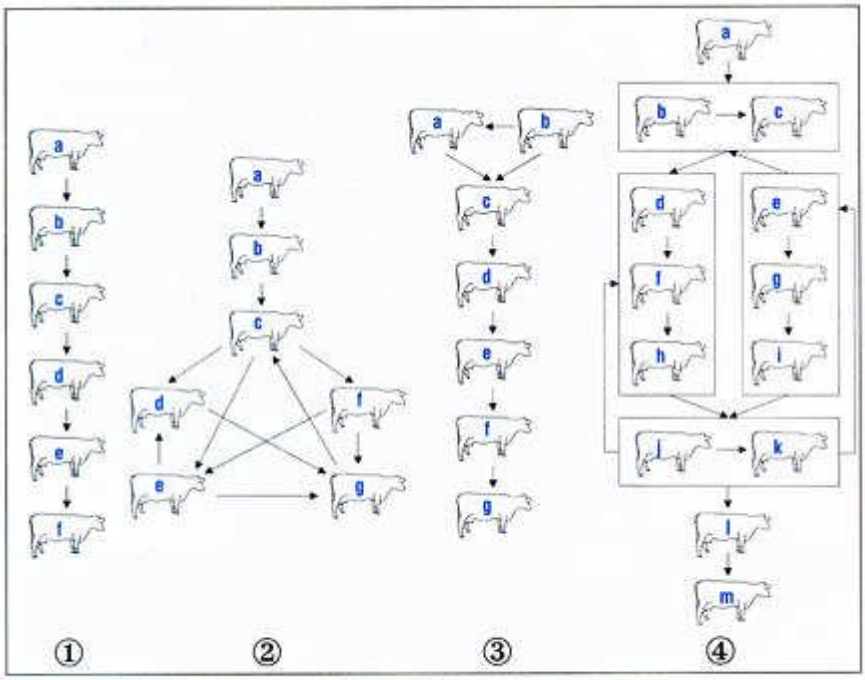


Figure 10: Four examples of hierarchy in a group of cows (BOUISSOU, 2002).

From the first hour they are exposed to a given situation, the hierarchy of a group of cattle is rapidly established and often without a struggle (review in INGRAND, 2000). The role of access to basic needs is sometimes disputed in favour of simple respect of the natural space (BERSTEIN 1981). The hierarchy is, however, particularly visible when resources are limited (BLACKSHAW 1984). It is stable in a given situation, thus avoiding aggressive behaviour in order to determine the order of access to a resource: space, food and mating partner (reviewed in PHILLIPS, 1993). It is often possible to observe relationships of 'triangular' hierarchy (figure 11). It is more difficult to observe the hierarchy in herds that have been returned to a wild state (LAZO 1992) or in semi-wild farms (HALL, 1986).

Dominance in cattle was described for the first time in 1955 by SCHEIN and FOHRMAN. This concept may be defined as the animal's capacity to inhibit the behaviour of one or several members of the group (BEILHARZ, 1983, review in INGRAND, 2000). Dominance may be observed -in varying degrees of intensity- in all situations where there is competition for a resource. (BOUISSOU et al, 2001).

Dominance is the combination of experience from early age, inheritance, sex, the physical character and temperament of the animal (ALBRIGHT and ARAVE, 1997). The importance of these elements is the subject of much controversy surrounding the subject. Moreover, the evaluation of dominance is a debated subject because the methods used (review in ALBRIGHT and ARAVE, 1997, and BOUISSOU et al, 2001) are numerous and varied. Several standardisation tests have been performed (BERSTEIN 1981, BEILHARZ, 1983, LE NEINDRE and SOURD, 1984, HAND, 1986, MARTIN and BATESON 1986) but the characterisation of cattle's social rank remains essentially based on the number of antagonistic interactions observed between it and its fellows.

Antagonistic interactions represent all aggressive behaviour, be it real (attack, combat) or simulated (postures, enacting a charge) and all behaviour in response to the aggression (avoidance): more often, the dominant animal mimes an intention to charge by advancing the head and the subordinated animal lowers its neck (figure 3, BOUISSOU et al, 2001). Movements such as rocking the head in the direction of a fellow animal, a sideways posture with the back arched, or head butting constitute threatening signals. The subordinated animal withdraws by adopting a characteristic posture: the head is lowered away from the dominant animal. While there is no established hierarchy, the threats may turn into a fight: horns locking, head butting directed at the neck (ALBRIGHT and ARAVE, 1997). When the hierarchy is established, a mere movement of the dominant animal's head is enough to remind the other members of their place (DANTZER and MORMÈDE, 1979).

The **determining factors of dominance** in cattle are varied and their relative influence is debated. It seems that a dominant character is acquired from the youngest age but observations are sometimes contradictory, perhaps in relation with isolated farming (or not) of calves (ALBRIGHT and ARAVE, 1997). The effects of genetic inheritance and hormone production are difficult to evaluate.

The relationship between an animal's social rank and its age is generally corroborated (BOUISSOU 1965, MENCH et al, 1990, reviewed in INGRAND, 2000 and WIERENGA, 1990) but it may be altered by regrouping and mixing animal groups (KABUGA et al, 1991). More often, it is the oldest animal that dominates (MENCH et al, 1990), but the seniority of its presence in the group is a determining factor (BOUISSOU, 1965). The influence of the weight and/or size of the animal are more disputed (BOUISSOU, 1965, ANDERSSON, 1987, BENNET and HOLMES, 1987, KABUGA et al, 1991). Other factors, such as the presence of horns (BOUISSOU, 1965), the social rank of the mother or sex may have a significant effect (BOUISSOU et al, 2001). Experiments have shown the correlation between social rank, race (BENNET and HOLMES, 1987, MENCH et al, 1990) and temperament (BOUISSOU et BOISSY, 1994, PLUSQUELLEC and BOUISSOU, 2005).

The impact of social behaviour on farming.

Social rank is often a determining factor in farming: it conditions interactions between animals in situations as diverse as the use of pastures, food and reproduction. The spacing between the members of a herd depends on the size of the group and the age of the animals that compose it (PHILLIPS, 1993, ALBRIGTH and ARAVE 1997, BOUISSOU et al 2001). The adult members maintain 10-12 metres between themselves even if the available space increases. (KONDO et al, 1989).

The group and its hierarchy play a role in choosing what varieties are consumed and the levels ingested sometimes vary significantly between dominant and subordinate members (FRIEND and POLAN, 1973, FRIEND et al, 1973, review in INGRAND, 2000). At the trough, the dominant animals spend more time feeding than subordinate animals (METZ and WIERENGA 1987). They also consume more silage (HARB et al, 1985) and their rumination time is significantly longer (KABUGA et al, 1991).

The social behaviour of cattle also determines the herd's reactions when faced with different farming situations. Hence, events linked with farm management (regrouping, isolation, the boarding of several groups of animals) constitute possible disturbances in the established order (BOUISSOU, 1976, BOE and FAEREVIK, 2003). The animals often feel this disturbance in the hierarchy as a source of stress, and a decrease in the production of milk may be observed (HASEGAWA et al, 1997). Equally, stressful situations are observed when animals of different race are mixed: the mix induces a stressful effect on the 'strangers' within the group, who consequently find themselves at a social disadvantage. The hypothesis of a cumulative effect of stress for the subordinate animals cannot be discarded (MENCH et al, 1990).

Thus, in all situations that lead to a modification in the hierarchy, it is crucial to allow time for the animals to adapt in order to establish a new hierarchical structure. Stable organisation is rapidly reinstated as the animals are used to these practices (MENCH et al, 1990).

'Leadership': why identify the 'leaders'.

Leadership is defined as the capacity of one animal to influence the movements and activities of a group to which it belongs (DUMONT et al, 2001). The lead animal ('leader') initiates movement and is followed by the other animals of the herd (figure 11). In a herd, the character of 'leader' is very stable for a given situation, but it varies according to the movement: the animal that drives the herd during movement in the pasture is not the same as the one that drives them to the milking room.

Figure 11: The 'leader' animal guides the herd during movement.

There is no relation between dominance and leadership (BOUISSOU et al. 2001). On the contrary, the leader is more often an animal of intermediary social rank. Several hypotheses may be put forward to explain this observation. In particular, the relative 'independence' of the leader given its insignificant rank: the animal, that has little social motivation, readily breaks away from its group and therefore reacts rapidly to changes in surroundings. However, the correlation between leadership and age is a strong one: the oldest animals, and therefore the most experienced, are more than often leader (REIHNART, 1983).

When a herd moves, the order of the animals is almost systematically the same (DUMONT et al, 2001 and 2005). Hence, one leader will initiate movement towards a new pasture (BAILEY, 1995) and another will encourage departure towards the milking room (DUMONT et al, 2001). However, when entering the cowshed, the animals are disposed according to social rank (FRIEND and POLAN, 1973).

Recognizing the leaders within the group involves several farming methods (DUMONT et al, 2001 and 2005). Thus the leader may be trained to guide the herd more rapidly and efficiently towards new pastures. It may also be used to render the herd more docile to drive (KILGOUR and DALTON, 1984).

Taking the herd's organisation and related behaviour into account is essential for good management of the herds. It enables the handler to better understand and predict the animals' reactions during the various events in farm life and thus to ensure that they are handled safely.

IV. – Individual activities: modalities and rhythms.

Individual activity, sometimes termed activities of maintenance or auto-centric behaviour, corresponds to innate behaviour that occurs frequently and which may be, genetic or 'instinctive' (GRAIG, 1981). It enables the animal to satisfy its needs and ensure its well being (CURTIS, 1967) but also to adapt to changes in its environment (review in ALBRIGHT and ARAVE, 1997).
Individual activities comprise such behaviour as feeding (grazing and drinking), rest (rumination and sleep), excretion, individual grooming, and movement (locomotion). More often than not, they follow a circadian rhythm (SCHRADER 2002) and have no direct relation with the hierarchy or the size of the group to which the animal belongs (SZUCS et al, 1991). Their duration (allocated time) is fragmented into several daily sequences and it varies according to the farming conditions.

Feeding: grazing and drinking

Eating and drinking are vital. Grazing is the cattle's original mode of feeding. Observing cattle living in a wild (LAZO, 1992) or semi wild state (HALL et al., 1988) makes it possible to describe grazing activity outside the constraints of farming.

The total duration of **grazing** per 24 hrs varies from between 4 and 12 hrs depending on the quality and variety of the vegetation, the climate and the competition to access grazing zones (PHILLIPS and LEAVER, 1985, FRASER, 1983, BENNETT and HOLMES, 1987, STAKELUM et al, 1987, FUNSTON et al, 1991, DOUGHERTY et al, 1994). The animals' physiological state bears little influence (DUMONT, 1996). The rhythm of food intake is most often expressed in mouthfuls per minute. It is used to calculate nutritional productivity, which reaches 50 mouthfuls on average per minute for an adult cattle (PHILLIPS and LEAVER, 1985, STAKELUM et al 1987, LACA et al, 1992, FUNSTON et al, 1991, GIBB et al, 1998).

Grazing activity is essentially diurnal but the relative proportion of diurnal grazing varies according to the season. On the farm, the total diurnal grazing time may vary

from between 74% (HASSOUN, 2002) and 92% of the total grazing time (O'CONNEL et al, 2000) depending on farming conditions and race (SALAS et al, 1990). The seasonal nature of the grazing time is marked: it is minimal in June (29%) and in September (33%) (HASEGAWA and HIDARI, 2001) in relation with the quality and variety of the vegetation (FEHMI et al, 2002).

Peaks in grazing intensity are observed at sunrise and sunset, with a decrease in activity in the middle of the day particularly in summer (SALAS et al, 1990, FRASER and BOOM, 1990, MATIAS, 1998, HASEGAWA and HIDARI, 2001, HASSOUN, 2002). The effect of the photoperiod on peaks of activity is disputed (INGRAND, 2000): experiments performed in constant light show that 80% of feeding activity occurs between 9am and 9pm, however long the daylight (TANIDA et al, 1984). In the cattle-shed, feeding rhythms are controlled by humans (FRIEND and POLAN, 1973, GONYOU and STRICKLIN, 1984, WIERENGA and HOPSTER, 1991b).

The cattle select its vegetation according to its dietary preferences, but also according to its anatomical characteristics (form of the muffle, aptitude for walking) and hence, race has a significant effect (HOGSON, 1979, D'HOUR et al, 1994). The choice of vegetation is limited to short and widespread varieties (DUMONT et al, 2001) and is essentially a compromise between how rapidly the animal can access a zone and the quality, density and length of the grass (BLACK et KENNEY, 1984, DISTEL et al, 1995, DUMONT, 1996, GINANE et al, 2002). Significant landmarks in the landscape may be a factor in the choice of grazing zones (CASSINI and HERMITTE, 1992, HOWERY et al, 2000).

The dietary preferences of cattle vary little throughout the day (DUMONT, 1996) and depend notably on the previous days' consumption (GINANE et al, 2002). The level of ingestion is linked to the physiological state of the animal (INGRAND et al, 1999) but it is stimulated by the diversity of the food available (DUMONT, 1996, DUMONT et al, 2001). Cattle are capable of regulating their feeding rhythm according to the quality of the vegetation and also implementing veritable dietary strategies to optimise grazing time (WIERENGA and HOPSTER, 1991a, RUTTER et al, 2002a).

The group affects the synchronisation of grazing activity (METZ and WIERENGA, 1987, HASEGAWA et al, 1997): its influential effect has been observed in herds and ingestion levels increase when the animals feed in groups. Equally, the improved well being of animals that are reared in groups encourages feeding activity (review in INGRAND, 2000). Consequently, feeding activities are affected by changes in the herd to the point where grazing may be delayed during the night DOLEZAL, 1984). Living in groups also creates competitive situations concerning food, in particular during grazing. The hierarchy determines the use of space (BOUISSOU et al, 2001) but the relationship between the duration of feeding and social rank is disputed. (KABUGA et al, 1991).

Drinking compensates the loss of liquid. This loss is due in part to the natural evapotranspiration (thermoregulation) of the animal and, in the case of dairy farms, to the production of milk. The sensation of thirst is due to this loss and is regulated by endocrinal channels (Mc KINLEY et al, 1987). In order to drink, the cattle plunges its muffle into the water with its nostrils above the water: thus its sucks the water up.

The quantity of water consumed depends on dietary intake and its characteristics (dry food or not, LITTLE and SHAW, 1978), on the temperature but also on the quality and accessibility of the water (review in PHILLIPS, 1993). On average, cows drink 40 litres of water a day, but significant variations have been observed between cows and over time (HALL, 2002). The temperature of the water (recommended between 15 and 27°C, review in ALBRIGHT and ARAVE, 1997) and its flow (BRAY et al, 1992) may also have an effect on the quantity of water consumed. An increase of 1°C in the temperature may engender an increase of over one litre in water consumption (ANDERSSON, 1987).

Cattle need clear access to water even if drinking usually occurs after eating (NOCEK and BRAUND, 1985). The frequency of drinking varies from between 1 and 6 times per day in temperate climates (ARNOLD and DUDZINSKI, 1978; ANDERSSON, 1987) but may be reduced to once every two days if the water is a considerable distance away (as is the case for herds on vast terrain in Australia: review in ALBRIGHT and ARAVE, 1997).

Drinking is a diurnal activity: 2 peaks are observed, based on grazing activity. In very hot weather, drinking activity may be delayed until the afternoon and night time (GONYOU and STRICKLIN, 1984). During grazing, the cows look for areas near to water in order to drink, refresh themselves and eliminate insects (CASSINI and HERMITTE, 1992), and also, sometimes, for calving (LIDFORS et al, 1994).

Rest: Sleep and rumination

Rest corresponds to 2 distinct types of behaviour: rumination and sleep.

Eating prompts **rumination**. The digestive system of cattle is based on the preponderant role of the rumen for digestion and the assimilation of vegetable food. Rumination occurs when the cow is lying down and takes up a large portion of the day (review in ALBRIGHT and ARAVE, 1997). The horizontal position of rumination allows the rumen to function while taking gravity into account (BALCH, 1955). The animal often lies on its left flank in relation with the anatomy of the rumen and the rate at which it fills up (JACKSON, 1905, WAGNON and ROLLIS, 1972). Several rest positions may be observed according to the particularities of the terrain (slope). Some positions may, however, hamper rumination.

The duration of rumination varies according to age, sex and the farming or grazing conditions. Seasonal variations are observed in relation to temperature and food (HASEGAWA and HIDARI, 2001). Calves spend less time than the adults ruminating because their rumen is not completely functional and their diet is not yet entirely based on grass consumption. During the first 5 months of its life, a young calf spends 90% of its time lying down. Depriving the young animal of this rest time may well engender death in very young calves (CARSON and WOOD-GUSH, 1984). The need for rest decreases to 75% of the total time after 21 to 25 weeks (COE et al, 1991).

On average, rumination takes 5 to 10 hrs per day (BALCH, 1955, ARAVE and WALTERS, 1980, DESCHAMPS et al, 1989, KROHN and MUNSGAARD, 1993, HALL, 2002) but it may take up to 16 hrs of grazing time (DESCHAMPS et al, 1988b) or 50% of the day for cows (RUCKENBUSH, 1972, ARAVE et al, 1994, ŠHIPKA and ARAVE, 1995). Rest and rumination constitute the main activities of cattle (apart from

grazing) and occur in several hour-long sequences (BALCH, 1955). The duration may be reduced to less than 4 hours if the pasture to cross is particularly vast (as for Nigerian herds, which cross up to 10ha per day: BAYER, 1990). When rumination time is decreased, that is to say, the time for which the animals are able to ruminate lying down, general weight gain decreases (HASEGAWA and HIDARI, 2001). Depriving the cows of several hours sleep will encourage them to recuperate half of this time in the middle of the day (WIERENGA and METZ, 1986). When the animals are deprived of food and rest, recuperation of this rest time takes precedence over hunger (METZ, 1985). Depriving them of 75% of their rest time engenders a significant increase in cortisol levels in the blood, which indicates significant stress levels. (KROHN and KONGAARD, 1982).

On farms, the total rest time varies according to the housing conditions. Thus, rest time is longer in straw-bedded areas and in the pastures than in the cattle-shed (DESCHAMPS et al, 1989a). Similarly, the rest position is determined by the available space and whether or not the neighbouring cubicle is occupied (ARAVE and WALTERS, 1980). When there is limited space, the hierarchy conditions rest time: cows of an inferior rank lie down less often at night when space is lacking (WIERENGA, 1983) and have less total rest time because they wait for longer to gain access to the food distributor (WIERENGA and HOPSTER, 1991a).

Rest is taken at night in particular (METZ and MEKKING, 1984, SZUCS et al, 1991, MATIAS, 1998, HASSOUN, 2002): up to 80% of the night (as opposed to 58% of the day) is devoted to rest. Rumination impedes sleep and enables a vigilant state. Activity of the rumen does not decrease during the night, but nocturnal rest is characterised by deeper breathing and lessened contractions of the rumen: the animal is thus in a maximal state of relaxation, whatever its position.

For a long time, the **sleep** of cattle was a subject for discussion: absolute loss of conscience has rarely been observed. Even in a state of total rest, the animals keep their eyes open except for very brief periods, and they remain reactive to the slightest of noises. Sleep is, therefore, light and transient. Its duration is estimated at ± 30 minutes per night (BALCH, 1955). It is associated with the position of the head resting on the flank, which corresponds to a state of non-rumination and REM sleep (GIRARD et al, 1993). In adults, this state of sleep only occurs during the night and represents 2 to 4% of the night time depending on the farm (KROHN and MUNKSGAARD, 1993), and is fragmented in 8 to 10 sequences.

Excretion

Activities linked to excretion correspond to the elimination of solid matters (faeces) and liquids (urine). The quantity of matter thus eliminated is sometimes difficult to estimate but it has a non-negligible effect on farm management. Similarly, it is important to consider the behaviour linked to excretion when analysing the state of health or emotional state of the animals.

Cattle defecate and urinate standing up. After the elimination of faecal matter or urine, the animal walks forward away from the soiled area. This behaviour enables it to avoid dirtying its hooves. In pastures, cattle avoid areas soiled by urine (BENHAM

and BROOM, 1991). The presence of faeces of another race leads to a decrease in the herd's movement within the pasture (review in PHILLIPS, 1993) however cattle do not mark their territory with urine. In farms, such movement may be restricted by a lack of space or by chains, thus engendering a source of discomfort for the animal (HAFEZ and BOUISSOU, 1975). Defecation and micturition are accompanied by characterised positions and hinder physical effort. Given the anatomy of cows, micturition takes longer than the excretion of faecal matter and forces the cow to stop (reviewed in PHILLIPS, 1993, ALBRIGHT and ARAVE, 1997). Whereas defecation may take place while the animal is moving or eating (ALAND et al, 2002).

The quantity of faeces and urine is conditioned by the temperature and the relative humidity, but also the quality and quantity of food (HAFEZ and BOUISSOU, 1975). On average, the animals defecate between 10 to 16 times and urinate between 3 to 9 times every 24 hrs (HAFEZ and BOUISSOU, 1975, SAHARA et al, 1990, review in PHILLIPS, 1993, ALAND et al, 2002). The variability of the regularity with which the animals defecate is linked to their dietary regime, the temperature, and the relative humidity, but also to the concentration of animals in a given area. A decrease in excretion has been observed during rest time, this is perhaps linked to the lack of movement.

The feed quality conditions the quantity of matter eliminated and the regularity of excretion (review in PHILLIPS, 1993). Animals in the pasture produce more liquid faeces and defecate 2 to 3 times more often than an animal fed with granules. Relative humidity is an important factor of excretion: The regularity of defecation passes from 3 to 12 times for a variation in relative humidity of 20% to 80% (HAFEZ and BOUISSOU, 1975).

Finally, stress engenders increased excretion: when faced with fear, one of the first reactions of cattle is to urinate and defecate. A calf isolated for the first time defecates more than a calf of the same age that was raised in isolation (ARAVE et al, 1985, BUENGER et al, 1987). A study performed on several races of dairy cow indicated that 68% of cows urinated or defecated in the milking room (GUPTA and DALL, 1990).

Individual grooming

Individual grooming activities correspond to the cattle's need to clean itself. Individual grooming does not include social grooming or grooming of the calf by its mother, which is treated under maternal behaviour.

Grooming includes several actions: the licking of the coat, rubbing and scratching and actual grooming (descriptive review in ALBRIGHT and ARAVE, 1997). Each of these actions is aimed at cleaning the coat and eliminating the parasites that live there. These activities concern only the areas accessible via the animal's muffle and therefore, do not include the head (figure 12). Apart from anything else, social grooming enables the animals to be groomed in otherwise-inaccessible areas.

Individual grooming activities occur more frequently in calves raised without their mothers (SATO and KURODA, 1993). Moreover, cows that are tied up tend to lick

their backs and flanks more often than animals of the same age that live in open housing (KROHN, 1994).

Figure 12: Individual grooming.

Movement: locomotion and bodily movements

Cattle movements or kinetic behaviour includes locomotion but also other movements of the head and neck. The movements not only depend on the kinetic (muscular) potential of the animal, but also on the constraints imposed by its environment (FRASER, 1982).

Cattle move naturally in a forward direction. Backward and lateral movements are possible, but essentially in response to fear or physical constraints. Several methods of movement from one place to another can be described: walking, trotting and galloping (see description in PHILLIPS, 1993).

Walking is the most usual method employed by cattle to move. They can cover several kilometres, and often do so in order to feed or drink (ARNOLD and DUDZINSKI, 1978). When walking, the position of the legs is important as it is directly linked to the condition of the legs and hooves, but it also depends on anatomical features. Limping is the most common alteration. It disturbs most of the activities and behaviour of the animals as well as their well being (FRASER et al, 1991).

Trotting corresponds to a more rapid method and is employed especially in reaction to fear or discomfort. The trot may reach a speed of 5 km/h. **Galloping** is defined by rapid steps and characteristic movements of the legs: the front legs move simultaneously, followed by the same movement of the hind legs and the tail is raised above the rump. However, galloping corresponds to forced exercise (reviewed in ALBRIGHT and ARAVE, 1997).

Lashing out and kicking are essentially responses of fear or pain. Some characteristic movements occur in response to constraints, most often when the animals are being contained. They show the animal's refusal or fear: sideways movement of the legs, bending of the front legs and any brisk movement forward or backwards. Similarly, kicking, swaying of the head, as well as movement of the ears should be interpreted as a sign of the animal's stress. Depending on the intensity of the stress felt, they are associated to other elements of observation: the production of foaming saliva, dilated

nostrils, slightly bulging eyes, and intensified breathing.

V. - Reproduction and Ontogenesis

Only the principle behaviour linked to reproduction will be described herein. Physiological aspects will not be addressed. In breeding, the reproduction of cattle is more than often controlled or assisted by humans (hormonal stimulation, artificial insemination, assistance during calving).

Cattle reproduction is accompanied by behaviour that is characteristic of courtship displays, pursuit and approach. This behaviour is equally observed in farms (reviews illustrated in PHILLIPS, 1993 and ALBRIGHT and ARAVE, 1997).

Flehmen behaviour enables the bull to detect the females in heat. However, the effect of pheromones is reduced if there is no contact (GEARY et al, 1991). The bull 'guards' the female several days before she is in heat and manifests his intention to eliminate all other males from the competition. He then attempts several approaches to reassure himself that the female is physiologically and behaviourally receptive: he sniffs the genital region, leans his head on the female's pelvis and finally attempts to cover. This behaviour may vary in farms and courtship displays are rarely observed (reviewed in ALBRIGHT and ARAVE, 1997). It can sometimes lead to fighting among bulls or attacks on humans.

An effect of the group and of its hierarchy can be observed: the dominant bull covers more often than the subordinate bulls (PETHERICK, 2005, reviewed in PHILLIPS, 1993) but choosing a partner is more a question of affinities between animals (CECIM and HAUSLER, 1988, ORIHUELA and GALINA, 1997). The size of the group influences the natural synchronisation of ovulation, the frequency of sexual activity and the identification of the physiological state of the females (GEARY et al, 1991).

Ontogenesis will be described herein as the development of the animal post birth: the first weeks of life marked by maternal behaviour, then the successive stages of development from youngster into adulthood. Only the transformation of sensory perception and behaviour will be described. The question of weight gain and size (in a farming situation) concern zootechnics and will not be taken into account.

In cattle, as with all ruminants, maturity is reached at an early age and the calves develop rapidly (NOWAK, 1998). Thus, from birth, the sensory and motor faculties of the calf are very developed, and it is rapidly independent in terms of its thermoregulation and locomotion. The mother plays an essential role in teaching the calf what to eat and social integration.

The mother-calf relationship

Calving is a critical moment in the reproductive cycle of cattle. In wild or semi-wild herds, the cow calves alone, isolated from the rest of the herd (HALL et al, 1988). Calving may last from between 2 to 3 hours depending on the mother's experience: in farming, it is often necessary to help primiparous heifers. Once the calf has been

delivered, the placenta follows and is subsequently eaten by the mother. The appeal of the placenta is very limited and is determined by the hormonal modifications of gestation: it is part of the desire to hide all detectable traces of the birth from potential predators.
Birth may occur during the day or at night (LETAIS et al, 1995), but the mother does have certain control over it: for example, she can prevent birth during milking (review in PHILLIPS, 1993).

Most often, the mother recognises the calf immediately (NOWAK, 1998) but recognition may be perturbed if there are too many other animals present. The mother recognizes the calf first of all via olfactory signals: the mother sniffs her young to impregnate its scent in her olfactory memory. Grooming activities are part of this olfactory identification and will be maintained for several months if the farm allows it. The role of scent in preserving the maternal link is proven by experiments (LE NEINDRE and GAREL, 1985) however, it doesn't appear to be obligatory and it assumes that the mother and calf are close to each other (SIGNORET et al, 1997). Visual recognition of the coat makes identification possible from a distance while the calf is growing and when there is a high concentration of animals. The vocal recognition of the calf by its mother seems to bear little significance within the herd, but the vocal recordings of the calf have a convincing effect on the mother's lactation (POLLOCK and HURNIK, 1978, McGOWAN et al, 2002).

The calf recognizes its mother via a combination of visual and social factors: it identifies its mother's mooing (BARFIELD et al, 1994, WATTS and STOOKEY, 2000), as well as the colour of its coat (MURPHEY et al, 1990).

The established maternal link may last for several years (REINHARDT and REINHARDT, 1981) but the duration and related maternal behaviour are determined by the farming situation and to a lesser extent, by race (LE NEINDRE and SOURD, 1984, LE NEINDRE, 1989a).

Maternal behaviour is conditioned by the hormonal profile at the end of the gestation period and at the moment of giving birth. In cattle, mothers are more than often active. They lick the newborn as soon as it is delivered: this initial behaviour has a soothing effect, it enables the coat to dry out and thus facilitates the newborn's thermoregulation. The mother grooms the newborn calf within 5 minutes of its birth, this grooming may last up to 30 minutes (ILLMAN and SPINKA, 1993). This activity is then regularly repeated and stimulates micturition (METZ and METZ, 1986, NOWAK, 1998). The importance of grooming in establishing a maternal link has been observed many times (LE NEINDRE, 1989a, review in ALBRIGHT and ARAVE, 1997). PRICE et al. (1985) observe a significantly inferior maternal link in twins and explain it by the reduced grooming time awarded to each of them.

The second type of maternal behaviour observed is the encouragement to feed. The calf stands within an hour after delivery and usually finds the teat within the hour that follows. The interval between birth and the first feed depends on the calf's activity, the conditions of its birth but also the behaviour of the mother as the calf is directed to the teat by the mother. The position in which feeding occurs varies with age: the newborn calf finds the udder by following the mother's flank and therefore feeds in a position that is 'inversely parallel' to its mother. As it grows, it adopts a perpendicular

position, or even feeds from behind its mother (NOWAK, 1998). The average interval between birth and the first feed varies from between 50 minutes and 12 hours. It conditions the young calf's passive immunity (STOTT et al, 1979, VENTORP and MICHANEK, 1991) but the role of the maternal colostrums in acquiring immunity is highly disputed (PHILLIPS, 1993, ALBRIGHT and ARAVE, 1997, WEARY and CHUA, 2000), as is the impact on the mother's health (METZ, 1987, KROHN et al, 1990). In wild or semi-wild herds the maternal milk is the natural diet of the calf until weaning. Several feeds are observed a day, 5 to 8 at birth and then 3 to 5, each feed lasting 10 to 15 minutes (PHILLIPS, 1993, HALL, 2002). Feeding is initiated either by the mother, by the calf, or sometimes it is provoked by another calf feeding.

The constraints of farming sometimes engender disturbances in maternal behaviour: Separating the calf from its mother, feeding it alternatively, isolation, adoption. Some of these disturbances constitute so-termed sensitive periods in the construction of the human-animal relationship (figure 13, see chapter 7).

Figure 13: an opportunity to construct the human-animal relationship.

Behavioural changes in calves

The development of the calf and young cattle into adulthood involves progressive changes in both individual and social behaviour. In livestock, the most visible changes affect feeding behaviour (weaning) in particular, but also the social relationships between the fellow animals of a herd. Given that these relationships are governed by the type of farming, we shall address them only briefly.

The age for weaning depends essentially on the type of farming, but in wild or semi-wild herds it can last until the calf is 10 months old (REINHARDT and REINHARDT, 1981, HALL, 2002).

Cattle herds observe a matriarchal type social structure: the cows form a structured group with their calves and young cattle. Males are not included in this group (review in PHILLIPS, 1993 and ALBRIGHT and ARAVE, 1997). Social hierarchy develops among calves and heifers and the use of space depends more on its availability than aggressive interactions. The age at which dominance is established is difficult to estimate and more than likely varies according to the type of farming: after weaning

(STRICKLIN et al, 1980), between 3 and 6 months (SCHEIN and FOREMAN, 1955) or after 12 months (KUROSAKI et al, 1981). The relationship between age and dominance more probably reflects the result of experience (BOUISSOU and ANDRIEU, 1977). Interactions with other members of the group increase with age, but remain essentially non aggressive until 2 months of age (BOUISSOU et al, 2001)

The calves learn quicker than adult cattle, their visual comprehension, in particular, is more acute (KOVALCIK and KOVALCIK, 1986). Youngsters are more attracted by novelty (MURPHEY et al, 1980). However, curiosity concerning novelty is a permanent cattle characteristic that (GRANDIN and DEESING, 1998). Feeding behaviour is learned by imitating fellow adult animals and also through individual experience (HALL, 2002).

VI. – The cognitive capacities of cattle

The repertoire of cattle behaviour and their capacity to learn are renowned and explain largely why they have been domesticated for over 8,000 years (review in ALBRIGHT and ARAVE, 1997). It is difficult to estimate how much behaviour is inherited (GRANDIN and DEESING, 1998). Learning refers to the acquisition of knowledge through the experience gained by an individual or passed on by the mother and fellow animals. Thus the distribution of wild cattle across their territory is the result of several lessons (HOWERY et al, 1998): Early experience (the mother teaches use of space), prior individual experience of the environment (spatial memory) and social factors (social transmission by the herd leaders). The same is observed in the learning process of feeding: the mother's role, individual experience and the role of fellow herd members (BAUMONT, 1996).

Cattle memory

The cognitive capacity of cattle is based upon memory and analysis of the information transmitted by the sensory perceptions: it employs the brain and various sensory organs.

The visual memory of cattle has been proven and may easily be tested in effective conditioning exercises (RENKEN et al, 1998, HOWERY et al., 2000). Sense of smell plays a very important role in the behaviour of cattle and effective memorization of olfactory signals is therefore essential. Auditory memory plays a role in cattle communication (DIMBERTON, 1999) and aids vocal recognition. Cattle memorization of sounds also facilitates the relationship between the breeder and his herd (calling the animals, recognizing the familiar sound of the tractor, etc.). It is more difficult to estimate the tactile and gustatory memories. The role of adaptation to continuous stimulation of the taste buds is recognised: it aids in the selection of food (review in GINANE et al, 2002). Equally, the memory of bad treatment (kicking or painful handling) by humans is described.

The **spatial memory** of cattle has been shown: it includes the memory of visual markers, the estimation of distances and their memorization, and the memory of the associated result (quality and quantity of food, for example). Spatial memory is most

often tested in mazes (KOVALCIK and KOVALCIK, 1986, BAILEY et al, 1989) or bullrings (LACA, 1998) and may be conditioned (BAILEY and WELLING, 1999). Spatial memory determines in part the distribution of animals in a known pasture: cattle are able to identify visual markers in the landscape and associate them with the quality and quantity of the grass or the presence of water sources (BAILEY et al, 1989, GINANE et al, 2002) and this memory may last over 8 hours or even several days (KSIKSI and LACA, 2002).

In a choice situation, cattle behaviour is the result of a combination of these different forms of memory and the capacity of animals to evaluate each of the alternatives (GINANE et al, 2002).

Individual learning

Individual learning is the result of information passed on by the mother to the youngster and the personal experience of the animal. The education offered by the mother is limited by time and concerns a reduced number of behavioural types: essentially feeding behaviour (review in ALBRIGHT and ARAVE, 1997).

Individual experience, that is to say the animal's prior exposition to an identical situation, is far more influential (VALENTINE, 1990). The choice of food also largely results from the individual experience of cattle (PROVENZA et al, 1992, PROVENZA, 1995, BAUMONT, 1996) and it is possible to condition the food choices of livestock (TROCCON, 1993, DUMONT et al, 2001).

Social transmission

Large herbivores are generally gregarious and rely on social interaction for learning purposes (VEISSIER et al, 1998b).

Social transmission is a determining element of cattle behaviour in general. Thus, movement is more than often initiated by the 'leader' animals. The role of leadership when undertaking a new activity is recognised and used in managing livestock and handling herds.

The impact of the social model on the search for food has been shown: the presence of 'experienced' animals within a group induces a significant increase in the efficiency of the other animals. Social transmission occurs via search methods: the search efforts of inexperienced animals are more concerted and therefore more efficient in the presence of a 'demonstrator' (KSIKSI and LACA, 2000). The extent to which a herd is familiar with a prairie (BAILEY et al, 1996), as well as the behaviour of fellow animals (NICOL, 1995) largely determines grazing methods.

However, the extent of imitation and/or social facilitation is difficult to determine (review in ALBRIGHT and ARAVE, 1997).

VII. – Genetic variability, domestication and temperament

Over a thousand different races of cattle have been recorded (HALL, 2002), they are divided into two principal species (*Bos taurus* and *Bos indicus*) and dispersed heterogeneously across the 5 continents under very diverse stock breeding forms (review in ALBRIGHT and ARAVE, 1997). It is the genetic characters of these different races that were chosen during domestication and which characterize the use of one race in a particular form of stock breeding (HALL, 2002).

Domestication may be defined as “a process by which an animal population becomes adapted to humans and the captive environment” via genetic changes from generation to generation (according to PRICE, 1984 in PRICE, 2002). The author adds that this “adaptation to captive conditions is due to environmental events that occur during development and reoccurring with every generation” The selection of genetic fila is an integral part of the principles of domestication. It is based on the selection of zootechnical performances (fattening up, milk productivity) but also on the selection of temperament (docility, aggressiveness) of a genetic basis, and, to a lesser extent, the anatomical character (thickness of the coat, size of the horns, size and aptitude to move around in a given environment, PRICE, 2002). The heritability of several behavioural characteristics has been calculated (PHILLIPS, 1993, PLUSQUELLEC and BOUISSOU, 2001): dominance in particular (WIECKERT, 1971) as well as the reaction to constraints and docility (BLOOCKEY et al, 1978, FORDYCE et al, 1882, HEARNSHAW and MORRIS, 1984, LE NEINDRE et al, 1995). However, the influence of farming conditions remains preponderant (BOIVIN et al, 1994). Farming environments where the animals are more independent of humans encourage a stronger individual variability than environments that are strictly controlled by humans.

Temperament is a determining factor of the animals’ reactions to humans. Emotivity is one of the principal psychological and determining elements of an animal’s behavioural response. It determines the perception and constant reaction of the animal in different situations (GRANDIN and DEESING, 1998).

The concept of the temperament (or personality) of cattle is characterised by the constant behavioural and/or physiological responses in time and space (BATES, 1989, MULLER and SCHRADER, 2005). In cattle, this definition has often been reduced to the animals’ response to human handling (Burrow, 1997 for review). The reactivity of one cattle in a given situation especially depends on its experience of the situation (review in PRICE, 2002). Moreover, repeated changes in the environment render the animal more adaptable (BOISSY et al, 2001). In this respect, a diverse social environment appears to be more beneficial than a stable one (RAUSSI et al, 2006), but only while the hierarchy is stable (RAUSSI et al, 2005). Temperament influences the majority of cattle behaviour (review in PHILLIPS, 1993, VAN REENEN et al, 2004).

The temperament of cattle is often measured by approach/ avoidance (review in PRICE, 2002, TOZSER et al, 2003). This test is used in a wide variety of given situations (contact with a strange object or person, in the presence (or not) of fellow animals, etc.). Other test situations involve: the more or less hasty exploration of an unknown room, feeding (or not) in a given situation, aggression towards a handler,

the ease with which they are lead inside a building, aggression during milking and the speed with which they leave the cage, etc. (KILGOUR, 1975, GRIGNARD et al, 2000, ISHIWATA et al, 2005, MULLER and SCHRADER, 2005). Physiological and biochemical tests complete the panel of techniques for evaluating temperament: dosage of cortisol in the blood or saliva and cardiac rhythm. The correlation between these tests sometimes gives contradictory results (RETLE, 1998, LANIER et al, 2001, KILGOUR et al, 2006). These tests probably characterise personality traits: curiosity, docility, gregariousness, anxiety… and may often be correlated to areas of zootechnical interest such as the resistance to illness or the quality of meat (VOISINET et al, 1997a, 1997b, BURROW and PRAYAGA, 2004, KADEL et al, 2006, MULLER et al, 2006).

Temperament is often underlined in the characteristics of the race and its heritable character is recognised (GRANDIN and DEESING, 1998). The localization of a temperament gene in the sex chromosomes has been proven (HEINDLEDER et al, 2003), as well as several genetic aspects of behaviour of cattle (review in PHILLIPS, 1993, BURROW and CORBET, 1999, BURROW, 2001, GAULY et al, 2001, HAILE-MARIAM et al, 2004, BOISSY et al, 2005, PRAYAGA and HENSHALL, 2005).

Temperament is likely to play a role in determining the hierarchy. Animals that are hierarchically dominant show less reactions of fear in social and non-social situations (BOUISSOU and BOISSY, 2005). Age is an important factor of temperament, in relation with animals' greatest experience (MURPHEY et al, 1981, PHILLIPS, 1993 for review). This is particularly true with livestock: the oldest animals have a much greater tolerance for disagreeable handling because they have endured it for a longer time.

VIII. - The human-cattle relationship

There are numerous ways of treating human-animal relationships (HAR). A farm animal spends months, even years, with his stock breeder. These regular meetings construct a behavioural relationship (HINDE, 1976, ESTEP and HETTS, 1992). The human-animal relationship (HAR) may also be defined as the level of connection or distance between the human and the animal i.e., a mutual perception that develops and is expressed in their respective behaviour (WAIBLINGER et al, 2006).

Agriculture has evolved since the Second World War: the dramatic rise of mechanisation and the increasing size of farms and herds are examples of this evolution. These factors have engendered a change and a decrease in the number of interactions between breeders and their animals. Breeders have less time to spend with their livestock and the relationship between humans and their animals has changed (RUSHEN et al, 1999). The decline of this HAR seems to be the cause of rather significant problems within farms relating to the animals' acute fear when faced with humans:

- animals suffer immuno-depression and health problems due to stress (BREUER et al, 2000, HEMSWORTH et al, 2003),
- they are difficult to handle (LE NEINDRE et al, 1996),

- there is a risk of injury for both the human and the animals (RUSHEN et al, 1999)
- there is a decrease in production and product quality (BREUER et al, 2000, 2003, LENSINK et al 2000a, b; HEMSWORTH et al, 2000 and 2003, WAIBLINGER, 2006).

Thus, the human-animal relationship represents a genuine concern of cattle farming. It is therefore essential to be familiar with the influential factors. Scientific research has shown that numerous factors were likely to affect the HAR in either a positive or negative manner: The *genetics and heritability* of responses to handling (for review, BURROW et al, 1997, BOIVIN et al 2003, GAULY et al, 2001, 2002, GRIGNARD, 2001, RAUSSI, 2003), the t*emperament of the animal* (MÜLLER and SCHRADER 2005, PETHERICK, 2005, WAIBLINGER et al, 2006), the *stock breeding system* (BOIVIN et al, 2003, RAUSSI, 2003), *the behaviour of the stock breeder* during interactions with the animal (BOIVIN et al, 2003, BREUER, 2000, LENSINK et al, 2001, HEMSWORTH et al, 2000 and 2002), the *stock breeder's work load* (LENSINK et al, 2001) and therefore *his presence near the animals* (BOIVIN et al, 2003), *prior experiences with humans* (in quality and quantity, RUSHEN et al, 1999 HEMSWORTH, 2003, ROUSING et al, 2004). These factors leave a more or less influential mark on the animal depending on its age: young age, weaning, calving.

This summary aims to describe the interactions between humans and animals, the influence of housing and other factors relating to the human animal relationship, as well as addressing the solutions for improving the quality of this relationship in cattle farms.

7.1 Interactions between man and the animal

In spite of a very long domestication, herbivores must be accustomed to the presence of humans in order to reduce their fear in reaction to his presence. Animals raised with minimal human contact will not seek human presence –rather they will flee from it- contrary to other animals that have benefited from agreeable contact (for review, BOIVIN et al, 2003, RUSHEN et al, 1999, HEMSWORTH et al, 2003). Stock breeding where human contact is minimal is common in farms where animals are numerous and the breeding is extensive (North and South America, Australia, New Zealand…).

In order to master his herd correctly, the stock breeder must understand how a cattle perceives the world it lives in and in particular, how it perceives humans. He must equally understand how this perception influences the human-animal relationship. It is necessary to introduce the notion of interaction between humans and animals (ESTEP and HETTS, 1992). An interaction may be qualified as such if the behaviour of an individual influences that of another and vice-versa. The relationships that develop between stock breeders and their productive animals are the result of real interactions: they are often repetitive (indeed, daily in the case of dairy herds). These interactions increase throughout the animals' life and they have reciprocal effects on both parties (HEMSWORTH et al, 2003). Hence, the nature of these interactions can influence the manner in which the HAR develops.

Evaluating the cattle's **safety zone** and **flight zone** (the distance at which one may approach before the animal moves away) makes it possible to describe the manner in which it perceives humans. If the negatively perceived human encroaches on this safety zone, the animal will turn and flee or attack the intruder when he is too close or the animal cannot escape (figure 14). Understanding the flight zone makes it possible to optimize herd manoeuvres: it is possible to direct the animals in the desired direction based on the angle of approach (figure 15, GRANDIN, 1997): With humans, the animal's **flight zone** will depend on its prior contact with humans, but also on the animals' environment (pasture, housing, corral) or its physiological state (recent calving etc.). A good understanding of the factors that increase this zone (fear, agitation) enable the breeder to decide on the most propitious moment to approach an animal.

Figure 14: The animal faces the human as long as he doesn't encroach on its flight zone.

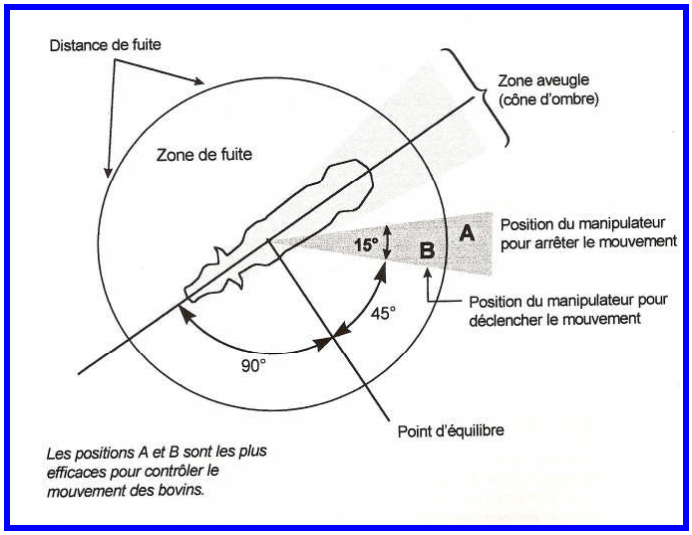


Figure 15: Flight zone and cattle manœuvres (GRANDIN, website).

Interactions between humans and livestock are diverse and may involve visual, tactile, olfactory, and auditory perception. Five types of contact can be described (WAIBLINGER et al, 2006):

- Visual presence (the human is visible but not moving)
- Movement near to the animals (without tactile contact)

- Physical contact (the human touches the animal)
- Food (reward)
- Invasive, disagreeable or stressful handling

As described in the first chapter of the document, the impact of visual, olfactory and auditory contact on the animals and the HAR has not been studied to the same degree as tactile interactions (HEMSWORTH, 2003).

7.2 The mechanisms for constructing the human-animal relationship

The human-animal relationship is essentially based on **human-animal interactions**. These interactions may be positive or negative, and engender fear, or on the contrary, an attachment to the human.

The research attempts to explain how repeated interactions may bring cattle to avoid humans or on the contrary, to approach them, to fear them or to seek their company. These interactions are often illustrated by the animal's reactions: notably fear as well as various behavioural reactions (WAIBLINGER et al, 2006). These reactions are varied: flight and avoidance of humans, approach, positive interaction with humans (exploration, licking, etc.), ease of handling (also known as 'docility[2]') and the possibility of reducing stress during disagreeable events through positive contact. They may be associated with physiological reactions of stress WAIBLINGER et al (2006) have compiled an exhaustive list of the methods for measuring the reaction of livestock (notably cattle livestock) to humans.

Cattle experience multiple interactions with humans throughout their lives: the distribution of food, straw bedding and milking constitute daily interactions, as do transport, animal insemination, foot trimming and various veterinary interventions. These interactions vary according to the farming system. They begin at an early age: aiding calving, grooming the calf, weaning from the first day, aiding suckling, dehorning, ear tagging and allotment. La multiplicity of these interactions contributes to the human-animal relationship. ESTEP and HETTS (1992), picking up HEDIGER (1965), classify the various perceptions the animal may have of humans following prior interactions and human-animal relationships already created this way.

Fear of novelty

Humans can be a worrisome element for animals, engendering fear in them. In turn, they may perceive humans as predators (ESTEP and HETTS, 1992). This is particularly applicable to the cattle, which, as an herbivore, is considered prey. The novelty of initial encounters and low levels of contact between humans and animals can create fear. This fear ensures the animal's survival when faced with an unfamiliar or barely familiar stimulus that may be dangerous. In experimental conditions, when calves have had no interaction with humans, they interact little with humans later on, as opposed to animals that are regularly exposed to human contact. It will present reactions that indicate fear: in expectation of contact with the human, an increased heart rate is observed (JAGO et al, 1999, BOIVIN et al, 2002, TALLET et al, 2005,

[2] This notion is often termed 'temperament' in Anglo-Saxon literature.

2006). When cows demonstrate certain vigilance despite the presence of an appealing food source, it is considered a sign of fear (RUSHEN, 1999): the animal pays close attention, it is immobile, it watches, listens and sniffs the air. WELP et al, 2004; MÜLLER and SCHRADER, 2005, and DE PASSILLÉ and RUSHEN, 2005 support this hypothesis. In 2004, WELP et al. observed that dairy cows are more vigilant in unfamiliar surroundings, in the presence of a dog and in the presence of a person who has handled them disagreeably. According to these authors, the cows modify their level of vigilance in direct response to the threat posed by a person or a dog.[3].

HEMSWORTH and COLEMAN (1998) consider that fearful reactions to the novelty of humans are rare on farms as the stock breeder handles the animals often and from the earliest age. The animals learn about human contact through experience. Therefore, humans can actually become an environmental element to which the animals are indifferent: the animal learns to ignore a stimulus that has no direct consequence for it (PEARCE, 1997; BALKENIUS, 2000). In practice, this simple mechanism of human habituation is difficult to test because of the very definition of farming: it is rare for animals to merely be exposed to humans without there being interaction. The presence of an unknown human before a bucket of concentrate will only disturb the calves temporarily and they will come and eat if the human does not move (BOIVIN et al, 1998).

The nature of contact: positive and negative reinforcement

The nature of the human contact is an important and decisive factor of the cattle's fear of humans (RUSHEN et al, 1999, HEMSWORTH, 2003, BREUER et al, 2003). In farming, the animals experience disagreeable handling during interaction with humans. Through the process of conditioning, the animal associates humans with handling and hence demonstrates reactions of flight, or indeed defence (BREUER et al., 2003; PAJOR et al, 2000 and 2003, ROUSING et al, 2005). The same conditioning mechanism applies to positive reinforcers, such as food or drink. Then, humans can be perceived as the suppliers of food or drink, in the same way that the sound of the tractor can be associated with food. For example, cattle may associate the colour of the stock breeder's clothes with the reward of food to come (DE PASSILLÉ et al., 1996, MUNKSGAARD et al., 2001, RYBARCZYK et al, 2001 et 2003). The association of humans with positive reinforcers may reduce the animal's flight zones and therefore, the associated fear, as well as facilitating handling (BREUER et al, 2003, LENSINK et al, 2000 and 2001). The conditioning process applies not only to the human, but also to the context in which the reinforcement takes places and the animals memorize the place (RUSHEN et al, 1998) and time where handling occurs (MURPHEY and MOURA DUARTE, 1983).

Attachment to humans

Humans are sometimes presented as the animals' social partner or indeed, fellow animal (HEDIGER, 1965, ESTEP and HETTS, 1992). This concept is based on our relationships with animals that are familiar to us, and is often cited by dog and horse trainers: the human must therefore behave like the dominant animal or the leader of

[3] The dog was used in the test assuming that he would be perceived as a predator.

the herd; he must be both the friend and master. LOTT and HART (1979) observe this same social structure between the African Fulani nomads and their herds. ESTEP and HETTS (1992) compile a list of different situations in which animals may perceive humans as a fellow, for example, when it imitates behaviour specific to the species of animal involved (SCHMIED et al, 2004). RUSHEN et al. (2001) underline the fact that we still know relatively little about the range of social communication registers of the animals we breed. Various bibliographic reviews (ESTEP and HETTS, 1992, RUSHEN et al, 2001 or BOIVIN et al, 2003) discuss the concept of attachment in livestock. Attachment is an individual's emotional relationship linked to the presence (soothing) or absence (stress of separation) of the subject of attachment (KRAEMER, 1992). The relationship is constructed through the proximity of the animals with no obvious reinforcer, although external reinforcers may accelerate the connection (SCOTT, 1992). The results obtained from cattle lead us to believe that the animals do have a certain attachment to their carer: the presence of a carer will calm lambs when they are placed in social confinement, and engender distress when he leaves them alone again (BOIVIN et al 2000, 2001 AND 2002). For cows, the presence of humans can be calming in a stressful situation (RUSHEN et al, 2001, WAIBLINGER et al, 2004). However, to our knowledge, there is no study to prove a genuine cattle attachment to humans.

Recognition of humans

Where an established human-animal relationship exists, it is necessary to discern whether or not it may be generalised to include all humans or whether it is specific to the animal's usual carer.

The capacity of cattle to differentiate humans has been addressed several times in scientific literature (review in DE PASSILLÉ and RUSHEN, 2005). Calves (DE PASSILLÉ et al, 1996), and cows (MUNKSGAARD et al, 2001, RYBARCZYK et al, 2001 and 2003) are capable of distinguishing between humans that have handled them in a gentle manner and humans that have handled them in a disagreeable manner. They rapidly learn to avoid the rough handler and to approach the gentle one (MUNSKSGAARD en 2001). Similarly, they are capable of learning quickly and of recognising familiar fellow members (HAAGEN and BROOM, 2003).

Cattle recognize humans by using visual markers such as the face, size and the colour of clothing from an early age. Indeed, very young calves (less than three weeks old) used by RYBARCZYCK et al (2003), were capable of associating food with an individual person and of differentiating this person from others who wore different coloured clothing. Visual factors are not the only factors they use to differentiate between humans. RYBARCZYK et al. (2001, 2003) show that cows are capable of discriminating between the human that provides positive contact and he who does not even if they are wearing the same clothes of identical colour. The use of smell to distinguish between humans is disputed (RYBARCZYK et al, 2001, 2003) although this sense is used to construct the social organisation of the herd.

Cattle may recognise people, but several studies show that they generalise their experience with one human and apply it to all others (KROHN et al, 2001, BREUER et al, 2003, ROUSING and WAIBLINGER 2003). MUNKSGAARD et al, 2001 showed that cows kept a greater 'safety distance' between themselves and a non familiar

person if said person wore overalls of the same colour as the disagreeable handler. LENSINK et al (2001) also observed that veal calves generalised their reaction to a known human and applied it to an unknown human when the test occurred in foreign territory.

In commercial farming, BREUER et al, (2003) observed that heifers approached a familiar person in the same way as they approached a non-familiar person. Normal farming conditions are, however, different from experimental conditions where the animals are 'trained' to associate a specific colour of clothing with a particular event (RYBARCZIK, 2001 and 2003, MUNKSGAARD et al, 2001). In stock breeding, the phenomenon of discrimination (different reaction depending on whether the human is known or a stranger) is less likely to manifest itself and may never be manifested. The animal will only react differently if the situation is stressful (touching, for example): The animal is more likely to accept contact from a familiar human than a stranger (BREUER et al, 2003, BOIVIN et al, 1998). The number of people the animal meets may be an explanatory factor in its reactions (DE PASSILLE and RUSHEN, 2005).

Therefore, cattle seem capable of associating humans with prior treatment they have received, be it agreeable or disagreeable. This is essential in understanding cattle fear and the development of the human,-animal relationship (RYBARCZYK et al, 2003).

7.3 The influence of housing and the social context on the human-cattle relationship

The animals' housing is the place where they eat, sleep and live. For cattle, housing corresponds to the farming method: stall housing, open housing, cubicles, and entirely open range (in which case the field is their housing). These different types of housing seem to influence the social behaviour of the animals and the human-animal relationship (RAUSSI, 2003, WAIBLINGER et al, 2003). On the one hand, living freely or being used to a restricted space modifies the animal's reaction to humans. On the other, buildings influence the conduct of a herd: either they live in groups or they are stalled. In isolated groups, the relationships (between the animals and between the animals and the breeder.) are completely different.

The presence of **the mother** seems to be an obstacle in maintaining a positive human-animal relationship when it is established at an early age (BOIVIN et al, 2003, KROHN et al, 2003). Indeed, during tests, the calves that had been reared by their mothers did not seek contact with humans as opposed to those who were separated from their mothers. For KROHN et al. (2003), it is probable that a primary socialization occurs with the mother thus preventing a secondary 'socialisation' with humans until the calf is separated from its mother (figure 16).

Isolated farming conditions engender particular reactions with humans. Male calves bred in isolation are consequently more aggressive with humans than those reared in groups (PRICE and WALLACH, 1989). It is possible that animals reared in individual cubicles are more afraid of humans and therefore, they are more aggressive if disturbed. It is also possible that the calf needs to learn to develop social relations with its fellow animals thus to develop a calmer human-animal relationship.

Humans may also represent a 'social substitute' for isolated animals. Calves bred in isolation approach humans more readily than calves bred in pairs (LENSINK et al, 2001). MORGENSEN et al (1999) also show that calves reared individually that have no possibility to socialise with their fellows, show more interest in humans, in contrast to calves reared in a group or under the mother. For these authors, calves that are reared under their mother have no contact with humans during mealtimes, whereas isolated calves associate mealtimes with humans, which seems to facilitate socialization with humans.

Figure 16: The mother: a hindrance to the relationship with humans?

As for animals bred on **open housing or open range** farms, they equally present specific behaviour due to the lack of contact they have with humans and the fear they may develop towards them. In experimental conditions, the calves reared in the traditional system: (two feeds a day under human supervision) are less aggressive than animals reared in open range conditions (BOIVIN et al, 1994, LE NEINDRE et al, 1996), and the least afraid during human handling than the animals reared in open housing farms. Animals living in restricted space are used to not moving and accepting human handling. Open range animals are less used to the farming constraints (confinement, proximity to humans, with fellow animals). When these constraints are imposed on open range animals, they are not received gladly. Thus, reactions of fear or panic may engender a risk of injury for the animal as for the breeder.

7.4 Solutions for improving the human-animal relationship

To improve the relationship between the breeder and his animals, several points must be considered. They concern both the breeder and his attitude towards the animals, but also the favourable periods in which to approach the animals. It is necessary to teaching stock breeders in order to modify their attitudes and to take

advantage of the favourable periods in which to initiate a relationship with their animals.

The stock breeder's behaviour and his attitude

Human-animal interactions depend mainly on the **behaviour of the stock breeder**: this can influence the animals' confidence, provoke fear and consequently affect the quality of the HAR. The initial studies in this domain were performed by SEABROOK (1972) who established a significant relationship between the change of cattle herds, personality (in particular self confidence, extraverted or introverted character) and dairy cow production. In 1975, RENGER equally showed that the behaviour of bulls produced via artificial insemination depended on the personality traits of the herd (balanced, calm, and violent) as well as its experience. Job satisfaction, but also an ability to understand the animals and to be attentive to their well being is essential for the construction of a good human-animal relationship (SEABROOK, 2001, PORCHER, 2002). Personality and behaviour of the breeder are the result of a long development of the individual. Therefore, they are not easy to modify via training and resist change (HEMSWORTH and COLEMAN, 1998).

The behaviour of the breeder depends on **his personality** and may explain the fearful reactions of the animals. Cattle are sensitive to rapid movement and shouting; they need familiarity and calm. They remember repeated negative interactions even if they are moderate and will associate humans with those experiences. It is therefore likely that emotionally unstable, rushed, stressed or extraverted people (exuberance, raised volume, frequent movement) will scare the animals through certain movements. The animals cannot understand these people, just as they cannot understand those who are inexperienced or lacking in confidence. If repeatedly subjected to this kind of behaviour, this lack of understanding will engender fear and chronic stress in the animal. This will lead to a decrease in production (growth, milk production) and inferior product quality (colour of the meat). Equally, LENSINK et al (2001) show that the breeder's attitude towards his own work (cleanliness of the animals, for example) is also an essential component explaining production results.

The breeder's behaviour is greatly determined by **his attitude** and by the efficiency of his behaviour with the animals (HEMSWORTH and COLEMAN, 1998). This theory was verified in pig farms (HEMSWORTH and COLEMAN, 1998 for review) but also on dairy cows and veal calves (HEMSWORTH and COLEMAN, 1998, BREUER, 2000, HEMSWORTH et al, 2002, LENSINK et al, 2000 and 2001, WAIBLINGER, 2002). Studies performed on commercial farms show that the carers' attitudes towards the animals signify their behaviour towards them and equally that of the animals towards the humans: a negative attitude on the part of the human will engender a negative behaviour towards the animals (kicks, yelling, agitation). Thus, the animals associate the presence of humans with disagreeable events and so behave in a negative manner. Positive behaviour, however, improves the animals' reactions (LENSINK et al, 2001). *"the behaviour of the breeder is closely correlated to the cows' behaviour. The cows that fled the least in the presence of a human were those that lived on farms where positive interaction was frequent and negative interaction less frequent"* (WAIBLINGER, 2002).

HEMSWORTH and COLEMAN (1998) showed that, via training, it is possible change the attitudes of breeders and then to observe the expected changes (HEMSWORTH, 2003 for review). Often, human behaviour that is perceived very negatively by the cows is observed in breeding practices: shouting, kicking or beating with a stick, sometimes using a pitch fork or an electric charge (HEMSWORTH and COLEMAN 1998, PAJOR et al 2003). It is important to **limit these negative interactions to improve HAR** (WAIBLINGER et al, 2004). STAFFORD et al. (2002) suggest using less painful techniques or anaesthetic or anti-inflammatory substances during the intervention -although these may be costly. HUSTON (1985) suggests compensating the animals after these interventions (stroking, food) in order to facilitate handling, or to employ gentle contact during these interventions (WAIBLINGER et al, 2004). However, good quality HAR is necessary to allow for the positive effects of gentle handling and to improve the negative perception of traumatic events such as isolation and constraint (BOIVIN et al 2000).

According to HEMSWORTH and COLEMAN (1998), the proportion of negative interaction received by the animals determines their fear of humans. To avoid the animals developing a fear of humans, it would be beneficial to **increase the quantity, quality and duration of positive interaction** (HEMSWORTH and COLEMAN, 1998, RAUSSI, 2003). BOIVIN et al (2003) underline the benefits of additional contact and cite experiments having found that: '*several days of positive contact with the animals (non aggressive presence, food and stroking) seemed sufficient to put a stop to aggression linked to fear of humans, perhaps therefore undoing the animals' perception of the human as predators"*. BOIVIN et al. (2003) underline the importance of the animals' memory in order to understand their reactions to humans. For example, it is well known that cattle are sensitive to change and that they require **a relationship based on trust** and **predictable human behaviour** (WAIBLINGER et al, 2006). The aggression observed in certain handling situations may be prompted by the animal's perception of a loss of control. The place in which the interactions occur is equally important for the animals because it may be a means for them to predict the manner in which the human will handle them (RUSHEN et al, 1998). DE PASSILLÉ et al. (1996) have shown that dairy calves can easily differentiate the gentle handler from the disagreeable handler when handling occurs in the same place, but that they were less capable of differentiating between them in a different place. Thus, if all negative handling occurs in the same place, it may reduce the generalised aversion to humans.

Sensitive periods

The period during which human contact is recommended is an important factor in HAR: the sensitivity of cattle to human contact seems to differ according to the animal's stage of life. In the literature, **three sensitive periods** have been described: young age, weaning (separation of mother and young) calving (BOIVIN et al, 2003). BATESON (1979) *suggests the definition of a sensitive period as a period of much reorganisation when the developing animal is more easily destabilised by deprivation or an environmental aggression*.

Young age is a very important period in the development of an individual, of its behaviour and its relationships (for review, SCOTT, 1992). Few studies have been

made of cattle. BOISSY and BOUISSOU (1988) observe the absence of sensitive periods concerning human contact in the first month of a dairy calf's life.
However, the regular contact of these animals with humans may have masked the sensitive period. Indeed, young age is a manifestly sensitive period in goats (LYONS et al, 1988) and sheep (MARKOWITZ et al, 1998). KROHN et al (2001) have characterised the sensitive period of young age in calves. In experimental conditions, with controlled contact with the carers, the calves that had been handled during the first four days after birth, had a reduced flight zone at 6 weeks old and approached humans more readily than calves having received the same care but at a later period (from the sixth to ninth day and the eleventh to fourteenth day). The latter were more reticent when it came to human contact.

These results suggest that is it possible to significantly reduce the flight zone of cattle by combining agreeable handling with feeding by humans soon after the calf is born. These practices enable the human to approach the calf, reduce its fear, and to improve the likelihood of future docility (KROHN et al, 2001 and 2003, LENSINK et al, 2000). BOIVIN et al (1994) and LE NEINDRE et al (1996) observe that in brood races, the calves' living conditions during the first three months influence their response to human handling until 20 months old, at least. Calves reared in a traditional system with the mothers tied up (two monitored feeds a day) are more docile than those reared open range. In open range rearing, the mother's presence, which is very protective during young age, seems to focus all of the young animal's attention (KROHN et al, 2003) and is a negative influence with regard to the humans (HENRY et al., 2006).

Weaning is another sensitive period for human contact. The upheaval that weaning represents for the animal and the rupture of social ties with the mother can facilitate the human-animal relationship *if* the stock breeder is present. BOIVIN et al (1992) observe that open range calves belonging to brood races that are weaned at 8/9 months become tame quicker and remember this lesson better than at 6 weeks after separation from the mother. MATTHEWS et al (2004) confirm this result. It is a widespread practice among breeders to take extra care of calves during this period.

Finally, the **calving** period appears to be sensitive too. HEMSWORTH et al. (1987, 1989) would approach the animal with hands filled with food and covered in amniotic fluid. The dairy cows appeared less reactive during entry to the milking room than animals that had not received such contact during calving. Therefore, they concluded that there seemed to be some periods that were more favourable than others for the socialization of calves with humans and that supplying the calves with additional and agreeable care seems to improve the human-animal relationship.

However, the lasting effect of this contact in young age is the subject of a polemic within the scientific community (BOIVIN et al, 2003). It would seem to be necessary to reinforce the contacts afterwards, even frequently for the effects (positive reactions towards humans) to be preserved (BOIVIN et al 2000). Moreover, contact during calving may prove to be risky with brood cows (BOIVIN et al, 2003). Finally, too much familiarity with humans may be dangerous in fattening calves or future breeders. Having reached adult maturity, a bull or bull-calf that is very used to humans - and therefore, has no fear of them may present a greater risk of accidents than bulls that are less at ease with humans (RUSHEN et al, 1999).

Regular interactions and genetics

Outside of sensitive periods, the human-animal relationship is essentially built on **regular interactions between humans and livestock**. As such, a recent survey was performed with stock breeders and breeders from the Limousin region in France and it confirmed their awareness (BOIVIN et al., 2005). The breeders questioned listed human contact above the quality of restraining tools as a means for cultivating animals that are easy to handle; genetic improvements were last on the list. However, this classification clashes with the reality of advancements in farming. Breeders want to reduce the constrictive work involved in farming (BECHEREL et al, 2005). Therefore, it can be assumed that they spend, or would like to spend, less time with the animals. They have an increasing number of animals and yet less individual contact due to housing conditions (open housing or open range). In this context, the **genetic selection** of the animals seems to be almost the only solution. Numerous publications show the differences between races and a significant heritability of the animals' reactions to humans (BOISSY et al, 2005 for review). Hence, brood races have a lesser flight zone (MURPHEY et al, 1981) and their selection is partly based on this characteristic. Differences linked to species, *Bos taurus* versus *Bos indicus*, have been observed but the farming method and previous experience of the animal seem to be of more importance (BOUISSOU, 1980, ALBRIGHT and ARAVE, 1997). In Australia, research on the temperament and reaction of cattle is essentially focused on this genetic dimension (for review BURROW, 1997, PANDHERICK, 2005). For example, a criterion of behaviour that is simple to measure, such as the speed at which the animal leaves a cattle crush, is associated to zootechnical areas such as growth, the quality of meat or the health of the animals. Such a criterion shows sufficient heritability (e.g. h^2=0.4, BURROW, 2001) to select the animals on this basis, thus improving not only the behaviour of the animals but also the economic performance. Therefore, stock breeding professionals today are investing a great deal in the genetic selection of this criterion (ANDREW FISHER, personal communication). However, the interpretation of this criterion with regard to humans must still be explored (e.g. KILGOUR et al, 2006). Another criterion of the genetic selection of animals is the docility test (LE NEINDRE et al, 1995, GAULY et al, 2001, PHOCAS et al, accepted for publication). In this test, the animal is isolated in a fold. The human attempts to keep the animal in the opposite corner of the fold to its fellow animals. This test presents a sufficient heritability for the animal to be selected (r^2=0.2). Today, it serves as a routine measure to detect calves that are potentially aggressive towards humans (4% of the population on average) and to make an initial selection of Limousin bulls selected for breeding. The results of this test also showed positive genetic correlations with zootechnical characters such as fertility but no correlation was found with maternal behaviour, which is important in brood races. These different studies show that selecting animal behaviour may improve the human-animal relationship, which would save breeders' time.

IX. - Conclusion

It is notably through understanding how the animals perceive humans that that it is possible to improve the human-animal relationship. This knowledge could be directly integrated in the training programmes of breeders and handlers, in order to change their attitudes and behaviour towards the animal as well as their farming practices.

The quality and quantity of cattle' prior experience of humans determines these behavioural and physiological differences in their reactions towards them. (ROUSING et al, 2005, RYBARCZYK et al., 2001, WAIBLINGER et al., 2003).Numerous studies have shown that 'positive' tactile and non-tactile interactions (speaking slowly, stroking, letting the calves suck the fingers occasionally, etc.) contribute to reducing the cattle' tendency to flee humans. Similarly, it has been proven that the association of positive contact with food improved the animals' motivation to interact with humans thus improving handling (KROHN et al 2001, RAUSSI, 2003). However, apart from feeding, we know very little about the motivation of cows to interact with humans. Several aspects such as the human's posture, facial expressions, or vocal and olfactory information should be researched, as should the various sensibilities of the animal with regard to human contact (eg: sensitivity in certain parts of the body touched by humans WAIBLINGER, 2006). *A contrario*, negative interaction or lack of human contact engender acute fear of humans and impede development of a good human-animal relationship. The knowledge we have of the plethora of fear provoking interactions is limited and more detailed research should be performed in order to identify the complete range of interactions that affect animals (HEMSWORTH, 2003). In particular, better understanding of positive/ negative interaction ratio and the conditions that enable the animal to predict and control its interaction with the human should make it possible to reduce the animals' fear and dangerous reactions.

Finally, the existence of sensitive periods for the development of the human-animal relationship, as well revealing the genetic basis of the animals' reactions to humans are current and applied subjects of research.

However, one can but conclude this review by observing that the literature has not addressed all types of cattle and interaction in the same manner. In particular, researchers have scarcely studied the accident-proning behaviour of breeding bulls or brood cows when defending their calves. While one appreciates the methodological difficulties that such a study engenders, one must hope that it will be developed in the future. One can also underline that few studies have analysed human-animal communication. It is described in a more empiric than scientific manner and a wide field has yet to be explored if humans and cattle are to understand each other better.

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