The Welfare of Crustaceans at Slaughter

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Abstract

The most common methods of slaughtering crustaceans include splitting, spiking, chilling, boiling, gassing, "drowning," and using chemicals or electricity. As crustaceans do not have a centralized nervous system, unlike vertebrates, they do not die immediately upon destruction of one discrete area, such as the brain. New technologies, including the Crustastun electrical stunning and killing system, may improve the welfare of crustaceans during slaughter, which is critically important as most if not all current techniques are inhumane.

Introduction

Crustaceans are aquatic arthropods possessing a segmented body, exoskeleton, and jointed, paired limbs. Decapods are those crustaceans with five pairs of legs, the first pair of which form grasping pincers. Lobsters, crabs, prawns, and crayfish are among these large decapod crustacean species with well-developed nervous systems.[1] In 2006, the United States was reported to have wild-caught 190,808 tonnes of lobsters and crabs.[2]

Though some[3,4] have long been concerned with the welfare of crustaceans, primarily decapods, killed for human consumption, consideration within scientific, governmental, and industry sectors, as well as by mainstream consumers, is fairly novel, yet increasing in prevalence. Indeed, though the body of literature on crustacean welfare is still limited, there exists robust scientific evidence in support of crustaceans being sentient animals with the capacity to suffer. Research has found the presence of opioids and opioid receptors in crabs, leading scientists to postulate that some crustaceans may possess an analgesic system like that found in vertebrates.[5] In an avoidance learning experiment, for example, crabs showed memory of aversive stimuli and learned to avoid the electric shocks by refraining from entering the environment associated with the painful stimulus, rather than simply escaping from it.[6] In a more elaborate study, scientists investigated whether prawns showed evidence of feeling true pain rather than simple, reflexive, nociceptive responses by using both physiological and behavioral approaches.[7] Noxious stimuli (irritating chemical solutions and physical pinching) applied to antennae caused prawns to display immediate reflex tail-flicking responses and also two prolonged activities, grooming of the antenna and rubbing of the antenna against the side of their enclosure. These responses were blocked with the application of the local anaesthetic, benzocaine. The researchers interpreted these results as crustaceans possessing the capacity to experience pain.[8]

As more evidence is gathered on the ability of crustaceans to experience pain and suffer distress, a broader interest in their welfare is developing. A 2005 report on the protection of animals used for scientific and experimental purposes, prepared by the European Food Safety Authority (EFSA) for the European Commission, concluded that the largest of the decapods have a pain system and complex cognitive capacity; therefore, these decapod crustaceans have been assigned Category 1 status—animals who are able to experience pain and distress. As such, the three Rs of replacement, reduction, and refinement will apply to crustaceans undergoing all experimental and scientific procedures[9] in attempts to decrease the levels of animal suffering where possible.

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However, humane slaughter legislation in most of the world has not been interpreted as applying to crustaceans,[10,11] despite the fact that many crustaceans have been shown to demonstrate complex behavior and physiological responses to noxious stimuli that provide evidence of their capacity to experience pain.[12,13,14,15] The relative disinterest in crustacean welfare may also be an important reason as to why less aversive slaughter technologies and practices have not been developed to the degree they have for other animals killed for human consumption. Indeed, the overwhelming majority of crustacean slaughter methods has been found to cause distress and, as such, is inhumane as they induce highly aversive behavior, including animals throwing off their own limbs, thrashing, or tearing at their own bodies with their pincer-like claws.[16] As well, physical methods of quickly destroying the nervous system of crustaceans are inefficient due to the diffuse nervous system of many species.[17] As a result, some believe that only the accurate and skilled practice of bisecting or pithing can effectively kill these animals in the least aversive way possible.[18]

With knowledge that some crustaceans can experience pain, it is ethically unacceptable to continue subjecting these animals to inhumane slaughter. Increasingly, public and consumers' negative perception of the conditions in which live decapods are kept and killed, more so than the scientific interest of nociception by crustaceans, has recently been the impetus for growing demand for improved welfare for these animals,[19,20] including those killed in restaurants.[21]

Common Slaughter Methods

The nervous system of many crustaceans consists of individual ganglia (well-defined clusters of nerve cells) connected along a main ventral nerve cord. Typically, a single ganglion in each segment controls sensory and motor functions. The central nervous system is small and located around the esophagus. Given the anatomy of the nervous system, it is not possible to kill crustaceans by trauma to one central location as with vertebrates,[22] which is an important aspect of rapid slaughter with minimal pain. One possible exception is the crab. Fusion of segments has condensed their nervous systems into two main ganglia. As such, crabs can be killed by "spiking" these areas (discussed below).[23] Generally, physically damaging nerve cords can be difficult. More widely used alternative options involve manipulating the animals' environment, such as changing the temperature, pH, or salinity.[24]

Splitting

In contrast to crabs, lobsters have a chain of ganglia with interconnecting nerves running through the animals' longitudinal midline (the length of the body).[25] One slaughter technique destroys these centers by rapidly cutting through the longitudinal midline of the lobster with a sharp knife.[26] Thus, "splitting" involves cutting the animal on the ventral side, bisecting the lobster into two identical longitudinal halves,[27]starting at the front of the head and continuing through the thorax and straight down through the midline of the animal where the nervous system is located.[28] In the New South Wales Department of Primary Industries' (NSW DPI's) summary of shellfish slaughter practices, specific details are presented on proper cutting methods, followed by the quick removal of the chain of nerve centers at the chest and head.[29]

Spiking

With this method, a knife is inserted into the animal's head to destroy the main nerve centers. Although an inappropriate slaughter method for lobsters as they have several nerve centers along their bodies, spiking is thought to be an appropriate method for slaughtering crabs due to their more centralized nervous system.[30] Crabs have two main nerve centers, as discussed above, one in the anterior region of the body, near the animal's face and one in the rear of the body. Both centers sit along the imaginary longitudinal line that bisects the animal into two identical halves. Rapid destruction of both nerve centers by piercing the underside of the crab with a thick, pointed pithing instrument by a skilled and effective slaughterer[31] is believed to be a rapid method that inflicts minimal pain.[32]

Chilling in Air

As crustaceans are cold-blooded animals, they generally enter a state of torpor at air temperatures of 4ºC (39.2ºF) and lower, rendering them insensible though still alive.[33] As such, chilling in air has been used as the initial part of a two-stage slaughter method, followed by splitting or spiking to destroy the nervous system.[34] It is believed that chilling helps reduce nerve function and metabolic activity.[35] Though, scientific proof of the association between chilling and the reduction of discomfort or pain is limited or unavailable, this process is commonly believed to be effective as the crustaceans subjected to chilling do not show behavioral signs of distress such as thrashing and autotomy (discussed in detail below) as they do as a result of other methods of slaughter.[36] However, the amount of time required to render crustaceans insensible by air chilling varies depending on size, species, metabolic state, and the rate of chilling.[37]

Chilling in Ice Slurry

For slaughter, chilling in ice slurry is less effective for species from more temperate waters,[38] but as tropical species of marine crustaceans are susceptible to colder temperatures, they are rendered unconscious by chilling in ice slurry.[39] Tropical crustaceans acclimatized to warm waters sense a greater temperature differential and hence greater temperature shock when plunged into icy waters than their counterparts already acclimatized to cooler waters. This may explain the difference of effectiveness on crustaceans originating from different geographical locations. As with chilling in air, the length of time required to induce unconsciousness varies according to many factors. Generally, however, a minimum of 20 minutes of immersion in ice slurry is required to induce unconsciousness in crustaceans.[40] EFSA recommends a ratio of ice to water of 3:1 and temperatures maintained at or below -1ºC (30.2ºF) until the animal is rendered unconscious.[41] Using this method to kill marine species is not advised because the osmotic shock caused by melting ice diluting the water's salinity adversely affects their welfare. Proper control of water salinity would help curb this problem.[42] Indeed, NSW DPI recommends using a salt water/ice slurry mixture. In agreement with EFSA, NSW DPI also recommends immersion in the slurry for a minimum of 20 minutes to ensure immobilization prior to slaughter, but suggests the ratio of slurry should be normal ice to salt water (at sea water salinity) of 3:1 at -1ºC (30.2ºF).[43]

Crustaceans generally exhibit few behavioral signs of distress during the process of chilling, and the method of chilling the animals has been commonly recommended as a method used to immobilize and render animals unconscious prior to being slaughtered.[44,45] However, some researchers have criticized the technique as being slow and inconsistent,[46] two critical issues that would reduce welfare and therefore make the method unacceptable. Additionally, there have not been studies on crustaceans that measure physiological responses indicative of stress or suffering of the animals while undergoing various slaughter treatments, such as chilling.[47] As such, other than visual observation of crustacean behavior, there is no objective way to make definitive conclusions about the level of distress they experience during these slaughter practices.

Boiling

The most commonly practiced slaughter method is placing live, fully conscious crustaceans into boiling water. Although this kills them, it appears to cause physiological shock and autotomy is commonly exhibited.[48] A behavioral response, autotomy results in limbs or other body parts being shed by the animal in response to damage or capture, or to stop the spread of potentially harmful stimuli to the rest of the body.[49] In addition to autotomy, lobsters struggle violently for approximately two minutes after being placed in boiling water before they stop moving.[50,51]

As scalding sensible animals to death is unnecessarily cruel, attempts were made to modify this method by first placing crustaceans in cool water before gradually raising the temperature.[52] Experiments were conducted during which crabs were placed in pots of cool tap water that were then gradually heated to 40ºC (104ºF) by stovetop. Findings revealed that the animals died in quiescence without showing the signs of vigorous distress observed when they were plunged into boiling water. As such, this two-phase method was claimed to be a less aversive method of slaughter.[53] However, contradicting results were found when crabs displayed escape

attempts from the cauldron as water temperatures rose.[54] Movements became uncoordinated at 32ºC (89.6ºF), and locomotion stopped and autotomy took place at 34ºC (93.2ºF). At 8.5 minutes, 40ºC (104ºF) was reached, at which point the animals ceased responding to any stimuli.[55] From a behavioral perspective, this method of killing crustaceans in slowly heated water may be considered inhumane as it reportedly subjects them to conditions they try to avoid.[56,57]

Carbon-Dioxide Gassing

Crustaceans are also killed by increasing the concentration of carbon dioxide in water, changing the pH, but the animals reportedly suffer distress by this method.[58] Caleb Gardner, crustacean research group leader at the Tasmanian Aquaculture and Fisheries Institute, found that crabs exposed to this treatment showed extremely aversive behavior, including tearing at their own sternums with their chelae (pincer-like claws), exposing internal organs.[59,60]

Freshwater Immersion or "Drowning"

A common practice of killing marine crustaceans involves altering salinity, effectively "drowning" saltwater species in fresh water by osmotic shock.[61] When marine crustaceans are immersed in fresh water, they die slowly from the eventual loss of salts from their blood.[62] Although hyposaline conditions have the effect of aiding in the prevention of limb loss in lobsters,[63] research has shown that immersing crabs in fresh water appears to cause suffering as animals have been reported to show aversive behavior, such as uncoordinated bodily movements and increased intensity of respiration.[64]

Anesthetics

The use of chemicals to kill crustaceans has also been studied and practiced. Clove oil is becoming a popular anesthetic for procedures such as handling and transporting some aquatic animals,[65,66] and has been tested on various species of fish[67] and octopus.[68] An alternative to tricaine methanesulfonate (which is mildly toxic) and carbon dioxide (which has been shown to cause violent aversive reactions),[69,70] clove oil has been employed in human medicine and dentistry as a local anesthetic and analgesic.[71] Some researchers believe that clove oil may be used effectively to kill crustaceans like crabs[72] as this natural compound has been shown to immobilize crabs without apparent signs of distress.[73] However, the long-term human health effects of this substance are still unclear.[74] Additionally, clove oil has a commonly reported noxious and strong odor,[75] which can affect the animals' flesh.[76] AQUI-S, a clove oil-based product, has been approved for the killing of fish for human consumption in New Zealand, Australia, Chile, South Korea, and Costa Rica; has no withdrawal time; and does not have a strong odor.[77,78] However, additional research may better assess its effectiveness with the killing of crustaceans and address regulatory issues regarding its use without withdrawal periods in animals destined for human consumption.[79]

The Crustastun

In 1975, John Baker, Oxford University zoologist, wrote that "[i]t is hoped that it may be possible to design apparatus capable of stunning many lobsters or crabs electrically…to reduce unnecessary suffering by other edible animals that are killed by boiling."[80] Nearly 30 years later, Simon Buckhaven, of U.K.-based Studham Technologies, developed the Crustastun and collaborated for two years with the Department of Food Animal Science at the University of Bristol to determine through experimental research how the device can be used to deliver the most effective and least aversive slaughter method to crustaceans.[81]

The developers of the Crustastun claim that the application of electrical stunning at 110 volts and 2-5 amps causes an immediate interruption in the animal's nervous system function, which prevents the crustacean from receiving stimuli and thus from feeling pain or suffering distress.[82] In this way, the Crustastun is said to render crustaceans unconscious in less than 1 second and, if the stun is prolonged to 5 seconds for lobsters or 10 seconds for crabs, it can kill the animals.[83] Two versions are in production: a Single Unit Stunner, aimed for

restaurant and point-of-sale use, and the Continuous Belt Processor/Batch Stunner, intended for large-scale processors.[84]

Conclusion

Gardner stated that "[u]nfortunately, product quality objectives and welfare objectives do not always coincide with crustaceans."[85] Indeed, the immersion of marine crustaceans into freshwater baths is used by industry to prevent limb loss and therefore to protect product quality, for example, yet this slaughter method is known to reduce animal welfare.[86] Increasingly, however, scientific inquiry is gaining better understanding of these invertebrate animals and working to improve their welfare, a desire seen more frequently in legislative and retail arenas.

In terms of slaughter, ESFA proactively summarized that the killing methods most likely to cause pain and distress are:

- any procedures whereby the abdomen is separated from the thorax;
- the removal of tissue, flesh, or limbs while the crustacean is alive and fully conscious;
- placing crustaceans in slowly heated water to the boiling point;
- placing crustaceans directly into boiling water;
- placing marine crustaceans in fresh water; and
- the unfocused microwaving of the body as opposed to focal application to the head.[87]

As such, splitting, chilling in air or ice, boiling, carbon dioxide gassing, and "drowning" are not recommended methods of slaughtering crustaceans. The new technology provided by the Crustastun appears to have many advantages over other conventional killing systems, yet its use has not yet become widespread, so crustaceans continue to be subjected to inhumane slaughter inducing pain, aversive behavior, and suffering.

In a paper on understanding the suffering of invertebrates, Jennifer Mather, a professor in the Department of Psychology and Neuroscience at the University of Lethbridge, Alberta, Canada, advises: "We could try to find out how they work by better accommodating, not ignoring, them."[88] Indeed, it is an ethical imperative not only to determine the least inhumane means by which to slaughter these animals, but to consider their welfare.

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