Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

Opinion of the Scientific Panel on Animal Health and Welfare of the Norwegian Scientific Committee for Food Safety related to the ability of various groups of invertebrates to sense and to perceive discomfort, pain and stress when these organisms are exposed to human handling.

Summary of opinion:

The Norwegian Scientific Committee for Food Safety was asked by The Norwegian Food Safety Authority to produce an opinion on the ability of various groups of invertebrates to sense and to perceive discomfort, pain and stress when these organisms are exposed to human handling.

A Scientific Report on these topics was made for the Panel by Professor Lauritz S. Sømme. The Scientific Report, “Sentience and Pain in Invertebrates”, can be found at http://vkm.no/eway/library/openForm.aspx?param1=16080&param5=read

The Panel on Animal Health and Welfare is of the opinion that conclusions regarding this question must be drawn quite cautiously. Research on sentience and nociception in invertebrates is virtually non-existent. Conclusions relevant for animal welfare in invertebrates must therefore be based on the more general scientific knowledge gained from mammalian research and adapted to existing knowledge on the structure and function of the nervous system of animals belonging to major groups of invertebrates. According to the literature reviewed in the Scientific Report, most invertebrates are probably unable to feel pain. However, the significance of the presence of opioids in the circulation of some invertebrate species is not known, and these substances might be involved in pain perception and relief much in the same manner as in vertebrate species.

The ability of invertebrates to experience discomfort and stress is more related to the unsolved question of to what extent they are provided with emotional and higher cognitive abilities like consciousness and awareness. The comparatively advanced brain of octopuses warrants further research on the extent of their cognitive abilities. As long as the questions of sentience and pain remain uncertain, concern should at least be given to the more advanced species of

invertebrates during handling and captivity. Cephalopods, in particular the eight-armed species (*Octopus* sp), and social insects, such as honeybees (*Apis mellifera*), may be particularly vulnerable. Definite answers to pain, discomfort and stress in invertebrates are impossible to provide until more research has been carried out.

Background:

As a consequence of the Report to the Norwegian Parliament on Animal Keeping and Animal Welfare, "St. melding nr. 12 (2002-2003)", a working group was established by the Government to work out a proposal for the elaboration of a new revised Animal Welfare Act. In relation to this work, the Norwegian Food Safety Authority needed to examine new animal welfare aspects and determine if new groups of animals should be protected under the Act. As part of this procedure, the ability of various groups of invertebrates to sense and to perceive discomfort, pain and stress when these organisms are exposed to human handling needed further elucidation.

The Norwegian Scientific Committee for Food Safety was requested by The Norwegian Food Safety Authority to give an opinion on these topics on the 24th of October 2004.
The Panel on Animal Health and Animal Welfare asked the Department of Animal and Aquacultural Sciences, the Norwegian University of Life Sciences to produce a scientific report on the topics as a background-document for the assessment. The discussions and conclusions of the panel are, to a large extent, based on the Scientific Report published on the VKM web sitehttp://vkm.no/eway/library/openForm.aspx?param1=16080&param5=read .

Terms of reference:

The Norwegian Scientific Committee for Food Safety Panel on Animal Health and Welfare was requested by the Norwegian Food Safety Authority to assess the ability of various groups of invertebrates to sense and perceive discomfort, pain and stress when such organisms are exposed to human handling. In particular, the assessment was to include species like *Mollusca, Echinodermata, Annelida, Insecta, Arachnida* and *Crustacea.*

Assessment:

A Scientific Report prepared by Professor emeritus Lauritz S. Sømme, University of Oslo with support from the Department of Animal and Aquacultural Sciences, the Norwegian

University of Life Sciences, describes the sensory and neural system of the particular species. In addition, cognitive abilities and the neurobiological potential for pain and suffering are presented to the extent this is known from the scientific literature. The Scientific Report is published on the VKM web site
http://vkm.no/eway/library/openForm.aspx?param1=16080&param5=read

Central nervous system

The central nervous systems of invertebrates show different levels of complexity. Echinoderms have a simple net of nerves, but no distinct ganglia. In annelids and arthropods the nervous system comprises an anterior brain and a ventral nerve string with ganglia corresponding to the segmentation of the animal. Molluscs, bivalves, snails/slugs are equipped with simple pairs of ganglia in different parts of the body. In cephalopods, and in particular in the eight-armed octopuses, the ganglia are concentrated in a large and complex brain.

The phylogenetic tree of the animal kingdom was divided in two branches several hundred million years ago. Vertebrates and echinoderms belong to one of the branches, and most invertebrates to the other one. With their long evolutionary history, the nervous system in vertebrates and invertebrates are quite different. In contrast to invertebrates, the vertebrates have compact brains and a dorsal nerve cord. Certain areas of the vertebrate brain are sites of consciousness. The great differences make it difficult to compare the cognitive abilities of vertebrates and invertebrates. Since all invertebrates lack the cerebral cortex associated with sentience and perception of pain in mammals, it is uncertain if these animals can feel pain consistent with the concept of pain as we know from humans. Rather, the reaction to a harmful stimulus may be limited to nociception. In contrast to pain, nociception is the unconscious response to noxious stimuli. It has also been argued by some researchers that some vertebrates, such as fish, are unable to feel pain due to the lack of a neocortex. However, others have challenged this opinion. Despite the fact that a neocortex is absent in fish, amphibians and lizards, as well as all invertebrates, it cannot be excluded that other parts of their nervous system have similar functions. Whether this also involves consciousness and awareness remains to be verified.

Senses

Through their neural systems, all animals react to noxious or dangerous stimuli that could result in damage to their skin or other organs. The escape mechanisms in animals are essential

adaptations partly based on reflexes, and not necessarily associated with conscious experience. Most invertebrates are equipped with numerous mechanical and chemical sense organs. Compound eyes are well developed in decapod crustaceans and insects, and cephalopods have eyes resembling those of vertebrates. In contrast to vertebrates, most sensory neurons in invertebrates are monopolar. The sense organs transform stimuli from the environment into neural impulses, and axons from sensory neurons lead to different ganglia in the central nervous system that completely or partially control the responses to these stimuli.

Nociception and reflexes

The capacity of animals to react to harmful stimuli is called nociception. In contrast to pain, nociception is the unconscious response to noxious stimuli. Rapid withdrawal in invertebrates is often based on short neural circuits from neural cells to muscles. Some rapid reflex arches include so-called giant nerve fibres. Examples of reflexes are the reaction to air movements in cockroaches, flapping of the tail in lobsters and hiding of the antennae in snails. The occurrence of series of reflexes is known from insects.

Most of the behaviour in invertebrates, even very complex ones, is inherited. In this way, behavioural patterns rely on rigid programmed avoidance and escape responses. To different degrees, behaviour is also modified by learning, in particular in octopuses and social insects (i. e. honeybees).

Cognition

The ability of invertebrates to experience discomfort and stress are related to the question of to what extent they are provided with emotional and higher cognitive abilities. Cognition includes processes involved in acquiring and storing information from neural impulses. Learning and the control of strategically directed behaviour are parts of cognition. Non-associative (habituation, sensitisation) and associative (conditioning) learning are found in most taxonomic orders from *Annelida* and upwards in the phylogenetic tree. Research indicates that such processes can be explained by cellular processes not necessarily involving consciousness or awareness. Cognitive abilities of insects are best known from honeybees, and octopuses apparently possess a high level of cognition.

Sentience and pain

The capacity of feeling is called sentience, and is the basis for experience of stress and pain. It is assumed that four-legged vertebrates are sentient, but it is not definitely known if this is the

case in fishes. In invertebrates, more research is required to show if they have sentience or consciousness. The function of opioids in invertebrates is not known, but the production of such substances reduces pain in vertebrates.

With the relatively simple nervous system of earthworms and other annelids, it is very unlikely that they can feel any pain. The wriggling of earthworms on a hook can be considered as reflexes.

In molluscs like snails, slugs and clams, the nervous system includes several ganglia, but their brains are poorly developed. Sentience in these animals is unlikely. In contrast, the brains of cephalopods, and in particular of octopuses, include large concentrations of ganglia. Although octopuses have a high level of cognition and great ability to learn, it is not definitely known if they can experience pain. Among invertebrates, however, cephalopods are definitely the animals that should be given the highest consideration when handled and kept in captivity. In Norway this also applies to *Todarodes saggitatus*, which is seafood for humans, even if this species does not belong to the highest developed cephalopods.

In spite of the violent reactions of lobsters and crabs when put in boiling water, it is assumed that these are reflexes to noxious stimuli. Different kinds of pre-treatment before boiling may reduce any possible feeling of stress. There is apparently a paucity of exact knowledge on sentience in crustaceans, and more research is needed. Lobsters and crabs have some capacity of learning, but it is unlikely that they can feel pain.

The nervous system and senses of insects appear to be better developed than in crustaceans since an active life on land may be more demanding. With the great diversity of insects, there are great differences in the organization of the central nervous system and senses. In general, insects are equipped with numerous sense organs. The brain is particularly well developed in social insects, and the size of certain neural centres can be correlated with learning capacity. Learning is also known from many solitary species of insects. Insects do not react to damage of their bodies, but may show strong reflexes to constraint. With our present knowledge, it is usually concluded that insects cannot feel pain. Still, doubts have been raised. Among invertebrates, social insects represent a high level of cognition, and their welfare should be considered during handling.

Conclusions and concern:

In conclusion, it appears that most species of invertebrates probably are unable to feel pain, stress and discomfort.

However, a definite answer to this question in all invertebrates may be hard to find, since it is difficult to assess if some of the species are indeed conscious and sentient beings. The detection of opioids in some invertebrates may indicate some level of endogenous ability for pain relief in response to noxious stimuli. More research is needed to elucidate whether this is a component of pain perception in these animals. Based on these uncertainties, special concern should be given to the more advanced species of invertebrates, such as cephalopods and social insects, during handling and in captivity.

References:

All references are available in the scientific report “Sentience and Pain in Invertebrates”.

Scientific panel members:

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