Animal pain

Identifying, understanding and minimising pain in farm animals

Expertise scientifique collective (ESCo) INRA
INRA Expert scientific assessment (ESCo)

Summary of the expert report

October 2009

expertises collectives

ALIMENTATION
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The multidisciplinary scientific assessment report, on which this summary is based, was written by the scientific experts without prior condition of approval by either the commissioning body or INRA. It is available online at the INRA site. This summary has been approved by the authors of the report.

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Authors and editors of the multidisciplinary expertise

Foreword

In modern society there is a growing awareness that animals may suffer pain. Pain in animals is perceived in a wide variety of contexts ranging from animal testing and experimentation, through mistreatment of pets and performing animals, such as in the circus, to the husbandry and treatment of farm animals destined for human consumption. This awareness has given rise to a rather difficult dialogue between animal rights activists who are against any animal exploitation, those who advocate improved living conditions for animals and the economic stakeholders who highlight the financial constraints that face them in their sector of activity.

There is thus a strain between the growing demand in the world for animal products and the social acceptability of the treatment of farm animals under modern farming systems. Over the second half of the 20th century, the capacity to supply markets was based largely on a concept of livestock farming which did not place animal pain at the forefront of its concerns. It was within this context that in 2008, at the initiative of the President of the French Republic, the Rencontres Animal-Société Animal-Society forum was held with the aim of providing a statement of the issues raised in the various domains of the relationship between man and animals. These meetings, which brought together members of the trade, scientists, politicians, government authorities and associations, progressively highlighted the need to come to agreement on the primary cause for debate: defining what constitutes pain and suffering in animals and what knowledge is available to clarify this issue? Hence the action plan emanating from the talks requested a multidisciplinary scientific assessment (ESCo) into animal pain. This request was addressed to INRA by the Ministers in charge of Agriculture and Research.

Expertise at INRA in support of public policy

The mission of public research in providing expert reporting in support of public policy-making was reaffirmed by the law on research direction (2006). Providing scientific argument in support of political stance is now a necessity in international negotiations. However, the ever-increasing volume of scientific knowledge emanates from very diverse areas and is inaccessible in the raw state to policymakers. The ESCo activity developed at INRA since 2002 can be characterised as putting together and clarifying for public policy-making relevant findings produced in very diverse fields of knowledge.

A charter for the expert scientific assessment at INRA

The expert analyses were guided by a charter outlining the principles of practice to follow in order to ensure the robustness of the assessment produced. The charter set out four principles of conduct: competence, diversity, impartiality and transparency. The principle of competence was manifested by the INRA institute only undertaking to report on issues that fall within its field of expertise, the scientific legitimacy of which is assured by strong anchoring in long-term research. This principle of competence was equally applied to the experts who were deemed to be aptly qualified on the basis of their scientific publications and also by their adherence to process quality in conducting the assessment. Plurality was taken as a multidisciplinary approach to the issues raised and dealt with from the perspectives of both the life sciences and human and social sciences. The plurality was also reflected in the diversity of institutional origin of the experts, since INRA called on outside assistance to complement the range of expertise available internally. By ensuring plurality in research domains and disciplinary perspectives the intention was to stimulate debate and favour discussion on controversial issues thereby enhancing critical analysis. The principle of impartiality was safeguarded by the multiplicity of points of view presented and by requiring each expert to declare any links held with stakeholders or groups with vested interests. Finally, transparency is guaranteed by the publication of the summary and work documents which are freely available to all.

Definition and functioning of the ESCo

The task assigned to an ESCo is to establish an inventory of academic scientific knowledge from which components are extracted and assembled to address matters raised by the commissioning body. The directives given to INRA were outlined in the terms of reference, decided upon after back and forth consultation between the Ministries of Agriculture and Research as commissioners and the group of experts, who fixed the content and scope of the expert assessment. A monitoring committee, convened on the initiative of the commissioning body, provided an interface between the experts and oversaw smooth running of the inquiry. The experts were required to sign the report and are responsible for their contribution. INRA undertook responsibility for the conditions under which the expert inquiry proceeded: the quality of the literature research for updating bibliographic sources, transparency of discussions between experts, providing leadership for the work group and writing of ESCo reports in a form that reconciled scientific rigour with intelligibility to a wide audience.

Prior to this present assessment, five collective expert scientific assessments (ESCo) have been conducted on a wide and complex range of topics concerning food and the environment: "Storage of carbon in agricultural soils in France", "Pesticides, agriculture and the environment", "Drought and agriculture", "The consumption of fruit and vegetables" and "Agriculture and Biodiversity". The present study is the first in the field of animal production.

Animal Pain: A Central Issue for INRA

INRA has been actively developing research programs on animal welfare for several years now. In 1998 INRA created the network Agri Animal Welfare (AgriBea), which now draws together a hundred research scientists from various research organisations, and conducts transversal leadership and support activities in this domain of research. INRA has not only been heavily implicated in work on the effects of rearing conditions on the welfare of animals, but as a research institute it is also involved in animal experimentation. The breadth of research conducted in this area is considerable, ranging from fundamental aspects to the techno-economic dimension, without forgetting reflection on ethical issues.

The information brought together in this expert report is destined to provide elucidation for public decision making, and beyond that, to bring a broad frame of reference to the debate on which positions and decisions can be argued and research needs identified so as to better respond to the questions raised.

Introduction

The conclusions of the Animal-Society forum pointed out a profound renewal of man-animal relationships over recent decades, attributable to changes in lifestyles in our societies. Among the factors inducing change, urbanization has played an important role in stretching the traditional link with farm animals to replace it with pets, which now often serve as the frame of reference for animal status. Other factors include changes in modern rearing methods which have changed the status of animals. Finally, and more recently, are the questions raised by animal experimentation. Animals are perceived differently according to the purpose for which they are raised, whether they be pets, livestock, farm animals or laboratory animals, and for each category there are models and specific norms dictating the degree of protection they are to be afforded.

The request for an expert scientific assessment

The French Ministries of Agriculture and Research issued a request for an expert scientific group assessment (ESCo) of the perception of pain by animals, particularly at the time of slaughter. The first questions to be addressed concerned the definition of animal pain in comparison with related concepts such as animal suffering and discomfort, and the clarification of the modes of expression of pain. Are all animals likely to feel pain and in what manner according to their phylogenetic position? The second question concerned the measurement of pain. What tools exist to identify and measure pain, and are they readily available to the experts? The consequences of pain on behaviour and performance of the animal were also to be documented. The group of experts was also required to report a list of alternatives and possible solutions to limit pain. Finally, they were requested to put the ethical and socio-economic stakes connected with the issue of animal pain into perspective.

The scope of the expert assessment

The conceptual framework for this expert report was defined as a position of acceptance of the legitimacy of livestock farming and its end purposes. Hence the assessment excluded extreme positions, consisting of the categorical refusal of the use of domestic animals for the benefit of man on one hand, and the total denial of animal pain on the other.

The scope of the assessment was limited to the component "pain" which constitutes a specific scientific question, while still being inter-connected to other aspects of animal welfare. The causes and management of pain in farm animals were required to be examined within the context of current animal rearing systems. The notion of pain at the heart of current debates is often poorly defined. The objectives of the expert report requested from INRA were to bring this public controversy up to date on the state of knowledge about pain in animals.

The generic part of the ESCo inquiry on the mechanisms and expression of pain, based on knowledge acquired in humans and in laboratory animals, may find applications to animals in general. However, the expert report is focused on pain in farm animals, in connection with intensive rearing practices, but excluding animals reared for their fur. The choice to focus on pain in farm animals reveals a widening of a preoccupation that was long the exclusive concern of the agricultural circle. This issue relates to today's societal debates on the quality and affordability of food, the modes of food production and the ethical considerations on food consumption. This is especially the case when the food is derived from animals as living and sentient beings.

Animal pain, a multidisciplinary approach

Specific questions were raised about pain so as to be able to treat the topic in an objective manner and the phenomenon as an identifiable and measurable psychobiological element. However several difficulties were encountered. The first factor is that scientific knowledge about pain is as yet little-developed. The recognition and taking into account of pain in human medicine - and even more so in veterinary medicine - are only recent. The second is that animals do not speak and can neither signal nor describe their pain, which can therefore only be

assessed by humans as external observers. From this arises a third obstacle related to the public debate about animal pain, a debate that involves cultural, ethical and religious components which modulate or exacerbate perceptions.

The questions raised focus on all phases of animal life from birth to slaughter. They revolve around three main themes: Firstly, what definition should be given to animal pain? What does it encompass in comparison to related concepts, such as stress or suffering? Can we say that animals are more or less likely to feel pain according to their degree of phylogenetic evolution? How should pain be assessed? Using what criteria, with which tools and what reliability? Finally, how is pain treated on farms today and what are the limits to it being dealt with?

Treatment of the questions addressed to the ESCo

Prior to an examination of the neurophysiological dimension of pain, it became apparent that to situate correctly the current debate on pain, it should be examined in a historical perspective. The genesis of the debate was retraced and the various, ethical, legal, economic and cultural elements clarified so as to examine under what terms the question is framed today.

The concept of pain was examined by crossing the acquired knowledge about pain in human medicine and in veterinary medicine. This comparative approach enables a better definition and appreciation of the specificity of the phenomenon of pain in animals.

The ability to measure pain in animals using reliable criteria, and, if possible, by means which can be applied in the field, is clearly a central issue for the ESCo. This would allow not only the identification and characterisation of the phenomenon of pain, thus demonstrating its existence, but also the consideration of ways to treat it.

Two chapters of this report are more specifically devoted to pain in animals in livestock farming. The assessment focused on a non-exhaustive list of situations in rearing and slaughtering livestock that are likely to cause pain and, where possible, alternative handling procedures which would minimize or eliminate pain.

Methods and Scope of the ESCo

The experts conducted a critical analysis of some 1400 scientific articles from which they extracted and assembled data that were useful in casting light on the questions raised. The aim of this exercise was to expose not only the areas of consensus, but also the gaps, uncertainties and controversies in the field of knowledge. The stakes are high in this area of recent research, which involves a wide range of disciplines. The rapid changes are stimulated by the recognition of more and more neurological capacities in animals and by the pressure of public debate. In addition, the ESCo assessment provides keys to understanding the questions posed, both in terms of definitions, concepts and ideas and in recalling the biological mechanisms involved. The assessment outlines the conceptual framework that will allow structured analysis and facilitate the appropriation by the public players involved in the debate.

The skills put to work on this report originate from a wide range of disciplines in the domains of the human, social and economic sciences (history, anthropology, philosophy, ethics, law and economics) and the life sciences (neurophysiology, human clinical, veterinary medicine, genetics and ethology). The expert scientific assessment brought together around twenty experts from INRA and other research establishments (Assistance Publique - Hôpitaux de Paris, Collège de France, CNRS, veterinary schools) both in France and from abroad.

The ESCo report does not provide turnkey solutions to respond to practical questions on animal pain. It establishes the most complete diagnosis possible on the current state of knowledge about pain in farm animals and indicates options for action that are available to reduce it.

1. The Question of animal pain: the issues for debate

The occurrence, reduction and prevention of animal pain may seem at first to be the concern of experts in the natural sciences and veterinary medicine. However, the issue of animal pain concerns all and this has led to a debate in society at large. The resulting range of diverse and often antagonistic points of view also requires the inputs of social scientists. The objective of this chapter is to clarify the issues around this debate by firstly retracing the history of man's perception of pain and suffering in animals and secondly by outlining the stages in the development of this contemporary issue.

This debate encompasses many disciplines in the fields of human and social sciences because the question concerns not only animals it also concerns the relationship between animals and humans, whose actions may cause, relieve or aggravate pain and suffering in animals. More broadly speaking, it is apparent that the issue is linked to the philosophical idea of man's moral responsibility for animals.

For western societies and particularly French society, modern ideas on pain and suffering in animals developed alongside a growing sensitivity to physical suffering in humans and particularly ourselves, but in general in all sentient beings so that the right to freedom from pain was progressively extended to all sentient creatures.

Expert analysis of the published literature reviewed by our committee has led to the identification of three stages in the development of current views on pain and suffering in animals. The first is the relationship between man and animals in traditional societies and the gradual recognition in the 19th and 20th centuries that animals are sentient beings and suffer accordingly. The second period saw a heightened debate on man's moral responsibility to animals as a consequence of this recognition. The third covers the last thirty years during which there has been a marked acceleration in investigating animal pain and the implementation of changes that reduce pain in animals.

1.1. The role of animals in traditional societies

1.1.1. Men and animals, "Mixed Communities"

Since the Neolithic period animals have always been present in human communities with consequent social connections established between man and animals. Anthropologists have highlighted the great diversity in the nature of these connections. They ranged from the protection of herds against wild animals through to hunting and fishing and from companionship, through to assistance with labour and to raising livestock to provide clothing and food for humans. These relationships, which could be the source of either pain or well-being for either party, show that animals were treated as members of a "hybrid society", to borrow an expression commonly used by researchers, meaning the animals fully integrated into human communities. The function and the status of the animals in the hybrid community were immediately determined by the differences in their physical, behavioural and social characteristics.

Anthropological analysis describes the way ordinary people can use analogy to understand animals by perceiving animals as being more or less similar to man. In the popular imagination animals are credited with having feelings, intentions, thoughts, virtues and failings similar to ourselves. These anthropomorphic images are perpetuated in everyday language: the dog "wants" to go out, he "loves" his master, a bee is "industrious" and the wolf "cruel". Likewise, humans are, or can be, compared to animals. This zoomorphism can be added to anthropomorphism and this double play of analogies exposes not only the differences between men and animals but also among people and among animals. From the human perspective animals are living beings as we humans are so we can use the same terms in thinking about them as we use to think of ourselves. There are differences among animals, just as there are differences between humans and animals. This gives rise to a wide variation in the nature of interactions that develop between man and animal and the resulting communication is an exchange between one living being and another.

As far as farm animals are concerned, their relationship with humans encompasses domestication, which ethologists define as a state or process that enables populations of animals to live and reproduce in environments imposed by man. The development of different breeds with their particular morphological characteristics can only be explained by human intervention whereby animals are selected for useful characteristics. This selection covers

a wide range of breeding objectives ranging from the production of food or clothing for humans to other breeding objectives that are far more difficult to characterise objectively, for example; social relationships or conformity with socio-cultural perceptions that go beyond the requirements of farming.

Almost all domestication has been of social species, and therefore all the consequences of the social hierarchy and dominance within the group have had to be dealt with. In fact, domestication only became possible because man was able to benefit from the social nature of certain species. Domesticated animals not only relate to each other and with their environment. They can also maintain a relationship with the humans who rear them and care for them, a relationship that is based on an exchange of goods, services and affection. Without any vocal exchange a negotiation of some kind takes place between man and domestic animals. Through mutual learning an arrangement emerges whereby the attitude of one is adapted to the expectations of the other and to which some authors attribute the notion of a “contract”.

Treating animals as subsidiary members of the human community places them in an admittedly, hierarchical and unequal relationship, but one that has made it possible to characterize each species according to the role they fulfil. This long coexistence has produced norms that vary according to time and place but that have for each particular norm, enabled the description of what constitutes a good cow, a good bull, a good (cart-drawing) team or a good dog as well from the human side, a good breeder, a good cart driver and a good shepherd.

In traditional farming, animals were not treated like people. They were put to death either to provide food or because they were no longer useful. But for all that, even though they were sometimes ill-treated, they were not simply considered as objects. There was a widely-held interest in their health and welfare.

1.1.2. The animal in the classical philosophical tradition

A particularly relevant reference to the position of animals in society is the theory of Descartes who, by drawing analogies between the functioning of animals and robots, proposed the existence of an unbridgeable gap between man and the animals. According to Descartes, only man has an immortal soul. Animals are merely machines devoid of any feeling and thus can be considered as objects, open to manipulation and use. It should be noted that it was only after Descartes that his conception of animals as objects, largely hypothetical in his mind, achieved the status of a practical dogma.

The popularity of Descartes proposal, however, did not replace an enduring tradition that had roots in antiquity with Plutarch and Lucretius and that was continued by Montaigne, Rousseau and Adam Smith. This tradition leads us to the view that man has a duty of care towards living things, whether they are animals or even plants. The ability to feel and express mental states such as pain, suffering and pleasure is common to humans and animals. We must therefore treat animals as sentient beings and show them respect.

Equally, part of Christian thought considers that God entrusted man with the wise use of nature. As the guardian of nature man is accountable to God for what is done to the creatures that surround him.

Spurred on by scientific discoveries during the 18th century, particularly the progress in comparative anatomy that revealed the closeness of man and the animals, philosophical criticism overturned the precepts of Cartesian theory. Indeed, as Descartes himself had postulated, if animals can be considered as machines then the human body must also be a machine because it, too, is an animal body. At the same time the sharp distinction between the notions of instinct and reason was questioned and the fact that sentient feeling is common to both man and animals was pointed out.

It was also during this century in England, and a little later in France, that a new feeling arose and along with it demands for social control of emotional outbursts, in particular violent impulses. This feeling led middle class people from these countries to condemn cruelty to animals. From a political standpoint, this condemnation came from conservatives, concerned with moral order, as well as from liberals, who linked protection of animals with democratic empowerment.

1.2. The development of the modern view of animal pain

1.2.1. A history of animal pain as mirrored by human pain

Recognizing human pain and taking it into account

Until the turn of the 19th century a certain degree of indifference was shown toward human pain, especially by the medical community. In deeply Christian societies, pain, that of Christ the Redeemer, the Christian martyr and the condemned, was valued positively. In the widespread tradition of French clinical medicine it was considered more as a guide diagnosis of disease than as an evil to be averted. Concomitantly the philosophical theory of vitalism was expanding. According to this theory, pain was a force-of-life reaction, a step in the healing process that should not be hindered. In addition, pain had been long considered as an exemplary means of punishment, such as in school corporal punishment. It was also seen as promoting masculinity notably in the military.

The 19th century seemed to mark a turning point. The advances in the understanding of the physiology of pain, in parallel with that of the brain and the nervous system, supported an increasing use of painkillers and analgesics, particularly for anaesthesia in surgery. This led to the widespread use of ether as an anaesthetic and to the discovery of chloroform and aspirin. However, the systematic management of pain in humans was limited, especially for very young children. These developments also answered to the population's growing intolerance towards bodily suffering, in a social context valuing the human person and privacy. Consequently society's demand for ever-more effective treatments against pain was strengthened. The rise in concern for animal pain was therefore closely linked to the increasing sensitivity of humans to their own pain.

Marginal consideration of pain in relation to veterinary medicine

It took even longer for veterinary surgeons to take an interest in animal pain. Only in the second half of the 19th century did advances in medical physiology, paradoxically through vivisection, enable an improved comparative knowledge of the nervous system and therefore a deeper understanding of animal pain. However, the treatment of pain in animals remained very marginal until the mid 20th century and only really concerned horses, cattle and dogs.

This slowness to consider pain in veterinary medicine was also noticeable in the slow uptake of anaesthesia in veterinary medicine. Traditional restraints such as twitches, nose grips, tourniquets and the use of alcohol (the latter particularly for cattle) remained in use for a long time (well into the 20th Century). Rather than for preventing animal suffering caused by the procedure, their purpose was to allow better control of the animal and to improve the ease with which the veterinary team could operate.

Until the Second World War, pain was essentially defined as a physiological phenomenon. Veterinary treatment of pain was primarily justified by economic and practical reasons. Pain affected productivity and could cause agitation and aggression which posed a danger for those handling the animals.

The issue of animal slaughter

The ESCo assessment only deals with the manner in which animals reared for meat are slaughtered. Apart from the issue of pain, slaughter procedures also raise concerns about food safety. Despite suggestions emerging from the current debate, slaughter is not a new issue. Historians report that from the 18th century middle class society complained over the slaughter of animals and the display of animal carcasses in full view of the public. From then on slaughter progressively was confined to purpose built slaughterhouses located on the outskirts of towns, thus facilitating increased surveillance by the veterinary authorities and closer attention to public health.

The issue of pain in animals acquired a new dimension with the emergence of industrial production of meat and the building of the first factory slaughterhouses in Cincinnati and Chicago in the 1900s. These were built in the total absence of regulations on animal pain, meat hygiene and safety in animal handling. As a consequence a wealth of literature appeared in the United States of America at the beginning of 20th Century denouncing the industrialisation of abattoirs as detrimental to animals and to the quality of meat products.

The usual practice at this time was to slaughter animals intended for human consumption by slitting the throat without prior stunning. Only adult cattle and horses were stunned before their throats were cut, this being for the safety of the handlers and probably not out of compassion for the animals. Veterinary surgeons were the first to stress the need to relieve the suffering of animals at slaughter and the practice of stunning animals by captive bolt before bleeding increased between the two World Wars. In 1942, stunning was made compulsory in Paris and this was extended throughout France in the 1960s.

1.2.2. From the recognition of animal sensitivity to animal protection

From recognition of a moral duty towards animals to the idea of animal rights

Recognizing that animals are sentient leads humans to better define the relationships they have with them, taking into account that humans have a moral responsibility not to inflict pain on sentient beings including animals. According to Kantian ethics, animals do not have the faculty of reason and as a consequence cannot be part of the moral community. Only beings that can consider themselves as “ends in their own right” and recognize the same quality in their own kind can have an “intrinsic value”. It is this quality that gives them rights and imposes respect for their life, their physical and moral integrity and their freedom. Animals, being no more able to assert their rights than to carry out their moral duties, have only an “instrumental value”. Therefore, they cannot have rights, but since they are sentient beings we have a duty to ourselves, not to be cruel by making them suffer unnecessarily.

As opposed to Kantism, contemporary pathocentrist theories take animal sensitivity into account directly. This corresponds with a general trend towards considering pain unbearable that has been extended to all sentient beings. Explicitly or not, associations that campaign for the animal cause follow this train of thought. Rather than adhering to the anthropocentric idea that humans just have duties to animals, followers of the pathocentrist school of thought have gradually come to the conclusion that the animals themselves have rights or at least their own interests. Philosophical streams reflecting these various ideas will be described subsequently.

The law applied to animals: from concern for public order to animal welfare

A legal framework for the treatment of animals appeared in the 19th century with the introduction of the first laws and the proliferation of organisations for the protection of animals. This legislation on the treatment of animals arose more from a desire to improve public morals, triggered by a heightened awareness of human violence, than from a concern for animal welfare. The Grammont law (1850), which penalized the ill treatment of animals in public is especially revealing of the attention the governing elite paid to common violence and their fear of its social contagion. It was the publicizing of violence that was condemned in this case. Killing animals continued to be considered necessary and was accepted. What characterized awareness of animal suffering was, above all, its visibility and the apparent pleasure of its perpetrators. Hence the Society for the Protection of Animals (SPA) and other protection groups did not campaign against the use of animals for transport and for slaughter but as far as possible to regulate these activities. The Grammont law remained in force for over a century.

In the 1880s a new wave of animal protectionists with very different ideas emerged. This was typified by the emergence of the anti-vivisectionist movement equipped with a more animal-centred ideology that rejected suffering and the death of animals for human needs. Their view was and remains, that an animal is valued as a sentient being whose suffering can not be tolerated or justified. The idea of establishing animal rights on the same basis as human rights began to spread. This current of thought has been gaining ground within animal protection circles, since the mid-20th century and it has contributed to the development of a public perception that the well-being of animals prevails over other moral justifications and public health.

1.3 The current debate on animal pain

1.3.1. Major changes in the relationship between humans and animals

Since the Second World War the relationship between humans and animals has gone through major changes. These changes were triggered by a combination of factors linked to post-war projects of economic and social development. The first of two major factors was the Monnet plan of 1946 for the development of agriculture, a global project for ensuring security of food production in France based on a modern, high-performing agro-industry. In this context, new husbandry practices based on the predominant industrial model were developed to guarantee regular supply of meat, milk and eggs to a growing urban market. Historians and anthropologists identify the high level of urbanisation during this period as the second factor. A consequence of the disconnection between rural and urban life was that urban dwellers no longer understood the realities of rural life. The concomitant passion for domestic pets that arose can be interpreted as a form of compensation for this separation from a rural environment.

These developments combined with a new sensitivity are thought to be key elements in the movement that rejected the view that inflicting avoidable pain on animals was acceptable and condemned any such practice. It was in this context that about thirty years ago ethical and legal frameworks concerning the treatment of animals began to appear. This ESCo assessment focused especially on the causes of animal pain in the context of intensive livestock production systems because, based on reports of pain and suffering the animals can be subjected to, it is the animal welfare in these production systems that has been most criticised.

Intensive systems of animal production

Specialists in animal production have traced the first appearance of intensive systems of animal production that increased yield and labour productivity to the beginning of the twentieth century. These systems have been successful because, despite significant increases in consumption, European countries and especially France, have achieved self-sufficiency in food and have even become net exporters for certain animal products. Simultaneously, decreases in the price of animal products have resulted in a decreased proportion of the household budget spent on food. Between 1965 and 1980, a fairly constant 31% of the household food budget was spent on meat. This then decreased to around 26% by 2006. Over a forty year span, INSEE data has shown a decrease in beef consumption of nearly 30% whereas the consumption of other types of meat has remained constant. Husbandry practices have come under increasing criticism because of the constraints the living conditions impose on animals and on workers.

The recent history of animal production shows that since the 1960s, agricultural research has contributed to the development of animals suitable for these high output systems of production. In the laboratory, animal scientists have deconstructed the whole animal to describe the physiological and biochemical control mechanisms for metabolism, growth, production and reproduction. From rumen microbiology to endocrinology, including nutrition, reproductive physiology and embryology a range of disciplines has been mobilised to improve the fit between the physiological characteristics of the animals and the performance expected from animals genetically selected to suit the production objectives and husbandry requirements for intensive production.

In theory, if not in fact, farm animals have become “animal machines” characterised by their high levels of production as is evidenced by the trend to replace the term “husbandry” with the notion of “animal production”. The organisation of labour, in particular for feeding, housing, health, and reproduction, has been rationalised following processes similar to those used in the industrialisation of manufacturing.

The resulting livestock production systems indeed have been developed using the methods of organisation and standardisation of work practices of the manufacturing industries. These systems are very dependant upon the animal foodstuff industry, the pharmaceutical industry and agro-business; particularly the slaughterhouses. They are nowadays far less dependent on farms and on farmers and especially so in the highly integrated systems. Intensive production systems for pigs, poultry and calves (veal) represent the extremes of these systems. These industrialised systems of livestock production coexist with other extensive farming systems such as those qualified as traditional, organic or contemporary extensive farming.

It was in the context of social criticism of contemporary industrial livestock farming that the scientific community responded and developed the concept of “Animal Welfare”. This scientific community is better established in the north of Europe than in France. It encompasses not only ethologists, specialists on animal emotion and cognition, and neurobiologists but also philosophers, theologians and animal ethicists.

It was this scientific community that transformed the claims of animal protectionists into the science of “animal welfare”. These scientists not only had the expertise to assess the reactions of animals to husbandry constraints but they also contributed to the definition of production standards. They are at the origin of the recommendations for each farm species and type of production and are taken into account by French and European regulations. The research carried out for the benefit of the animal welfare cause has improved the living conditions of animals in intensive production systems. It has also helped to integrate parameters of robustness and welfare into some genetic selection programmes.

The question of slaughter

A full analysis of animal pain must also address the question of slaughter. The general and technical aspects of slaughter are dealt with in the following chapters but here we examine the cultural dimensions of slaughtering animals in observance of religious rites.

Ritual slaughter following the religious rules of Judaism and Islam requires the cutting of the throat of the animal without prior stunning. On the basis of the freedom of worship this is authorised in France by special dispensation. The religious laws of these two faiths require animals to be conscious at slaughter, therefore they oppose stunning before blood letting. European directive 93/119/CE renders stunning animals before throat cutting compulsory. However, an exemption is granted for ritual slaughter. Various animal welfare movements recommend the labelling of products specifying “slaughtered according to religious rites”. In practice the complexity of marketing chains will result inevitably in some meat produced by ritual slaughter being sold as meat produced by conventional slaughter. Clear labelling would inform consumers concerned about animal welfare and who wish to avoid consuming meat produced by religious slaughtering. The risk is however, that labelling would introduce some discrimination against these products for reasons other than animal welfare.

Animal pain and suffering and livestock workers - an under-explored link

The unique characteristics of working with animals as opposed to other types of agricultural work are being studied by experts in occupational psychology and ergonomics, in an emerging field of research. These studies highlight the suffering expressed by some workers in industrial farming operations. The organization of labour on these farms and the precedence given to economic rationalization have lead to deterioration in the relationship between handlers and the animals. The physical and psychological health risks facing these workers are related to the environment in which the livestock are reared (work accidents, injuries, exposure to dust and pathogens) and to the nature of the relationships they have with the animals. The status of the animals as a resource to be used, especially in the pig industry, has a negative impact on the status of workers themselves Some workers feel that they do not have sufficient recognition from the animals they care for, their peers or the consumers.

There have been many studies on the physical consequences of these health risks but as yet there has been little research on the consequences of the psychology of the human-animal relationship on the health status of the livestock handlers or of the animals.

The relationship between livestock handlers and animals is a significant aspect of animal welfare, but so far it has been treated not so much in terms of the intersubjectivity of the relationship as in terms of stress on the worker, which is in turn, has a negative influence on animals.

1.3.2. Deliberations on the definition of animal pain: philosophical and ethical considerations

A question increasingly discussed in the philosophical literature

In philosophical literature over the last fifteen years, increasing importance has been given to papers dealing with either pain or with animals. However, in few of these articles have the two been examined simultaneously and even more exceptional are papers dealing specifically with animal pain.

Other fields of philosophy are also involved in these discussions because, even though pain is not dealt with directly, it is integrated into philosophical reflections on the foundations of morality and law. The application of philosophy has rarely considered in any detail, the applied aspects of animal pain and when it does, it concerns itself mainly with livestock farming and experimentation on animals.

Despite the differences in approach in the literature it seems that some universal issues can be identified in the various streams of philosophical thought. They can be grouped under three principal headings: pain and suffering in relation to consciousness; the moral status of sensitivity to pain and the economic and cultural contexts in which pain is imposed on animals.

A reassessment of cognition in animals based on recent scientific advances

Recent developments in disciplines such as ethology, especially of primates, neurophysiology and cognitive sciences demonstrated continuities in cognitive abilities among animals and humans. Specialists in cognitive sciences have studied the ability of some species of animals to build up images of their environment and of events that take place within it that enables them to respond and if necessary, adjust their responses. In this regard some authors speak about “animal subjectivity”.

Advances in these scientific fields led to the acknowledgement that animals, particularly mammals, have cognitive abilities and a range of mental states that go far beyond those previously attributed to non-human sentient beings. This conceptual change has coincided with the increasing perception that animals reared in intensive farming systems are merely machines for production. Similarly, in bio-medical research, animals are exploited largely as laboratory tools. This contradiction between the concept of animals as beings deserving moral consideration and the manner in which they are used has stimulated the emergence of the field of animal ethics.

The concepts of pain, suffering and welfare and the overlap among them

The literature on animal ethics deals almost solely with suffering and rarely with pain. For example, in a review of 84 papers in this field only three dealt with pain.

Among those authors who deny the existence of animal consciousness there is controversy over the consequences of this distinction between pain and suffering. Some authors consider that animals cannot imagine pain and therefore cannot be in a state of suffering. Hence they are not relevant moral beings. On the contrary, other authors consider it is precisely this alleged inability that could make pain worse because the animals are unable to rationalise and justify outcomes as humans can. Some authors conclude that in the absence of knowledge of the way each species experiences painful situations, logically, the benefit of the doubt should be given in favour of animals.

There are also varying interpretations among those authors who consider as pertinent the notion of animal suffering, linked to the consciousness of pain. Some authors have developed the idea of gradualism (gradual evolutionary change) in animals, setting different ethical norms for categories of animals depending of their degree of evolution. The specific vital needs and mental abilities of animals are very diverse and need to be determined for each species. This way, broad categories of animals can be differentiated depending on their cognitive abilities and accorded specific rights in proportion to their vital needs and mental abilities.

Moral considerations may go beyond simple concerns for animal welfare. They can be broadened to include the idea that animals should have a life fitting their species and that includes the freedom to express their natural behaviours. This position is founded on the idea that from its own viewpoint, a living being has had a satisfactory

life if its capacity for certain actions and behaviours has been fulfilled, and that it is unfair to prevent them from this fulfilment. For instance, whatever their social, physical or mental handicaps all human beings have the right to choose the life they want to lead and to have the opportunity for self-development in line with their abilities. When extended to animals, this call for justice requires that humans take the necessary measures to ensure that all species are given the opportunity to develop according to their own aptitudes.

The concept of animal welfare, on which the regulations on rearing animals and on the conditions for slaughtering animals are based, is seen as an attempt to reconcile these different points of view. It substitutes an approach based on pain with a positive approach that takes into account the factors considered decisive to the respect of the animals perception of pain and suffering. The concept of animal welfare is founded on Five Freedoms: 1. Freedom from Hunger and Thirst, 2. Freedom from Discomfort, 3. Freedom from Pain, Injury or Disease, 4. Freedom to Express Normal Behaviour, 5. Freedom from Fear and Distress. The animal welfare approach places greater emphasis on the duties humans have towards animals than on specific animal rights, marking a transition from the requirement for avoiding harm to that of doing good.

The question of the boundaries between pain, suffering and consciousness will be treated in greater detail in Chapter 2.

The emergence of the issue on animal rights: animal ethics

Most authors, at least the philosophers, agree with the idea that animals are not moral subjects, in keeping with Kantian philosophy on this point. Nevertheless, in no manner does this undermine the current point of view that animals can be regarded as moral beings if feeling pain is taken as a valid ethical criterion for animal welfare. This implies not only, that humans have the duty of care for animals but goes further by granting animals rights or at least recognising that they have their own personal interests. However, these duties or rights need to be further defined. In the extension of moral consideration to animals there has been a tendency to copy moral theories established for organising human affairs and for enforcing norms on actions and decisions liable to have an impact on other humans. The moral interest for animals does not always allow for a cruel and degrading treatment to be distinguished from one that is humane. For this reason, an assessment of a welfare situation cannot be left entirely to the subjective analysis of humans because it will differ according to individual sensitivity and cultural diversity. It is in this context that animal ethics emerged and differentiated into two main streams, both of Anglo-Saxon origins. On one hand there is the utilitarian approach where the interests of all sentient creatures are brought together in an overall calculation and on the other hand the deontologist approach that supports non-negotiable rights for animals.

Sensitivity is clearly taken into account in the utilitarian approach according to which it is necessary to maximise the well-being and to minimise the suffering of all sentient beings. There is no reason for limiting this consideration to humans. All sentient creatures can therefore be included in an assessment of any action on the basis of the ratio between the costs to the individual under consideration (in terms of suffering or pain) and the benefits (in terms of wants or desires satisfied). The cost-benefit assessments done by some researchers are in fact, an application of this ethical principle. Other authors limit the relevance of such an evaluation by stressing that it is not egalitarian because the ones that suffer are not necessarily the ones that benefit from the suffering. It is worth noting that in absolute utilitarianism terms, it is possible to accept the sacrifice of individual interests for the common good. As a consequence protection is not granted to each individual, whether human or animal. Individuals can only be assured that their torments and satisfactions will be taken into account in an egalitarian manner in an overall assessment, the results of which may be disastrous or even fatal for them.

For this reason, some authors think that to protect both humans and animals it is necessary to grant them all moral rights. This is the deontological position, exemplified by the stance of the American philosopher, Tom Regan; the recognised authority on deontology. Even though in practice his line of reasoning encompasses actions similar to those of the utilitarian position, it differs significantly in theoretical foundations, putting him in opposition with Peter Singer, the figurehead of utilitarianism. According to deontologists, the rights granted should be more or less extensive depending on the complexity of the mental faculties of the animals and on their cognitive abilities. For the supporters of deontological ethics all creatures, or at least those above some level of complexity, are “subjects-of-a-life”. They have an “intrinsic value” and therefore treating them as having only an “instrumental value” or

inflicting the slightest harm on them should be prohibited, whether in farming industries or in scientific experiments. This stance of an absolute right to equality is translated beyond vegetarianism into veganism. This way of thinking about animals extends the rejection of death to the rejection of any exploitation. It excludes the consumption of honey, eggs and milk since farming these products involves putting to death bees, male chicks and calves and culled animals. Consequently even if the primary objective of these production systems is not to produce meat, the innocence is only apparent. In an even more radical position vegans practice a complete change of lifestyle and have added leather, wool, silk and any animal labour to the list of unacceptable items.

Box 1. Vegetarianism

The vegetarian movement originated with the views of the evangelical religious movements in England at the end of the 17th century which spread around the country during the following century. During the nineteenth century the development of vegetarianism in England and The United States was linked to evangelical groups. In France and in the rest of the European continent the spread of vegetarianism was more under the auspices of medical philanthropy. In common to both was the prescribing of social and moral norms for the well-being of animals that went far beyond a mere non-meat diet. However there was a difference between religious vegetarianism which related to the quest for spiritual purity and vegetarianism on the grounds of health and lifestyle where the emphasis was above all on bodily health and on the improvement of the social status of the poor and the working class. Vegetarianism is still more prevalent in Great Britain than in France. Ten percent of the British population is vegetarian as opposed to two percent of the French. There are also wide differences in practices and considerable diversity among followers and related institutions. While, as in the past, concern about animal pain is basic to the vegetarian movement it is not first and foremost on the agenda. It is rather the pursuit of an extensive reform of health and social status that is at the heart of the vegetarian ideology. It is also worth noting that since the end of the nineteenth century there has been a minority vegetarian tradition in some French anarchistic circles. Today this can be traced to French anti-specist vegans who bring an anarchistic dimension to the political discussion on the status of animals in society.

Other theoreticians put forward the idea that it is enough to have a “conative life”, that is, one with drives and mental states, to have interests and, therefore, rights. As animals have a conative life, they have a right to health, should not be excessively restricted in their movements. Inflicting suffering, mutilation or deformity on them must be avoided. On the other hand, for the authors of the Universal Declaration of Animal Rights (1978), animal rights stem first and foremost from the animals’ vulnerability.

These schools of thought do not clearly define the species concerned by these rights, probably due to insufficient knowledge regarding the mental and emotional universe of animals.

In a closely-linked viewpoint, some authors consider that humans have been able to communicate with the animals they have been associated with. Without reciprocal benefits, domestication would not be possible. Such an exchange of services, information and sensibilities brings with it obligations: wherein lies the significance of the expression “domestic contract”. It is as if the “life story” of domestic animals has been woven together from all sorts of different beliefs, repeated across generations into the mixed societal form now in existence. These relationships are reciprocal (the obligations are not one-way), but non-egalitarian (very non-egalitarian, since they include the possibility of putting animals to death). Such a contract results in the necessity of “taking care” of animals, which implies providing them with food, protecting them (against predators, parasites and disease) and taking charge of their reproduction, while at the same time ensuring them of a certain “well-being”. It also includes devising husbandry systems which assure every animal of a certain freedom of movement, the opportunity of exploring its environment, of expressing behaviour appropriate to its species and forming relationships with its own kind.

Beyond the potential divergences of these viewpoints, it is possible to find consensus on the reality of the moral issue of this question: that animal pain is thought to be have been aggravated by the intensification in husbandry practices and that there has been a rise in social concern regarding the condition of animals in our society. For the authors, animals have become a moral concern; therefore they should be protected by the norms ascribed to any human actions and decisions which may impact upon them.

The role of animal protection organizations

Movements of thought and action concerning animals were formed and developed later in France than in the Germanic or Anglo-Saxon world. The French Society for the Protection of Animals (SPA) was founded in 1845, followed soon after by the adoption of the Grammont Law which the newly-created SPA put into practice.

Since the nineteenth century, similar associations have multiplied, one feature remaining constant over their increasing diversity: their social composition. Their members are mainly from the middle and upper social classes, wealthy, educated and urbanized. This probably explains their belated interest in farm animals, with the exception of horses. The issue of farm animals was not brought into focus until 1961 with the creation of the *Oeuvre d'assistance aux bêtes d'abattoir, (OABA)* or the Society for the Protection of Farm Animals, at the same time as the first large post-war reorganization of slaughterhouses and meat production systems.

A panoramic view of the organisations shows a great diversity in their concept of the animal condition and the relationships they look for between humans and animals. Very broadly, it is however possible to differentiate, as is often the case in activist movements, two types of position, between which lie numerous real variants:

– moderates, reformists, who want mainly to provide animals with decent living conditions or at least to improve the conditions in which they are kept;

– radicals, who call themselves "abolitionists", abolition referring to any type of animal exploitation and therefore, as a safeguard, suppression of all relationships with them in order to return them to a supposedly happy natural state, free from human slavery.

While the objectives, operating methods and the spheres of influence of the many organizations vary greatly, they nonetheless share common ground in organizing their activities on three levels:

– activities which aim to improve the fate of animals in a very concrete way, by protecting them, taking them in, treating them etc;

– activities to raise public awareness, through traditional methods of activism (information campaigns, circulating pamphlets, petitions, demonstrations, etc.), or through education (some organizations are authorized to visit schools);

– finally, through pressure groups, most often by lobbying national or European public authorities and by professional and contact networks but sometimes also through violence against economic concerns (particularly pet shops, laboratories, and fur producers or sellers), indeed even – and this has happened in Great Britain and in the United States – against human targets, in line with the logic of terrorist movements.

1.3.3 Taking animal pain into account in the law

A comment of a lexical nature should be made as a preamble: it can be observed in fact that the legal vocabulary used for describing different states of pain is very diverse – "well-being" and "suffering", "fear", "anxiety" "ability to suffer and to remember", "behavioural needs". It is not possible from this diversity to conclude whether they translate an awareness of animal complexity and of a form of mental suffering or whether they simply reflect the usual uncertainties on this issue.

The way animal pain is taken into consideration by the law is not easily comparable with the way human pain is taken into account. In fact, whereas compensation and the fight against human pain are fundaments of central and time-honoured branches of law, such as criminal and civil liability law, it is only in recently-adopted laws in the health field that any explicit mention is made of the necessity of taking responsibility for pain in human beings. Recently, as the concept of health has widened to incorporate physical and psychological dimensions, an increased will to treat human pain specifically has been observed, including in the medical and hospital contexts. This new dimension in the law can be linked either with the lowering of the threshold of tolerance for suffering and the end of life, or the end of Christian glorification of suffering, or with the emergence of new ways to fight pain.

As for taking animal pain into account in law, it can be traced back to the first laws on animal protection - in France with the adoption of criminal laws to curb cruelty to animals, in Europe with the publication of directives setting minimum standards for activities involving animals.

In French law, the spread of a new attitude of caring for animals was embodied in the evolution of regulations for animal protection. Starting with the Grammont Law, it became more clearly established in 1959 with the decree making cruelty punishable in the private as well as the public domain. Animal protection laws/regulations then followed on rapidly, increasing the possible penalties, granting power to animal protection societies and widening the range of offences (maltreatment, acts of cruelty or serious abuse, voluntary or involuntary life-threatening attacks, etc). What is fundamentally implicit in these legal provisions is the recognition of the animal's capacity to feel. Another explanation could be animals' dependence and vulnerability vis-a-vis humans. When they are no longer labelled as dependent or vulnerable, animals become the subject for other solutions (nuisance animals, dangerous dogs etc.).

Based on the law of 10 July 1976, French law states that "any animal being a sentient being shall be placed by its owner in conditions compatible with the biological needs of its species" (article L.214-1 of the Rural Code). There is consensus on the importance of this law: animal feelings are placed at the heart of animal protection legislation. However there is still controversy regarding the implications of this wording. Does it mean recognition of the specificity of the animal amongst legal things (a category differentiating them from "people")? Does it demonstrate the existence of a third legal category in addition to the traditional dichotomy between people and things? Or could it demonstrate that animals are no longer legal property or things but legal subjects, limiting the owner's freedoms and providing animal protection societies with the ability to take action against certain breaches of the law?

This recognition of animals as sentient beings has not however, as the law stands, closed the remit and terminated the rights of ownership over animals. Contrary to what might be commonly imagined, the law does not seem to see a contradiction in the references to "being" and the application of the rules of "having". The law of 1976 makes reference to the owner of the animal. In this sense, it appears difficult, therefore, not to describe animals as property when they are able to be appropriated or are owned. The description of property remains unchanged in French law and can be traced back to Roman law. It justifies in principle the definition of the animal as a legal object, (as opposed to a legal subject) or a legal thing (as opposed to a legal person). It does not dispute the quality of "being able to feel"; legal objects (or things) are not limited to inert objects but include anything that does not qualify as a subject (or person).

In European law, the issue of animals' legal status has not been expressed in the same terms as in French law. The jurisdiction of the European Communities and then the European Union being limited, animals are defined according to those limitations. In the Treaty of Rome (1957) animals are defined as agricultural products, within the framework of the common market and free movement of goods and people (the fields of agriculture, transport, internal market and research falling under community jurisdiction). This definition remains unchanged, but it has not prevented the community legislator from adopting laws/regulations so as to ensure the minimum protection for animals on the farm, while being transported and during slaughter or when used for experimental purposes. The animals concerned are primarily those which are likely to enter and be transported within the domestic market, essentially farm livestock.

The protection of livestock in Europe

European and community laws (the Council of Europe and European Communities and then the European Union) play a key role in the evolution of rules related to animal protection. However, French law already had criminal rules of law in place protecting animals before the first European directive was adopted. Within their jurisdiction, the European Communities, which became the European Community and then the European Union, basically intervened to ensure a minimal harmonization by the different member states on the subject of animal protection in agricultural, trading or experimental contexts. What should be noted is that the European directives set out higher demands for animal protection regarding certain activities, which therefore lead to greater consideration of animal pain. On the other hand, they do not resolve the question of the legal status of the animal and do not prescribe criminal penalties against those responsible for animal suffering.

Hence, the European Community adopted a series of directives concerning animal protection: stunning animals before slaughter (1974, repealed in 1995), protection of laying hens on the farm (1986, replaced in 1999) veal calves and pigs on the farm (1991, modifications in 1997 and 2001), protection of animals during transport (1990, modified several times and replaced by a regulation in 2004). In 1998, a directive concerning animal protection on

farms set out a general framework for their protection. This fixed the rules on the housing of animals, on their care and husbandry methods (prevention of injuries and suffering, protection of animals reared outside) and is the basis for the whole range of community regulatory formalities applicable to all livestock.

This community legislation fixes the minimum general norms for farm animal protection according to the “five freedoms” stated above.

In 1997 a protocol on the protection and welfare of animals, annexed to the Treaty of Amsterdam was proposed. It asserts that when formulating and implementing community policy in the areas of agriculture, transport, the domestic market and research, the European Community and the member states will take the requirements of animal welfare fully into account, while at the same time respecting legislative or administrative provisions and the common practices of the member states. This concerns in particular, religious rites, cultural traditions and regional heritage. However in 2001 and 2008 the European Community’s Court of Justice refused to qualify “animal welfare” as a general principle of community law. Nevertheless, the reference to animal welfare appeared throughout the texts and documents of the community’s institutions.

The project for a Treaty establishing a Constitution for Europe (2004) gave animal protection a place by stating that “when they implement Union policy in the areas of agriculture, fisheries, transport, the domestic market, technological research and development, the Union and the member states will take animal welfare fully into account recognizing them as sentient beings, at the same time respecting the legislative or administrative provisions and the common practices of the member states. This concerns in particular, religious rites, cultural traditions and regional heritage”. This wording, which is very close to the one in the protocol annexed to the Treaty of Amsterdam, was not retained as the Constitution was rejected by referendum in some countries.

The issue of animal welfare has however been integrated into Common Agricultural Policy (CAP) reform via the conditionality of subsidies (which may be coupled or decoupled from the first pillar and certain subsidies from the second pillar of the CAP). Conditionality enforces compliance with certain measures (known as the minimum basis) in order to receive the full amount of the subsidies. Non-compliance with these measures means, after checks and certification, a reduction in subsidies. The sanctions vary according to whether the non-compliance is judged intentional or not, (from 1% to 20% if the non-compliance is intentional, even up to 100% in extreme cases). Besides environmental aspects, animal identification, public health and food safety, animal health, the respect for animal well-being (animal protection section) has been included in the minimum basis since 2007. No assessment of non-compliance rates within the criteria of animal protection is available for the time being.

Finally, the European Commission presented a community action plan in 2006 setting out the activities it intended to carry out in the area of animal protection and welfare. It consisted however, of a document on Union policy which has no legal value. The efforts made in view of having the criterion of animal welfare accepted by the World Trade Organization (WTO) have been unsuccessful.

Livestock protection in French law and regulations

Concerns about animal pain have been progressively incorporated into French law and the legal framework for animal protection has widened proportionally to the range of protection afforded. It now concerns animals used in research, pets, as well as livestock (methods of animal husbandry, housing, transport and slaughtering of animals). A large number of regulatory texts have been adopted since the seventies, some stemming from community directives or from commitments contracted by the ratification of conventions, in particular those of the Council of Europe. These regulations concern husbandry practices (with specific provisions for veal calves, pigs and laying hens), transport and slaughter. Since 1974, stunning all animals before slaughter is compulsory, with special dispensation for the religious and emergency slaughter of animals. Also training for those in the trade (those who transport animals in particular) and veterinary drug administration are regulated. At the European and French levels, committees are charged with implementing regulations concerning animal welfare.

The body of community or national laws and regulations is underpinned by advancements in scientific knowledge regarding animal behaviour and their sensitivity to pain. In particular, this is the case for livestock, the laws/regulations relying most often on regularly updated expert assessment. Changes in legislation are also the result of power struggles between movements and groups in society, as witnessed by, for example, the recognition of the

right of animal protection societies to file a civil suit for certain offences committed against animals (Code of French Criminal Procedure, article 2-13).

The French Rural Code now has a chapter devoted to animal protection (in which article L214-1 appears, from the 1976 law already mentioned) among different chapters dealing with the keeping of animals, their transport or the fight against animal diseases. Animal protection as an objective thus appears clearly at the heart of the law on animal production.

In France, the status of animals falls mainly within the provisions of civil law, criminal law, rural law and criminal procedure law. This segmentation of legal interpretations, linked to the number of different ways of using animals, to the diversity of the animal species concerned and to the different aims at stake, does not facilitate understanding of animal status by the parties involved in a lawsuit. In the same way, the diverse occurrences of the word “pain” and its metamorphoses (suffering, maltreatment, etc.) make understanding animal pain in animal protection law more complicated, in particular regarding livestock.

1.3.4 Taking account of animal pain in the economic context

In the literature pertaining to animal welfare there is also the question of determining the actual nature of consideration for animal pain. Is it a public good which must be respected in the general interest? Is it a farming externality (that is, the consequences of taking animal pain into account by the farmer have an influence on other members of society but the farmer receives no remuneration in exchange) that has to be internalized by the public authorities? Is it a private good or a psychological externality which is only contingent on the working of the market? Depending on the authors, opinions diverge and the question remains open.

In the case of animal welfare, the regulatory route has been given priority by the European Union with the adoption of the “welfare” directives already mentioned, considering welfare, therefore, as a public good. Amongst the member states, some have only taken this route (such as Norway or Finland); in other countries like France, taking animal welfare into account on farms has given rise to some attempts to show its value in the market (voluntary quality assurance measures).

How society perceives animal pain

Social demand for reducing animal pain is difficult to quantify and must be distinguished from other expectations such as respect for the environment, the economic viability of farms and industry networks, health safety standards, the organoleptic quality of the products, by players with different motivations (farmers and retailers, animal protection organizations, citizens and consumers...).

The studies available today on the economic factors involved in taking pain in animals into account are mainly Anglo-Saxon. They show that the public’s perception of animal pain compared to the human experience of pain remains uncertain and that those working with animals agree that animals do feel pain. A significant number amongst them are of the view however that animals do not feel pain as strongly as humans. On the other hand, there are no studies on producers’ willingness to change to more animal-friendly practices according to the costs involved in such changes.

A Belgian study confirms differences in perception between producers and other citizens. While all of them associate animal welfare with physical health, provision of food and water, warmth and protection, citizens who are not producers add to that list freedom of movement, which they consider unsatisfactory nowadays on farms. For the producers, although the economic interest of their farms and the positive impact that improvements in animal welfare could have on the image of their trade predominates, they are also showing rising concern over animal pain.

Consumer expectation

Consumers' specific request for taking pain in farm animals into consideration must be allowed to be expressed through the market. The work available on this subject concerns animal welfare rather than animal pain. Numerous surveys on the welfare of livestock reveal strong interest on the part of consumers for animal welfare with, in certain cases, positive and significant willingness to pay for produce resulting from more animal-friendly farming methods. These studies must however be interpreted carefully as it has been shown elsewhere that there is sometimes a wide discrepancy between declaration of intent and purchasing behaviour. Besides the issue of the methodological validity of the existing surveys (and particularly the definition of animal welfare given to those participating in the survey), this gap may signify either a lack of information on the part of the consumer (which suggests a policy of adapted information and/or labelling) or a dichotomy between the citizen who wants to see him or herself as a person of certain values and the consumer who often seeks out less-expensive products, whatever the production methods. Consumers are aware of a contradiction between the idea of wanting a pleasant life for the animal and prospect of slaughtering it for consumption.

Generally, it can be observed that consumers associate animal welfare with quality in the wider sense (health safety qualities, organoleptic qualities...) of these animal products. Consumer acceptance of new production methods needs to be studied beforehand therefore, when taking animal pain into consideration. In fact, certain solutions for managing animal pain such as using biotechnology for vaccines, or the use of pharmacological products, with the risks they carry of leaving residues in the animal products, can to a large extent counteract the consumers' expectations. The few studies which exist on this question will be dealt with in Chapter 5.

Possible tools for demonstrating the market value of taking of animal pain into account

If sensitivity to animal pain only concerns consumers, taking it into account is the role of the private sector. The demand for animal welfare protection and taking animal pain explicitly into account, open opportunities to niche markets and/or for market segmentation, to satisfy interested customers. The consumer still needs to be clearly informed about the proposed product and its attributes, with, for example, suitable labelling, initiated by private parties with the help of specifications, and/or supported by the public authorities. This would have the aim of protecting consumers from the risk of fraud by guaranteeing the authenticity of the qualities claimed.

Such actions would allow interested consumers to validate animal products in the market from farms with animal-friendly practices that meet their expectations. Specific voluntary procedures for taking charge of animal pain can be implemented, or else quality assurance measures which exist already could be extended. Such quality assurance measures exist and some of them already include aspects relating to animal welfare. These aspects can be central or more often complementary to others (health safety, taste...).

It would be advisable not to add these initiatives to the multiplicity of existing measures. A rationalization of those measures and a clear indication of the methods for taking animal pain into account in livestock, and by extension the levels of animal welfare in farms, would have the advantage of providing information efficiently to consumers. The relevant criteria for such labelling still remain to be defined. The role of the World Organization for Animal Health (OIE), a competent organization on this issue, could be important on this point.

In parallel, large supermarket chains today appear to be a key factor for a market solution. They have already taken up some consumer concerns in order to demonstrate the value of the voluntary measures carried out in the food sector. These primarily target food safety. Other concerns such as working conditions, the environment or animal welfare remain secondary, as their value is less able to be recovered in the market, even if this hierarchy in concerns varies from country to country. From their market power and their extensive supply chain, often crossing national boundaries, large supermarket chains could play an important role in encouraging farmers to change, by assuring them of remuneration for these new improvements in their farming practices. Thus, in the United Kingdom where a tightening of regulations had forced veal calf production to relocate, the large supermarket chains took the initiative of organizing a joint effort between producers, public authorities, veterinary surgeons and animal protection activists to elaborate improved veal welfare standards, thus stimulating veal consumption by British consumers. Moreover, some multinational catering companies have forced their suppliers to adhere to strict quality standards on the subject of animal welfare, without stating the motivation (ethical, marketing...). These measures show that a precise demand expressed by consumers or citizens can, through the market and the power of large multinational companies, cause animal pain to be taken into account on a large scale.

The regulatory route

If animal pain is considered a public good, recognized by all, consumers and citizens alike, it falls to the State to have this dimension recognized by adopting the appropriate regulations. Tools such as conditionality, which, since 2003, links payment of subsidies to farmers who fulfil environmental requirements or to matters of animal welfare, can then be used and adapted. The new regulations requiring farmers to take responsibility for and deal with animal pain would then be integrated into the minimum basis for the payment of subsidies.

Solutions for reducing animal pain on farms could, depending on the solutions chosen, cause over-expenditure. Such over-expenditure due to changes in farming practices puts the industry in a difficult position, running the risk of having to relocate production without any benefit to animal welfare. As a case in point, there is the example of the adoption of regulatory measures on the welfare of veal calves in the United Kingdom at the beginning of the 1990s. This regulation paradoxically resulted in a decline in animal welfare, since many producers relocated their production out of the United Kingdom. As this involved the transport of live animals there was an implied deterioration in their well-being.

The OIE is therefore advocating that accompanying measures be taken in addition to taking animal pain into account on farms (such as relevant labelling or relevant information for consumers) so as to guarantee a fair return to producers on their products on the national or international market and to preserve the economic viability of the industry and its competitiveness on international markets.

Voluntary measures taken by the farmers and remunerated by the public authorities can also be developed. Contracts negotiated with the public authorities (in the framework of the second pillar of the CAP: with measures concerning agricultural competitiveness – axe 1 and/or Agri-Environmental Measures – AEM), for example, include taking pain in farm animals into account. The creation of specific AEMs or adding to those available today in France on aspects of taking charge of animal pain could be considered.

Putting such measures into place would therefore allow some farmers, following the example of consumers, to modify their husbandry practices voluntarily and express their preferences.

A major obstacle: the World Trade Organisation's (WTO's) position on production methods and the absence of international standards on animal pain

The WTO's rules aim to avoid protectionist behaviour in countries, and leave little place for ethical or social demands concerning animal husbandry methods. They state that if the products are qualitatively identical, their import cannot be rejected on the grounds of production methods. In this context, better farming practices for the benefit of animal welfare are not considered to produce animal products any different from those obtained by classical industrial methods. These arguments are also valid for the question of taking animal pain into consideration at the farm level.

Only bilateral or multilateral agreements remain acceptable, but require time and sometimes difficult negotiations. On the other hand, the adoption of international standards regarding pain in farm animals, according to the species concerned, would make a recognized international framework available. This framework would be of great use for the rationalization of voluntary measures and would become the tool of reference for the development of a rational labelling strategy, as envisaged by the European Union. There is no recognized international standard today concerning animal pain. The OIE, a competent international institution on this matter, has recently published a report on the question of pain in animals as it has previously done on animal welfare, but no official position has been defined.

Concerning animal welfare, it should be kept in mind that, six different norms have been adopted by the OIE. Five of them concern transport, (by land, air or maritime routes) or animal slaughter (for consumption or for health safety ends). The sixth concerns stray dogs.

From this analysis, it appears that there is some difficulty in taking the expectations of consumers or citizens into account on the subject of animal welfare and by extension on animal pain, at the single country level.

1.4. Summary

The analysis of knowledge produced in the different disciplinary fields gathered together in this chapter shows a convergence of representations, knowledge and the law on recognition of animal pain which can no longer be assessed only by economic or health safety criteria. The question of animal pain has now been raised in society, by consumers and citizens. The current reference has extended to animal welfare incorporating pain in a wider framework, on the model of the definition of human health, adopted by the WHO, which now includes psychological and social components.

The current state of play on the issue is a result of multiple changes in society:

- The manner of taking human pain and by extension pain in animals into account has strongly evolved. Whereas pain was in the past considered as inevitable, solutions exist now to reduce, if not to eliminate it.

-The public has distanced itself from farm animals and farming realities. The relationship of urban populations to farm animals has become rare and the only animals with which they are in contact are pet animals, whose status is different.

- Production systems designed in the different livestock sectors of the industry in order to answer production requirements now raise multiple questions.

- The stakeholders involved in the debate have steadily increased. Whereas before, only the farmer had to take decisions, nowadays all the players in the industry, from farmers to consumers, not forgetting the retailers and also the other players, such as animal protection organizations, are all concerned in the debate.

2. Pain: definitions, concepts and mechanisms in humans and farm animals

Although human pain involves unique features when compared to animal pain, as assessed by humans, it is obvious that the underlying neurobiological mechanisms fall along the lines of an evolutionary continuity. This chapter reviews the generic knowledge on pain that has been established by work done in humans and laboratory species. The degree to which this knowledge on pain can be transposed from man to farm animals (including mammals, gallinaceous and web-footed poultry, fish and cephalopods) is examined based on arguments ranging from phylogenetic analysis to the work on emotion in animals and to current debates on the concept of conscience in relation to pain perception. The precautions that need to be taken and the questions raised by such transpositions are discussed.

2.1. A growing scientific interest

Over the last thirty years there has been a constant growth in the total number of scientific publications on pain. Although this output has concerned animal species as well as humans, it was only at the end of the 1970s on a global plan and at the end of the 1990s on the European level that research on pain in animals increased in earnest (Figure 1A).

There has been a steady ratio of 50:1 in the number of publications on pain reporting studies in human clinical medicine or on generic knowledge of the mechanisms of pain, especially the study of chronic pain, as opposed to pain in animals. The proportion is basically the same for Europe as worldwide (Figure 1A). This data supports the hypothesis of a fundamental and increasing interest in human suffering and a collective will to gain control over pain. Following the “publication share” index (Figure 1B) for publications specialized on pain as a percentage of all publications in the biomedical domain confirms the increase in the production of data on human pain. This interest may have played a driving role in studies on animal pain but this is not evidenced by the “publication share” for the field of animal pain which has shown a slight decrease rather than sustained growth.

The work reported in the literature is thus generally carried out with a view to relieving human suffering. In practice the studies are often conducted on animal models, mostly rodents or more rarely on primates. They are also conducted according to specifically controlled protocols arising directly from human clinical medicine.

Improved knowledge of the mechanisms and the control of pain is derived from various disciplines. The general approach is to combine the use of new investigative tools (brain imaging and genomics) with studies in the areas of behaviour, cognitive neuroscience, neurophysiology, neurobiochemistry and neuropharmacology. Currently new specialities are appearing and proliferating in the field of research on pain, particularly in human clinical medicine. Over the last ten years research aimed at elucidating the mechanisms of pain has been centred round either the elementary genetic characteristics of noxious stimuli receptors (nociceptors) or the assessment of perceptive capacities and the associated levels of consciousness.

2.2. Gradual widening of the scope of studies on pain in humans

Pain is an aversive experience that comprises sensory, cognitive and emotional components. It serves as an alert warning of the presence of a threat to the physical integrity of the subject and triggers biological or behavioural mechanisms for defence or adaptation/coping (avoidance, escape). It should be noted that the lack of an ability to feel pain, a rather rare human clinical condition, is accompanied by serious pathologies. Increasing knowledge has led to a gradual widening of the whole concept of pain, both in its definition and in the range of human beings considered likely to feel it.

Figure 1. Bibliographic analysis of publications on the topic of pain

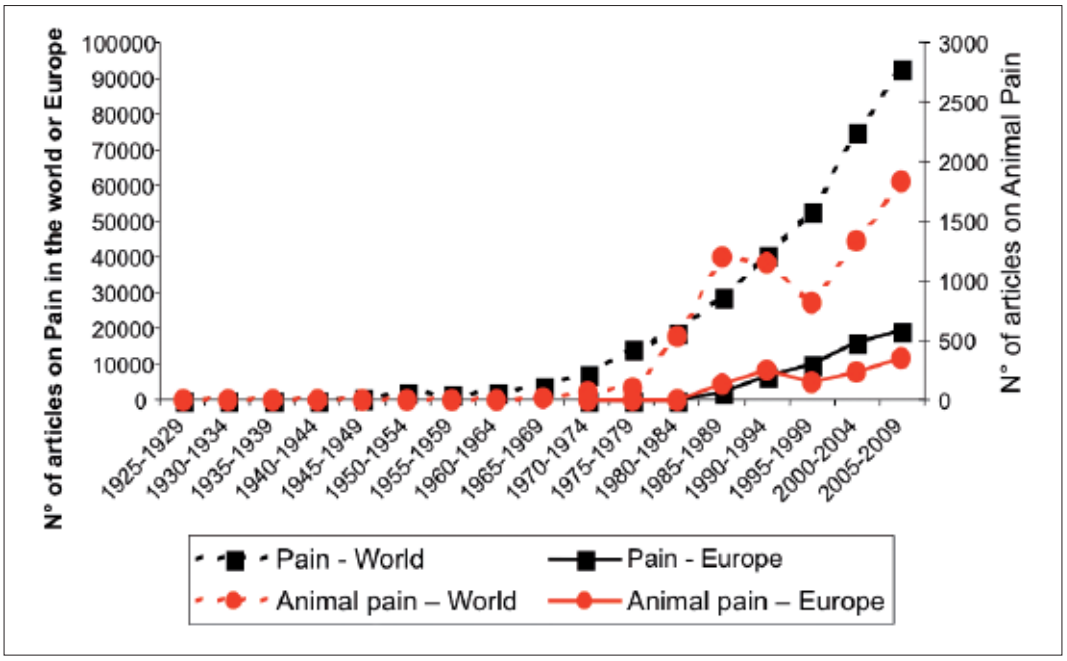


Figure 1A. Number of publications on pain per 5-year period in all species including man or specifically in non-human animals without distinction of species, worldwide and at the European level:

A Medline search of articles published between 1950 and 2009 was conducted. The terms covered by the search were: pain, nociception or nociceptors, pain, alertness or awareness. The specific search on "animals" included the following English words: animals, domestic or animals, laboratory or animals, newborn or animals, poisonous or animals, suckling or animals, wild or animals, zoo or cattle or swine or fishes or sheep or ruminants or birds or poultry or swine The main disciplines included in the studies on pain are the same in France, Europe and worldwide: Neurosciences & Neurology, Biochemistry & Molecular Biology, Pharmacology & Pharmacy, Behavioural Sciences, Psychology.

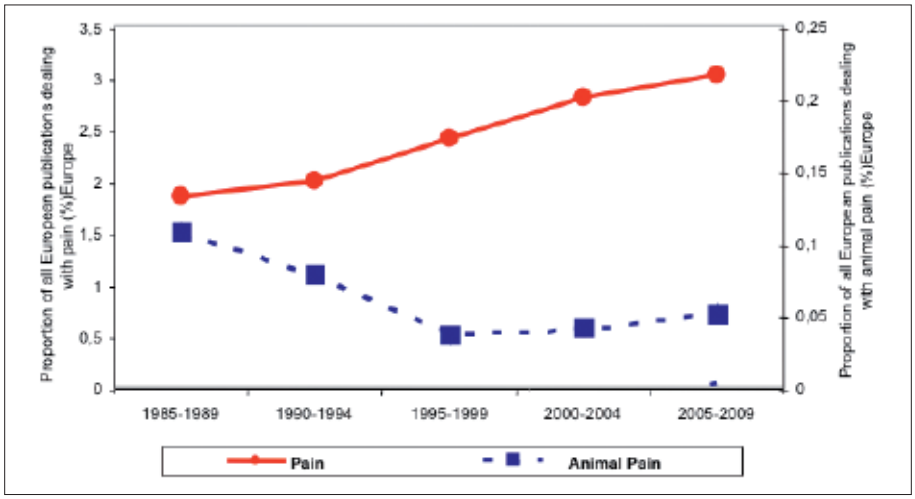


Figure 1B. Percentage of all European biomedical publications dealing with pain in general or specifically animal pain over the period 1985-2009

Red circles: % of publications in the biomedical field on pain. Blue squares: % of publications specific to animal pain.

* Defined by OST (Observatoire des Sciences et Techniques : www.obs-ost.fr), the percentage is the ratio between the number of publications from a specific actor (research institute, country, field of research…) and the number of publications in a specific database (e.g. country of the research institute, the world, or the biomedical field), multiplied by 100.

Source: MEDLINE data base in the biomedical field.

2.2.1. Broadening the concept of pain

For years, clinicians and researchers considered pain as a sensation that either indicates trauma or tissue injury, or appears during the development of a pathological condition. This rough definition did not take into account the succession of emotions inherent in any long-lasting pain. Nor did it cover the chronic situations where, despite the absence of an obvious biological cause, the resulting pain can be just as debilitating as pain for which the bodily origin has been identified. Additionally, there is a great variability from one individual to another in the perception of pain.

A first distinction was made between acute and chronic pain. Acute pain is transitory and results from the activation of the system transmitting the noxious message. This acute feeling is an alarm signal that allows a wound or injury to be diagnosed. When this pain is prolonged and not treated quickly, it loses its biological function as a warning and becomes detrimental, giving rise to chronic pain. It affects the personal life and relationships of the individual, causing disturbances in appetite and loss of sleep. It invades the emotional world to become the dominant concern, interfering with daily life and leading to social, professional and family repercussions.

Furthermore, there are pains that cannot be readily associated with trauma or obvious injuries (projected pain that in humans is felt not at its source but in a cutaneous area, phantom pains that occur after amputations). In human clinical medicine, a nomenclature has been defined to describe the different types of pain that are not related to trauma or injuries, but to dysfunction of the nervous system.

It has been established that a person's environment is a crucial factor in determining the person's perception of pain. The social and cultural context modulates the way pain is felt. Thus, some ethnic and religious rituals (mutilations, for example) do not seem to have painful connotations and seldom lead to the externalisation of pain. The threshold of pain itself is modulated by cultural factors. It has been shown that the perception of pain by an individual varies according to the level of attention to or distraction from the pain, whether or not the pain is curable, whether it is acute or chronic, reference to a similar prior experience, to the impact of the pain on lifestyle, and to the medical or the emotional environment.

All pain has an impact on affectivity. It has more or less effect according to the previous state of the individual, the intensity and duration of the pain, and can vary from transient anxiety to depression. Thus, pain can not just be taken as a simple, unequivocal reaction since its purpose is to allow the various facets of physical integrity to be maintained. Pain occupies a special place in the diversity of sensations experienced by living beings and must be understood as a feeling associated with an emotional dimension for mobilising attention.

The consideration of these facts, added to the demand from society for better pain management for patients, has resulted in the adoption of three successive pain management plans in France. This initiative, launched in 1998, will be completed in 2010 with a series of measures aimed at better pain management for hospitalised populations and among the most vulnerable patients, including children and adolescents, persons with multiple disabilities, the elderly and terminally ill. At the completion of this initiative, the medical treatment of pain, particularly chronic pain management, will have been restructured to improve the effectiveness of the whole system of patient care.

2.2.2. A recent extension to all human beings

Consideration of pain in the newborn child and disabled people who are unable to express themselves verbally and, even more recently, the interest shown in pain in the foetus reflect a broadening of the range of humans recognized as being able to feel pain. The first articles published on pain in the newborn or foetus date from 1987, and those for disabled children in 1996 and 2002. It should be borne in mind that the IASP (International Association for the Study of Pain) has pointed out that an inability to communicate verbally does not mean that a person does not feel pain and does not need treatment for pain relief.

The disabled

A number of recent studies using validated measurements, show that people with intellectual disabilities exhibit specific reactions in response to pain arising from their condition, even if they have more difficulty locating it or if they respond to it more slowly due to modified sensory perceptions, impaired language or communicative

expressions, or variability in basal levels. These specificities explain the difficulties of using conventional clinical examination. Interpretation is hampered by problems with verbal communication and pre-existing neurological disorders. It has been shown that cross evaluations by those close to the patient and unfamiliar observers provide a good indication of the patient's state of pain and discomfort provided a validated tool is used.

Pain in children

For children aged 0-5 years, the presence of pain that can be presumed to be enduring should be sought based on the differentiation between the various manners in which the child beckons. The diagnosis can only be made by gathering the accounts given by all those involved with the child (nurse, paediatric nurse, physiotherapist, psychologist, occupational therapist, nursing auxiliary, doctor ...) and trying to identify patterns that express discontent, desire for affection, "physical pain" and psychological distress. The child should then be examined using identified means of communication, in peaceful and caring surroundings and in a serious, rigorous, calm and progressive manner.

Pain in the human foetus

The case of foetal animals, mammalian foetuses in particular, does not fall specifically within the framework of the present study. However, the use of certain foetal tissues from animals prompted the examination of the sampling procedures used and the potential negative effects they could give rise to. In line with the approach adopted where data on human pain are presented so as to clarify the understanding of the mechanisms at work in animal species, here reference is only made to cases involving human foetuses where the question of pain was examined.

Available data have shown that in the human foetus, pain pathways as well as cortical and sub-cortical centres involved in the perception of pain are fully developed in the last third of pregnancy. The neurochemical systems currently known to be associated with the transmission and modulation of pain are functional. However there is no data to determine whether activating these structures involved in pain actually results in a newborn infant feeling pain in a similar manner to a child or an adult. While it has been demonstrated that the foetus develops a hormonal stress response to invasive procedures (an increase in stress hormones circulating in the bloodstream), it is not possible to conclude that the foetus feels pain.

2.2.3. The current definition of pain for humans

The definition of pain has evolved over the last three decades. Pain experienced and described by patients despite the absence of an identifiable pathophysiological cause is now also listed in the classifications. The normalised protocols for the treatment of pain have been expanded in parallel, accompanied by the appearance of patient charters and awareness slogans ("stopping the pain is a patient's right"). Instead of just trying to sedate pain the concern now is to anticipate the likely experience of pain in conjunction with therapeutic interventions

The definition used here is the one which has been adopted worldwide by the IASP: "pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".

This definition refers to pain without stimulus of external origin, which shows the existence of pain of central origin, in other words being literally fabricated by the brain.

2.3. Pain: mechanisms and structures involved

2.3.1. The elements of pain

Nociception

The term nociception (from the Latin nocere, to harm) was introduced in the early 20th century to characterize the ability to specifically detect nociceptive stimuli which have in common the ability to threaten the integrity of tissues or of the body and to activate a set of sensory organs, the nociceptors. Nociception is considered as an alarm system that protects the body by triggering behavioural and reflex responses (somatic and vegetative responses) whose purpose is to suppress the cause and to limit the negative consequences. It contributes to the dynamic maintenance of general physiological equilibrium (homeostasis).

Nociceptors are made of thin unmyelinated nerve fibres which are undifferentiated at their end. They are found in varying densities depending on the innervated tissues. Some tissues, which are part of solid organs such as the brain or the liver, lack nociceptors. Nociceptors are preferentially sensitive to noxious stimuli and many of them, named polymodal nociceptors, respond indiscriminately to several types of stimuli whether they are mechanical, thermal, or chemical (Figure 2). Nociceptors send information directly to the spinal cord (for the body) or to cranial nerve nuclei (for the head) via bundles of sensory nerves. At the level of the medulla network, the organization of the afferents makes it possible to localize the source of information on the basis of a spatially ordered neural architecture. This organization constitutes the basis of body representation and the substrate for spatial location of noxious stimuli borne by the body or coming from the viscera (analytical component of sensation).

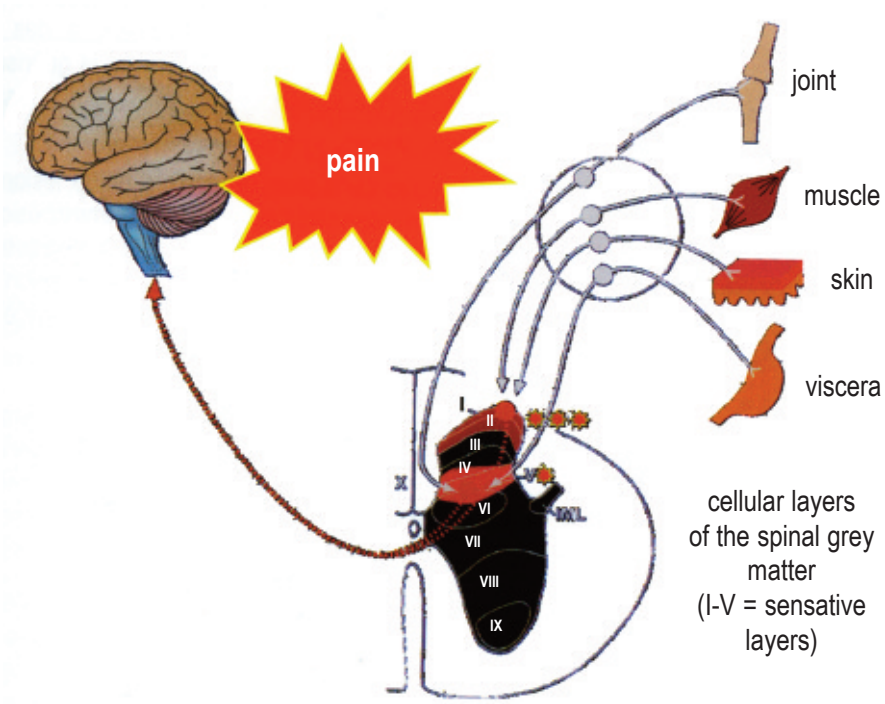


Figure 2. The peripheral sensitive afferents of nociception in humans
(J.Servière, personal communication)

Nociceptors are located in peripheral tissues (joint, muscle, skin, viscera) and their nerve fibres conduct the information to the spinal cord via sensory nerves (through the dorsal horn of the grey matter). The cell bodies of the sensory neurons are located on both sides of the spinal cord in the dorsal root ganglia. The synaptic junction is anatomically located in different cell layers of the dorsal horns depending on the tissue of origin. Superficial layers (I & II) receive signals from the skin whereas signals from visceral organs reach a deeper layer of cells (V).

From peripheral mechanisms to brain integration

Pain is more than just a discriminative sensory experience enabling the determination of the characteristics (intensity, duration and location on the body) of a noxious stimulus. It is associated with an emotion that is caused by the confrontation with a situation involving the interpretation of reality. The aversive emotional state associated with the sensation of pain is a powerful motivation to perform an act of protection. This emotion whether "unpleasant" (illustrating the sensory component) or "aversive" (illustrating the behavioural component) is an intrinsic part of painful experience. Emotion is indissociable from pain experience which makes pain a more complex sensation than touch, vision, or hearing. Because of its profound aversive nature, pain has strong abilities to capture the subject's attention, to interfere with any other activities and to mobilize resources and defence strategies.

Pain can be classed in three categories according to pathophysiological mechanisms: acute or physiological pain, inflammatory pain, and neuropathic pain. Various function modes of the somatosensory system (the sensitivity of the body) are at the origin of these three categories. Pain of different kinds may co-exist, leading to "mixed" pain that is often difficult to diagnose and treat. Acute pain is often associated with inflammatory pain as, for example, after tissue damage or after surgery. This is called "pain due to excessive nociception".

During an inflammatory episode, nociceptor responses are modified leading to increased sensitivity, or even to the involvement of receptors that were initially "silent" when the tissue was intact. The pain threshold is consequently lowered so that even a gentle touch can become painful (allodynia) while a noxious stimulus is perceived more intensely (hyperalgesia). Hyperalgesia may result from a disturbance in receptor peripheral sensitivity as well as from a modification in pain thresholds of central origin due to the control of descending pathways from the brainstem and spinal cord interactions. In this case, pain may extend beyond the duration of stimulation or may even occur spontaneously, after a reorganization of the neural networks involved. Such changes promote healing by adjusting reactions and behaviours such as resting the injured area and protecting it through an analgesic posture.

Neuropathic pain may result from long-term consequences of an injury (e.g. due to amputation) or from a functional change of the somatosensory system which then evolve in an abnormal and inappropriate way. Persistent pain with no biological purpose has a pathological nature. It develops independently of whether the initial injury is maintained or not, and relies on mechanisms of neural plasticity. In the case of neuropathic pain, the physiological system that is normally involved in nociception generates the sensation of pain itself.

It is possible to follow the progression of events occurring in the nervous system from the peripheral activation of nociceptive responses to the integrative responses in the brain structures responsible for the onset of the painful sensation. Cortical and diencephalic nuclei which are responsible for processing emotions, memory, basic consciousness (awareness, alertness…) are activated in parallel with motor pathways which organize movements and protective behaviours.

Once in the spinal cord, nociceptive signals are simultaneously directed towards both spinal motor neurons responsible for reflex activities, and to higher brain centres. Nociceptive and thermal sensory information follow a specific ascending pathway in the spinal cord (bundles of nerve fibres assembled into distinct anatomical pathways or ventro-lateral tract). Functional brain-imaging techniques (functional magnetic resonance imaging and positron emission tomography) have shown in humans that the cingulate and insular cortices are particularly activated. These structures, belonging to the limbic system, are crucial in generating emotions. To a lesser extent, the somatosensory, primary and secondary cortices are also activated by noxious stimuli. It appears that it is a whole network of brain areas that is responsible for the perception of pain and not just a unique structure (Figure 3).

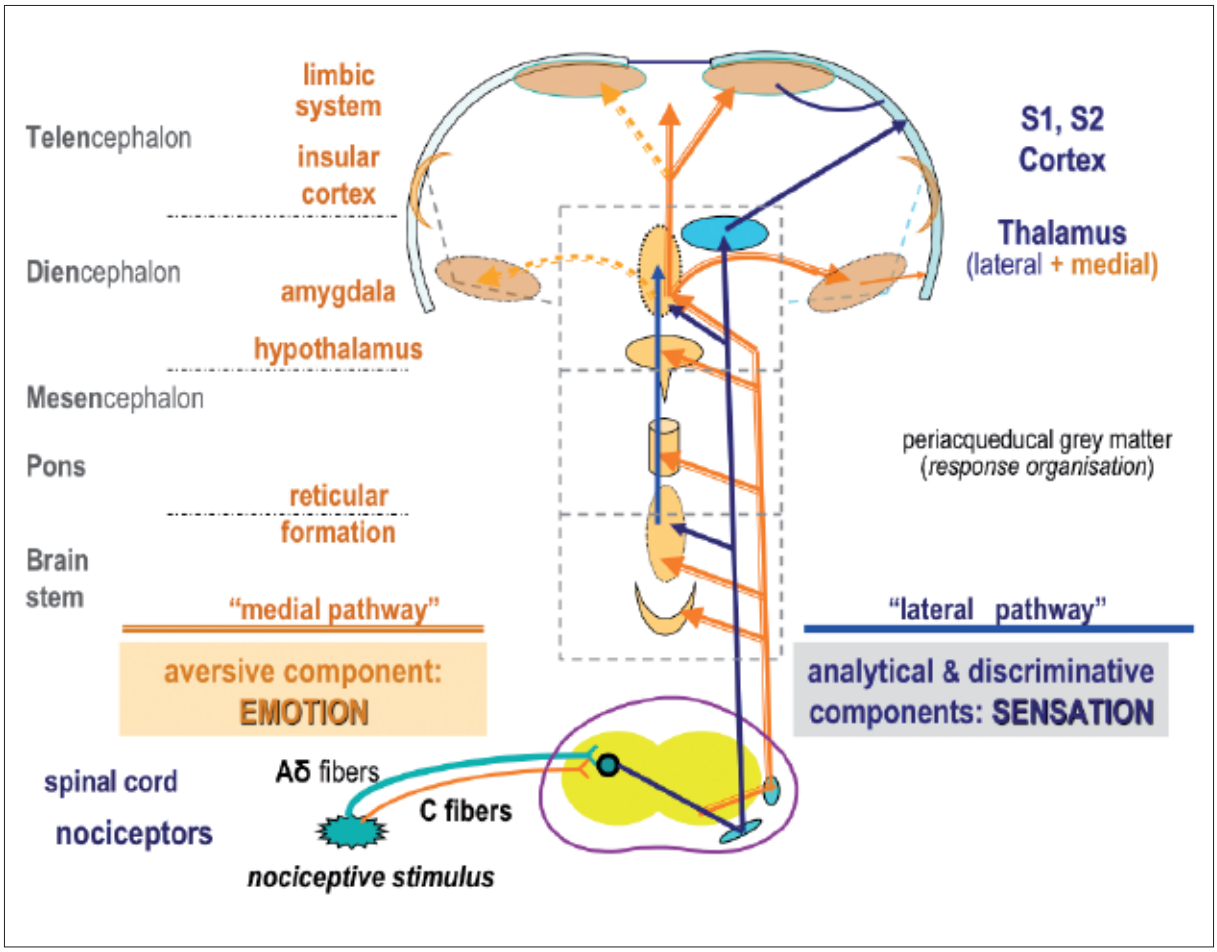


Figure 3. The spinothalamic tract. This is the main pathway for transmission of signals from nociceptors and thermoceptors (in primates) (Jacques Servière personal communication)

After the initial relay in the spinal cord, nerve signals are conveyed in parallel to higher centres via two types of pathways that transmit different components of pain. The signal is relayed differentially according to two major functional characteristics. The alarm and discriminative sensory components of the stimulation (location in the body, intensity, duration, repetition ...) are conducted through the spinal cord by nerve fibers of the "lateral pathway" which project into the ventral posterior lateral nucleus of the thalamus and then reach the S1 & 2 somatosensory cortex. The "unpleasant" component of the sensation is transmitted via the slow "medial pathway" from which the fibres are distributed to a set of nerve centres located along the antero-posterior axis of the brain.

The pain response system allows the analysis of nociceptive information and triggers protective reactions. It differs from other sensory systems (vision, hearing) in that it necessarily activates structures involved in processing events that are beyond the mere sensory analysis. Pain networks are at the junction of the domains of physiology and psychology because they can trigger simple vegetative responses (heart rate, levels of adrenaline...), protective motor responses (flight reflexes), or more complex behavioural strategies (specific postures, withdrawal strategies, social isolation) that may be associated with complex emotional experiences.

Emotions

From the cognitivist viewpoint, emotions are defined as complex affective reactions combining body and brain functions. These reactions include a subjective mental state (anger, fear, anxiety, depression, compassion, love...), a drive to flee or attack which may or may not be expressed behaviourally, and physiological changes (increased heart rate, blood pressure, altered muscle tone ...). Some of these changes prepare the individual for actions of

sustainable duration. Additional observable responses (posture, gestures, facial expressions...) may serve as signals to communicate what it is experiencing, or manipulate, to the signaller's benefit, how others interpret its motivational/emotional state.

Negative human emotions are the consequences of dramatic events in a person's life, associated with their lot, the values and ideas they hold close to their heart as well as their beliefs about themselves and the world they live in. The emotion is triggered by a personal assessment of the meaning of what is happening. The dramatic episode varies from one emotion to another, each emotion having its own history. The onset of emotions involves complex processes to assess the current situations. These processes are correlated with the activation of brain structures that are relatively recent on a phylogenetic scale.

The functional interactions between phylogenetically recent structures (like the cerebral cortex which is particularly developed in nonhuman primates and in humans) and phylogenetically older structures which are also found in non-mammalian species (limbic system, hypothalamus, brainstem nuclei such as the periaqueductal grey), show how different anatomical levels of the nervous system interact. These complex interactions modulate the autonomic responses associated with pain, or may modulate the experience of pain itself (cf. response thresholds of the receptor). Thus, in some rodents, the response thresholds to noxious thermal stimuli are modulated by social emotional components (presence of a conspecific, hierarchical position).

Emotions result from cognitive processes which lead to the assessment of the characteristics of the stimulus encountered in the context of its occurrence. It appears that what is called "somatic markers of emotion" reflects in fact a sensory and cognitive analysis, usually performed automatically first, and then involving different levels of the central nervous system that are activated in parallel.

Sensory awareness

Consciousness as a psychological phenomenon has rarely been addressed in studies on the neural mechanisms of pain. Research is focussed on aspects of emotional experience and the concept of consciousness is very rarely developed. In the present report, we restricted the definition of consciousness to the level of vigilance which corresponds to awareness from a neurophysiological point of view, and combines the perception of information from the environment and sensations from the body. In the neurological form of arousal, stimuli are transformed into sensory information, and noxious stimuli can be perceived as painful. This form of consciousness is always associated with, or triggered by, sensory information and corresponds with what is qualified as primary consciousness. Reflexive consciousness or self-consciousness does not lie within the scope of this assessment.

The functional dimension of consciousness (alertness and vigilance) has important practical implications, especially when animals are slaughtered for human consumption. It is the level of vigilance that allows or suppresses the emergence of a conscious sensation of pain resulting from the application of a noxious stimulus, such as bleeding at slaughter. Conversely, the lack of consciousness prevents higher structures of the nervous system (mainly the neocortex and the thalamus) to transform sensory stimuli into a sensation. The animal is in a state of partial unresponsiveness characterized by specific patterns of electrophysiological brain activity which can be observed during sleeping, some types of unprovoked seizures (epilepsy) or deep coma.

Experimental data collected by neuroscientists come mainly from work on humans and some primate species. Based on their work it can be proposed that emotions of sensory origin (primary emotion) involve the existence of a basic form of consciousness called phenomenal consciousness which is simply experience. In this view, emotions arise because of primary consciousness (this does not require self awareness) and an individual's drive to react would rely on this type of consciousness. In the case of pain, the first response is to rapidly move away from the noxious stimulus, and then to develop behavioural and postural strategies that make healing possible.

The world-wide accepted definition of pain was initially designed for humans. The relevance of this definition was to state that pain necessarily implies an emotion, in the sense of a primary emotion for protection and survival, which according to some authors falls into the category of "basic" or homeostatic emotions. However, it is noteworthy that even if it was formulated for humans, this definition does not mention phenomenal consciousness and its related forms, such as an increased level of vigilance, which corresponds with being on the alert. Questions on phenomenal consciousness have only emerged in recent years.

2.3.2. Related notions

Suffering

The word “suffering” is frequently used as a synonym for pain which includes sorrow, grief, disorientation, fear, anxiety, distress and depression. The official definition of the IASP, essentially formulated for medical studies, states that suffering is an "emotional distress associated with events that threaten the biological or psychological integrity of the individual”.

Irrespective of this definition, formulated for humans by physicians and neurologists, some philosophers have tried to distinguish between pain and suffering. Their argument is based on two facts. The first is that suffering is often associated with severe and long-lasting pain which affect body image and mental integrity. The second fact is that suffering occurs commonly in the absence of pain of physical origin.

Stress

Pain is very often associated with stress because of its aversive dimension. Stress is defined as a reaction to a situation threatening the adaptability of the subject and which results in the activation of two systems: (1) the hypothalamic-pituitary-adrenal (HPA) axis which releases glucocorticoid hormones (cortisol and corticosterone), and (2) the sympathetic nervous system with the adrenal medulla which releases adrenaline and noradrenaline. Stress refers to a standard physiological response that is not specific to the stimulus provoking it. It covers a wide range of phenomena of physical (abrupt changes in the environment), immunological (pathogens) or psychological (threat) origin. The concept of stress refers to the uniqueness of the physiological response towards extremely diverse stressors. Whereas common usage of the term stress may confound the aggressing agents and the organism’s response to them, here stress is defined as the overall, non-specific responses of an organism to stressors. The brain structures involved in stress responses are localised in the brainstem and the hypothalamus. Activation of these structures leads to a series of neural responses directed to the spine and the endocrine glands, the so-called stress response. Functional interrelations between the pain neural network and the autonomic nervous system are found at peripheral and central levels. The most obvious sign is the relationship between acute pain and increased heart rate, blood pressure and peripheral vasoconstriction (paleness). The biological function of these responses is to enable the body to adapt to the threatening situation with a complex set of reactions such as energy mobilization, cardiovascular regulation by the autonomic nervous system, anti-inflammatory properties of glucocorticoids and their effects on the central nervous system. It must be borne in mind however that, although pain causes stress, a stress response is not necessarily painful. Stress responses may therefore help to detect the nature of noxious stimuli, but are in no way characteristic of pain.

Health

Health is defined by the World Health Organization (WHO) as "a state of complete physical, mental and social well-being, and not just the absence of disease or infirmity."

In the past, health was seen as the opposite state of disease. Addressing health issues meant fighting against diseases. With the WHO definition, prevention and care are no longer the only means for safeguarding health. Laws, regulations and political guidelines on environmental issues and land management are now included. The health of the population has become a political responsibility (Ottawa Charter, 1986).

The various elements defining pain that are exposed in this assessment are described in Figure 4 along with related concepts that are not directly taken into account. The scope of the ESCo assessment is represented by the red dotted line.

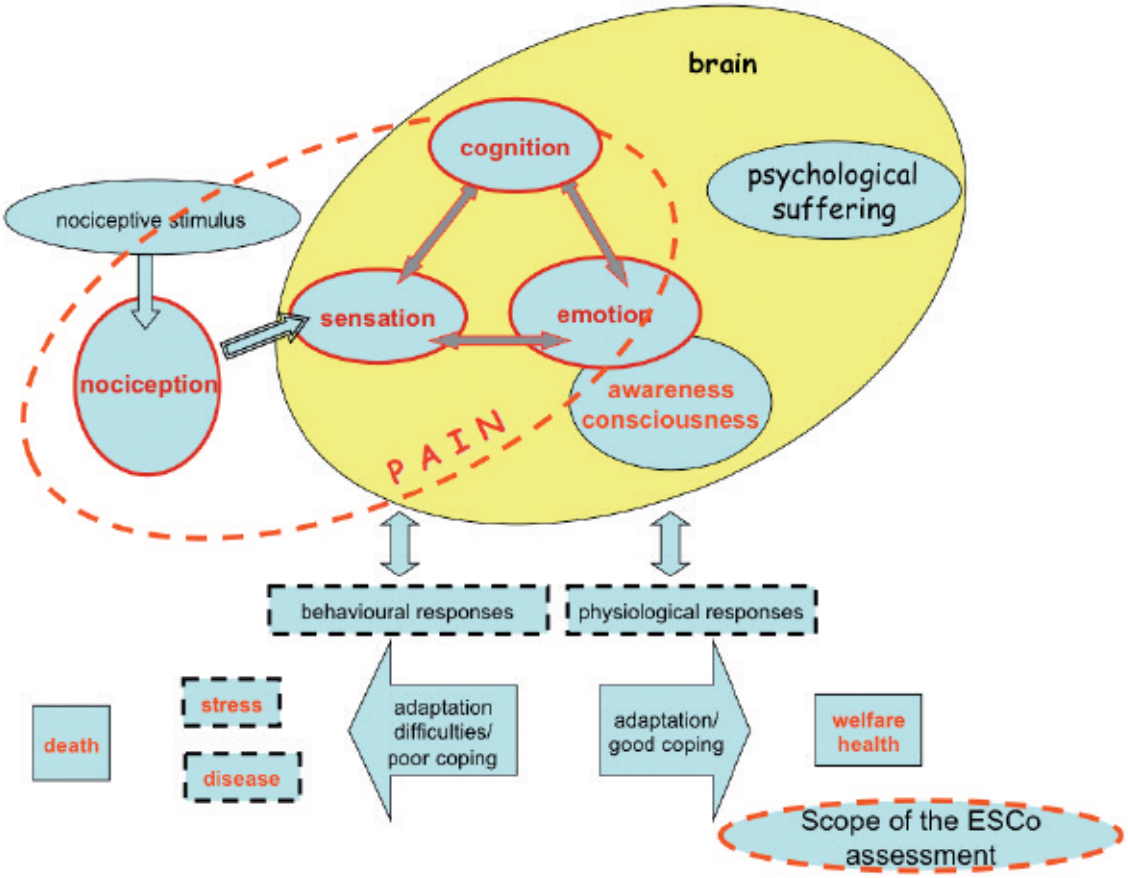


Figure 4. Representation of the main concepts used in the ESCo assessment on animal pain

2.4 Transposing the concept of pain from humans to animals

Nociception and pain in animals (if characterized as such) is likely to have the same biological functions as in humans: protection of the individual. Nociception and pain are just as vital to animals as they are essential to humans. However, it may be that the mechanisms involved in animal species (including non-human primates) are not strictly identical to those found in humans. This raises the following question: are the characteristics of noxious sensory-emotional experience in animals similar to those in humans, partly identical or fundamentally different? This question is frequently posed by ethologists who study cognitive and emotional states in animal species.

2.4.1 Pain in animals

Definition of pain in animals

The definition of pain given by the IASP was formulated for humans and is not applicable to animals. Since animals are unable to communicate verbally, they cannot reveal the characteristics of their sensory experience to humans. The original definition of pain was therefore modified in order to provide one that was more suited to animal abilities. Hence pain is defined as the awareness that an animal has of an aversive sensory and emotional experience associated with actual or potential tissue damage.

The definition applies to vertebrates only and specifies that a painful sensory experience must trigger:

- protective motor responses withdrawal of a limb,

- neurovegetative responses (increased heart rate, higher blood pressure, peripheral vasoconstriction, transitional change in breathing),

- learned avoidance responses (long-lasting avoidance of a conspecific, avoidance of a predator or a place associated with an aversive experience, behavioural changes: animal becoming fearful, decreased exploration of a novel place ...).

This definition, which is widely accepted by the scientific community, includes the concepts of emotion and saliency. The inclusion of emotion emphasizes the fact that pain is an aversive and unpleasant sensation, which is considered as a primary emotion. Referring to saliency draws attention to the fact that the existence of a form of consciousness has become, under the influence of cognitive sciences, a key element in recognising mental states in animals. It refers to the functional dimension of consciousness as defined in section 2.3.1, also called phenomenal consciousness.

Many animal species have emotions

Only behavioural and physiological responses can characterise emotions in animals. This approach is based on work from cognitive psychologists who state that emotions result from an assessment of the situation experienced. The level of assessment varies according to the cognitive abilities of a species. The assessment process relies on: i) the characteristics of the triggering stimulus (suddenness, novelty, pleasantness ...), ii) the corresponding inconsistency between the triggering stimulus and the individual's needs or expectations; iii) the possibilities for adaptation proffered by the environment. The overall assessment leads either to a positive or a negative emotion. From this perspective, the study of the emotional repertoire of farmed species is aimed at linking the neurobiological process involved in evaluating a particular event with the behavioural and physiological responses.

A series of studies undertaken on mammals, mostly rodents, indicates that the anatomical and functional substrates involved in the emotional state triggered by physical pain and those involved in the distress responses displayed after disruption of strong social bonds (separation of mother and young, for example) are similar. The fact that a small dose of morphine reduces significantly the vocal activity of rat pups separated from their dams suggests that such distress response relies on neurochemical mechanisms and brain structures that are also involved in physical pain. It can be assumed that there is neural network regulating the expression of emotions and that it may be activated by physical as well as by psychological threats.

Identification of neural structures activated by noxious stimuli in humans has shown that the negative affective state associated with it involves several brain areas of the cortex which are phylogenetically old, as well as the cortical somatosensory area SII. In contrast, non noxious somatosensory stimuli activate preferentially the cortical somatosensory area SI which is considered phylogenetically more recent; this cortical area is found in all primates. The distinction between these two kinds of stimuli (noxious vs. non noxious) shows that there are two functional somatosensory components and that they are controlled by distinct neural pathways. It has not been established yet if this distinction is found at different levels of the animal phylogeny with the same characteristics. This raises many questions about the nature of the sensations experienced by species that differ as widely as vertebrates and invertebrates.

The characteristics of pain are modulated by the social environment

Modulation of nociceptive thresholds

The study of emotions and cognitive abilities opens up new perspectives for a better understanding of the emotional state of animals when they face noxious events, especially in livestock farming. Because of its affective component, animal pain might be modulated by emotions like it is in humans. The influence of emotions on pain has been investigated in animals by taking into account the context in which noxious events take place. Inducing positive emotions on farms may help improve the quality of animal life, in particular by reducing the perception of

pain as has been shown for humans. Beyond the emotions themselves, which are by definition short-lasting, it is also important to take into account the consequences of a persistent emotional state, commonly called mood or basal affective state, which results from the accumulation of emotional experiences on the perception of pain.

One question posed to breeders is whether reared species have the ability to "perceive" the emotional states of other animals reared with them. In the specific case of negative emotions triggered by noxious stimuli, the question is whether or not the perception and interpretation of distress signals (postural visual cues, olfactory cues, vocalizations) can alter the behaviour of the animals receiving the signals. Experimental data in mice show that the response to pain may vary with the status of the individuals present (familiar, unfamiliar, dominance relationship ...) and is modulated by a genetic component. It is the same for the existence of specific reactions to distress calls by the offspring of the species. This has probably led some authors to prematurely adopt the idea that there is a form of empathy in some species. In this interpretation, the emphasis is placed on the role of emotional reactivity among conspecifics. It should be remembered that the concept of empathy comes from observations initially made with primates. If we want to extend this capability to all animals, especially to farm livestock, this will require confirmation based on experiments with each species. Extending the proposition that empathy exists in all animals (especially in farm livestock) requires confirmation based on experiments with each species.

Modulation by inter-species relationships: the incidence of the human-animal relationship on the expression of pain in animals

Several review articles show how animals and humans develop inter-individual relationships, especially in the case of experimental animals and farm species. Recently, the cognitive abilities involved in communication between humans and animals (dogs, horses) have received particular interest, e.g. the existence of reciprocal attention between humans and animals. The subjective interpretation of the situation determines the animal's reaction. This is particularly true for their emotional perception of humans. Animal fear of humans has been studied in particular because of its effects on animal behaviour, physiology, and production capacity. Pain, as a perception of a physical threat, may be influenced by the human-animal relationship, especially if animals are afraid of humans. This fear is genetically inheritable but it is also influenced by the individual's previous experience. Thus, the animal can easily associate the pain due to a specific veterinary or farm procedure with the presence of a specific person and remember it.

Fear is an emotion that is defined as the perception of a real or potential danger and which prepares the animal to face it. However, fear is not the only emotional state that can be investigated and which may affect the responses of animals to humans and to painful procedures. Animals can indeed perceive certain situations positively and have positive emotions in the presence of humans. These situations may improve the human-animal relationship and enhance approach responses towards humans. Some types of human contact may generate positive emotions in animals. For instance, studies have shown that tactile interactions, mimicking positive allogrooming between animals, diminish heart rate and induce relaxation postures, and facilitate contact with the animals. The presence of humans in such conditions can reduce pain perception by animals. Studies on this topic, however, are still scarce.

Pain in the mammalian foetus

In order to feel pain, all animals must: i) have fully functional neural structures allowing the detection of noxious stimuli from the environment or from within the body, their transmission to brain structures and their expression as sensations ii) be able to reach a state of awareness iii) be able to identify the characteristics, the intensity and the duration of noxious or stressful stimuli in order to perceive them at the cognitive and emotional levels as an aversive experience. While for mammals, adults and their fully-grown young are generally considered as sentient beings, the question remains for young that are still neurologically immature and foetuses.

In a review on the physiological characteristics of foetal sheep, New Zealand scientists put forward the theory that the sensory environment in utero maintains the foetus in a state close to permanent sleep, in other words, the individual would be unconscious. They concluded that states of awareness and alertness are not reached until shortly after birth. During the birth process, profound changes in auditory, visual, tactile and thermal sensory inputs trigger the process of awareness and the onset of consciousness, making the young a sentient being.

2.4.2. Concepts associated with pain in animals

Definition of suffering in animals

Some researchers suggest that suffering may be experienced when the conditions imposed on the animals prevent them from “fulfilling their life project” or in other words performing the natural behavioural pattern of their species. The needs of a species are considered as covered when their behavioural repertoire can be expressed entirely. Experimental data indicate that when animals are prevented from displaying some behaviours, their natural drive for action evolves into tension that pushes them to react in an unsuitable manner, that may cause frustration and discomfort. This is the case for animals reared in restricted and impoverished environments in which they cannot display all the behaviours that are typical of their species. Such a state of psychological distress, which is not associated with tissue damage, may result in the animal developing stereotypies, which are repetitive acts expressed without apparent objectives. In other cases, apathy or resignation dominate in an attitude reflecting the individual’s lack of interest in or concern about the surrounding events, illustrated by the absence of a reaction. This type of psychological suffering is beyond the scope of the present assessment.

Definitions of animal welfare

The European Community has been emphasising the ethical importance of animal welfare over the last twenty years by presenting it as a political concern and a collective cultural preoccupation. This impetus has been paralleled by a steady increase in research on welfare, both at national and European levels.

There have been many attempts to provide a definition of animal welfare. One of the first refers to a state of harmony between the animal and its environment. This equilibrium should lead to full mental and physical health, but the definition does not specify exactly what harmony is.

A second definition, widely adopted by scientists working on animal welfare, focuses on the adaptability of a species. It specifies that a high level of welfare is reached when adaptation to the environment can be achieved at low cost to the animal, e.g. without significant energy expenditure. On the other hand, if the adaptation processes require the animal to rely heavily on its reserves (e.g., extremely low temperatures, allocated space limiting the expression of some behaviours or generating social aggression) then the level of welfare is considered to be low.

Another definition, formulated for practical on-farm usage, assembles the criteria characterising farm animal welfare into major components. This approach puts emphasis on the environmental conditions and the level of care that all farmers should comply with. Thus animal welfare depends on the respect of five basic rules (Five Freedoms):

- Freedom from thirst and hunger - by covering basic needs to maintain full health and vigour,
- Freedom from discomfort - by providing an appropriate environment,
- Freedom from pain, injury, and disease - by prevention or rapid diagnosis and treatment,
- Freedom to express normal behaviour - by providing sufficient space, proper facilities and a satisfactory social environment,
- Freedom from fear and distress - by ensuring conditions and treatment which avoid mental suffering.

More recently, the World Organisation for Animal Health (l’Office international de la santé animale: OIE) stated that “animal welfare is the result of a complex public organization with multiple components comprising scientific, ethical, economical and political dimensions." This definition, less focused on the animal than the previous ones, emphasizes the complexity of the human factors which determine the living conditions of the animals, including during transport.

2.4.3. Examples of transposition to non-mammalian species

Factors in a phylogenetic approach to pain

Humans have always been taken as a reference to understand what pain could be in a given animal species. This approach necessitates the combined use of criteria concerning the neural structures involved and the behavioural and cognitive abilities.

As a matter of fact, the criteria found in the literature depend on the authors' scientific discipline. Thus, neurobiologists focus on behavioural, cognitive and neuro-anatomical features, while many ethologists and specialists in animal welfare favour the behavioural and emotional aspects, using only occasionally information on neural cues, or cognitive, sensory and motor performances.

Comparative anatomy of the brain (homology between species e.g., presence or absence of frontal, telencephalic, limbic, cingulate cortices...) and the comparisons of behavioural abilities between species suggest that non-human mammals feel pain. In contrast, the issue about the existence of pain is still debated in birds, fish and marine molluscs like cephalopods.

We will limit this section to key data that support the hypothesis for the existence of well-characterised pain, in contrast to nociception which is defined as a more restricted sensation lacking the emotional dimension and consciousness. The methodological difficulties that helped the experimental validation of a given position on nociception, emotion and awareness of sensation will be reported as will the scientific controversies.

Whether there may be forms of mental representation of the body's state other than those described for mammals remains to be tested.

	Nociception	Emotion	Primary sensory consciousness (Sensory awareness)	Pain
Mammals	+	+	+	+
Birds	+	+	+ / ?	+ / ?
Reptiles	+	?	- / ?	-
Amphibians	+	-	?	-
Fish	+	-	?	-
Cephalopods	+	?	? / +	- / ?

+ = Presence of a positive response
- = absence
? = uncertain
? / + = debated

Table 1. Summary of the existence of perceptual phenomena associated with the concept of pain in the six categories of animals presented in this assessment, based on current state of knowledge

Existence of pain in birds

Comparative Anatomy

Structures homologous to those involved in nociception in mammals are found in birds. In particular, electrophysiological studies conducted in chickens and pigeons have shown that their nociceptors have similar properties to those found in mammals. The neural mechanisms described at the level of the spinal cord do not differ significantly from what is known in mammals, however, our current state of knowledge of birds is not as extensive as for mammals.

Birds display strong behavioural and physiological responses (activation of the HPA axis and sympathetic system) when submitted to frightening situations, conditions of food frustration or social separation. Fear responses have been particularly well described. They are associated with an activation of brain structures quite similar to those described in mammals, and include the posterior pallial amygdala and the archipallium, which could be homologous to the mammalian amygdala, the nucleus of the stria terminal and the paraventricular nucleus of the hypothalamus. These activation processes do not rely on the type of stimulus but on the way the situation is assessed. In particular they are modulated by previous experience. The mechanisms involved in memory have also been studied, especially in the case of conditioned fear. Conditioned fear is an emotion provoked when an animal is put in an environment that has been previously associated with an aversive experience (e.g. electrical shock). As in mammals, conditioned fear activates the hippocampus in birds.

Neurobiological studies performed on pigeons have shown that situations generating nociception also trigger significant emotional responses, and the brain structures involved in these responses are similar to those reported in mammals. Chickens and pigeons that have been trained with a classical aversive conditioning protocol using tone-shock associations, later display exacerbated fear behaviour and an increased heart rate when they hear the sound alone. This response is blocked by lesions of the archipallium which, like the amygdala in mammals, is involved in the onset and the control of emotions. It appears that in birds the nociception system and the associated memory processes activate upper brain structures involved in the expression of emotions.

Nonetheless, it has been shown that cortical decerebration of chickens does not inhibit the protective postural behaviour of leg bending to avoid standing on a foot when it is made sore by intra-plantar injection of urate crystals. This suggests that some of the protective behaviour is controlled at the level of the brainstem, thus, in the absence of any conscious emotional component.

Behaviours

Very soon after hatching, birds display escape responses when confronted by a noxious stimulation. In response to a nociceptive stimulation, birds exhibit defensive behaviours and attempts to escape. If they cannot put an end to their aversive experience, they are overcome with exhaustion and apathy. Changes in posture are often observed in birds, with the appearance of limping and, as the severity of the lameness increases, a total reluctance to move or inability to stand. Phasic changes in behaviour are observed in animals subjected to feather plucking: initially, the animals are reactive, try to escape (jump up, flap their wings), or vocalize, while later on, they crouch down and remain motionless suggesting a state of resignation.

Several experiments in chickens, pigeons and quail have shown that the behavioural responses triggered by nociceptive stimuli are reduced or disappear after an injection of morphine. The impairment of these responses due to morphine treatment shows that the abnormal stance observed in the animals studied is not due to a functional handicap but to a nociceptive phenomenon or even pain. The injection of non-steroidal anti-inflammatory drugs can also improve the stance of chickens which were previously limping. These data demonstrate the existence of receptors for substances like morphine, which is consistent with data from phylogenetic studies showing the presence of opioid-like receptor families in almost the entire vertebrate phylum and even sometimes in very primitive marine invertebrates.

These behavioural responses are not just reflexes because they can also be modulated by endogenous analgesia provoked by other motivated behaviours. Thus, a hen that is about to lay will crouch down on both legs even though she previously avoided standing on a leg in which arthritis had been induced experimentally. Similarly, a strong motivation to feed can diminish or eliminate the expression of joint pain in the chicken.

Cognition

Even though birds are quite capable of expressing protective and escape behaviours of nociceptive origin in combination with emotional responses, the level of consciousness, and therefore the characteristics of the sensory and emotional experience of pain, may vary according to the species. It must be borne in mind that the avian class includes animals with a wide range of cognitive abilities. Gallinaceous and web-footed poultry, and quail, which constitute the majority of farmed birds, have very reduced cognitive capacities in comparison to other birds,

especially the corvids and the parrots. Work performed on jays has shown that these birds are capable of forming episodic memories very similar to some of the most complex memory processes in humans. Some parrots seem able to count, to combine shapes and colours from oral instructions, to indicate the location of an object that has been hidden, to such a point that some authors believe they have a high form of consciousness. It is quite possible that the diversities in cognitive abilities and in levels of consciousness (in the sense of alertness and perception of the environment) evolved in parallel.

In conclusion, the neurobiological data confirm the behavioural and physiological results. They suggest that noxious stimuli trigger emotional responses, and in that regard we can suspect the existence of pain in birds, not just nociception, although this is still being debated in the scientific community, especially for farm species.

Existence of pain in reptiles and amphibians

There is still very little data in the literature on these two phyla.

Reptiles

Phylogenetic review articles on brain functions reveal that the first events associated with a form of consciousness (sleep / wake cycles, primary emotions, positive reinforcement) are seen in the reptiles. Elements concerning the expression of pain (nociception, emotion, phenomenal consciousness) are still too fragmentary to make clear conclusions.

Amphibians

In the frog the existence of somatosensory and chemical nociceptors can be demonstrated by the swift and vigorous extension of the hind limbs in response to stinging or to the application of an acidic solution to the skin. Work on amphibians is mainly focused on the identification of peripheral nociceptors or at the level of the spinal cord. Recently, a chemo-nociceptor that is sensitive to a neuropeptide known for its analgesic effect in the spinal cord in other vertebrates has been characterized in the frog. This receptor is specific to nociceptin and differs in its structure and properties to opioid receptors (mu, delta and kappa) which are found in many animal species. It can be concluded through phylogeny that the analgesic properties of nociceptin found in the frog indicate the presence of elementary nociceptors.

However, the huge differences in the anatomical organization of the nervous system between amphibians and mammals make it very difficult or even impossible, in the current state of our knowledge, to speak about pain in the former. Thus the predominant involvement of the forebrain in the identification of chemical stimuli (smell), in addition to the lack of cortex, makes it difficult to conclude to the existence of elementary sensory emotions associated with a primary form of consciousness.

In conclusion, the escape responses described in amphibians are controlled by brainstem centres which receive information from peripheral nociceptors. These are reflex responses which, if they appear rather elaborate, do not include the participation of emotional awareness in the way it is applicable to mammals. The organization of such protective behavioural responses does not exclude the existence of elementary forms of sensory awareness, often described by the concept of sentiency.

Existence of pain in fish

Fish form a very vast and heterogeneous phylogenetic group. Current knowledge on this class is limited to a small number of species and cannot be generalized to all fish.

Anatomy

Anatomical and electrophysiological work has recently demonstrated the existence of nociceptors in trout. These nociceptors are located on labial areas of the head and respond to mechanical, thermal and chemical stimuli. They send information to the brain via small trigeminal Aδ and C fibres (a cranial nerve), the number of which is much smaller than in mammals and birds. It should be noted that neither nociceptors nor a system of nociception have

yet been found among cartilaginous fish (elasmobranchs) even though such features are essential for the survival of individuals.

Trout present five different types of nociceptive responses and its nociceptors have similar characteristics to mammals. The receptors do not show, however, the sensitization phenomenon widely described in mammals after invasive chemical or thermal stimulation known to induce inflammatory responses and hyperalgesia. Instead, after such stimulation these receptors display either the same response as that initially observed, or become irreversibly insensitive. Trout and goldfish have opioid receptors which respond to Met-enkephalin and leu-enkephalin, two substances found in the nociceptive system of rodents. A stressful event induces the secretion of met-enkephalin in goldfish.

Behaviour

Fear-like behaviour is observed in the trout after introduction of an unfamiliar object into its environment. The same type of behaviour is displayed after a subcutaneous injection of an acidic solution into its mouth; the effect is neutralized by an analgesic treatment of morphine. Other studies in goldfish show the existence of long-term memory, resulting in the avoidance of situations previously associated with a noxious stimulation.

In conclusion, experimental results in teleost fish confirm the existence of nociceptors and avoidance behaviours which can help memorizing the context where a noxious stimulation was experienced. However, proof for the existence of an emotional component is still lacking, therefore there is no solid evidence to prove that these elementary reactions reflect pain. This issue is still being debated within the scientific community but experimental data is still patchy and limited to a few species.

Existence of pain in cephalopods

Very few species of invertebrates are raised for human consumption. Revision of the EU Directive on the use of animals in experiments (EEC 86/609) has extended the scope of application to some invertebrates, including cephalopods. Data on nociception and pain in marine cephalopods should therefore be examined.

The diversity of adaptive niches and species does not exclude the existence of differences in conscious sensory activity (primary consciousness) like alarm, awareness and alertness according to the type of cephalopod.

Neuroanatomy

Cognitive and behavioural performances of cephalopods are linked to their considerable brain size (520 million neurons in the octopus). Removal of the cephalic lobes (superior vertical optic lobes), has been performed but only to gain understanding of the neurobiological bases to visual recognition. These lobectomy experiments do not solve issues on homology of brain structures between cephalopods and vertebrates in regards to the processing of nociceptive information.

Behaviour and Cognition

The behavioural performances of cephalopods are strongly linked to predation. They reveal important cognitive and adaptive abilities (discrimination between shapes, colour or intensity of stimulations; special memory; learning by visual observation; categorization of shapes) that are very similar to those found of vertebrates.

Data on aversive learning could be relevant for assessing the potential existence of pain in these species, in the sense that any aversive stimulus, whether of nociceptive origin or not, can trigger a minimal withdrawal response or avoidance. Threatening stimuli trigger immediate flight responses in cephalopods, followed by hiding or protective behaviours. This can be caused by a particular element of the environment or the situation, or by the context itself (contextual learning).

Aversive situations are memorised for several days after a single experience. This is typical of the consequences of being exposed to a noxious or potentially dangerous stimulus, such as the reaction to bitterness (quinine) which in many species is associated with the risk of being poisoned.

In conclusion, cephalopods are clearly sensitive animals, with highly developed memory and cognitive abilities. While some behavioural expressions described in the literature are characteristic of nociception, the emotional components, associated with pain in higher vertebrates, remain largely unexplored. The level of consciousness so far determined for cephalopods still corresponds to elementary forms of sensory awareness. The debate within the scientific community on emotion and consciousness in cephalopods shows that there is a need to develop further work on this matter.

Conclusion

This brief review on the phylogenetic aspect of nociception and pain seems to indicate that elementary solutions have been conserved down through evolution. This is the case for peripheral nociceptors, all of which have free nerve endings that do not have peripheral structures or some spinal neuronal receptors responding to analgesic substances (opioids analgesic neuropeptides) which are found in animal categories as diverse as cephalopods, amphibians, fish, birds or mammals. Protective reflexes are present at all evolutionary levels and are often associated with the ability to memorize aversive sensory experience. However, the organizational diversity of the nervous systems is such that protective behaviours cannot be assimilated to more complex forms of responses to pain and to mental representations of pain as seen in primates (emotions, forms of sensory awareness). The emergence of these components may be dated phylogenetically to the time of transition from the aquatic to the terrestrial environment, including in the embryonic forms (amniotic egg). We still have very little knowledge of this phenomenon and there is a need for an interdisciplinary approach. Thus asserting that basic emotions (primary emotions) exist in lower vertebrates and some aquatic invertebrates is premature.

2.5. Summary

Reviewing our current knowledge on the neurological mechanisms of nociception and pain reveals the following key points:

The definitions of words and concepts relating to pain, which are accepted worldwide, were originally chosen to characterize pain in humans. Pain and its emotional and cognitive components are well-defined in humans. It is not the case for non-human animals.

Pain is indissociable from an emotional component that is linked to primary emotions. This type of emotion is related to the concept of homeostasis.

Pain is not a single, unequivocal entity. There are different kinds of pain, depending on where it is located in the body tissues (with a special distinction between somatic and visceral tissues), the duration of trauma and the associated neural mechanisms. Different types of pain can be distinguished by their acute or chronic nature or whether or not they are associated with an inflammatory process.

Lack of acute pain management can induce neurobiological changes leading to neural plasticity that may result in changes in sensitivity and for which the interpretation in terms of chronic pain in animals is the subject of scientific debates.

It may be that the various forms of pain described in mammals are not the only ones that exist in the animal kingdom. In this respect, research needs to be undertaken to test the hypothesis of the existence of other forms of pain in infra-mammalian species. That such a hypothesis has never been examined very seriously is probably because the extensive knowledge gained from work on primates, including man, has influenced our concept of pain.

Sensitivity to noxious stimuli, characterized by response thresholds, is modulated by socio-emotional factors such as relationships between conspecifics or the mother-young bond.

Transposing data from one animal species to any other is only relevant from a phylogenetic perspective. There is no consensus in the scientific community (neuroscientists, cognitive philosophers and ethologists) on the abilities of all vertebrates and some invertebrates to feel emotions associated with avoidance of noxious stimuli, to reach

consciousness and experience pain as higher mammals do. A similar question can be posed for nociception: some researchers believe that it participates in the emergence of the most basic forms of consciousness.

Based on the current state of knowledge, we can suppose that pain, with its sensory, cognitive, and emotional components is present in mammals and birds, however it must be borne in mind that there is no consensus for birds.

In contrast, there is a more clear-cut position on other species such as fish. In general, fish appear to be more similar to amphibians, reptiles and cephalopods, which indeed have a neural network enabling efficient detection of noxious stimuli, the expression of protective responses, and the ability to remember stimuli which threatened their physical integrity. However, the characterization of emotional components of pain still remains to be established for these species.

3. How should pain in farm animals be assessed?

To avoid pain, it is essential to identify and if possible to quantify it. In most cases humans can describe and assess their own pain and communicate about it with others. In the absence of verbal or written communication (in babies or non-verbal disabled people, for example), this self-assessment of pain is not possible and it is necessary to resort to behavioural or physiological criteria (hetero-evaluation). In animals, self-assessment is obviously not possible and the problem of evaluating pain is very complex. Numerous scientific reviews and guidelines on the assessment of pain have been published. These studies draw mainly on examples taken from mammals and there are strong similarities between the criteria selected and those used in assessing human pain. What's more rats and mice are very often used to test drugs to relieve pain in humans.

The discomfort of pain has a high biological value since it favours survival. It warns that tissue damage is taking place, is about to take place or has already occurred, enabling the individual to react in a manner to stop, prevent or reduce the damage that could endanger its health or survival. Most of the criteria for pain assessment correspond with physiological or behavioural changes, the function of which is precisely to stop the cause and / or reduce the effects of noxious stimuli that threaten the physical integrity of the individual (Table 2). These modifications can also be found in states of stress, anxiety or discomfort that do not necessarily involve a nociceptive component, so it is very difficult to identify criteria that indicate specifically the presence of pain. In addition, these alterations can be the cause of reduced animal performance. An approach based on tissue damage can be added to the physiological and behavioural assessment of pain. When tissue damage is identified it can be assumed that there are painful consequences.

Table 2. Physiological and behavioural parameters that may be modified by pain in mammals (adapted from Mellor, 2000 and Prunier, 2000[1])

Physiological criteria	Behavioural criteria
Hormone concentrations (in blood, urine or saliva) HPA axis: ACTH, glucocorticoids Sympathetic system: adrenaline, noradrenaline **Blood metabolites** Glucose, lactate Free Fatty Acids **Autonomic responses** Heart rate Respiratory rate Blood Pressure Skin, eye or internal body temperature Dilatation of the pupil Sweating **Inflammatory response (blood)** Haptoglobin, fibrinogen ... **Brain Activity** Electroencephalogram (EEG)	**Vocalizations** Number and duration Intensity Spectral components **Postures, movements** Reflex withdrawal Analgesic posture Licking, scratching, rubbing Tonic immobility Excessive or lack of locomotion Escape and avoidance **General Behaviour** Loss of appetite Agitation Prostration Isolation Aggressiveness

[1] Mellor D.J., Cook C.J., Stafford K.J. (2000). Quantifying some responses to pain as a stressor. /In/ The Biology of Animal Stress: Basic Principles and Implications for Welfare, (Moberg G.P., Mench J.A., eds.), CAB International, Wallingford: 171-198. Prunier A., Hay M., Servière J. (2002). Evaluation et prévention de la douleur induite par les interventions de convenance chez le porcelet. Journées de la Recherche Porcine 34: 257-268.

To identify and measure animal pain, one can rely on the monitoring of physiological parameters, observation of behavioural changes, clinical assessment of tissue damage, or reductions in animal performance. It must be borne in mind though that it is not possible to obtain a "pain score" from a simple chemical or electro-physiological test and it is necessary to combine several types of criteria. In this assessment, the criteria for evaluating pain are described for each target species, firstly in ruminants (mainly cattle and sheep) and in pigs, and then in birds and fish. Although it is generally accepted that mammals and birds can feel pain it is clear that there is not the same degree of complexity in the emotional component of pain in all of the species studied. This emotional component implies that the animal is conscious, therefore it is accepted that pain is not felt under general anaesthesia. In fish, we refer to nociception, as the existence of pain in this class of vertebrates remains controversial (see Chapter 2). Very often, the criteria for assessing pain were defined in situations where pain was induced during common farm practices like, for example, castration in males. These farm interventions and the justification for them are not described in this chapter but are dealt with in Chapter 4.

In the particular context of slaughter, where pain is potentially acute and intense and where animals are usually stunned prior to bleeding/ exsanguination, the approach to pain assessment differs according to the stage in the whole slaughter process. Before slaughter, it is essential to identify the situations that may cause pain (e.g., fights between animals, use of electric goads by the abattoir staff). During slaughter the stunning phase is distinguished from the bleeding phase and the assessment of pain is focused on the animal's level of consciousness, being the determining factor in its ability to feel pain, and behaviour, which allows the identification of possible signs of pain. After slaughter the carcass can be checked for the presence of lesions and injuries that may have been source of pain prior to death.

3.1. Measures based on tissue damage

Clinical examination of animals, necropsy or histopathological analysis can reveal tissue damage that may cause pain. Fractures, skin lesions, abscesses, inflammation and neuromas are likely to cause pain in mammals and birds, or nociception in fish.

In pigs and ruminants

In mammals in general, tissue innervations and pain mechanisms are similar to those observed in humans. Injuries and lesions that cause pain in humans are hence considered to have the same effects on non-human mammals.

Histopathological analysis was used to assess the long-term effects of teeth clipping and tail docking in pigs. Histological comparison of tooth sections at different ages shows many anomalies when the teeth are cut the day after birth: pulp cavity decay, dentine fracture, bleeding, pulpitis, abscesses and necrosis (see Chapter 4). This approach also was used to determine whether tail docking induces the development of scar neuromas (uncontrolled proliferation of glial cells or axons) known to cause painful phenomena in humans. In pigs, such cellular changes have been observed in histological sections of tail stumps, but their painful nature has not been demonstrated by other means (see Chapter 4).

A much more classic approach is to record injuries, bruises, abscesses and, in extreme cases, fractures. The number and severity of skin or hoof lesions/injuries are among the most frequently used criteria for all species, in addition to tail injuries specifically for pigs. Skin lesions are common when unfamiliar pigs are gathered in a pen/yard and tail biting reflects a form of cannibalism. Assessing the number and the seriousness of such lesions constitutes a measure for scoring the animal welfare status as determined by the Welfare Quality® programme.[2]

[2] Welfare Quality® is a European research project, one of the aims of which is to develop a scoring system to determine farm animal welfare. This system includes measures for 12 welfare criteria which are pooled to obtain a final score. Among the measures retained figure injuries revealed by lameness and deterioration of the integumentary system (e.g. hair loss or tissue damage), animal health based on an evaluation of troubles in the respiratory (coughing), gastrointestinal (diarrhoea) and reproductive tracts (vulvar discharges), mortality and the replacement rates of the animals. Assessment protocols and a system for integrating the scores into a single overall assessment score have been defined.

In birds

Pathological studies have been conducted in different contexts to cast light on the painful aspect of tissue damage in farmed species. This has been undertaken in studies on beak trimming, which consists of cutting off or otherwise removing the tip of the beak usually before 7 days of age. Examination of birds that have undergone late beak trimming reveals the formation of neuromas which are potentially painful (see Chapter 4).

Evaluation of the plumage condition and the wounds caused by pecking, common in a range of species, provides an indirect assessment of the seriousness of this abnormal behaviour. In a similar way, the scores used to measure the pododermatitis in chickens (skin lesions on the underneath of their feet) enable the discrimination between mere inflammation and secondarily infected ulcers. High scores are associated with withdrawal reactions triggered by touch, suggesting painful phenomena. As shown by this example, additional criteria, in particular behavioural responses, can be used to diagnose the painful nature of a lesion or injury.

In fish

Several types of tissue damage are found in farmed fish. The most frequently described are fin or skin erosion, and injuries to the eyes. Such tissue damage has multiple causes (infections, environmental factors, food ...) and affects the health of the animals concerned.

At slaughter

It is difficult to conduct routine reports on animal pain in slaughterhouses given the work constraints. In most cases, the measurements are performed post-mortem on carcasses. The measures used to assess tissue damage are generally associated with factors that presumably involve intense pain (bruises, broken bones ...) arising before or during slaughter. Bruising is mainly due to agonistic interactions between animals (pigs, cattle), sexual behaviour (mounting between bulls) or knocks against the walls of restraining areas and transport trucks. In the case of cattle, sheep and pigs, leg fractures and dislocations occur when animals slip or fall, often due to slippery floors, or lose balance during transport. In poultry, leg and wing fractures or dislocations, as well as intramuscular bleeding, often occur when the animals are loaded onto trucks or shackled by their legs at the slaughterhouse.

Fractured vertebrae may be observed in pigs. This generally occurs during electrical stunning and is therefore only indicative of pain if the pigs were inadequately stunned. In ruminants, evaluation of the impact of the stunning bolt can indicate the degree of stunning achieved and, when there is failure to reach loss of consciousness, give insight into the reasons why (see Chapter 4).

Conclusion

Tissue damage is a key element in the identification of sources of pain in all farm animals. However, complementary observations are required to confirm the assessment of the wounds and lesions as having a painful or nociceptive nature, which often proves to be a difficult task.

3.2. Physiological responses

A painful stimulus activates structures of the nervous system directly involved in the perception of pain and emotion. This activation also triggers the pituitary-adrenal axis and sympathetic nervous system, which has numerous effects on the body (e.g. acceleration of heart rate and respiration rate, increase in body temperature, etc…), and on behaviours (Table 2). However, handling the animals or environmental disturbances (noise, general activity ...) can induce the same physiological phenomena in the absence of pain. Measurements of the activation of these systems must be conducted under perfectly controlled conditions so that the effects due to pain are not confounded with those caused by stress, environmental factors or by the procedure itself (e.g. stress due to restraining techniques or to the insertion of the needle during blood sampling). Behavioural or clinical observations must complement these physiological measurements to ensure correct interpretation.

In ruminants and pigs

Many studies have reported an increase in blood cortisol levels after a painful procedure in pigs (castration), calves (castration, dehorning) and lambs (castration, tail docking). The use of local or epidural anaesthesia reduces the amplitude and the duration of the peak of cortisol after surgery demonstrating the role of pain in the activation of the HPA axis. Several other experiments have also shown that the use of non-steroidal anti-inflammatory drugs prior to surgery (analgesics) can limit the increase in plasma cortisol after castration (calves) or after tail docking (lambs).

Measuring plasma ACTH concentration (AdrenoCorticoTropic Hormone) can also help evaluating the activation of the HPA axis even if it is used much less frequently than cortisol. ACTH increases very quickly and sharply after castration in pigs. ACTH levels give a more sensitive measure than cortisol levels after painful procedures but the concentrations are also more easily affected by the stress associated with handling or by environmental factors (i.e. lack of specificity).

To evaluate the response of the sympathetic system within minutes or hours after an intervention on an animal the blood concentrations of the catecholamines adrenaline and noradrenaline can be measured directly. It is also possible to measure the concentrations of the catecholamines or their metabolites in the urine to study changes over several hours or days. Several other measures can also be used to assess indirectly the activation of the sympathetic system since this system has many effects on the body. For example, respiratory rate, heart rate variability, pupil diameter, surface resistivity of the skin, blood pressure, body or eye temperatures, and plasma concentrations of several metabolites (glucose, lactate and free fatty acids) can be measured. It should be noted that some changes, such as heart rate variability, actually result from a change in the balance between the tonus of the sympathetic system and that of the parasympathetic system. In general, the sympathetic system is very sensitive to the effects of noxious stimuli and the response times are very brief, but it is also very sensitive to animal manipulation and environmental disturbances. One should therefore be even more cautious in interpreting these results than for the HPA axis. Nonetheless, some results clearly show increases in plasma catecholamines and/or lactate as well as heart rate, or a transient decrease in eye temperature after castration or dehorning and there is evidence that local anaesthesia may reduce or even eliminate the changes observed.

Other biological markers reflecting the activation of structures of the nervous system involved either in the detection and perception of pain or in the control of pain can be added to those described above. They include the expression of early gene activation such as for the c-fos gene in the dorsal horn of the spinal cord after castration in pigs. In response to pain the body releases endogenous opioids such as endorphins and enkephalins. Hence these can also be used as indicators of pain, as they have been for horses. Lastly, noxious stimuli modify the electrical activity of the brain. Graphical recordings (EEG - Electroencephalograms) obtained via electrodes placed on the skull can be used to analyse the changes in electrical potential that take place at the level of the cortex. The brain electrical activity is classified into four categories of wave frequencies: delta (<4 Hz), theta (4-7 Hz), alpha (8-13 Hz) and beta (> 13 Hz). In adult humans, alpha and beta waves are characteristic of a state of wakefulness and delta waves are characteristic of sleep. Beta waves become more abundant under anaesthesia induced by pharmacological agents. Using this method, it has been possible to show in piglets anaesthetized with halothane (an anaesthetic gas that has no analgesic properties) that alpha and theta waves were less abundant in the minutes following surgical castration and that this effect was largely lost if the animals received local anaesthesia with lidocaine beforehand. Similar effects were observed after dehorning in calves.

In the same way that the approach based on tissue damage can reveal the origins of pain, detection of proteins during the acute inflammatory stage is an indirect indicator of pain since it reveals tissue inflammation and it is known that inflammation usually causes pain. The measurement of serum concentrations of certain proteins (haptoglobin, fibrinogen, ceruloplasmin, amyloid A serum) may be very useful for detecting subclinical inflammation.

In birds

The main physiological variables used as indirect criteria for the assessment of pain are cardiovascular changes, plasma corticosterone concentrations and EEG activity.

In most cases, exposure to an acute nociceptive stimulus triggers heart rate acceleration in birds. However, no work on heart rate variability during a painful episode has ever been published for poultry. Blood pressure increases after activation of the sympathetic system. This parameter, however, has very rarely been studied in birds because of technical difficulties in recording it without restraining the animals. Changes in the EEG does not seem relevant at the moment because the data available so far have shown similar changes in birds that were subjected to either a fearful situation (tonic immobility during a frightening situation) or to a noxious stimulus (pulling out feathers).

In fish

Most studies published so far deal with physiological responses of farmed fish exposed to stressful situations (endocrinological variables such as corticosteroids, or indirect criteria such as respiratory or cardio-vascular changes) and none of them addresses specifically the consequences of a noxious stimulus. It is known that applying a noxious stimulus alters the movement frequency of the gill plate which is an indirect indicator of gill ventilation and therefore of increased breathing rate. Further studies, including the response of the HPA axis to a noxious stimulus, would be very useful.

At slaughter

Most studies on the effectiveness of stunning and/or bleeding rely on measures reflecting the level of consciousness or the brain's ability to perceive stimuli from the environment. EEG analyses are also used to measure the brain activity, to characterize its responses to sensory stimuli, or understand the way the brain maintains reflex responses or vital functions in animals.

EEG analysis focuses on the type and intensity of the rhythmic electrical activity of the brain. The presence of delta waves, characteristic of sleep patterns in humans, suggests a reduced level of consciousness. A flat or nearly flat EEG indicates a state of deep anaesthesia, and ultimately brain death. Evoked potentials (EP) correspond to transient changes in the EEG when the animal is subjected to auditory, visual or somato-sensory stimuli. To identify the level of consciousness of an animal at slaughter, some authors refer to the presence of delta waves, others to a significant and sustained reduced brain activity, or to the impairment of EP. Some combine several criteria. In some cases, the different criteria may lead to divergent conclusions. This is partly due to the circumstances in slaughterhouses that make measurement very challenging: EEG recordings may show artefacts because of the difficulty in maintaining the electrodes in place and/or the existence of electrical interference. Furthermore, it should be kept in mind that although impairment of EP clearly indicates a loss in the brain's ability to integrate sensory information, the presence of EP only means that the integrity of the sensory pathways involved has been preserved but not necessarily the perception of stimuli and awareness.

The effectiveness of stunning can be assessed by other methods based on the measurement of blood pressure, the observation of postures (animal collapsing or not) and various reflexes (palpebral-ocular or respiratory reflexes, physical reactions to noxious stimulation, and righting reflex of the head or of the body). However, vestibulo-ocular and respiratory reflexes depend on the activity of the brainstem that may persist despite a state of unconsciousness. Therefore, a lack of reflexes indicates that the activity of the brain stem is profoundly disturbed and that the animal is unconscious while their presence does not necessarily mean that the animal is conscious.

Conclusion

Examining physiological criteria renders the identification of pain possible in many animals. The means are often invasive and are generally based on complex methodology. The results may be difficult to interpret since stressful situations void of any nociceptive component often lead to similar physiological changes. Hence, the experimental conditions required to ensure accurate identification of the presence of pain using physiological criteria render this tool impractical for use in situ on farms or in slaughterhouses. Physiological criteria remain nevertheless very useful, especially in mammals, for the identification of sources of pain and in the development and validation of protocols for pain management and of objective scoring systems for pain assessment.

3.3. Behavioural responses

Behaviour in animals and in humans denied of verbal or written communication may constitute valuable criteria for identifying and locating pain (Table 2). However, as is the case for other criteria, using behaviour as a tool has its limitations. The first one is the variability in behavioural expressions both between animal species and within each species, according to the context. Another limiting factor is that the interpretation of behaviours by the observers, whether breeders or veterinary surgeons, differs according to their knowledge of the behaviour of the species, of the individuals and their personal perception of pain. Some behaviours such as apathy, self isolation or anorexia may also be seen in situations of stress or discomfort without nociceptive components. In addition, the behavioural response to a noxious stimulation may vary over time, or be expressed differently by individuals of the same species or breed. Behavioural responses may be modulated by endogenous analgesic mechanisms that are triggered in response to pain. They may also be influenced by specific physiological states such as pregnancy and parturition in mammals or egg laying in birds. One must therefore remain cautious in the interpretation of behaviour even when it may be very evocative of pain.

Despite the limits mentioned above, observation of behavioural responses (vocalizations, activities and postures, facial expressions) is one of the methods most frequently used by scientists and veterinary practitioners to characterize animal pain. This method has significant advantages because it is generally non-invasive and is fairly sensitive. Methodological precautions must be taken in order to avoid problems of interpretation and to validate the criteria used. Firstly an ethogram should be established to characterize the behavioural repertoire of the species and to define the conditions of expression of each relevant activity, its function, and the ontogenetic and phylogenetic changes.

Several behaviours can be distinguished: automatic behaviours to escape from the noxious stimulus (reflex withdrawal of a limb); behaviours to avoid the stimulation of the painful area (resting, analgesic postures such as limping); behaviours intended to signal the existence of pain to conspecifics and to encourage them to either avoid stimulating the painful area, or to lick, rub or scratch the area to relieve pain (this behaviour probably masks nociception through other sensory signals); behaviours that facilitate learning and thereby help the animal avoid subsequent noxious stimulation. It is important to conduct observations on animals subjected to a painful procedure, in association with an anaesthetic or analgesic treatment for some and without for others, in order to ensure that the criteria used do indeed reflect pain, and not just a stress response resulting from interactions with the operator.

In cattle and sheep, pain induced by numerous husbandry procedures has been analyzed using this method. Most of the behavioural criteria chosen as indices have been validated by cross-comparison between responses and by comparing the responses of animals that were subjected to an intervention to those that did not, either in addition to receiving or not receiving an analgesic treatment for each group. This method has been partly validated for pigs and for birds for some painful situations, but hardly at all for fish exposed to nociceptive stimuli.

In ruminants and pigs

Behaviours to be taken into account are well described for a number of painful procedures (tail docking, castration and dehorning) according to the stages of the procedure and the techniques used (see Chapter 4 for details of these procedures). Some studies have compared different behavioural criteria for sensitivity (ability to identify a painful situation) and reproducibility of measurements. Comparisons with physiological criteria have also been conducted to estimate their sensitivity.

Vocalizations are frequently used as indicators of pain in mammals and several types of analyses can be undertaken. The number of vocalizations can simply be counted or the duration or intensity can be measured. The vocalizations can also be analysed by spectral analysis. Experiments during castration in pigs have shown an increase in the number and intensity of vocalizations, as well as changes in their spectral characteristics. All of these changes may be reduced or eliminated by local anaesthesia.

Reflex withdrawal responses are frequently observed in animals subjected to a noxious stimulation. These

behaviours are used to measure the response to a controlled noxious stimulus in cattle or sheep. The measures include, for example, the latency to leg withdrawal or kicking when a limited area of the leg, shoulder or rump is subjected to a painful stimulus. Laser beams heating specific parts of the leg have thus been used to characterize the reaction of cattle to pain in certain contexts.

Defensive behaviours during painful procedures are also very common. Movements of legs and of the body during castration or teeth clipping in young piglets, jumping or kicking during hot-iron or liquid nitrogen branding in cattle are typical examples. During branding, the animals also push much more strongly onto the sides of their restraining cage than in simulated situations. Defensive behaviours (kicking for example) can also be observed when touching a painful area.

Certain other behaviours that are directly linked to a painful area are relatively easy to interpret. This is the case, for example, for licking, rubbing or scratching which may reduce the intensity of the nociceptive signals (see above). Avoidance behaviours and analgesic postures are observed in complement to behaviours stimulating the painful area. One typical example is limping. Lesions of the leg often lead to a reluctance or inability to bear weight on one or more limbs and to a high score for lameness in cattle. Objective scoring systems are available to quantify the degree of lameness (Table 3). That the scores are directly linked to the level of pain is evidenced by the fact that they are lowered when the animal receives analgesic treatment. Instead of conducting a visual observation of the animal, it is possible to determine the degree of lameness by measuring the weight the animal puts on each leg by using sensors, as it has been demonstrated in cattle for example.

General behavioural disturbance such as reduced food intake, reduced mobility, a high level of agitation or, conversely, prostration, as well as changes in behaviour towards humans are often described after a painful procedure or during chronic pain, such as that associated with lameness.

Table 3. Scoring for lameness in dairy cows (from Thomsen et al. 2008[3])

	Uneven gait	Arched back, walking	Arched back, standing	Short Strides	Head bob	Affected leg evident	Reluctance to bear weight
1 Normal	No	No	No	No	No	No	No
2 Uneven gait	Yes	Yes	No	(Yes)[a]	No	No	No
3 Mild lameness	Yes	Yes	Yes	Yes	No	No	No
4 Lameness	Yes	Yes	Yes	Yes	Yes	Yes	No
5 Severe lameness	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[a] Uneven gait and short strides may be difficult to identify

In birds

As for mammals, flight or withdrawal reactions are observed when a painful area is stimulated. Defensive behaviours during painful procedures are also very common.

Vocalizations may be used to reveal the existence of pain in birds as in mammals. The calls emitted when an individual is being pecked by other birds are however described as being only moderately loud, softer than the distress calls emitted during capture. However, methods as elaborate as those used to characterize pig vocalizations during castration are not available for use with birds.

[3] Thomsen P.T., Munksgaard L., Togersen F.A. (2008). Evaluation of a lameness scoring system for dairy cows. Journal of Dairy Science 91(1): 119-126.

Birds inhibit some spontaneous movements and postures to avoid stimulating specific painful areas. As an illustration, late beak trimming of chickens and turkeys reduces pecking. Removing the end of the beak may temporarily reduce food intake, drinking and pruning. As in mammals, lameness is sometimes observed, with birds adopting a posture that allows them to avoid stimulating a painful area of a leg. In comparison to healthy animals, lame chickens spend less time walking, feed less frequently and are more often seen lying when they eat. The time spent lying or standing on one leg decreases after an analgesic treatment and the effect on behaviour is dose dependent.

It seems that after a while chickens that cannot escape from painful stimuli cease to show defensive or avoidance reactions. Feather-pecked chickens, for example, eventually adopt a lying posture with the head drawn into the body.

In fish

In very few studies has the relationship between behaviour and nociception in fish been analysed. In the studies that have been conducted, behavioural responses were not measured in a systematic and standardized manner. However, the results indicate that some fish are able to learn to avoid noxious stimuli. In studies on trout that were submitted to a noxious stimulus (subcutaneous injection of acetic acid) the fish displayed avoidance behaviour, stopped ingesting food and expressed behavioural changes, such as rubbing the injected area and body swaying. These behavioural changes could last for several hours but were diminished when an analgesic treatment (morphine) was given which shows that they were the direct consequence of the injection of acetic acid.

At slaughter

Numerous studies describe aggressive interactions (pigs, cattle), mounting behaviour (bulls), slipping and falling (all species) as possible sources of pain. Behavioural indicators (drooping posture, avoidance reactions, for example) can also be used to assess the level of consciousness.

Conclusion

Behavioural responses are very sensitive criteria for detecting pain and are suitable for observations on farm or in slaughterhouses. However, considerable methodological precautions are required and the conditions of observation of the species as well as the animal's physiological state and experience must be taken into account in the interpretation. Observers should be sufficiently trained to identify and interpret the behavioural indicators of pain correctly.

3.4. Criteria related to livestock productivity

Pain may have detrimental effects on some behaviours, like feeding, and may stimulate the release of stress hormones that affect metabolism, immunity and reproductive function. A decrease in livestock productivity can be expected which is the case for growth rate (average daily weight gain), milk production, egg production and feed conversion ratio. However, as opposed to the behavioural and physiological impairments, these changes do not take place immediately. They appear at a later stage if the impairments persist for a length of time. They can still be useful criteria for alerting farmers, particularly when it is not possible to observe all animals individually. In addition, animal mortality can be used as an on-farm indicator of pain as it is likely that death is preceded by painful phenomena.

In pigs and ruminants

Assessing the direct impact of pain on cattle production has been the purpose of only a few studies. The adverse effects of pain are more commonly extracted from work investigating the impact of stress on economic criteria and on agricultural productivity or on health problems in cattle. Some studies do show that the use of local anaesthetics to reduce pain limits the weight loss that usually results from castration.

In cattle, stress has detrimental effects on the reproductive performance of males and females, due to interference with the secretion of sex hormones. In general, musculoskeletal disorders affect the reproductive performance in both sexes as well as milk production in cows, but whether this is due to a lower feed intake, the activation of the HPA axis or inflammatory processes is unknown. The economic impact of other diseases has been quantified in dairy cattle (e.g. mastitis) however, as in the case of lameness, what is attributable to the disease itself cannot be distinguished from what is due to pain. Nevertheless, studies comparing sick animals that either received or did not receive analgesic treatment suggest that pain plays a significant part in the economic loss. There are hardly any studies on beef cattle available.

In pigs, several authors have tried to characterize the impact of teeth clipping, tail docking and castration on the growth of piglets in experimental situations. These interventions do not seem to affect the growth rate, excepting when the intervention penalizes the piglet's access to the teats of the highest milk-producing glands of the udder (as was the case in studies on selective teeth clipping where only some piglets in the litter had their teeth cut) or in the case of castration performed on males before 3 days of age. Tail biting may cause reduced growth rate, increased morbidity and mortality, and any injured parts of the carcass may be seized at slaughter after inspection and removed from sale. Lameness may be the cause of reduced growth in young pigs, low reproductive performance in mature animals, and premature culling of sows and boars from the piggery.

In birds

In poultry, feather pecking can be a major welfare problem in laying hens since victims of repeated pecking show apathetic behaviour and reduced food intake leading to reduced egg laying. Beak trimming is carried out to alleviate this problem (see Chapter 4). It is known that lameness may result in reduced growth rates or even mortality but overall there is little data on the consequences of pain on animal production. As for mammals, pain is often associated with diseases that may themselves have a direct effect on the performance of the animals, in which case it is difficult to identify the part played by pain itself. In addition, because of bird density it is impossible to evaluate individual performances on a poultry farm, which makes the use of criteria based on animal productivity to identify pain difficult when only a small percentage of birds are affected.

In fish

In the only studies in which the negative consequences of exposing farmed fish to stress were investigated, the focus was on animal performance (growth, reproduction, immunity or adaptation). In none of these studies were the effects of noxious stimuli taken into account.

Conclusion

The direct impact of pain on livestock performance has been assessed in very few studies. Criteria based on livestock productivity are of little use in assessing pain and are most often used in addition to other criteria or as warning signals, especially when the observation of individual animals is impossible.

3.5. Multi-parametric scales for assessing pain

The physiological and behavioural responses to pain provide a clinical overview from which pain can be assessed in a reasonably objective manner. The simultaneous observation of several indices evocative of pain is indeed correlated with a higher probability that the animal in fact feels pain.

Furthermore, a multi-parametric approach is recommended in the assessment of pain in animals as it appears that pain intensity is usually proportional to the number and the severity of the indices observed.

Although each individual parameter cannot reflect the level of pain taken on its own, there is an overall relationship between all the clinical signs observed and the level of pain. This global view should enable the assessment of the intensity (low to high), the frequency (occasional to continuous), the duration (acute to chronic) and the type of pain

(see classification of pain in Chapter 2). These scales should help in deciding whether or not to treat pain and in what manner, in assessing the effectiveness of a treatment, and monitoring pain over a given period of time.

In pigs and ruminants

There are no real multi-parametric pain scales for these species, but relatively simple scales for assessment are available to help detect locomotor problems, particularly in cattle (Table 3). These are only based on observation of animal postures and gait.

More complex evaluation scales ought to be developed for assessing pain on farm. Criteria based on tissue damage and behaviour could be used on farm for pigs and ruminants. The observations could be made by farmers, veterinary surgeons and technicians even though a training course might be necessary. One could add criteria based on livestock productivity knowing that they are generally less sensitive than behavioural criteria, as well as some basic physiological parameters like changes in respiratory rate. These evaluation scales could be designed using some of the measures that were selected for use in the Welfare Quality® project on the assessment of the welfare of farmed animals, such as those specific to tissue damage and health (lameness, coughing, diarrhoea). Any information gathered in slaughterhouses on carcasses being removed by an inspector because of health problems or cannibalism, should also be included.

In birds

No multi-parametric scales are available in poultry for the identification of pain or the measurement of pain intensity. The only scoring system available is based on observations of walking activity to measure the severity of locomotor abnormalities. Behavioural criteria are very rarely used given the difficulty posed by the huge numbers of animals raised together on poultry farms. In consequence, the assessment criteria could be based on tissue damage and livestock productivity instead.

Existing multi-parametric scales

Multi-parametric scoring systems are only available for rodents, dogs and cats (post-surgery care) and horses. They cannot be extrapolated directly to pigs, ruminants and poultry in on-farm situations but they will be mentioned as examples. These scoring systems have in common a strong emphasis on behavioural parameters. In most cases, the aim is to detect abnormal behaviours induced by pain. However, behaviours are specific to the species, the breed, the individual temperament and the context more than clinical and physiological variables are. In addition, the location and the type of pain, and its source, influence behavioural expression. It is therefore necessary to validate the behaviour displayed in a specific situation for each species and each physiological state.

In France, the most frequently used scoring system in veterinary medicine was developed by the Veterinary Association for Animal Anesthesia and Analgesia for the care of dogs after surgery. It takes into account a global subjective assessment of pain, the general demeanour of the dog, its interactions with the observer, its heart rate and its reaction to manipulation of the operated area.

This type of scoring system reduces the inter-observer variability. A score is assigned for each parameter. The total score provides information on pain intensity and is compared to the classification of the World Health Organization (WHO) so that the most appropriate treatment can be given if treatment is deemed necessary. Three levels of pain have been defined in this manner, corresponding to three types of treatments with increasing antalgic properties: NSAIDs (e.g. salicylic acid), weak opioids (e.g. codeine) in combination with NSAIDs, and strong opioids (e.g. butorphanol) given in combination with NSAIDs.

The decision to change from one level of pain treatment to the next is taken after the assessment of the pain experienced by the patient and the pain relief afforded by the existing treatment.

A multi-parametric scale has been developed recently for horses that were subjected to experimental orthopaedic pain (Table 4). This scale was evaluated by comparing animals receiving different types of painkillers. The results suggest that the behavioural responses, including posture and pawing, and the reactions to palpation, are the best criteria because they are reproducible, sensitive and specific.

Table 4. Pain scoring system used in horses in an experimental situation of orthopaedic pain
(from Bussières el al., 2008[4])

Physiological response		**Score out of 12**
Heart rate	Normal compared to basal level (increased by < 10%) Increased by 11 to 30% Increased by 31 to 50% Increased by > 50%	0 1 2 3
Respiration rate	Normal compared to basal level (increased by < 10%) Increased by 11 to 30% Increased by 31 to 50% Increased by > 50%	0 1 2 3
Stomach rumble (movement of food in the gastrointestinal tract)	Normal motility Reduced motility No motility Hypermotility	0 1 2 3
Rectal Temperature	Normal compared to basal level (variation < 0.5°C) Variation between 1°C and 1.5°C Variation between 1.5°C and 2°C Variation > 2°C	0 1 2 3
Reaction to humans		**Score out of 6**
Reaction to human presence	Attentive to people Over-reaction to auditory stimuli Over-reaction to aggression towards auditory stimuli Stupor, prostration, no response to auditory stimuli	0 1 2 3
Reaction to palpation of the painful area	No reaction Mild reaction Resistance Violent r eaction	0 1 2 3
Behaviour		**Score out of 21**
General appearance	Glossy coat, head and ears low, no hesitation to move Glossy coat, alert, occasional head movements, no hesitation to move Restless, ears erect, dilated pupils, abnormal facial expressions Excited, constant movement of the body, abnormal facial expressions	0 1 2 3
Sweating	No evidence of sweating Damp when touched Wet when touched Sweating excessively	0 1 2 3
Kicking the abdomen	Standing calmly, no kicking 1-2 kicks / 5 min 3-4 kicks / 5 min >4 kicks / 5 min, attempt to lie down and roll	0 1 2 3
Stamping the ground	Standing calmly, no stamping 1-2 stamps / 5 min 3-4 stamps / 5 min >4 stamps / 5 min	0 1 2 3
Posture and gait	Standing calmly, normal gait Leaning slightly, weak muscle spasms Abnormal distribution of weight, one leg off the ground Analgesic posture (trying to urinate), prostration, muscle spasms	0 1 2 3
Head movement	No movement 1-2 lip and head movements / 5 min 3-4 lip and head movements / 5 min >4 lip and head movements / 5 min	0 1 2 3
Appetite	Eats hay quickly Eats hay hesitatingly Shows little interest in hay, eats very little, mouthing without chewing or swallowing Shows no interest in and does not eat any hay	0 1 2 3

[4] Bussières G., Jacques C., Lainay O., Beauchamp G., Leblond A., Cadoré J.L., Desmaizières L.M., Cuvelliez S.G., Troncy E. (2008). Development of a composite orthopaedic pain scale in horses. Research in Veterinary Science 85(2): 294-306.

Conclusion

Whatever the level of sophistication of the scoring systems, pain can only be assessed correctly if the evaluator has been properly trained and if the scoring system is well adapted to the species and the situation encountered. In other words, the method of evaluation will be different for pain-related lameness in sows, mastitis in dairy cows and feather pecking in broilers. The considerable task of developing and validating scoring systems for assessing pain in farm livestock has yet to be undertaken.

3.6. Summary

The various types of measures available for assessing pain can be combined to evaluate pain in farm animals as objectively as possible. The criteria for assessment are more or less detailed depending on the species considered (Table 5) with a much wider range of criteria for mammals than for birds, and even less for nociception in fish.

The existing measures, whether they are based on tissue damage, physiological responses, behavioural responses, or livestock productivity, are not sufficient to make a reliable diagnosis of pain in farm livestock when used individually. The solution therefore lies in the development and validation of multi-parametric scoring systems that are based on the combination of these criteria. Such methods have been developed in other species for post-operative care (dogs, horses) and should be adapted for use with farm animals. This will be challenging as these new scoring systems must be adapted for routine on-farm use within the constraints posed by the rearing conditions.

Given the progress in knowledge of farm animals, the requirements for future research on pain assessment differ according to the species. There is a need for developing and validating multi-parametric scoring systems for ruminants and pigs, identifying and validating criteria to characterize nociception in fish, and for research in all areas for farmed birds. Concerning slaughter, research is needed to clarify the relationship between physiological and behavioural responses of unconsciousness, and between these criteria and the absence of pain.

Table 5. Development status for different types of measures used for assessing pain / nociception in various broad categories of livestock

Measure	Pigs/Ruminants	Birds	Fish	Slaughter	Advantages	Disadvantages
Tissue damage	+++	++	+	++	- Often non-invasive	- Requires combination with other criteria - Diagnosis may only be post-mortem
Physiological responses	+++	+	-	++	- Sensitive	- Not specific - Not suited to on-farm conditions as difficult to use - Often invasive
Behavioural responses	+++	+	+	++	- Sensitive - Non-invasive	- Not always specific - Varies according to species, physiological state/stage of development and source of pain - Not reproducible if insufficient training
Livestock productivity	+	+	-	Not applicable	- Non-invasive	- Poor specificity - Not sensitive

(+++) Numerous studies and measures already in use, (+ +): some studies, (+) preliminary data available but validation required before use, (-): no studies currently available

4. Sources of known and/or potential pain in farm animals

In Chapter 2 we defined pain and the concepts related to it and in Chapter 3 we discussed methods of measuring it. Now, in Chapter 4, we aim to identify the main sources of pain in farm animals including the specific issues for each type of production before looking, in the last chapter, at ways of managing pain in animal husbandry. Also, we will analyse for each class of livestock (pigs, ruminants, poultry and fish) the comprehensive list of sources of established or potential pain reported in the literature. This analysis will not include game birds such as pheasants, partridges and wild ducks for which there is very little information to draw meaningful conclusions and which were not part of the expert panel's terms of reference.

In this chapter we will not only cover the sources of pain associated with the rearing practices of animals but also those related to slaughter, from the transport of the animals up until the time of their being put to death. In addition, we will cover the role of genetic selection in the development of certain painful conditions. We will not be discussing sporadic or unprovoked disease conditions except if their frequency and severity can be related to the conditions in which the animals are reared. However, the way in which they are detected (Chapter 3) and dealt with (Chapter 5) are in no way different and pain linked to these diseases should be handled in a systematic manner. In addition, for some surgical procedures, this chapter will describe in particular the use or not of local anaesthetic during the operation bearing in mind that analgesia may be used postoperatively. Aspects of pre-, peri- and post-surgical anaesthesia/analgesia will be dealt with more thoroughly in Chapter 5.

4.1 Background to the different types of animal production and their regulation

The system of animal production is one of the vital elements in preventing potential pain in domestic animals. Domestication and then the development of large scale breeding operations have, in effect, given rise to particular practices and activities that have led to known or potential pain and also to pain that is specific to each type of animal production. In general, we will see that populations of animals that have been subject to strong genetic selection specifically for production traits seem to be more susceptible to some health disorders.

The protection of animals within these systems of production is regulated. In general, in Europe, these regulations about animal welfare come from two sources, the Council of Europe and the European Union. The Council of Europe is an intergovernmental organisation of which the European Union as well as its member states form a part. Its permanent committee adopts generalist agreements and clarifies them with specific recommendations. An agreement about the protection of farmed animals was adopted in 1976. Six months after recommendations are adopted they become mandatory for the contracting parties unless they have notified the Permanent Council as to why they are not or are no longer able to implement them. At the level of the European Union, the treaty of Amsterdam (1999) affirmed that animals were sentient beings and that the European Community and its member States were responsible for the welfare of animals. The European commission, or its executive, was made responsible for working out the proposals and how they should be regulated (http://europa.eu/documents/eur-lex/index_fr.htm). One general directive establishing the minimum standards for the protection of animals raised on farms was adopted in 1998 (98/58/CE). The texts adopted at the European level are applicable to each member State after being passed into national law for the directives and immediately for regulations.

4.1.1. Pigs

There are three major systems of rearing pigs: First, breeders who produce piglets and who have only sows, their piglets and sometimes a few boars for detection of heat. Second, fatteners who buy the piglets and rear them to about 186 days of age for a mean live-weight of around 116 kg. Third, breeder-fatteners who have both breeding sows and growing pigs. There are a few more that 27 000 commercial piggeries who house nearly 500 animals each on average. Virtually all of the sows and fattening pigs belong to breeder-fatteners. There are around 15 million pigs in France of which about 1.2 million are sows. Annual production of carcasses is around 25 million. Slaughter is done in 182 abattoirs concentrated essentially in the west of France. Almost all production is in

“conventional” piggeries since “organic” piggeries contribute only 0.5% of sows and about 0.2% of pig meat. The amount of quality-labelled pig meat is also small, being only about 2% of production.

Most sows and practically all fattening pigs are housed in closed buildings. During pregnancy, sows are run in groups or are held individually mostly on slatted floors in buildings specially designed for breeding or gestation. About 10 days before farrowing the sows are transferred to specialised farrowing houses where they are confined in individual pens with slatted floors. When the sows are raised outside, they are not, of course, totally confined but are housed individually in small pens where they have huts for farrowing. Sows are generally run in “batches”, that is, their reproductive cycle is synchronised. This facilitates adoption or “cross fostering” of piglets at farrowing and thorough cleaning and disinfection of the pens between each batch. The piglets stay with their mother until 25 days of age except in “organic” piggeries where they must stay for a minimum of 40 days. At around 30 kg, or 2.5 months, the piglets are transferred into fattening units where they are generally housed on slats in conventional piggeries and on straw in organic or quality-labelled piggeries. Overall, rearing of pigs is very successful from a husbandry point of view because sows average 2.5 farrowings and wean 27 piglets per year. Meat animals are slaughtered at around six months of age with a daily weight gain of nearly 680 g per day and a feed conversion ratio of 2.7 (i.e. 2.7 kg feed for every 1 kg gain in live-weight) between weaning and slaughter. These figures are not available for organic piggeries but are much poorer.

European legislation imposes certain constraints on the housing and conduct of piggeries (directive 91/630/CEE modified by directives 2001/88/CE et 2001/93/CE). Added to these are the constraints imposed by the law for organic piggeries and by the code of conduct for quality-labelled pork. The present set of rules limits painful interventions in the pig industry. So, directive 2001/93/CE forbids all painful procedures outside of those used for therapy, diagnosis or identification. Nonetheless, there are several exceptions (see section 1 of the Appendix). Thus, tail docking and teeth reduction by clipping or grinding is allowed during the first seven days after birth. Also, castration of male pigs by means other than tearing the tissues, which is forbidden, is permitted up to seven days. These practices can be performed by a veterinary surgeon or a trained and experienced operator using appropriate means and hygienic conditions. Tails may be docked after seven days of age if anaesthesia using an analgesic is performed by a veterinary surgeon. Teeth clipping and tail docking cannot be carried out routinely but only when there is evidence that the sows’ teats or the ears and tails of other pigs are being injured. In Norway and Sweden the law requires anaesthesia at the time of castration while in other countries like The Netherlands the farmers have committed themselves to using anaesthesia. In these different countries the law or the commitment of the producers has foreshadowed the elimination of castration of pigs in the long term (see Chapter 5). Directive 2001/93/CE also contains a section on nose ringing pigs which is only authorised for out-door rearing systems. This is to limit the degree of soil destruction due to excessive rooting. In France, there are few sows in out-door piggeries so the effect of inserting nose-rings will not be covered further in this document.

European legislation (CE No. 889/2008) on organic animal husbandry of pigs plans to impose compulsory anaesthesia or analgesia for castration from 1st January, 2012 (articles 18 and 95), regardless of the age of the piglets. In addition, it will forbid teeth-clipping and tail docking, but will allow possible exceptions for reasons of health of the animals (article 33).

4.1.2. Ruminants

The number of cattle herds has decreased since the end of the 1960s. Agricultural statistics from November, 2007 fixes the number of farms running cattle at 208 000. The reduction in the number of herds has been accompanied by an increase in the number of animals per herd. In 2007 there was an average of 92 cattle per farm as opposed to only 38 in 1983. Dairy farms and beef herds with more than 30 cows accounted for 87% of milking cows and 79 % of suckling cows. In 2007, in France, there were 19 124 000 cattle of which 3 759 000 were dairy cows (mainly Prim'Holstein, Montbéliarde and Normande) and 4 163 000 suckling cows (mostly Charolaise, Limousine and Blonde d’Aquitaine). The production of beef in France in 2007 rose to 1774 billion tonnes carcass-weight equivalent and the production of milk to 22 229 million litres.

About 50% of heifers are destined to be breeders and these are involved in dehorning. Nine percent of male calves from dairy herds and 5% from beef herds become steers. It should be noted that there are specific regulations for calves.

The total sheep flock stands at 8.2 million of which there are 5.5 million ewes spread over 75 000 farms. The number of flocks has fallen by 60% in 20 years. Milk production was 256 million litres in 2007. In goats, the total flock was 1.2 million head in 2007, of which 853 000 were does. Dairy goats produced 443 million litres of milk. The production of goat meat reaching the market, either as young goat or culled does, is relatively small.

The conditional requirements for receiving European aid take into account the concept of "pain" and refer to recommendations of the Council of Europe that are available on the site:
http://www.coe.int/t/fr/affaires_juridiques.

The main points are:

1. Operations involving the loss of a significant amount of tissue or modification of the bone structure of cattle should be banned, particularly:

- Modification or mutilation of the tongue,
- Dehorning by means other than surgical dehorning,
- Amputation of the tail.

2. Some exceptions to the bans proposed in paragraph 1 could include.

- Operations conducted for the purpose of veterinary medicine,
- The following operations, which can only be done when in the interest of the animal or if it is necessary for the protection of people in contact with the animal and carried out according to paragraphs 3 or 4 below :
    - Destruction or ablation of the horn at an early stage of its development (disbudding) to avoid later dehorning,
    - Dehorning if it done by surgical ablation of the horns,
    - Inserting nose rings into bulls or cows,
    - For the following operations which should be avoided whenever possible but which can be done if they conform to paragraphs 3 & 4 below and under the following conditions:
        - Castration of bulls and male calves, preferably by surgical ablation of the testicles, but on condition that the methods used do not impose pain or cause unnecessary or prolonged stress.
        - Castration of calves for fattening, if it is permitted by national legislation.
        - Notching or piercing of the ears if it is permitted by national legislation.

3. Operations in which the animals are subject to, or risk being subject to, considerable pain should be done under local or general anaesthetic by a veterinary surgeon or other qualified person conforming to the national legislation. Such operations include castration of cows, dehorning and disbudding of animals over 4 weeks of age.

4. Operations on animals that do not need anaesthesia should be conducted on animals in a way that causes no pain whatsoever nor unnecessary or prolonged stress. Such operations should be done by an experienced person and include, according to the conditions in paragraph 2, above:

- Destruction or ablation of horn buds in animals under 4 weeks of age,
- Inserting nose rings in bulls and cows,
- Notching or piercing ears of animals.

4.1.3. Poultry

There are seven types of poultry making a significant input to production in France. The genus Gallus is the most common in terms of volume of production as much for meat (broilers) as for eggs (laying hens) but they are also the most common in scientific research so there is much more literature about them. Production figures, per year and per type of bird, released by the National Office for Meat and Dairy Products and by the Institut Technique de l'Aviculture (ITAVI, Technical Institute for poultry production) are as follows: broilers, 705 million; laying hens for commercial eggs, 46 million, of which 20% are reared outdoors; turkeys, 73 million; mule ducks, 44 million; guinea fowl, 28 million; and quail, 25 million. Most of the studies that address the potential sources of pain in domestic birds focus logically on broiler birds and laying hens. There are a few studies with ducks and turkeys but there is practically no information on quail and guinea fowl.

We can distinguish two major types of farming alternatives: cage systems versus non-cage systems and confined versus free range systems. On the whole cage systems are those in which humans do not enter to look after the birds while in the non-cage systems humans are more heavily involved. Each species of poultry is potentially produced in several systems of production but the phenotypes and genotypes are often specifically associated with a particular method of rearing.

• **"Cage systems"** are used for the majority of laying hens and 80% of eggs for consumption are produced in this way. Cages are most often laid out in batteries and located within climate-controlled buildings, i.e. under confined conditions. The genotypes of birds used have anatomical and behavioural characteristics that, in the context of the rearing conditions, renders necessary specific husbandry procedures (de-beaking, de-combing, toe-clipping and shortening of spurs). At the selection stage, male and female breeding stock for the lines used to generate commercial genotypes are mostly raised in individual cages, but in France their offspring, which furnish the production stock for commercial farmers, are reared on the floor.

• **"Non-cage systems"** are used for the growing period for all meat bird production and for rearing the breeding stock for several species or production types such as broilers, turkeys and ducks. A certain proportion of laying hens of certain genotypes, probably less than 25% of the total flock, are also raised in these systems. The buildings used for floor–reared laying hens generally have a single level, are equipped with nest boxes and may or may not have access to an outdoor exercise run. Though not very common in France, another system for housing laying hens is the aviary. This system consists of several tiers of platforms and to a certain degree corresponds to a battery system without doors. Meat birds are generally floor-housed for reproduction. The sexes can be mixed (for broiler production) or separated (guinea fowl, turkeys and Pekin ducks for producing mulards ("mule ducks") in which case artificial insemination (AI) is always used.

With poultry, the European convention of 1976 for the protection of domestic animals has been increasingly strengthened by further recommendations of which several concern the poultry species "Gallus" (1995), web-footed birds (1999, 3 recommendations (T-AP [95/5], [94/3] & [95/20]) and turkeys (2001, T-AP [95/16]). For the poultry industry, special directives have been made about hens raised for table egg laying (88/166/CEE & 99/74/CE) and broiler chickens (2007/43/CE). In addition, directives and non-specific regulations about transport and conditions in abattoirs, feed additives, zoonoses, environment, traceability, and organic production (834/2007/CE et 889/2008/CE) have been adopted and can concern poultry species. Any national legislation in force can only be more restrictive than the European regulations, as is the case in certain countries for laying hens.

4.1.4 Fish

Production of farmed fish in France is divided between salmonids farmed in fresh water tanks (mostly rainbow trout), pond fish (carp, roach, pike) and ocean fish (bass, royal bream, croaker, salmon and turbot) reared in floating cages or in tanks on the sea-shore. The latest information puts the production of rainbow trout at 35 000 tonnes per year and 60 000 head of ocean fish alevins per year of which more than half is exported. Trout are produced in nearly 600 sites belonging to 400 operators of various sizes: 20% of them produce 80% of the fish. Most of the produce from trout farming is destined for human consumption and the rest is for restocking and for recreational fishing. Farming in ponds takes up 112 000 hectares and there are 80 operators who use this form of production solely for fishing or fishing activities associated with recreation and tourism. 12 000 tonnes of pond fish (of which 6 000 are carp) are produced annually and of these 9 000 tonnes are used to restock the fishing waters. Marine fish culture produces 8 500 tonnes per year of which 4 200 tons are bar and this is more than the amount of bar that derives from commercial fishing. Marine culture is confined to about 50 firms of which about 10 specialise in hatching and 80% of the annual trade of 60 million euros is generated by only 10% of these firms. When the price of these marine species is considered, the sales turnover corresponds to about 50% of that coming from trout production.

The Council of Europe has made a recommendation about aquaculture. European legislation is in the process of being set up and faces - a number of challenges. Notably it has to keep the economic sector viable, to guarantee food security and animal welfare, to resolve environmental problems and to stimulate research.

4.2. Sources of known and potential pain associated with the practice and conduct of farming

For each species or group of species (poultry, pork or ruminants) we outline here the main sources of potential pain with which the animals are confronted. We will cover this in conjunction with farming practices, the systems of production and slaughtering as well as with the impacts of genetic selection.

4.2.1. Sources associated with care and identification of the animals

There are some potential causes of pain such as abscesses that develop in some animals as a result of injections (of iron or vaccines) or from tattooing of piglets or ear-tagging for identifying animals (pigs, cattle, sheep, goats) or inserting nose rings to avoid behaviours that could pose problems for breeders (sucking among bulls or heifers, degradation of fields by sows in open air) but there is little literature and the consequences for pain seem to be minor. Complying with good practice for injecting iron or vaccines can reduce the risk of subsequent abscesses. To reduce pain and wounds following some practices used for identification, other systems using microchip implants are being developed.

Among other potential sources of pain we can identify surgical treatments and practices that are done to care for animals that have particular problems. For example, there are Caesarean operations in the case of cows having calving problems and hoof care involving paring to cure hoof problems in ruminants. Detection and management of these types of pain enters the medical domain and the possible need for analgesic treatment. Therefore they will not be covered in this report.

4.2.2. Sources associated with handling of the animals by humans.

The case of catching poultry.

Catching and transport of reproductive animals to another site or of all birds to the abattoir requires capture and carries a strong risk of wounds and fractures as a result of human intervention. As well, laying hens are very susceptible to problems of fracture at the end of their breeding life, particularly when they are removed from their cages. Effectively, they have brittle bones (osteoporosis) which results directly from the heavy metabolic toll associated with laying eggs as well as the cage-rearing. The fracture rate can be as high as 25% but this is very variable and depends on whether they are reared in cages or on the ground, the competence of the collection teams and the type of obstructions in the building. Since the 1980s mechanical harvesting of broilers and turkeys has developed wherever the shape of buildings permits. This technique generally means that the harvesting of the animals has a lower level of mortality than when catching is done manually.

The case of force feeding geese and ducks

The consequences of force feeding and the conditions of housing of certain genotypes of fat palmipeds (geese [3%] and ducks [97%]) to produce fois gras and magrets can be a source of pain. Two situations involving pain are envisaged here: 1, the force feeding itself which is practised for 11 or 12 days in the mule duck and 15-18 days in the goose. This practice is claimed not to be painful due to anatomical characteristics of the tissue in the wall of the digestive tract of the birds. However it can lead to accidental wounds or encourage pathological dermatological conditions: 2, Hypertrophy of the liver and steatosis[5] which is the equivalent of nutritional cirrhosis of the liver with neither tissue damage nor cellular degeneration and is totally reversible. Anatomical studies show that the liver cannot be the source of painful sensations in birds. The average cumulative level of mortality and culling of the

[5] Steatosis is lipid storage in the cells of an organ, eg in the hepatocytes in the liver where it is called fatty liver. In birds and fish, lipid synthesis takes place overwhelmingly in the liver, whereas it occurs mainly in adipose tissue in mammals.

"weakest" birds is about 2.5% in force-fed ducks but varies with the conditions of housing and management of the animals. It can be much higher in extreme situations such as heat waves. Further analysis of the causes of mortality and need for culling is necessary to understand better the effects of force-feeding on the physiology of the animal. The possible existence of stomach pains associated with the amount and speed of introduction of the food for force-feeding has not yet been studied.

The case of fish

The protocols for rearing that are currently in use imply that fish are manipulated frequently. They are manipulated in the phases when they are sorted, when their tank or breeding site is changed, when they have veterinary treatment, when they are weighed or when they are taken for slaughter. All of these operations imply that the fish are removed from their breeding environment for a variable amount of time. Techniques presently in use have usually been modernised and use systems that manipulate the fish rapidly while maintaining an aqueous environment at all times. For specific tasks on a small number of individuals, such as applying treatments, removing tissue or marking individual fish, the use of anaesthetic is more or less obligatory for the success of the operation. Where fish production is done under well-run and managed conditions it is unlikely that these sorts of manipulations produce substantial nociception.

4.2.3. Sources associated with the housing and management of the animals

Examples from poultry

The degree of prevalence of often-observed foot lesions, such as dermatitis of the foot (pododermatitis), keratosis, or swelling, depends on the rearing system and also on the genotype of the birds and the type of equipment. Pododermatitis is common in poultry and turkeys that are in fully closed conditions. This is also true in poultry that have access to a run. Pododermatitis probably causes little pain when it remains superficial but in an advanced stage, such as when ulcerated, these lesions are often infected and the development of pain is very probable. Certain types of litter favour the development of inflammatory pododermatitis. Thus, moist litter is much more likely than dry litter to induce inflammatory responses in the tissue of feet. The prevalence of pododermatitis has been proposed as an indicator to evaluate the level of welfare within a farm and to establish acceptable densities for individual breeding establishments (European directive on broilers). The relevance of this use as an indicator is still under evaluation.

Joint injuries and locomotive problems are a potential source of pain in domestic poultry. Thus, in broiler poultry, there is little movement by the birds. They spend a lot of their time sitting which is on a par with the rapid rate of growth that characterises the lines of birds used in this type of production. The incidence of postural problems and lameness is also high. Since the beginning of the 1970s, a regular census of lameness in industrial breeding establishments has confirmed this high prevalence. It shows especially the relationship between conditions of chronic physiological pain in rearing and the behavioural adaptations that are observed such as lameness and postural problems. This confirmation of distressful conditions or true pain is based on several types of observation: 1. The existence of nociceptors in the feet of poultry, 2. anatomical and anatomo-pathological data on the feet and pelvic joints that show several potential sources of pain related to bone deformation together with stress on the joints and dislocation of the tendons or simple tendonitis, and 3. Studies of behavioural pharmacology that show positive effects of analgesics or anti-inflammatory substances on posture and locomotion.

Examples from pigs

A significant source of pain in pig rearing arises from musculoskeletal problems, especially those caused by poor stance and walking difficulties and the resulting lameness. This lameness comes from many sources, including genetic factors in particular but also factors associated with the flooring, especially when it is too hard, with a lack of exercise when there is insufficient space and with the feeding regime when it encourages a rate of growth that is too rapid and hence problems with leg conformation.

Examples from cattle

Among the sources of potential pain many can be associated with:

- restriction of available space for the animal either in stalls or on slats,
- the quality of the ventilation and the density of the animals, factors that predispose animals to infections such as digestive or respiratory disorders in calves,
- the quality of the hygiene of the bedding for the animals - a primary source of pathogens that can cause, for example, intra-mammary infections and diarrhoea in calves,
- the type of flooring which, in cattle, can induce varying frequencies of lameness and foot problems,
- the quality of the feed and the modalities of its distribution which, if it is rich in fermentable carbohydrates, can lead to subacute ruminal acidosis along with many possible subsequent pathological problems,
- the mode of gathering the animals which can lead to agonistic interactions, more frequent combat and thus wounds and bruising, particularly if the group is large.

Examples from fish

Fish being bred domestically are subject to attack from predators all through their breeding cycle, which causes significant losses. For salmonids bred in fresh water the principal predators are birds such as heron and cormorants, and otters and martens. In a marine environment, seals and birds are the main predators. The consequences of these attacks are multiple. The fish may be killed but also they may only be wounded and thereby made vulnerable to infection. Different methods are used to reduce the activity of predators, for example, the use of nets and cages, installation of acoustic or visual systems to scare the birds or seals.

Fin erosion is a major problem that has been described for several species of bred fish, particularly for salmonids in European and American farms. The term fin erosion covers a variety of tissue problems ranging from a simple crack in the skin to necrosis of the tissue and even, sometimes, haemorrhaging. Affected tissues show signs of inflammation with hyperplasia of the epithelium, thickening and formation of nodules. In addition, as nociceptors have been found in fins it is probable that these conditions cause nociceptive responses. However, there are no existing studies and targeted research will be necessary to confirm this hypothesis. The main cause of fin erosion would be aggressive biting associated with fighting between individuals and the establishment of a dominance hierarchy. However, other, secondary causes are described in the literature such as handling the fish, abrasive substances in the interior of the rearing tanks, sun burn, exposure to stressful situations, or to corticosteroids which can modify the structure of the skin and its capacity to regenerate.

In general though, there is little data available on the prevalence of these afflictions (all species considered) in the different systems of rearing.

4.3. Sources of known or potential pain associated with mutilations

Regardless of the species, poultry, pigs or cattle, one of the principal sources of pain on farms comes from the practice of mutilations that are carried out for a variety of reasons (see Table 6). This is particularly the case when the mutilations are done badly.

4.3.1. Mutilations done to reduce the risk of injuries to animals

The case of teeth clipping of piglets

Teeth clipping/grinding is seen as a means of reducing injuries to the teats or vulva of the sow as well as to other piglets in the litter. It involves clipping or grinding the canine and incisor teeth (needle teeth) of both jaws, making 8 teeth in all. These milk teeth, which are very sharp at birth, are clipped with a pair of pliers or ground down with an electric grinder by the breeder on the day of birth or soon after. The proportion of the tooth removed varies between 1% and 31% depending on the operator and the tooth being treated. At the behavioural level, the piglets are seen to be defensive during grinding and display strong chewing movements just after teeth clipping/grinding. By contrast, the interval between the intervention and first sucking is unaffected compared with control animals, similarly to what one sees in other behavioural activities such as lying, standing or activity at the udder. Neither is

Table 6. Examples of frequent practices that may cause pain in domestic animals (other than slaughtering) and the reasons proposed for practising them

Species	Potentially painful practice	Reason
Poultry	Debeaking	To prevent pecking of other birds
	Decombing	To prevent pecking of combs and visual problems in some species that are seldom used in France
	Caponising	To improve the quality of the meat, prevent pecking
Pigs	Castration	To improve the quality of the meat by removing unpleasant odours, and behaviour by reducing aggression and sexual mounting. This practice reduces feed efficiency and increases the cost of production
	Tail docking	To reduce the risk of tail biting in pigs reared on slatted floors
	Teeth clipping	To reduce injuries to other piglets and is believed to avoid damage to the teats of the sow
Cattle	Dehorning	To avoid blows and injuries inflicted on herd-mates and humans and to facilitate entry of animals into stanchions or corridors
	Castration	To allow steers and heifers to be run together in extensive systems, to improve the quality of the meat and reduce aggression among herd-mates and towards humans. However, it also reduces the rate of growth which leads to the use of hormones in much of the world outside of France

there any evidence of activation of stress-response systems in the minutes and hours following teeth clipping. Histological analysis of longitudinal sections of clipped teeth at different ages shows anomalies that may be potential sources of pain. In particular, one sees breakages in the pulp cavity, dentine fracture, bleeding, pulpitis, abscesses, osteodentines (deposits of calcium that are similar to scar tissue) and necrosis. In all, the frequency of abnormalities is higher when the teeth are clipped with cutting pliers than when they are ground. In view of the fact that the dental pulp is innervated and that the structure of teeth in pigs is similar to that in man, it is highly likely that these sorts of anomalies induce severe pain.

In summary, the information from the literature suggests that there is mild and moderate pain during, and for some hours after teeth clipping to which we can probably add the later discomfort associated with inflammatory reactions and abscesses. Given that several studies suggest that the benefits of teeth clipping are limited, it has been suggested that this technique, which according to the law is not to be used routinely anyway, be abandoned.

The case of debeaking poultry

Beak trimming and other mutilations of the beak are the practices that have been most studied and are the most controversial. The reason for these practices is to reduce the prevalence and consequences of pecking which can produce wounding and cannibalism. Pecking behaviour is a potential source of pain in animals that are victims and can also lead in certain cases to high levels of mortality in breeding establishments. Such deaths oblige the farmer to carry out debeaking later in life and so provoke further pain in the debeaked animals. In practice, three techniques are used: 1) cutting the end of the beak, or just the upper jaw for ducks, with small secateurs after immobilising the head, 2) cauterisation using a heated blade, a technique called hot blade beak trimming, 3) infrared beak treatment using a machine that focuses a high intensity infra-red (IR) beam at the tip of the beak. The different terminologies associated with operations on the beak are thus a function of the extent of the amputation, the method used and the age of the animals (early if done before 10 days and late if done after 10 days); debeaking (more than a third of the beak sectioned early by cutting), beak trimming, (less than a third of the beak sectioned early by cutting) or IR treatment of the beak (less than a third of the beak sectioned early by IR).

Behavioural and electrophysiological indicators as well as neurobiological knowledge lead us to believe that there is severe pain particularly in the hours after debeaking. Debeaking is more traumatic than trimming and IR treatment of the beak particularly if the operation is done at a late stage. In the chicken, discharges are seen in the intramandibular branch of the trigeminal nerve during the first four hours after trimming. In addition, the long term risk associated with debeaking is the formation of benign tumours of the nerves which are tissue masses formed by uncontrolled and extensive regrowth of Schwann cells and nerve fibres. These tumours, called neuromas, have been described in humans and can provoke severe pain for the life of the animal. This risk is also higher when the amount of beak removed is greater and when the operation is carried out when the bird is four weeks or older. Functionally beak trimming affects the anatomical integrity of the bird and, as a consequence much of its behaviour such as ingestion of food and drink, preening of feathers, gathering material for nest building, attack and defence. A hypothesis of chronic pain similar to “phantom pains” experienced by humans after amputations (see Chapter 2) has been proposed whereby the birds have a “phantom beak” but this has been put to question by recent studies on the anatomical organisation of nerve centres in the brain.

The case of tail docking of piglets

The aim in tail docking piglets is to avoid cannibalism post-weaning or during fattening, a problem encountered especially in piglets reared on slatted floors. Tail docking is a routine practice in a lot of piggeries regardless of the sex of the piglets. In 2007 more than 90% of piggeries in the European Union were involved. The tail is cut on the day of birth or soon after, either with a scalpel, cutting pliers or a cauterising knife. The amount of tail removed varies from a few millimetres (the tip only) to more than three quarters of the length. Physiological and behavioural studies indicate that the cutting itself is very probably a source of pain. The tail is innervated along its whole length in new-born piglets and they react defensively and cry out as the tail is cut. However no activity in the stress-response system has been seen in the minutes and hours after tail docking. We could presume that there would be chronic pain following the removal of the tail similar to that described in humans after amputation (see Chapter 2). Indeed, several studies refer to the presence of tumour-like neuromas, known to cause hyperalgesic phenomena, or phantom pains like those in human amputees but this question is still unresolved since it has not been confirmed by behavioural studies in the pig.

In summary, we can suspect mild pain in the hours that follow tail docking and chronic pain in the days and weeks that follow. However the frequency and intensity of chronic pain from this source suffered by piglets are not known.

The case of dehorning cattle

The main aim in dehorning calves is to minimize the risks of animals causing injury to each other or to humans by horn butting. It also allows easier access to feeders and systems of confinement. Practically all dairy calves that are to be reared are currently dehorned. It is common in France to dehorn beef breed heifers between 16 and 24 months of age. Animals of beef and hardy breeds generally have horns that are bigger than those of dairy breeds because they were mostly bred for pulling yokes. Cultural or aesthetic factors enshrined in breed standards have maintained these characteristics. The methods of dehorning should be adapted to take into account the specific conformation of the horns. Late dehorning is more frequent in France than in many other countries particularly Anglo-Saxon countries which have favoured the rearing of genetically polled cattle such as the Aberdeen Angus or the selection of genetically polled cattle including lines of beef cattle such as the Charolaise or Limousine that originally come from France. Despite the fact that the practice of dehorning is covered by precise recommendations in the European agreement and the code of good farming practice, it seems that very few breeders use local anaesthetic and analgesics (around 20% for anaesthetic and 10% for analgesics, see also Chapter 5). Legislation in France prevents them from obtaining anaesthetics and practicing local anaesthesia. Dehorning without anaesthetic or analgesia is known to be painful for both young cattle and adults. It induces, in particular, a big change in cortisol levels and behaviour. Among the methods used, the technique of dehorning (disbudding) by heat cauterisation seems to be less painful than the use of chemical pastes or crayons which can lead to lesions of the eyes if these products run into them. In turn, these methods would be less painful than dehorning by metal shears.

Overall it appears that for dehorning calves:

- Disbudding by cauterisation is the least painful method.
- The ideal analgesic protocol is a combination of sedation with alpha 2 agonists like xylazine, a preoperative administration of non-steroidal anti-inflammatory drugs (NSAIDs) and local anaesthesia of the cornual nerve before the operation (cf Chapter 5).

Regulations for dehorning cattle and goats: recommendations about dehorning of cattle are laid out in a Council of Europe agreement on farm animals but there is, so far, no such regulation in France. The agreement makes clear that dehorning by methods other than surgical excision should be banned with two exceptions: (1) cattle less than 4 weeks old for which disbudding without anaesthetic by cauterisation or chemical means is possible; (2) for cattle more than 4 weeks old dehorning, destruction or ablation at an early stage of the part producing the horn by surgical methods or by cauterisation is allowed if it is done under anaesthetic by a veterinary surgeon or qualified person. Investigations in France and Canada report various effective field practices carried out by breeders, without systematically resorting to an analgesic protocol. The code of good practice proposed by French professionals recommends dehorning of cattle before 6 weeks of age. For the dehorning of adult animals, it is recommended that an analgesic or, preferably, anaesthetic be used.

The case of removing combs and/or wattles from birds

Several procedures are used in birds: (1) removing the comb, known as dubbing, is not often carried out in France. It is often associated with caponisation or with particular genotypes of laying and broiler breeds in which the comb is excessively large. The comb limits the field of vision and is associated with injuries. It reduces feed intake and interferes with copulation ; (2) wattle removal[6] is done for the same reasons in reproducing turkeys ; (3) operations on the feet, like declawing and despurring are practices that are designed to prevent wounding during interactions between pen-mates during the growth phase (Muscovy ducks) and during mating during the reproductive phase in certain species.

These practices probably cause pain because some of the tissue removed is richly innervated. However, as far as we know, there are no studies that have analysed the degree to which these practices cause pain.

4.3.2. Mutilations to reduce the risk of outbreak of disease

The case of tail docking in cattle

In France tail docking in cattle was practised to avoid injuries to the tail and consequent gangrene after trampling underfoot particularly when animals were run on slatted floors. In other countries, especially in New Zealand it was practised to avoid contamination of the clusters of milking machines by pathogens. It is almost never practised in cattle any more in France because it has now been shown that it gives almost no advantage to the animal except in certain therapeutic applications. In addition, the removal of the tails is a source of acute and chronic pain particularly associated with the development of necrotic growths where the cut is made, particularly when done on adult animals.

This practice is authorised in France, including by the code of practice for organic agriculture, even though it is banned in many countries such as Switzerland, Germany, Denmark, Sweden, the United Kingdom and several states of Australia.

The case of tail docking in sheep

Tail docking of sheep is practised to (1) reduce soiling of the rear end by faeces and urine and consequently reduce fly-strike and (2) facilitate obstetrical practices and avoid complications at parturition. It is performed most often in

[6] Wattle removal is the act of cutting the protruding portion of the caruncle (or wattle), which is a bright red fleshy membrane that covers the head and extends over part of the beak and neck.

lambs under two weeks of age and is carried out in three major ways: surgically, by cauterisation or by constriction, usually using rubber rings. It is mainly directed towards future breeding animals and especially maiden ewes for reasons of hygiene and the surveillance of lambing. The information in the literature shows that all the methods used are sources of acute and chronic pain even if they do not lead to death. Constriction by rubber rings appears to be the most painful procedure.

4.3.3. Castration

This is an age-old practice in all species and is found in all systems of rearing whether intensive, organic or quality-labelled. It is done for reasons that are connected with the quality of the meat or the behaviour of the animals.

Piglets

The major motivation for castrating piglets is to improve the quality of the meat of male pigs by eliminating male odours in the carcass brought on by sexual hormones. In addition, it makes rearing easier by reducing the amount of aggressive and sexual behaviour of the animals and hence the amount of wounding. In Europe 80% of pigs are castrated by surgical means. In France, as in most other European countries, castration is performed by surgery without anaesthesia or analgesic treatment (see Chapter 5 for the cultural, regulatory and economic constraints that explain in part this situation). Behavioural observations and physiological studies show that this practice is a source of acute pain as the tissues involved are innervated. During castration most piglets scream loudly and at a frequency that is characteristic of painful situations. Just after the castration the HPA axis and the sympathetic nervous system are activated but this activation disappears by the next day. The behaviour of the animals also changes following castration. This happens in the first hours after the operation and is marked by a reduction in movement, isolation, prostration, less time at the udder of the sow, stretching of the hind legs, trembling and spasms. Some of these disturbances continue for several days after the operation, for example, huddling up, showing less synchrony of activities with litter mates, scratching the incision in the rump and tail wagging. Finally, there does not seem to be any clear effect of the age at castration on the outcome in terms of the pain caused by the procedure. Even though healing is better when the piglets are castrated very young, it seems that they have a slower growth rate due to being disadvantaged in the competition for teats which results in their use of the less productive ones.

In summary, castration is a practice that has positive effects in the long term on potential sources of pain in intensive piggeries by limiting aggressive behaviour and thus lesions, wounds, lameness and fractures. However the information in the literature clearly shows that pain is acute during castration, then strong for several hours afterwards, followed by more moderate pain for several days following castration.

Cattle and sheep

Castration of cattle and sheep results principally in a reduction in the level of testosterone. There are a range of reasons for castrating. The first is to allow joint rearing of young females and castrated males (heifers and steers for cattle) on the same pastures in grazing systems. Secondly, it reduces between-animal aggressiveness and sexual activity and improves the docility of the animals. It also results in greater marbling of the meat (increased intramuscular fat), a quality appreciated by the consumer, but leads to a slower rate of growth than in entire males. There are three major methods of castration of calves; crushing of the testicular cord, usually by the Burdizzo clamp, constriction, usually using rubber rings and surgical removal.

Studies into castration of cattle show that it is a source of acute and chronic pain. This is the case regardless of the technique used and/or the age of the animal being castrated. However there are some differences in intensity according to the technique and age. Increases in cortisol levels and the incidence of abnormal behaviours and postures are manifestations of this effect. The existence of chronic pain is inferred from specific behaviours associated with the site of castration and abnormal posture. It seems that the intensity of the pain at the time of castration with the Burdizzo clamp is less strong than with surgical castration, although the Burdizzo is rarely used in France because of its cost, its danger to the operator and the possible failures of the technique. Surgery is the

technique that causes the briefest pain. It is as dangerous for the operators as the Burdizzo but is much less onerous. There are no failures or setbacks except for possible post-operative problems. The rubber ring is the means of castration most used by breeders, except in the United Kingdom. It induces chronic pain that is more difficult to detect and to manage than that observed following castration by other methods. Finally, the intensity of the pain is proportional to the age of the animal. Only a minority of breeders use anaesthetics to castrate their calves except in Switzerland where its use is mandatory. In contrast most veterinary surgeons use anaesthetics for castration (see Chapter 5). In sheep, the situation is similar: The Burdizzo method is recognised as being the least painful while the rubber ring method is the most practical for its ease of use. However the practice is not common in France.

In summary, it is evident from the literature that castration of calves should be practised:

- as early as possible; preferably by one week of age and not later than 45 days of age,
- by using the Burdizzo clamp method,
- using an analgesic protocol associating administration of NSAIDs 20 minutes before the operation with a local anaesthetic by infiltrating 2% lidocaine (about 5 ml) into the distal scrotum. Adding the use of an alpha 2 agonist at or around the time of the operation is also worth considering.

Poultry

Castration of poultry, or caponisation, is mainly practised in chickens and more occasionally in guinea fowl. It has a double purpose: (1) to avoid pecking and the significant mortality that can result and (2) to obtain marbled meat of the desired gustatory quality. Caponising consists of removing the testes, which are internal, by way of one or two lateral incisions, most often on conscious animals without anaesthesia or analgesia. Typical behavioural indicators such as vocalisation and raised blood concentrations of corticosterone indicate a high level of stress from the time of capture and restraint onwards then strong reactions during the surgical act. Combined use of a tranquiliser and an anaesthetic has been proposed. General anaesthetics are difficult to use in poultry because there is a wide variation in the duration of effect of the anaesthetic and the first animals to wake up must be immediately separated from their mates to avoid cannibalism and post-surgical complications resulting from them soiling the wounds of their still-anaesthetised companions (see also Chapter 5).

4.3.4. Non-use of pain relief for mutilations

Even though the mutilations described previously often have many justifications, such as health, decreased risk of wounding and husbandry benefits, it does not make them any less painful and this is exacerbated by the fact that the pain produced is not treated pharmacologically. In Chapter 5 we highlight more explicitly the therapeutic possibilities, but we can note at this point that very few studies are available on ways of implementing the interventions that we have described. We must also emphasise the legal impossibility of having access to certain substances either for use by the breeder (for example local anaesthetics) or for their utilisation in commercial animals (cf Chapter 5). Finally, for some species of fish and poultry there existing chemicals that can be used and the scientific questions about the reality of pain in these species remain unanswered. (cf Chapter 2)

We have available some information that comes from surveys of breeders and veterinary surgeons working in the pig and cattle industries in France and several other countries in Europe (see Chapter 5). For castration in pigs, there is no treatment for pain presently in use in France. In cattle, the practices used by veterinary surgeons in France and the rest of Europe seem similar except for some specific situations like the dehorning of calves, for which the differences can be explained by the legislation in place in the various countries. The main differences for the other mutilations relate not to the use of local anaesthetic, which is used practically universally, but rather to the use of complementary, post-operative treatment with NSAIDs which seem to be used more routinely in the rest of Europe (see Chapter 5) than in France. Some studies report that the cost of substances and the regulations that control their accessibility are the stumbling blocks to their use by breeders. There is general agreement however in these studies on the existence of pain in cattle and on the necessity for pain relief, as much for ethical and medical reasons as for husbandry considerations.

4.4. Known or potential sources of pain associated with genetic selection

From the 1960s onwards, animal selection became organized in breeding programmes for genetic improvement of commercial animals, looking in most cases at the economic viability of animal breeding in the broad sense. The combination of genetic selection for improving production and enhancing the conditions of animal husbandry may have had consequences for the metabolism, reproduction and/or the health of the animals.

4.4.1. Examples in pigs

A significant source of pain concerns locomotor problems, and particularly problems of leg conformation and lameness which follows from them. This lameness is multifactorial but genetic factors are strongly implicated in the weakness of the limbs linked to problems of ossification of the cartilage (osteochondrosis).

A well-known example of the negative effect of genetic selection in the pig is a muscular problem, PSE, which develops as a result of an acute stress or exposure to halothane anaesthetic (see Chapter 5) and is characterised by rapid death of the animalCertain breeds of pig, particularly the Piétrain, have a high frequency of this syndrome as well as a general muscular fragility. Animals of this genotype often have locomotor problems when being moved (mortality, inability to move, cardio-respiratory trouble) and this is probably associated with pain. However, the Piétrain is only maintained as a pure breed by specialised studs and artificial insemination centres because it is used exclusively as a terminal sire. The relevant genes are recessive, so pigs destined for the abattoirs who carry them are unaffected by the syndrome and do not pass on the anomaly.

Certain behavioural disorders that are multifactorial in their aetiology and are partly heritable, seem to be more frequent in genotypes selected for lean carcasses. A case in point is aggressiveness which is a potential source of social stress and tissue damage due to biting. Similarly, it seems that there is a genetic element to tail biting, with probably a higher risk in genotypes selected for very lean carcasses. A particularly undesirable form of aggression is the behaviour of the sow towards her newborn litter.

Yet another adverse effect of genetics concerns the selection of sows for higher prolificacy which is accompanied by an increase in the mortality of the piglets. In addition, with certain very prolific sows, the number of piglets exceeds the number of teats which forces breeders to carry out cross fostering of piglets or to wean them at a very early age.

4.4.2. Examples in poultry

Selection of poultry for production traits has had significant impact on the appearance of situations involving pain. Furthermore, the very practice of genetic selection involves measuring the characteristics of the animals intended for selection on an individual basis, and so they have to be reared in individual cages. This type of accommodation can lead to an increase of the prevalence of foot problems, leg conformation and dermatitis of the foot in meat birds.

The most common selection criteria are: for meat birds (1) selection for growth, which results in an increase in sexual dimorphism in certain species and improvement in the food conversion index, two characters that are genetically linked; (2) selection for increased mass of pectoral muscles which constitute the most "noble" meat of the carcass, which leads indirectly to joint problems in the lower limbs in certain genotypes due to the forward displacement of the centre of gravity of the animal; and for laying hens (3) selection for the number of eggs produced, and therefore intense phospho-calcium metabolism which increases the risk of mineral deficiency and with it an increased risk of fractures by the end of the laying life because the skeleton becomes more and more osteoporotic as the animal gets older.

In addition, in certain species genetic selection has been accompanied by behavioural responses that can cause injuries or panic likely to cause suffocation, for instance in the mule duck which has well-established escape reactions when facing humans.

Of course, these potentially-stressful indirect consequences of the selection process should be weighed against the benefits of the possible prevention of much pain by introducing characters which are associated with pain prevention into selection schemes (cf. Chapter 5).

4.4.3. Examples in cattle

Several sources of pain potentially linked to the genetic selection of cattle are described in the literature. Undesirable genetic correlations have been shown between milk production and parameters associated with metabolism and health. The health of the highest producers of milk in dairy breeds seems more fragile than that of the others. In addition, susceptibility to mastitis, respiratory diseases and calving difficulties as well as risks of digestive disorders, lameness or wounds of the limbs and joints are implicated in several studies as genetic factors indirectly linked to selection for criteria that relate to the capacity to produce milk.

In beef cattle, calving difficulties are frequently seen, especially in certain breeds and in young animals, such as those calving at two years of age. An example is that of the muscular hypertrophy linked to the presence of the double muscle gene (culard gene) which can cause problems in the limbs and, above all, difficult calving, which leads directly to an increase in the number of Caesarean sections. The procedure is potentially painful if practised without anaesthetic which raises questions about the repetition of Caesareans necessary to extract calves of the Belgian Blue breed of cattle (see Chapter 5).

As far as we know, no study has examined the genetic impact of breeding programmes for beef cattle on aggressive or deviant behaviours. There is reasonable genetic variability for ease of handling and docility. This could have implications not only for the safety of the stockbreeders but also for the frequency of the incidents during handling and therefore on painful events. However no experimental proof yet supports this hypothesis.

4.5. Known or potential sources of pain associated with slaughtering

In France there are about 64 commercial poultry abattoirs and 340 large animal abattoirs of which some are specialised (29 for pork; 9 for adult cattle and 2 for calves). The number of abattoirs has fallen in recent years. About a third of these slaughterhouses are licensed to carry out Halal and Shechita ritual slaughter.

4.5.1. The regulatory framework for slaughtering

The slaughter of commercial animals destined for consumption is regulated by articles R214-63 and R214-72 of the rural law code. We will refer here only to some particularly important points. First, the fact that the measures provided by these articles are not applied in three specific cases:

- technical and scientific experiments which are under the control of veterinary services,
- animals put to death during cultural or sporting occasions,
- game killed in the course of hunting (see article R214-63).

All stages of the slaughter process are covered, starting with transportation and including lairage at the abattoir, immobilization, stunning and finally killing/ slaughtering the animal (note that slaughtering corresponds to causing the death of animals by bleeding). Article R214-67 points out that all sites, installations, and equipment of abattoirs must be designed, constructed, maintained and used so as to spare the animals any avoidable stress, pain and suffering.

Among the most important stages of the process is the stunning of the animals which is compulsory before slaughtering or killing, except in three cases:

- ritual slaughter,
- putting farmed game to death when the killing method leads to immediate death. The techniques for killing animals without bleeding them are only permitted for small farmed, feathered game and for fowl for recognised traditional culinary usage (article R214-72).
- putting animals to death as a matter of great urgency/ emergency slaughter (article R214-70).

For ritual slaughter, special measures are fixed by the rural law code (articles R214-73 to R214-75) which point out that it is mandatory for ritual slaughter to take place in an abattoir, after mechanical immobilization for sheep, goats and cattle both before and during bleeding. It must, by definition, be carried out by a sacrificer authorized by the recognised religious organisations.

For killing or slaughtering animals outside of slaughterhouses, special rules are fixed by articles R214-77 and 78 of the rural law code and concern only the following cases: the fight against infectious diseases, dangerous or potentially dangerous animals, animals bred for their fur, chickens and embryos that are eliminated at the hatchery level, or certain big farmed game slaughtered or put to death on the farms where they are reared and where hunting is allowed.

The measures for slaughter or killing animals as part of a biosecurity process (for example outbreaks of certain epizootic of diseases), are regulated and will not be covered in this review. The killing conditions are defined only for animals with fur and chickens and embryos eliminated at the hatchery level. In addition, euthanasia of animals on the farm by stockbreeders is a currently debated topic (see Chapter 5). We have practically no data on the number of animals put to death on farms by stockbreeders or the conditions under which this is carried out, except for the particular case in rabbits where one study notes that about 7 % of young rabbits are eliminated by farmers at birth. It seems that this type of euthanasia is also practised in certain cases by pig farmers but no data are available. This situation has led the Veterinary Academy of France to suggest that this practice be tolerated in particular situations and under precise conditions of practice and regulation.

4.5.2 Pain associated with slaughter of farmed animals

The period prior to slaughter

This period consists of loading the animals at the farm, transport to the abattoir (with or without passing through a sale-yard), unloading at the abattoir and holding them in lairage until it is time to lead them to the stunning area. This period is complicated with several factors that could potentially cause pain. Handling procedures and aggressive interactions between animals are the most frequent reasons for animals having pain. Many steps have been taken by the industry in this domain. The first is the training of the persons associated with transport and handling. The design of trucks has been overhauled and the transport fleet has been improved to a great extent. Handling yards have also been improved considerably to avoid mixing young cattle, to facilitate the movement of animals and to minimize risks for both them and the handlers. It should be pointed out that these improvements concern not only animals being sent to abattoirs but are equally applicable to animals that are transported long distances to change farms. In particular this concerns cattle from dairy herds intended for fattening (young bulls fattened in Italy for instance).

Poultry are gathered either manually or mechanically (see section 4.2.2.) and transported to the abattoir. At the abattoir, when stunning by electronarcosis is in use, the bird is hung upside down by the legs and moved, head down, to an electrified bath. This technique is probably painful, especially if the shackle size is badly adapted to the size of the legs.

Ruminants have to be moved from the lairage area at the abattoir to the stunning box. The most frequently used methods to encourage forward movement of the animals through the facilities comprise not only vocal means, but also include prodding with sticks and electric goads, both of which cause pain. A recent study showed that more than 97 % of carcasses of large cattle had contusions, some due to blows with a stick, but also because the animals bash against barriers when being moved or due to fighting among themselves. The frequency and degree

of contusions are a function of the density of the animals in trucks, whether or not they have been through a sale-yard and the quality of roads and conditions during transport. In the abattoir, these contusions may be due to poorly designed or unsuitable equipment in the raceways and the stunning box (absence of devices for head restraint, swinging rails and anti back-up devices). In slaughter calves, sliding and falling, linked to their being frightened or having spent a long time in transport and waiting at the abattoir, also cause contusions and potential pain.

In pigs, a common practice is to mix several rearing pens of animals together for transport and this leads to fighting between animals, resulting in lesions and wounds.

In fish, the preparation for slaughter requires the animals to be grouped. They are either slaughtered next to the rearing pond, transported a short distance to a slaughter room at the breeding site, or transported over a distance of variable length to a specialized abattoir. All of this requires that the fish be removed from their normal environment and often exposes them to air. At the moment we do not know if exposure of fish to air causes nociception. Nevertheless, harvesting the fish in big nets constrains them and can damage scales or gills, and is a potential source of nociception. Different techniques for loading fish are used depending on the species (by pump, fishnet, or conveyor belt). Harvesting and loading result in hormonal changes and behavioural responses that are more or less marked according to the species and the conditions. These responses vary according to the techniques used.

Stunning

Except under exemption, pre-slaughter stunning (either reversible or not) is mandatory. The objective of stunning is to induce rapidly an unconscious state that lasts long enough so as the animal does not regain consciousness during bleeding. The technique itself should not cause pain. The method of choice depends in general on the species. Depending on how the technique is implemented, it may induce psychological stress due to isolation or unfamiliarity with the environment. The main techniques used are: electronarcosis, the captive bolt and stunning by gas.

Bearing in mind the signs covered in Chapter 3 under the heading of slaughter, the source or sources of pain at each of the stages of stunning and/or bleeding were evaluated on the basis of the time taken for the animal to lose consciousness. We will discuss unconsciousness rather than pain, because the state of unconsciousness guarantees the absence of pain.

By passing a current through the brain, electronarcosis (or electrical stunning) consists of inducing a synchronized discharge of the neurones (epileptiform EEG). These neurones no longer function properly until they are repolarised. In addition, the electronarcosis causes a release of glutamate and aspartate in the brain which are also partly responsible for the loss of consciousness. Depending on the species (pig, cattle or sheep), and according to the age of the animal, "head only" electronarcosis causes epileptiform waves for 25 [±2] seconds in calves, (250 Volts for 3 seconds), or for 65 [±3] seconds in sheep (200 Volts for 3 seconds). We often see a tonic stage then a stage of more or less regular contractions (clonic), of variable length according to species. The main behavioural sign of lack of consciousness is the absence of a corneal reflex, which reappears before the clonic stage in sheep, and after it in pigs and calves. If a third electrode is put on the breast ("head-body" electronarcosis), it leads to cardiac fibrillation. Preliminary studies show that "head-body" electronarcosis causes cardiac fibrillation that extends unconsciousness and often results in the death of the animal by cardiac arrest. "Head-body" electronarcosis therefore seems to augment, in most species, the effectiveness of electronarcosis (unconsiousness in 24 [±12] seconds in sheep), but these results are yet to be confirmed.

In France, electronarcosis is used principally for pigs, sheep and poultry. Electronarcosis has the advantage of having an instantaneous effect and being employable for all species. One of the major disadvantages of electronarcosis, especially when it is automated, is associated with poor handling and difficulties in positioning the electrodes and adjusting the settings. If wrongly used electronarcosis can stimulate pain receptors and cause pain without inducing unconsciousness. Depending on the abattoir, the quality of the equipment and the size and shape of the animals, the amount of current passed can be insufficient and painful. Thus, a New Zealand study in 2001 reported extreme values of percentages of unsatisfactory electronarcoses varying from 2 to 54 % in sheep depending on the circumstances. In these animals, the presence of wool might have contributed to the ineffectual electronarcoses.

The second technology for stunning is the captive bolt. The bolt can be penetrating (the most commonly used which produces mechanical tissue damage) or not penetrating. In both cases, the technique produces a percussion, or, in other words, jolts the brain within the skull causing axonal damage. The captive bolt also produces considerable lesions on the skull and in the brain. It can be a reliable and very efficient way of inducing an instantaneous and lasting loss of consciousness. However, in practice, and depending on the type of animal, failure rates may range from 6 to 16 % in cattle at commercial abattoirs, and therefore there is a risk of pain.

The third technology is stunning by gas. This comprises immersing the animal in a mixture of gasses, often containing a high concentration of CO2; in general 40 % for poultry and at least 70 % for pigs. Other systems use argon and nitrogen. The behavioural responses of the animals, notably agitation and the attempts to escape, strongly suggest that the perception of this gas is unpleasant, or even painful. In poultry, the addition of oxygen reduces the adverse reactions. The time taken to induce loss of consciousness varies with gas concentration, but is around 17 seconds for the pig (collapse of the animal) and from 32 to 34 seconds for poultry (closing of the eyes). The technique is widely used in some countries of Northern Europe. In France, several pig abattoirs have recently been equipped with this system (cf. Chapter 5).

Bleeding

The objectives of bleeding are to cause death of the animal and drain the blood from the carcass. There are two choices of incision site from which cattle and sheep can be bled: the throat (severing both carotid arteries and both jugular veins) or the thorax. For the latter in cattle, the jugular groove is first cut at the base of the neck. In sheep and pigs, thoracic bleeding is done with a single stroke. Persisting unconsciousness and death result probably from the lack of oxygen due to reduction in arterial pressure and the absence of breathing.

In calves and adult cattle, the effectiveness of bleeding from the throat is very variable. This variability is explained by the formation of blood clots, which appears to be related to the retraction of the artery within its connective tissue sheath. Impaired blood flow is reported in some studies to occur comparatively often (in up to 16 % of adult cattle and 25 % of calves). It is especially a problem if the stunning is reversible (electronarcosis) or in slaughter without pre-stunning (special case of ritual slaughter, see below). It postpones the death of the animal and can result in its regaining consciousness in the case of reversible unconsciousness. In general, thoracic bleeding is more efficient than bleeding from the throat as it allows better blood flow, but it takes longer and is trickier to perform in adult cattle so can only be used if the animal is stunned.

Unilateral bleeding gives poorer results in pigs and poultry than bilateral bleeding.

In the special case of ritual slaughter, the animal is not in a stunned state during bleeding. The throat is cut in a single gesture with a very sharp, long knife. The operator cuts the skin, the muscles, the trachea, the carotid arteries, the jugular veins and the vagus nerve, but leaves the spinal cord and the spinal arteries and veins intact. Cutting the arteries causes a loss of arterial pressure which reduces the exchange of nutrients and oxygen between blood and organs, including the brain, resulting in a variable delay in the animal losing consciousness and dying. The effectiveness of ritual slaughter in inducing unconsciousness varies according to the species, but also according to the technical competence of the operator and the equipment used and also according to the individual animal. In sheep, unconsciousness develops rapidly, after 14 seconds on average. In calves and adult cattle, there is wide variability in the time taken to loss of consciousness, with extremes from 8 seconds to 11 minutes, the longest interval being due to the formation of blood clots at the caudal ends of the cut carotids. In the absence of such blood clots, isoelectric EEG is acquired between 36 and 54 seconds. A limited number of studies in the field show that blood clots occur in 17 - 18 % of the animals during Muslim (Halal) and Jewish (Shechita) slaughter. In addition, in poultry, as in cattle, depending on the abattoir and the effectiveness of the operator, manual bleeding gives very variable results in terms of the time delay until loss of consciousness. For example, in chickens depending on whether bleeding is uni- or bi-lateral, the time taken to loss of consciousness varies from 60 to 120 seconds. As in the case of stunning, depending on how the technique is implemented, it may induce psychological stress due to isolation or unfamiliarity with the environment.

There are other potential sources of pain during exsanguination in conscious or poorly-stunned animals, such as inhalation of blood into the trachea in cattle or technical problems in poultry (for example, section of the spinal cord during bleeding), but, so far, there are no studies that confirm the existence of pain linked to these practices.

The specific case of slaughter of farmed fish

Farmed fish are slaughtered by different methods, according to species and their habitat.

Bleeding and asphyxiation in air are methods that bring about slow death (several minutes to several hours depending on the temperature and the species).

Percussive stunning by a blow to the head is a technique which, if correctly performed, causes virtually instantaneous death. It can be done manually or, less commonly, with an automatic mechanical stunning system. This automated system has been shown to be useful for several species but its use is still delicate, and can also make bleeding difficult.

Anaesthesia by CO2, achieved by saturating the water with CO2, causes, intense muscular activity in salmon for the first minutes followed by death after 5 minutes. It is not known if the perception of CO2 is nociceptive for fish, but, in several species, it leads to changes in hematocrit and in plasma concentrations of glucose and cortisol.

For electronarcosis an electric current is passed through the water. With the right settings, it can render eel unconscious (lack of response to a nociceptive stimulus) almost instantaneously. In turbot, this electrical stunning induces a short period of unconsciousness, associated with the secretion of a lot of mucus which could be a sign of discomfort. Unconsciousness can be induced in salmonids by using the appropriate settings of voltage and time.

The partial destruction of the brain by inserting a spike ("spiking") requires skilled technical ability, but it causes very quick death to sea bream. However if the procedure is badly carried out, signs of nociception and intense muscular activity have been noted.

Immersing fish in a chilling tank of very cold water (around 0°C) can be considered equivalent lethal anaesthesia for some species. This method is widely used for bass and sea bream which are temperate water fish species. It is not suitable for turbot or trout and strong stress reactions have been seen in these two species.

The most adapted method of stunning depends mainly on the species because depending on their habitat, certain fish are very resistant to being immersed in a chilling tank or to an increasing shortage of oxygen. For certain species such as the sea bream, the eel and the African mackerel, the morphology of the skull prevents sufficient transmission of a concussive blow to the brain necessary to induce unconsciousness. Because of the level of precision required, "spiking" is only used for species like salmon and tuna that are of sufficient size, greater than 4 kg, and can be handled individually. Finally, in an attempt to optimise the conditions of slaughter, different methods can be used together. Thus, the method of "live chilling", which associates cold anaesthesia in oxygenated sea water at 1°C, with asphyxiation in CO2 at 1°C, followed by bleeding has been developed for salmon with good results. Likewise, it is possible to render eels immediately unconscious and maintain them in an unconscious state until they are killed by combining electronarcosis with exposure to a strong concentration of nitrogen in the water.

4.6. Summary

Certain practices and conditions in animal husbandry and slaughtering that are carried out for a range of reasons (husbandry, human health and safety and cultural), are painful or potentially painful, notably:

- interventions (mutilations) that are often carried out without analgesia in farming,
- housing conditions, which can be a factor in producing and aggravating problems of lameness for example,
- all steps in the chain between the farm and slaughter (rounding up, handling, holding, transport, etc).

In addition, genetic selection based solely on production criteria can lead to an increase in the susceptibility of animals to certain health disorders and therefore to potential pain.

Some mutilations are done to avoid behavioural problems which could be very harmful for the animals. These behavioural problems are multifactorial but very often have a genetic component.

The short term effects of mutilations are reasonably well enough known, but the long-term effects are still largely unknown, for example, whether or not hyperalgesic phenomena or phantom pains exist. Similarly, the consequences of humans performing these practices on the subsequent relationship between humans and animals have not been sufficiently studied.

There are regulations and recommendations to avoid or restrict painful practices, but sometimes they are not followed. In addition, there is a gap in the law concerning slaughtering outside of abattoirs by stockbreeders themselves (euthanasia), as is the case in pigs for instance among other species.

5. Means of reducing pain in farm animals

The aim in this chapter was to identify avenues for eliminating or reducing pain in animals while also taking into account their practicality and cost. The principles and means of action are first described in general terms, and then examined in detail for several procedures that have been identified as being painful, such as castration or slaughter. Possible actions based on new genetic selection models are also envisaged.

5.1. General approach for reducing pain on farms

Chapter 4 pointed to both the reality and the complexity of the issue on pain in farm animals as it is raised in livestock production but also in human health and safety and cultural considerations.

The welfare of livestock in intensive farming systems is based on five basic rights, as defined by the experts in the Brambell Committee in 1965. One of those rights explicitly mentions the absence of pain, injuries and diseases, by preventive veterinary care, rapid diagnosis and appropriate treatment, as a condition for the welfare of animals.

5.1.1. Major principles

The use of laboratory animals for scientific research has been the topic of extensive discussions aimed at minimizing and better justifying the resort to in vivo experimentation. This deliberation led to a methodological problem-solving approach aimed at providing guidelines for the use of animals in experiments. This approach proves to be exemplary in achieving one of the major goals of the present expert assessment: structuring pain management and reducing pain in farm animals. The principles of the 3Rs (Replace, Reduce, Refine) have been widely accepted since the 1960s and now strongly regulate the use of animals in experimental research. We will refer to them in the consideration of alternatives that eliminate (“suppress”) sources of pain in farm animals. The second step is to “substitute” painful procedures with others that are less painful. Most often this involves seeking techniques for which the intensity or impact of pain is minimized. If it is not possible to eliminate (“suppress”) pain completely, consideration should be given to relieving it (“soothing”) with pharmacological treatments such as analgesia or the use of local anaesthetics. The analogy with the "3Rs", designed to reduce the number of animals used in experimental procedures, led us to follow a similar methodology to limit pain in farm animals based on the "3Ss": eliminate sources of pain (“Suppress”), substitute painful procedures by other means (“Substitute”), and relieve pain in farm animals (“Soothe”).

In parallel to applying the "3Rs" principles, the use of laboratory animals has been monitored by establishing local ethics committees. The role of these committees is to supervise the use of animals in research and to assess whether the integrity of the laboratory animals is maintained. Although it would be more difficult to implement, it seems obvious that a similar surveillance of farming practices would permit a better understanding of and control over the sources of pain associated with the production of food derived from animals.

Overall, solutions found in the literature to improve upon the use of procedures known to be painful can be divided into five categories: (1) if the procedure is not justified and in the absence of alternatives, stop using the procedure (eliminate the source of pain: “Suppress”), (2) whenever possible, rear animals that no longer require the use of such procedures (eliminate the use of sensitive animals: “Suppress”), (3) replace the procedure with another one that is less painful (“Substitute”), (4) improve the procedure in order to limit pain intensity (“Substitute”), and (5) relieve pain (“Soothe”). Proposing the ultimate solution, which is to stop livestock production and therefore to stop eating animal products such as meat (vegetarianism) or even eggs and milk (veganism), does not fall within the scope of this assessment. Hence, this chapter focuses on farm practices causing pain, the sources of which are presented in the previous chapter, and the possible improvements that may be made on them.

5.1.2. The means of action

Several means are available to mitigate the suffering of farm animals:

(1) focusing on animals: changing genetic selection processes by including new criteria along with performance checks,

(2) focusing on industry conditions: changing farming practices and/or rearing conditions, changing the laws, training farmers, encouraging rearing requirements that take less painful practices into consideration, improved problem management,

(3) focusing on pain management: use of anaesthesia or analgesic drugs.

Focusing on animals: genetic improvement

The main focus of selection criteria for farm animals over the last 40 years has been on increasing productivity and improving product quality, such as selecting for leaner meat. This type of genetic selection has probably favoured the emergence of fear behaviour, abnormal aggressive behaviour, or a reduced ability to adapt to environmental constraints (for example resistance to heat), the development of musculoskeletal disorders, birthing difficulties (cattle), reduced survival of newborns in favour of higher fertility (pigs), or increased susceptibility to diseases. Robustness (or 'functional' traits) has been taken into account in selection schemes since the late nineties. For example, this applies for the leg conformation (poultry and pigs), the ease of calving (animals) and the newborn survival rate (pigs), the number of somatic cells in milk (dairy cows). This strategy has shown its effectiveness in reducing some sources of pain (less lameness, improved neonatal survival, decreased infection rates) and should be continued or even extended to other more complex characters (general resistance to stress, selecting against behavioural disorders). It should be noted, however, that the time required for the impact of such strategies to be visible depends on several factors: the heritability of the character, the selection pressure or the selection schemes implemented, as well as the interval between generations. Hence the benefit is only perceptible after several years.

Finally, since most painful situations are of multifactorial origin and include the effects of housing and animal management, genetic selection by itself is not sufficient to eliminate the problems.

Focusing on industry conditions

According to the context there is currently some leeway for minimizing or eliminating certain sources of pain caused by the industry conditions. This would mainly involve improving the facilities and the techniques or practices in use on farms and in slaughterhouses. Attempts to improve the welfare of farm animals are focused on three main factors that are often inter-linked: (1) the physical health and the satisfaction of the physiological needs of animals, (2) the minimization of negative situations (pain, fear, anxiety), and (3) the ability for animals to express their natural behaviours.

In the livestock industry increases in production efficiency need to be balanced with maintaining consumer safety from health risks e.g. ensuring the absence of drug residues and diseases. Thus, the means proposed to minimize or eliminate pain in the specific context of a livestock production system must take into account the legal, economic, health and safety and cultural constraints for farmers, and food safety constraints for consumers, as well as the medical and behavioural constraints for the animals.

Focusing on pain management

Pain is treated by administering drugs that affect either the ability to feel pain (general anaesthetics administered intravenously, intramuscularly or by inhalation) or the physiological mechanisms of pain (painkillers or analgesics). Anaesthetics induce a loss of consciousness; inhibit memory and the unpleasant perception of a noxious stimulus, although there are still changes in physiological markers. Painkillers or analgesics, administered orally or intramuscularly, reduce the animal's sensitivity to pain. Non-allopathic analgesic treatments (homeopathy,

naturopathy) and non-pharmacological treatments (osteopathy, acupuncture, physical restraining techniques such as the twitch for horses or hypnotic postures for sheep) are also available. However, there is insufficient scientific data on their effectiveness and their usefulness in specifically reducing pain to promote their use on a wide scale. It is nonetheless particularly worthwhile considering these alternatives in the context of farming since they reduce the need to resort to expensive allopathic treatments that are sources of residues in animal products.

5.2. Alternative means for preventing or reducing pain in farm animals

5.2.1. "Suppress": Can sources of pain in livestock be eliminated?

Non-surgical as opposed to surgical castration

Whatever the species or the method, castration of males is considered to be painful when performed without anaesthesia or analgesia (see Chapter 4). For cattle and poultry, there is no current alternative to surgical castration. In pigs, this procedure can be replaced by rearing intact males or by immunocastration (Table 7) as already practiced in some countries (for example, intact males in England and Spain, immunocastration in Australia and Brazil).

Table 7. Advantages and disadvantages of possible methods as alternatives to surgical castration of piglets without anaesthesia

Alternative method	Advantages	Disadvantages
(1) Rearing entire males in association with: *a- Sorting carcasses to remove those with too strong an odour* *b- Genetic selection to limit the release of malodorous substances*	- Leaner carcasses (better nutritional value of meat) - reduced nitrogen excretion due to better protein retention, hence less nitrogen in effluent - Lower production costs due to better efficiency of food conversion	- Presence of sexual odours due to the presence of androstenone and skatole - Other meat quality problems: “dark cutting” and / or less tender meat and softer fat - More aggression and mounting behaviour, and therefore deterioration of welfare conditions for some animals
(2) Immunocastration	- Efficient method to remove the sexual odours associated with the presence of androstenone and skatole - Feed conversion efficiency and nitrogen excretion prior to immunization close to that for entire males - Behaviour close to that of castrated males once they are immunized (less aggressive behaviour and mounting) - Available: vaccine received the European marketing authorisation in 2009	- Inspection of carcasses required to verify the effectiveness of the immunization - Behaviour close to that of entire males (mounting and aggression) prior to immunization - Reluctance of consumers because of vaccination against a sex hormone
(3) Surgical castration with anaesthesia and analgesia	- No side effects	- Additional costs compared to current practices - The administration of analgesia and anaesthesia only by veterinary surgeons or also by other authorized persons is currently being debated

However, all of these alternatives present disadvantages in their implementation (Table 7). In countries where piglets are not castrated, consumers complain about the presence of malodorous compounds in the meat. These are mainly androstenone, a pheromone secreted by the testicles, and skatole, a molecule derived from the intestinal metabolism of tryptophan, of which the degradation in the liver is inhibited by sex hormones. Pain relief (soothing) during surgical castration with anaesthesia and analgesia will be discussed later (see Section 5.3.3.).

Rearing entire male pigs for consumption is feasible if the percentage of animals with undesirable odours is reduced to a level that is economically acceptable, and if a reliable method of odour assessment can be put in use on the slaughter line. For effective evaluation of these odours, thresholds of acceptability for consumers must be defined and effective and inexpensive methods to quantify odours must also be available. Some procedures have been evaluated or are under development, but no satisfactory method is currently available. Genetic factors play an important role in controlling the amount of androstenone in the fat, and to a lesser extent, that of skatole which is more dependent on nutritional and environmental conditions. The identification of the genes involved in the production of androstenone and skatole has given some hope for a solution, or at least a partial solution, through genetic selection. However, the task is complicated by potential negative effects of a selection against androstenone on sexual maturation and the performance of the animals.

Immunocastration is another possibility and a commercial vaccine currently in use in some countries (e.g. Australia and Brazil) received European marketing authorisation in 2009. Although the method has been proven successful on a technical level, some animals may be missed in the vaccination program and therefore inspections will be required to ensure the carcasses are free of sexual odours (with checking procedures similar to those described previously for entire male carcasses). Furthermore, the effects on animal welfare are still poorly documented. Other uncertainties lie in the acceptability of the method to the general public and the risks taken by the personal handling and administering the vaccine. A recent Swedish survey shows that the potential health risk associated with the use of biotechnology is acceptable to Swedish consumers in order to improve animal welfare, so long as the taste of the meat is unchanged. In Switzerland, castration using anaesthesia and analgesia is being maintained in parallel to immunocastration so as both categories of products can be offered to consumers.

In conclusion, surgical castration of piglets without anaesthesia or analgesia could be replaced by immunocastration and the production of entire male pigs. Neither of these solutions is completely satisfactory at the present time and their implementation requires an adjustment of the processing of carcasses by the pig industry.

The case of castration of broilers (caponization)

Caponization or castration of chickens is mainly practiced in slow growing breeds. The primary objective is to obtain meat with specific organoleptic qualities which requires that the rooster does not reach sexual maturity. Another advantage of caponization is that it prevents the expression of aggressive behaviour, including pecking and cannibalism, which is most often seen in sexually mature animals. It should be noted that there are currently no satisfactory alternatives to castration without anaesthesia or analgesia (see Section 5.3.3). Caponization has been discontinued in some countries, including Belgium.

The case of teeth clipping in piglets

Stopping the practice of teeth clipping could be envisaged without causing major problems. Some studies have shown that giving up this practice did not result in more damage to the teats of the sows although there was a slight increase in skin lesions in piglets. As stated in French and European regulations, teeth should only be clipped in specific cases when injuries are seen in sows or piglets and when other possible causes (lack or insufficient production of milk) have been excluded. Teeth clipping is excluded in organic farming (see Chapter 4) with promising results but the rearing conditions differ to most farming standards on a health and structural basis. There is very little data from long term studies available to help conclude on the possibility of extending such measures to a larger scale. The presence of skin wounds that piglets inflict on each other, however, has to be taken into account. Establishing a special code of practice without teeth clipping could incite farmers to implement these measures if associated with consumer approbation. For consumer recognition to be an effective encouragement it

is essential to have good communication on the objectives (health, nutritional or organoleptic characteristics) and advantages (animal husbandry, welfare) of the different production systems, labelling and classification of products that are on offer.

Alternatives to tail docking in various farming systems

The case of tail docking in cattle

Tail docking in dairy cattle is an interesting case of a painful practice that was used in past years and was given up without any repercussions on health or economic impact. Until recently, docking was mainly used to reduce the incidence of dirty udders and concomitant bacterial infections, but also to facilitate milking for farmers. After the recent demonstration that this practice could be stopped without significant negative effects on the cleanliness of the cows' udder, the incidence of leptospirosis, or even on milk quality, tail docking is now prohibited in many countries, and has been renounced in France for many years.

The case of tail docking in horses

Tail docking was also traditionally performed on some breeds of horses to facilitate heavy work. This practice is almost no longer observed, mainly due to regulatory incentives (banned in competition). In the rare cases where it is still authorized (Trait du Nord horses used for agricultural or forestry work), veterinary surgeons deal with pain management (aseptic surgery on restrained animals with the use of analgesic drugs) for the procedure.

The case of tail docking in piglets

Tail docking of piglets cannot be discontinued as long as slatted floors remain in use in the majority of post-weaning and fattening units of piggeries because the risk of tail biting and cannibalism would be too high. Tail biting is a behavioural disorder of multifactorial origin with nutritional, environmental and genetic components. Environmental enrichment, including the provision of litter, prevention of nutritional deficiencies, maintenance of stable groups, and possibly genetic selection, would reduce the risk of the development of behavioural disorders and ultimately permit the practice of tail docking to be discontinued. This mutilation is not performed on organic farms where animals are reared on deep litter.

Beak mutilation in poultry

In some European countries (Sweden, Norway, The Netherlands), national law prohibits de-beaking and beak trimming. However, an exemption has recently been issued for the second time in The Netherlands. In fact, compliance with this regulation is currently only feasible in very specific situations, at the risk of facing an outbreak of feather pecking and cannibalism, and only for certain genotypes, such as the white egg-laying Leghorn hens. Giving up beak trimming is therefore not conceivable at the moment in France, where consumers buy mostly brown eggs.

Genetic selection as an option

Genetic selection is a long-term undertaking but it has the advantage of focusing on the causes rather than compensating for the consequences of pain-causing factors. The goal is to modify certain characteristics of the animal, either to accompany the phasing out of painful mutilations or to reduce the incidence of painful conditions/disorders.

Taking the example in dairy cows, selection was initially based on the quantity of milk produced. There was a rapid evolution in the selection criteria to improve the amount of dry matter in the milk and then to focus on morphology. Taking functional traits into consideration led to new indices on fertility, mastitis resistance and longevity, and finally, on ease of calving. The relative weighting of these criteria varies according to the breed. In theory, the aim in using these selection indices is to have a zero effect on fertility and a positive effect on all the other characters. The selection index for mastitis is based on the cell count in milk and, since recently, includes the incidence of clinical mastitis.

The genetic approach can also help eliminate certain sources of pain by intervening directly on the sources. Examples of positive developments on the limitation of pain are: a decrease in the incidence of the acute stress syndrome in pigs, for which the molecular mechanisms have been identified; ease of calving in cattle (for calving difficulties due to calf size), reduction in aggressive behaviour observed when animals are re-grouped; reducing unpleasant odours in meat without resorting to surgical castration.

Recent work on the behavioural characteristics of animals has shown that it is possible to develop selection programmes based on specific behavioural traits and therefore eliminate extreme phenotypes that cause problems. Several studies indicate that certain behaviours such as feather pecking in poultry, sometimes associated with cannibalism, or aggressive behaviour in mixed groups of pigs may be reduced or eliminated through the use of appropriate genetic selection programmes. Although research suggests that behavioural traits of animals are genetically controlled, detailed quantification remains difficult, so at the moment there are no plans for the large scale introduction of behavioural indices in breeding programmes.

One alternative to dehorning cattle may lie in the introduction of the “polled” gene from polled breeds into horned breeds, especially in beef herds. This option is already being put into practice, especially in Britain, but it may generate cultural reticence since the horns are popularly considered emblematic of the species.

5.2.2. "Substitute": What possible improvements can be made to reduce the pain induced by certain farming practices?

When a source of pain cannot be avoided, the next attempt is to improve the farming practices concerned in order to limit the intensity or duration of the pain. In general, training the personnel involved in livestock production always fosters progress. To ensure that improvements are put into practice, consideration needs to be given to providing incentives, such as regulations, communication, recognition of rearing schemes that go beyond the legal requirements or product promotion.

Alternatives for reducing pain associated with castration of calves

Castration of calves without anaesthesia is considered to be painful, regardless of the technique used and/or the age of the animal (see Chapter 4). It seems, however, that castration with the use of Burdizzo forceps may cause less pain, in both intensity and duration, than surgical castration. In addition, based on the literature, it seems that calves should be castrated as early as possible, preferably at one week of age, as it seems to be much less painful than at three weeks of age, and even less than at 45 days. Leaving castration until 6 to 16 months of age, which is sometimes recommended to take advantage of the growth potential of intact males, makes the procedure more difficult to carry out and potentially more painful.

The case of dehorning cattle

Dehorning either calves or adult cattle without anaesthesia or analgesia is recognized as being painful. A recent study has given a lead for the improvement of dehorning techniques so as they are less painful by resorting to cauterization of the horn-producing zones at a young age (before the age of one month which is before the start of horn development). It should be noted that this preventive method is therefore applied to all the animals and does not just target the animals causing problems.

The case of beak mutilations in poultry

Prior to finding long-term solutions, based on improved husbandry and breeding, to eliminate the source of the problem that currently necessitates beak mutilations, one feasible option to reduce the associated pain is to de-beak or beak trim chicks at a very early stage (see Chapter 4). Studies conducted on various species show that specific practical improvements should be considered for each farming system (genotype, species, mode of production).

Acute pain in infancy?

Young age is still used as a justification for ignoring the existence of pain in animals. However, not only has it been clearly demonstrated that animals as well as humans can experience pain at a very early age, but also that such pain may alter their neurological development with the risk that they may be rendered more sensitive to pain in the long term. Most often, surgical procedures are performed in young animals for practical (small size, ease of restraint), medical (lower surgical risk, rapid healing) and cultural reasons. Pain treatment should be considered for two reasons: because the intervention is considered as potentially painful, and to avoid the risk of disturbing the development of the animal's nociceptive system with long-term consequences (sensitization to pain, chronic pain). Such confusion between young age and sensitivity to pain is found in national regulations: dehorning cattle is recommended before four weeks of age, and castration of piglets within 7 days, without the requirement for any means of pain relief. The regulations are often misinterpreted as implying that the constraints of anaesthesia or analgesia can be dispensed with for surgical procedures conducted in infancy. While the regulations advocating that certain mutilations be carried out at a young age may be well-founded, the use of anaesthetic and pain relief ought to be recommended in accordance with the level of pain associated with the procedure. ("Relieve" pain - see 5.3.).

Pain related to chronic diseases

Many diseases are painful, particularly because of the development of inflammation, so disease control is important to ensure farm animal welfare. Even though pain due to chronic disease sets in progressively, giving animals an opportunity for adaptation, it often continues over a long period of time with long-term effects on animal welfare. Mutilations can induce chronic pain through neuromas, dental abscesses, etc.

In pigs

Lameness and foot disorders in pigs (especially osteochondritis) have multiple origins. The factors responsible for the development of these sources of pain are in particular linked to nutrition, housing, lack of exercise and genetic traits. Treating these disorders using pharmacological means or by limited adjustment to the housing remains difficult and success is limited to mild cases. The best solution lies in preventing and reducing the occurrence of these chronic disorders. Several measures can be taken to minimize injuries: improving the quality of the flooring (avoiding slippery floors and surfaces that are too hard or abrasive), favouring exercise (giving the animals the space and freedom to move, enriching their environment), or limiting aggressive behaviour (giving them sufficient space, adjusting the pens to reduce inter-individual competition and promote avoidance behaviours in social conflicts). Genetic selection against osteochondrosis may also reduce locomotor problems.

In cattle

Increasing the comfort of housing for animals is often crucial in preventing the occurrence of lameness related to foot or joint disorders. Attention should be paid to bedding quality, ensuring access to a resting area, ease of access to sufficient food and water, providing adequate facilities for the access to the milking room, etc.

In poultry

Musculoskeletal disorders (lameness) are still found in poultry, but their prevalence is now reduced because of efforts made by farmers and breeders. They are most often of multifactorial origin with a strong genetic component and a combination of nutritional and husbandry factors contributing to their appearance. It has been established that the occurrence of diseases associated with these disorders is usually increased by nutritional growth stimulants.

Several basic options should be considered to prevent and therefore reduce pain associated with musculoskeletal disorders:
- Decreasing food availability which reduces the onset of growth. In order to maintain high body weight at slaughter, it has been recommended to alternate a day of high-energy diet with a day of high protein diet;
- Using lighting programmes which provide longer nights in the first weeks of life and which slows down the onset of growth;
- Promoting physical activity for young animals which strengthens the musculoskeletal apparatus, for example by increasing the distance between feeders and drinkers.

It has also been shown in laying hens that bone quality is a moderately inheritable trait; therefore genetic selection on this trait may be effective in reducing the number of bone fractures due to osteoporosis.

Organic poultry and other alternative production systems that emphasize access to outdoor areas in their code of practice may have mixed effects in terms of limiting pain. Mortality rates are slightly lower (1 to 2%) in slow growing genotypes of broilers compared to conventional production systems even though they are reared over a longer period of time. In contrast, the mortality rate in laying hens that have access to an outdoor area is about twice that of caged animals. This is due to specific diseases and increased pecking behaviour. Pecking and mortality rates are currently being reduced by selecting genotypes better suited to outdoor conditions. Meanwhile, a high incidence of fractures of the sternum has been reported in indoor systems using above-ground platforms with several levels (aviaries), resulting in all likelihood from the birds impacting against the edge of the platforms when they try to fly.

In horses

Painful diseases relating to farming conditions have never been reported in horses. An interesting point is the difference in the way horses for meat production are treated in comparison to those reared as pets or for sport (see Section 5.3.3.).

5.2.3. Improvement of slaughter conditions

The improvement of facilities and slaughterhouses

Improving structures and procedures in slaughterhouses is strongly recommended, such as:
- Designing loading and unloading platforms, stalls, yards and corridors to facilitate unloading the animals into lairage with minimal use of electric goads or sticks, which inflict pain,
- Properly equipping abattoirs to facilitate the flow of animals. The requirements include avoiding visual obstacles or contrasts in lighting, and installing equipment such as treadmills, anti-backup devices, etc…
- Ensuring stunning boxes restrain the animals properly but not too tightly. Ensuring good maintenance of the stunning devices.

Other parameters seem crucial for minimizing animal pain at the slaughterhouse and for improving working conditions for staff, especially in terms of safety:
- The right balance between the production rates demanded and the realistic potential given the facilities in the abattoir,
- Appropriate training of the personnel.

Improving the stunning procedure

In standard slaughter procedures

Recovery of consciousness before the animals are bled to death means that they may feel pain again. Recovery of consciousness varies with the species and the stunning method used but the risk of recovering may be limited by:

(1) Adapting the procedure. For electrical stunning, the voltage and amperage required to induce instant insensibility must be adapted to the species. The electrodes must be held in firm contact with the head and the

equipment correctly set up. For captive bolt, the device must be properly positioned (generally on the forehead) and adapted to each species. For gas, proper concentration and duration of exposure must be ensured for all the animals, for example by limiting the number of animals (especially poultry) exposed to gas at the same time, so as a sufficient amount of gas rapidly reaches all the animals and in the case of reversible stunning, there must be enough time to bleed all the animals before they have a chance of recovering.

(2) Reducing the interval between stunning and bleeding to limit the risk of recovery.

(3) Increasing the duration of unconsciousness, for example through the application of electrical head-body stunning (instead of head only stunning) which generally induces deeper electronarcosis with longer loss of sensibility (often resulting in the animal's death).

In ritual slaughter procedures

In France, ritual slaughter by throat cutting is often carried out without stunning the animals either before or after bleeding. The manner in which the act is carried out is crucial to its effectiveness in establishing a rapid loss of consciousness. As with standard slaughter procedures, the training of religious slaughterers and slaughterhouse operators to ensure consistent and effective ritual cutting, the equipment used, the method of restraining the animals and an adapted/appropriate work rate are all factors determining success. If no conventional pre-cut stunning is applied, there are two conceivable options for avoiding the pain associated with ineffectual bleeding and delay in loss of consciousness, which is often observed in cattle.

(1) In some countries (Britain, The Netherlands and New Zealand and for species such as poultry, sheep and goats) reversible stunning is performed before Halal sacrifice. Further research is needed to ensure that the animals subjected to reversible stunning do not perceive pain in the time lapse until death through bleeding.

(2) Stunning the animals after ritual bleeding, as practised in Austria for Halal or Shechita meat. Consideration can be given to routine stunning of all animals after throat cutting or just of cattle when impaired bleeding due to the formation of blood clots at the caudal ends of the carotids retards the loss of consciousness. Thus, the rapid use of a captive bolt just after bleeding for animals that bleed too slowly and do not show satisfactory loss of consciousness within seconds, would shorten the pain and discomfort of slaughter. One difficulty here is in the rapid recognition of animals that bleed too slowly in order to decide on the use of stunning.

Box 2. Ritual slaughter in New Zealand

Personal communication from DJ Mellor, Professor of Animal Welfare, Applied Physiology and Bioethics, co-director of the center of animal welfare and bioethics.

For at least 30 years, in New Zealand, commercial slaughter of lambs/sheep for export has been by the Halal method, including head-only, reversible electrical stunning. The Muslim requirements as expressed then, and reaffirmed since, of the animal being alive and healthy, and that death be caused by the neck cut, are met by the prior use of this form of stunning, because it does not itself kill the animal. When this was demonstrated to Muslim clerics, and provided that the neck cut is done by a Muslim slaughterman well versed in the religious requirements, they accepted this form of commercial slaughter as complying with Halal requirements. This approach remains in place today. Of course, this approach also meets the general animal welfare requirement in commercial slaughterhouses that the neck cut must be preceded by effective stunning.

For the New Zealand Jewish community the question of preslaughter stunning has been problematical, because it has been regarded as against Kosher slaughter requirements. For the last 10 years no sheep or cattle have been slaughtered by the Shechita method in NZ, as the Jewish community here has chosen to import their requirements for such meat while a new code of welfare for commercially slaughtered animals was being developed. Comparatively small numbers of chickens have been slaughtered via the Shechita method for use only within NZ by the local Jewish community. This matter is still under review, and requires consideration to be given both to the New Zealand Bill of Rights Act, which allows the free practice of religion and belief, and the Animal Welfare Act, which prohibits the slaughter of animals in ways that cause unreasonable and unnecessary pain and distress, but at the same time states that the NZ Bill of Rights Act provisions for free practice of religion and belief must also be considered. This matter remains under review.

There is currently very little data concerning on-farm killing (slaughter performed by the farmer without consumption of carcasses) for emergency reasons relating to the welfare of the animal, routine culling of surplus newborn and unwanted, low value animals (e.g. very weak one-day-old rabbit pups or chicks) and non-emergency slaughter of casualty animals or for the purposes of disease control. The regulations are more precise in the case of sanitary culling. Weak or injured animals that are unfit for transport to the abattoir must be slaughtered on farm but the terms for on-farm methods of euthanasia are not clearly defined. Administration of barbiturates or overdoses of anaesthetic by veterinary surgeons is rarely adapted to these situations, mainly because of the cost.

Council Directive 93/119/EC of 22 December 1993 on the protection of animals at the time of slaughter or killing, fixed minimum common rules in the European Community. The application of these rules is, however, little controlled on-farm and can potentially lead to painful killing practices (choking, stunning). In rabbits, the killing of the weakest newborns from each litter remains without regulation despite a significant number of individuals concerned (around 6-8% of births).

The need to establish detailed standard operating procedures that are adapted to each farm condition and each species is highlighted in the literature. For small animals (less than 3 kg) maceration, using a large high-speed grinder, or gassing are the most commonly used techniques because they cause rapid death.

For larger animals, using proper stunning or sedating methods before killing them in a rapid and standardized manner, and the verification that the animals are actually dead, are recommended. The problem of the availability to breeders of slaughter equipment and euthanizing drugs remains a significant obstacle. A solution based on the possibility for farmers to use euthanasia services at a lesser cost, managed by a group of technicians trained to perform animal euthanasia, would reduce pain due to non-conforming killing methods.

5.3. "Soothe": Pharmacological treatment of pain

5.3.1. General principles of pain management in veterinary medicine

Pain management methods have been developed for use in veterinary medicine and in theory are suitable for livestock. Therapeutic treatments for birds and fish are less available because of physiological differences and the low number of studies in these species. In practice, the use of analgesics and veterinary treatments for animals reared for food production is limited because of certain restraints (limited pharmaceutical market, limiting the risk of drug residues in meat, availability to farmers). As such, pharmacological treatments are given as a last resort, and the priority is rather focused on prevention (see 5.2.). When the sources of pain cannot be avoided ("suppress") or reduced ("substitute"), the possibility of relieving pain with a veterinary treatment ("soothe") becomes an ethical issue.

General recommendations

Analgesia is based on three good practices: (i) preventive analgesia (if possible, prevent pain in any animal undergoing mutilation), (ii) interventional analgesia (always treat pain during surgery); (iii) rescue analgesia (or curative) which aims at relieving any pain so as to limit the symptoms and the economic impact. The analysis of a painful situation allows an appropriate analgesic procedure to be established (see Table 8).

Local Anaesthetia

When possible, local or regional anaesthesia is fast, easy and inexpensive to perform. There are various ways to administer lidocaine as close as possible to the affected nerves (cranial nerves, nerves innervating the testis and the limbs, epidural, paravertebral ...). This anaesthesia permits the short-term reduction of pain (a few hours maximum). Complementary analgesic treatment is usually required for longer duration of action to relieve post-surgical pain, and in particular pain of inflammatory origin.

Table 8. Questions to be posed in choosing an analgesic strategy

	Questions to be posed	Procedure chosen	Substance (Administration)
1	Possibility of local anaesthesia?	Local anaesthesia	Lidocaine (perineural)
2	Inflammatory process?	Systemic analgesia	Non-steroidal Anti-inflammatory Drugs (NSAIDs) (IV, PO)
3	Chronic pain or severe and persistent pain?	In association with: §	Ketamin (SC) Butorphanol (IV) Lidocaine (IV) Xylazine (peridural)
4	Need to restrain?	Sedation	Xylazine or detomidine (IV)
		General anaesthesia	Ketamine (IV), Isoflurane (Inhalation)

* NSAIDs: non-steroidal anti-inflammatory drugs, IV: Intravenous; PO: Per Os (oral), SC-Sub-Cutaneous. Systemic: SC or PO. §A Marketing Authorization (MA) has not been issued for lidocaine and butorphanol for intravenous injection in cattle and therefore they are subject to the provisions of the cascade for minimum withdrawal periods (see 5.3.2)

Several studies indicate that regional anaesthesia is effective in desensitizing the testis and the spermatic cord when performed before castration in horses, cattle, small ruminants and pigs. The anatomy of birds does not favour the use of local anaesthesia even though it has been considered for the castration of broilers. Other painful conditions can be relieved by local anaesthesia, such as dehorning calves (cornual nerve anaesthesia) or inserting nose-rings in bulls (anaesthesia of the infraorbital nerve).

Anti-inflammatory -based analgesia

The administration of non-steroidal anti-inflammatory drugs (NSAIDs) is recommended for surgical or accidental tissue trauma to limit the development of inflammation and pain associated with it. Inflammation starts shortly after surgery and attenuates over the following days.

Note that for the treatment of chronic pain, whether severe or persistent, the most effective analgesics are morphine derivatives (opioids) and are commonly used in pets.

The use of pharmacological products for restraint - sedation or general anaesthesia

Finally, the possibility of resorting to pharmacological products for animal restraint should be mentioned. When physical restraint and pain management using local anaesthetics and anti-inflammatory drugs are not possible or are inadequate, two types of pharmacological agents can be administered. Sedatives (Xylazine or detomidine) can induce a deep state of detachment and relaxation enabling immobilization of the animal in standing position, the effectiveness of which depends on the intensity of pain. General anaesthesia is more efficient and induces limited and reversible complete loss of consciousness required for certain surgical procedures (deep laparotomy, orthopedic surgery, major injuries). General anaesthesia is more difficult to use routinely on-farm and in general can only be practised by a veterinary surgeon. The special case of the use of general anaesthesia by farmers for the on-farm castration of piglets will be developed in a separate section.

5.3.2. Limitations on the use of pharmacological agents on livestock

A basic rule for consumer protection is to reduce the risk of drug residues in food (antibiotics, anti-inflammatories, toxic or active substances...). Thus, EU regulation provides a list of active substances for which a maximum residue limit (MRL) is set. Only these products can be administered to livestock. In addition, the marketing authorization (MA) for a pharmaceutical drug includes a withdrawal period during which animal products from an individual that has received a pharmacological treatment are not suitable for human consumption. This withdrawal

period is based on experimental and clinical studies. During this period, milk or eggs are discarded, and the animal cannot be slaughtered for human consumption. Veterinary surgeons are responsible for ensuring that withdrawal periods are complied with. Thus, sedatives and anaesthetics granted full marketing authorization (MA) are available for several species of livestock and can be used if needed.

When a drug has not been granted MA for a certain indication in a given species, such as for anti-inflammatory use, the "cascade" provision can apply for the prescription of a product for which the MRL has been set, and for which the MA has the same indication in a similar species, or in this species but for another indication. In such case, a minimum withdrawal period is implemented (for example in cattle, 28 days for meat and 14 days for milk). This system allows, for example, the use of Lidocaine in cattle. Prescribing an anti-inflammatory drug for systematic peri-surgical administration by the farmer is therefore possible, provided that the farmer is also informed on the withdrawal period. The development of specialty pharmacological agents by pharmaceutical companies in view of obtaining marketing authorization in Europe, with indications for use in analgesia in farmed species, is a very expensive process. Legislative change is required to make the analgesic market more attractive. In the meantime, one option may be to facilitate the possession and use of such veterinary products in on-farm pharmacy.

Lidocaine is a complex example because it combines recourse to the “cascade” principle (no MA for livestock in France) and the intervention of a practitioner. Like the use of sedatives and general anaesthetics, performing a local anaesthetic is regulated by the Rural Code in Section IV. Practicing veterinary medicine and surgery on animals is restricted to veterinary surgeons. While it is possible for farmers to have prescriptions for local anaesthetics filled, anaesthetizing a nerve by subcutaneous injection of the product is reserved for veterinary surgeons. A special exemption is granted non veterinary surgeons by law (Article L243-2 of the Rural Code) for surgical castration in species other than horses, dogs and cats. This opens the possibility of considering whether local anaesthesia could be performed by the farmer on the condition that it is recognized as being part of the intervention. This would require special mention in the Rural Code. In the case of dehorning, giving farmers permission to carry out the procedure when the calves are less than four weeks of age, but in the absence of any form of analgesia, and prohibiting them from anaesthetizing the cornual nerve (which considered as an act of veterinary medicine) does little to foster the use of this simple and inexpensive pain relieving procedure.

For farmers to be permitted to administer local anaesthetic in combination with NSAIDs, veterinary surgeons must ensure they are adequately trained. They must also accept responsibility for the consequences of the delegation and for the use of drugs without an MA. This is currently the case in Switzerland, for example, for gas anaesthesia for castration of piglets. In this country, the veterinary services train field veterinary surgeons, who in their turn train farmers in anaesthetizing their animals, and in the cleaning and the maintenance of the equipment.

Another obstacle to the use of analgesics or anaesthetics is the persisting lack of awareness among farmers and veterinary surgeons of the problem of pain. An information campaign among farmers would not only lead to better identification and recognition of pain, it would more importantly encourage the use of preventive and curative practices. The cost of administering anaesthetic and analgesic drugs also appears to be a major disincentive for farmers. Yet, the cost of the anaesthetic itself is often low (approximately 1 euro for the amount of lidocaine necessary to anaesthetize the cornual nerve). Indirect costs (work time) seem to be an even more important economical constraint to farmers who do not see in pain management a direct return on their investment. An economic study undertaken in 2009 focused on the additional costs generated by surgical castration with anaesthesia in pigs. For a production of identical quality, the increase in cost of meat production is estimated at 0.1 to 0.3% in the case of local anaesthesia administered by farmers, and 0.9 to 1.6% for local or general anaesthesia administered by a veterinary surgeon. In the latter case a large part of the variation was due to the size of piggery, the cost being more significant for small units. Moreover, even if French or European authorities consider that the presence of drug residues in very low concentrations is safe, export to other countries could be penalized if those countries contest the notion of there being no risk. The use of veterinary products must always be conducted with openness, with checking of doses and adherence to withdrawal periods so as to maintain control over the impact on food.

From a consumer’s perspective, the development of a product in observance of practices guaranteeing animal welfare at the risk of increasing the presence of drug residues, must maintain a substantial equivalence in the animal product ("like-product") and not lead to a degradation of its nutritional, health and gustatory qualities.

5.3.3. Examples of pain management applicable to livestock

Pain management for mutilations – the example of castration

Dealing with pain during castration is particularly difficult because castration is a procedure that farmers are entitled to perform while access to painkillers and anaesthetics is restricted to veterinary surgeons. This situation gives justification to the long-standing practice of performing this act in the absence of analgesia. Nonetheless, farmers could be authorized to administer local or general anaesthesia and NSAIDs in a well-defined framework once these acts are considered an integral part of the procedure.

One technique of general anaesthesia seems promising for the castration of piglets: applying a mask for the inhalation of anaesthetics (isoflurane with or without N_2O) in oxygen. This technique is easy, quick and without post-operative complications. It is performed by farmers in Switzerland but its use is not without drawbacks (release of a toxic gas into to the environment). A variation based on the administration of carbon dioxide is used in The Netherlands. Administering local anaesthesia, sometimes in association with an anti-inflammatory drug, as is practised in Norway, is another possibility.

In broiler chickens, a variety of available substances have been tested for conducting caponisation under general anaesthesia and/or local analgesia, but the implementation of this method is difficult because these products have a very heterogeneous duration of action in birds. This heterogeneity of effect can lead to cannibalism during the postoperative period if the first animals to recover consciousness are not immediately removed from their conspecifics. Gas anaesthesia is used in veterinary practice for pets or wild birds and also in experiments but has not been tested in poultry farms for technical and financial reasons.

In ruminants, surgical castration combined with chemical restraint (sedation or general anaesthesia), local anaesthesia (in the distal pole of each testis) and analgesia (if possible anti-inflammatory drug 20 minutes before surgery to relieve postoperative pain), is practiced in some countries and is recommended in organic farming. Adopting these practices is conceivable but the increased cost would be significant.

In the case that use of analgesia for conducting mutilations becomes widespread, and more particularly in regards to the specifications for organic farming, it should be noted that pain and anxiety are factors that destabilize homeostasis and lead to reduced immunity. The administration of analgesics such as anti-inflammatory drugs also depresses the immune system, but so far there has been no clinical study examining the balance of the benefits brought about by administering in pain relief in terms of homeostasis and the negative effects of anti-inflammatory drug administration on immunity depression. However, it has been established that the physiological effects of untreated pain are related to its duration and intensity just as the side effects of anti-inflammatory drugs are dependent on the dose and the duration of the treatment. Therefore, once again, it appears that the strategies aimed at eliminating or substituting the sources of pain prove to be more effective than those aimed at relieving pain afterwards. For pain management during surgical castration or castration by the use of a rubber ring, for example, local anaesthesia is, according to our current state of knowledge, the most effective and easy to use and is followed by fewer side effects. The administration of anti-inflammatory drugs is also possible. The dose and duration of treatment need to be adjusted to the type of pain caused. Preventive administration before the mutilation probably gives the most effective outcome and enables the shortest treatment time. A single administration minimizes side effects while providing a minimum level of analgesia.

Managing pain caused by diseases

Certain diseases, mostly chronic diseases but also those involving a significant inflammatory component, may be accompanied by clinical signs of moderate to severe pain that require pain management. Non-steroidal anti-inflammatory drugs (NSAIDs) can relieve pain over several days and have proven to be effective for the treatment of lameness. For clinical mastitis, NSAIDs are associated with local anaesthesia in the case of teat infection, for example, or butorphanol or xylazine in case of severe visceral pain. The systemic administration of anti-inflammatory drugs is often necessary to reduce the symptoms of acute mastitis and to avoid the development of toxic mastitis. In contrast, the use of intramammary corticosteroids is controversial and should be assessed on a case by case basis to allow a rapid improvement in local symptoms.

Pain management in the horse industry

The horse industry benefits from modifications to the regulations specific to horses. Resulting from the flexibility required for veterinary treatments used for horses in sport and recreation, the regulations for meat horses allow an additional list of veterinary pharmaceutical substances (denoted "essential") which comprises several anaesthetics and analgesics for which the use is permitted despite the fact that no MRL has been established. A withdrawal period of six months is imposed before slaughter. While this model could be followed for animals from which only the carcass enters the human food chain, a withholding period of six months appears difficult to put into place to allow the systematic use of some products in the cattle industry or in other industries. Further research is required to propose minimum standard withdrawal periods in the dairy or the poultry industries.

5.4. Summary

In the current state of knowledge and according to the rearing and slaughtering situations, there is flexibility available for limiting or **avoiding pain** by **adapting equipment, techniques or practices** in place on farms and in slaughterhouses.

Medical treatments for pain are available, but current regulations, which favour limiting the risk of drug residues in animal products, and cost and labour optimization are often barriers to their use.

Some **strategies for genetic selection** and/or certain **rearing codes of practice** may reduce the risk of the development of pain.

The introduction of **incentives and enforcement of adequate regulations** can facilitate the use of solutions to avoid, reduce or treat pain in farm animals see legislation, training and information for industry personnel.

In **some species such as poultry and fish, there are few analgesic procedures available.** Their implementation or development would require experimentation and validation on a commercial scale.

General conclusions

The purpose of this study conducted by a panel of INRA scientists was to analyse pain in farm animals. Scientists with competence in various disciplines of human- and life-science extracted and integrated pertinent data from scientific publications, which in turn provided a basis for responding to the following questions: How to describe, understand and alleviate pain in farm animals? This synthesis draws upon work in the fields of ethics, economics, law and biology.

A complicated social debate

The involvement of the social sciences, as requested by the organizers of this project, proved to be extremely fruitful. Their analysis reveals a large body of relevant work from several disciplines, including philosophy, ethics, anthropology, sociology, law and economy. Across these disciplines there is a general consensus concerning the importance of the conditions of the life of animals for the various actors. The analysis also underlines the difficulties that arise when animal pain is separated from other concepts, such as suffering and welfare of animals.

The current focus on the question of animal pain, in particular that of farm animals, reflects a variety of changes in our society:
- There have been major advances in the understanding of pain and clinical attention given to this issue in humans, and consequently in animals. Although pain was previously considered to be unavoidable, it can now be reduced, or even eliminated.
- Urbanization has separated the public from farm animals and there is little awareness of breeding and management practices. City dwellers rarely have contact with farm animals; the only animals with which they interact are pets, which have a different status to farm animals and a closer relationship with their human owner.
- The systems of animal production that have developed in response to commercial demands give rise to a multitude of questions.
- The range of stakeholders involved in the debate has expanded enormously. Previously, the breeders alone made the decisions. At the present time, however, all of the actors in the production network, from the breeders to the commercial distributors, are involved in the debate, as well as associations for animal welfare/protection.

Animal pain, human pain: need for an integrated approach

Scientific study of the physiology of pain has involved close collaboration between a number of disciplines, including neurobiology, physiology, veterinary science and animal production. As discussed above for the social sciences, the analysis of the literature reveals that animal pain, suffering and welfare cannot be readily separated.

Clinical studies of human pain have also been very important. To a great extent, our current understanding of this question is based upon studies of humans and laboratory animals. This research has resulted in significant alterations in the conceptualization of pain, and greater awareness of the range of situations in which it occurs. In particular, assessment of pain in non-verbal humans necessitated a change from self-evaluation to hetero-evaluation, the obligatory method for studying animals. The originality of this approach should also be noted: while animal studies are often presumed to provide data that are relevant to human questions, in the present context, the human model is a source of information to address animal issues.

The chosen definition of pain in animals is similar to that established by scientists and clinicians who work on human pain. This definition has three primary components: nociception, emotions and consciousness.

Pain is an aversive sensory and emotional experience represented by the animal's "awareness" of tissue damage, or the threat of such damage.

The assessment and description of animal pain remain difficult.

Pain, as described in this manner, occurs in non-human mammals, and presumably to a lesser extent in birds. Whether it exists in fish, amphibians, reptiles or invertebrates continues to be a subject of scientific debate.

An animal's subjective experience of pain can only be assessed indirectly, using various physiological and behavioural indices, observable tissue damage and livestock performance. This multi-parametric method may provide a basis for developing graded scales of pain. At the present time, however, validated pain scales only exist for dogs; validation trials with cats and horses are ongoing.

Numerous factors foster the occurrence of pain

To identify painful stimuli or events encountered by farm animals, it is useful to consider the context of the rearing system in which they live. It should be recalled that the primary objectives of these systems are profitability, security and safety of food production, and health of the animals. The analysis shows that certain systems increase the risk of pain as a consequence of space limitations, poor environmental conditions, physiological or nutritional disturbances associated with attempts to maximize production, and unstable social groups. Moreover, health risks for animals and the humans who work with them may increase when the personnel do not pay adequate attention to animal pain. Alternative production systems, in particular those that practice organic methods, emphasize the prevention and treatment of pain.

Painful procedures may be employed to treat problems that result from the rearing situation, or because of considerations of product quality or worker health and safety. The primary examples include: castration of piglets and calves, horn trimming in cattle, de-beaking in poultry, tooth clipping and tail docking in piglets.

Pain associated with slaughter has also been the subject of an analysis that considers not only the slaughter technique per se, but also the transport and pre-slaughter contexts. When stunning techniques are correctly applied, animals will be unconscious when slaughtered. A considerable interval between the moment of throat cutting and unconsciousness is observed in a significant percentage of cattle when stunning is not used.

Suggested methods to reduce pain in farm animals based upon the present study.

The ongoing study generated a number of proposals for the reduction of pain in farm animals. Alternative rearing methods that limit pain and are currently practiced, or being developed, in several countries, are reported. These methods are consistent with the approach that has been labelled "3Ss" that is analogous to the "3Rs" approach adopted for animal experimentation.

• The first solution is to eliminate ("suppress") sources of pain that provide no benefits for the animals or the breeders. For example, tail docking of cattle has recently been eliminated. Tooth clipping of piglets is likewise unnecessary. Dehorning can be gradually obviated by introducing genetically hornless animals into the reproductive population. Genetic selection for resistance criteria, which is now practiced with chickens and cattle, has lowered the incidence of painful mastitis in cows and lameness in cattle and chickens. This issue is a major focus of ongoing research.

• The second solution involves substituting ("substitute") a less painful method for one that is known to be a source of pain. Accordingly, it is preferable to castrate piglets and calves at the youngest possible age. In a similar manner, when dehorning of calves is practiced, it should be performed at a very young age with cauterization of the areas that produce the horns. Grinding the teeth of piglets is preferable to clipping them. De-beaking of poultry has been replaced by less painful beak trimming. Improved breeding and housing systems may limit the risks of wounds and deaths resulting from aggressive interactions or when animals are moved, especially in slaughterhouses.

• Finally, general or local-acting pharmacological analgesics may alleviate ("soothe") pain that is knowingly elicited, as is the case for mutilation, or unpredictable, for example, lameness in cattle. These treatments take into account the duration of pain, which may continue after the intervention in the case of certain mutilations or pathological conditions. Moreover, effective stunning techniques can lessen the pain associated with slaughter.

It is interesting to note the following steps and initiatives that are relevant to the problem of animal pain:
- The French government has instituted a plan (anti-pain) to limit human pain. It underlines three essential recommendations for limiting pain in patients that could also be applied to animals: development of methods to evaluate and monitor subjects in pain; training of professional staff; the need for further fundamental and applied research.
- In Switzerland, an ongoing study of agricultural breeding and production systems will allow the concomitant assessment of pain in these different contexts.
- Commercialization of products derived from animals may point out the care taken by the various actors in the production network to limit animal pain, which would serve as an alternative method to foster more humane agricultural practices.
- Pain is taken into account in the international plan drawn up by The World Office of Animal Health (l'Office Mondial de la Santé Animale), which is evidence of the worldwide preoccupation with this issue.

This report further clarifies the conceptualization of pain in farm animals and the methods used to study that problem. In addition, it identifies painful situations and possible solutions to eliminate or at least attenuate pain. The considerable body of pertinent data allows the proposal of confident conclusions. However, this investigation also points out the need for additional research to elucidate the question of animal pain and do away with current uncertainties and controversies.

Research Priorities

Elucidation of the underlying basis, and methods of evaluation of pain in particular species

The present investigation revealed limitations in the scientific knowledge of pain in farm animals.

For certain taxonomic groups, such as fish and birds, there has been little scientific study of mechanisms and situations that may provoke pain. Relevant research with **fish** provides only fragmentary understanding of nociception and stress in a few species. Although relatively more research has been devoted to pain in **birds**, the current data base remains limited and further in-depth studies are needed.

Across the total range of farm animals, there is a need for clear **measures of pain** that would provide a basis for the development and validation of multi-parametric pain scales. Differences in the focus of ongoing research between species reflect the current state of knowledge of those animals. While there is a major requirement for the construction and validation of multi-parametric pain scales for pigs and ruminants, particular emphasis needs to be given to identification and validation of nociceptive criteria in fish, while a wide array of issues should be investigated in avian species.

Further elucidation of precise physiological indicators of unconsciousness is needed, and would also have practical implications for slaughter routines. Likewise, the relationship between unconsciousness and pain (or its absence) is poorly understood. There is a general need for greater specification of the role of emotions and consciousness in the expression and perception of animal pain. Additional research should assess the influence of the social/psychological context, including the relationship between animals and human handlers, on pain.

Sources of pain in farm animals

The identification and quantification of **sources**, or potential **causes**, of farm-animal **pain** remain difficult. Analysis of the available scientific evidence suggests a number of research questions that should be addressed, and stresses the importance of acquiring information concerning the frequency of particular painful procedures (notably mutilations) and details of the methods employed in this context (descriptions of the procedures per se, training of staff, analgesic protocols). Because of the paucity of relevant data a thorough analysis of risks is not possible. It would also be useful to conduct systematic evaluations of the

prevalence of presumably painful diseases, the factors that contribute to the occurrence and increase of such diseases and their economic impact (associated costs and losses). Moreover, there is little information regarding the frequency and methods of slaughter of diseased farm animals (aside from euthanasia performed by veterinary surgeons). While the short-term effects of injuries and mutilations are known to at least some extent, long-term effects, such as the existence of hyperalgesia or pain associated with amputation (phantom-limb pain) remain unclear. Likewise, the consequences of these aversive practices for animal-human interactions have been the subject of little scientific investigation.

Finally, further understanding of the attitudes and perception of pain, as well as its detection and treatment, by the different members of the agricultural production network would be beneficial.

Possible solutions to the problem of pain in farm animals

The alleviation of pain in farm animals can be addressed by different research strategies. For example, identification of improved housing/treatment methods and genetic selection for specific traits could eliminate or reduce sources of pain, such as injuries and lesions. Genetic selection for robustness (i.e. effective adaptation of the animal to its environment) could contribute to the avoidance of painful situations. Elucidation of the underlying molecular basis and variability of the selected traits would allow those markers to be incorporated into the selection criteria. At the present time, there are few **analgesic procedures** that are appropriate for poultry and fish. Thus, there is an obvious practical need for research concerned with the development and validation of such analgesics.

Socio-economic consequences of addressing the problem of animal pain

As seen above, it is possible to identify and alleviate pain in a number of farm species, especially mammals. However, precise assessments of the **costs and benefits** associated with the various pain-control methods have not been conducted. The economic impact of proposed solutions would presumably vary across the various levels of the production/distribution network. Furthermore, different characteristics of animal products (e.g. animal pain during rearing, meat hygiene and palatability, environmental considerations) would not be affected in an identical manner. Knowledge of consumers' attitudes (acceptance, for example, of biotechnology, substitution of vaccination for castration in piglets, or systematic use of analgesics), and their likely response to the economic consequences of attempts to control animal pain would be important before introducing those solutions. Would the public support modifications of agricultural methods based upon concerns for animal pain? Detailed studies of the broad socio-economic consequences associated with the goal of pain reduction are needed across the entire range of farm-animal production and distribution.

Regulatory mechanisms and the legal status of animals

Both for individual countries and on an international scale an evaluation of the socio-economic impact of a possible change in the legal status of animals will be necessary. The current wide array of recommendations and regulations pertaining to farm animals (local codes, European rules, national laws and recommendations, requirements of specific products/brands) pose problems of interpretation and implementation for agricultural workers. A global analysis of potentially painful practices would facilitate the establishment of coherent regulatory mechanisms and foster clearer public understanding of the realities of farm animal production.

Appendix: Methodology

1. Definition and organisation of the project

The collective scientific assessment (ESCo) was conducted in support of a public mandate: in response to a complex question, an international multi-disciplinary data base was reviewed to ascertain the existing body of relevant scientific knowledge and to identify major uncertainties, deficiencies and controversies.

The ESCo project was initiated in 2002 in accordance with the principles established by the INRA charter of scientific investigation. The Institute provided necessary administrative support for the project (gathering and updating reference material, certification of the qualifications and independence of participating experts, and transparency of the procedures). The experts are solely responsible for their contributions. The ESCo does not formulate opinions or recommendations apart from future research needs.

The monitoring committee

The monitoring committee was composed of members appointed by the commissioning body. It was responsible for validating the official directive, meeting two or three times during the course of the project to examine whether the orientation of ongoing work conformed to the original terms of reference, and, if warranted, modified the scope of work in progress to reflect recent political and regulatory developments. At the same time, progress of the work and problems encountered by the experts, such as the absence of bibliographic material, were reported and discussed. At the completion of the assessment, the committee met for the presentation of the conclusions. During this seminar the final version of the report was presented.

The scientific experts

The ESCo is the joint effort of a group of scientists from different disciplines with converging interests in the multi-faceted question of animal pain. This group of about 20 scientists was divided into sub-committees that were responsible for the bibliographic analysis and drafting of the report. External experts were also consulted when appropriate.

For each ESCo dossier, a scientific chairperson was appointed by the pertinent INRA director. These chairpersons were all experienced, competent scientists who approached the problems under consideration from a broad perspective and provided effective leadership for their co-workers.

The scientists worked on the ESCo for approximately one year following the official approval of the project.

The final report reflects the comments and suggestions of the external referees who read the initial draft.

INRA was responsible for the administrative support of the ESCo. This included facilitating and organizing the work of the scientific experts and collaboration with other agencies. The ESCo had complete access to INRA library facilities and data bases, and that agency also provided secretarial, management and editorial assistance, organized scientific meetings and prepared printed versions of documents produced by the ESCo.

Results of the ESCo

The work of the ESCo culminated in an electronically published report in French that is several hundred pages long, and an abbreviated version intended primarily for policy makers and its English translation; these documents are available on-line on the INRA website.
(http://www.inra.fr/presse/expertise_douleurs_animales_chez_animaux_elevage).

The abbreviated document highlights the major points of the assessment report in a manner that should make it useful for addressing the problems that originally motivated the creation of the ESCo. The scientific conclusions did not take into account the current economic and political context since that was not the object of the project.

The conclusions of the ESCo were presented and discussed at a conference open to the public.

2. Participating Scientists

The ESCo can be defined as a critical analysis of the available academic knowledge. Therefore, the main criterion for the choice of participants was scientific competence, as evidenced by their peer-reviewed publications and evaluations/recommendations by colleagues. Complementary criteria were also taken into consideration, such as scientific administration and leadership activities (e.g. directing French or European research programs), membership in governmental work committees, or participation in the scientific evaluation of various projects (e.g. political initiatives, management policies).

This recruitment strategy based upon scientific competence, rather than practical experience in the field, should be underlined to avoid misunderstandings following publication of the ESCo.

To assure the involvement of diverse scientific "cultures" and techniques, and strengthen the credibility of the evaluation, the work was conducted independently of INRA supervision, and scientists external to that institute also participated in the project. The group of scientists was composed of 11 INRA researchers plus 9 affiliated with other institutions (Veterinary schools, CNRS, Collège de France, French health service, Universities). More than a dozen additional scientists made contributions to particular themes considered by the ESCo.

3. Bibliographic note

During the course of the evaluation, the group of scientists analysed a great number of scientific publications and international reports that served as the basis for the final results and conclusions. Approximately 1,400 bibliographic references are cited in the report. Technical support was provided by two INRA information specialists whose responsibilities included information and document retrieval, organization and reproduction of the extensive body of bibliographic material, and compilation of the list of cited references.

Principal sources of information

Web of Science. A product of Thomson Scientific (formerly ISI), this is the most extensive data-base for scientific publications in the entire world. All domains of Science and Social Science are covered, thereby allowing searches that cut across several specialty areas or the identification of articles whose content falls at the interface between traditional disciplines.

CAB Abstracts (CABI Publishing). This data base covers the published literature related to "agriculture" from a broad perspective (animal production, veterinary science, health, economics, rural sociology, human food consumption).

Econlit (American Economic Association). A data base primarily devoted to economy and management. Sources of cited articles include periodicals (400 titles), monographs, edited volumes, congress proceedings, theses, and working papers/reports.

Medline/Pubmed (National Library of Medicine, USA). A bibliographic data base covering all domains of biomedicine (biochemistry, biology, clinical medicine specialty areas, economics, ethics, pharmacology, public health, toxicology, veterinary medicine).

Additional sources of scientific and technical data were also considered: EFSA (European Food Safety Authority – scientific documents), ProdInra (institutional archives of INRA publications), Cairn, Renaweb, Techni-porc, and Vigie-Viande.

Methodology

Keywords validated by the ESCo scientists were combined in search queries and were used to survey the bibliographic data bases. Definition and refinement of the keywords necessitated frequent interactions between the information specialists and ESCo scientists.

More than 10,000 bibliographic references were collected. The original body of literature was reduced and refined by a lexical analysis performed with Le Sphinx ® software. This resulted in a working bibliography of 1,200 references (format Endnote TM), that was supplemented by specific targeted searches.

Throughout the evaluation period, research articles and technical documents were forwarded directly to the ESCo scientists. A collaborative web-site (SilverPeas®) enabled the scientists to interact via a computer network.

Cited References

A total of 1,391 references are cited in the report. As seen in Figure 2, the number of bibliographic citations was roughly similar across the 5 Chapters. Recent work accounted for most of the citations; 30% of the references were published within the last 5 years (Figure 2).

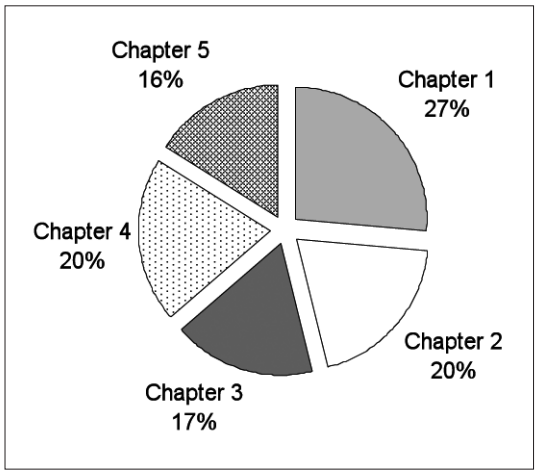


Figure 1. Proportion of total references cited in each of the chapters.

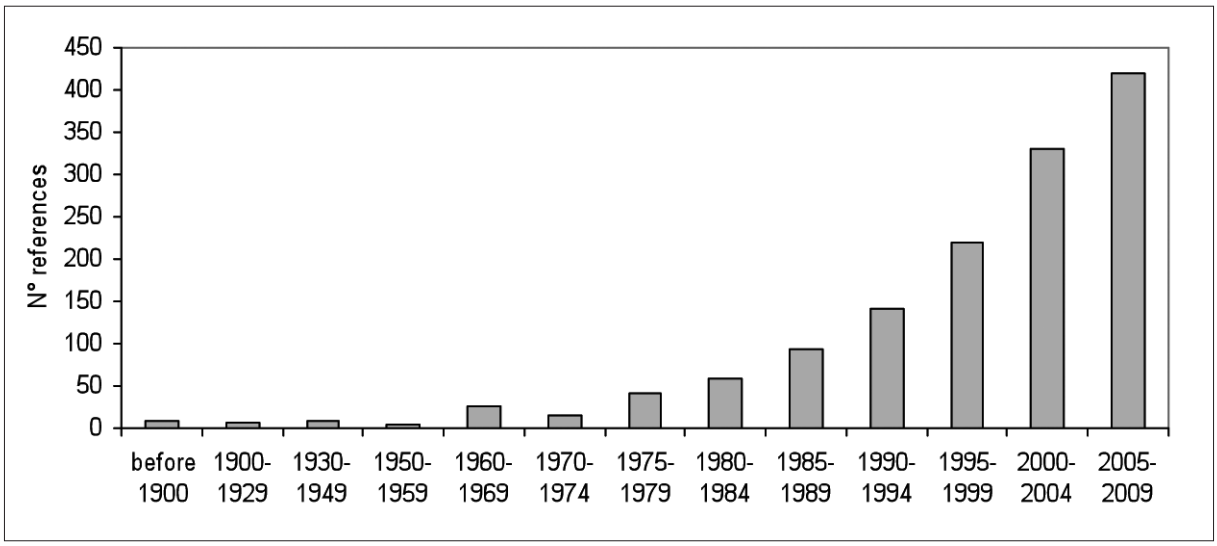


Figure 2. Publication year of bibliographic references cited in the report.

The majority of cited articles were published in international scientific journals (69%), which is consistent with the stated definition of the project (Figure 3). An international journal of applied ethology was the source of the greatest number of references; this was followed by 14 veterinary and agricultural science journals (Table 1).

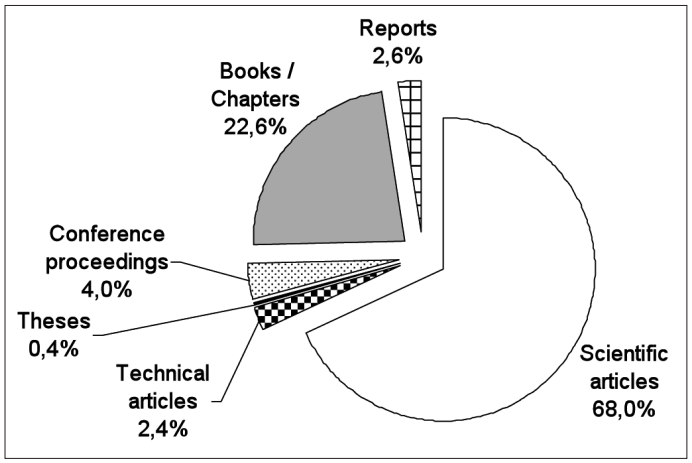


Figure 3. Percentage of cited references from various categories of publications.

Table 1. Scientific journals in which the greatest number of cited references were published

Journals in which cited articles were published	Number of cited articles
Applied Animal Behaviour Science	63
Journal of Animal Science	37
Veterinary Record	33
Research in Veterinary Science	33
Journal of Dairy Science	32
Meat Science	31
Veterinary Journal	22
New Zealand Veterinary Journal	21
Poultry Science	21
Pain	20
Livestock Production Science	18
Animal Welfare	16
Animal	15
Physiology & Behavior	15
JAVMA	13
British Poultry Science	13

A secondary category of cited material consisted of scientific and technical reports published by international institutions (e.g. EFSA, AFFSA, European Commission, ITP), and papers presented at international symposia (e.g. organized by the International Society for Applied Ethology, the American College of Veterinary Anesthesiologists, or the International Veterinary Academy of Pain Management).

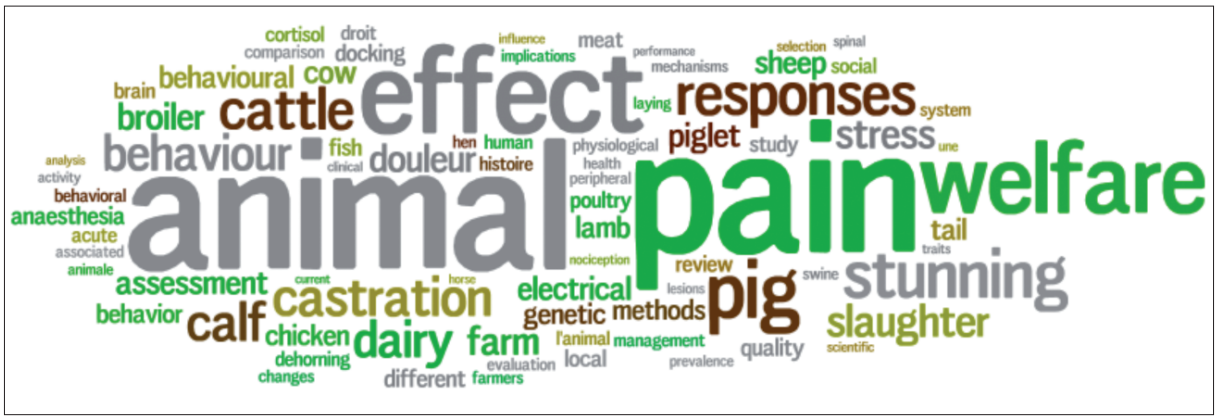
Finally, articles published in technical journals, such as INRA Productions Animales, Les Journées de la Recherche Porcine, and Cattle Practice, were a source of information concerning painful agricultural practices and alternative procedures.

The major themes of the ESCo as reflected by the reference titles.

The credibility of the ESCo is dependent on the bibliographic references. It is therefore interesting to verify a posteriori not only the quality of the cited references, but also their relevance to the major themes addressed by the ESCo.

A frequency analysis of the words appearing in the titles of the cited references was performed with the program Wordle.net. The size of the words in Figure 4 is proportional to their frequency of occurrence in the reference titles. For example, the word “pain” appeared in the title of 199 references, while “castration” was found in only 61 titles. This figure portrays the correspondence between the major themes treated by the ESCo and the content of the bibliographic material.

Figure 4. Word cloud depicting the relative frequencies of occurrence of words appearing in the titles of the references cited in the ESCo report. (http://www.wordle.net/)



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