Alien Pain

Can a squid suffer? What about a prawn? The more we learn about these strange creatures, the more pressing such questions become, says Tamar Stelling

A SCIENTIST and a seafood chef walk into a bar. "We have a mutual interest," says the scientist. "I study crustaceans and you cook them." But the chef wanted to know just one thing. Do they feel pain?

Robert Elwood had been working with crabs and prawns for the best part of three decades when he bumped into TV chef Rick Stein in a local pub on the coast of Northern Ireland . Yet he was stumped. "It was the first time I ever considered the question," he says.

Although some people are horrified by the idea of cooking lobsters alive, or the practice of tearing claws from live crabs before tossing them back into the sea, such views are based on a hunch. We know next to nothing about whether or not these animals – or invertebrates in general – actually suffer. In Elwood's experience, researchers are either certain they feel pain or certain they don't. "Very few people say we need to know," he says.

The global food industry farms or catches invertebrates in their billions every year, from shrimp and squid to wasps and worms. But unlike their vertebrate cousins – pigs, chickens, fish, and so on – they enjoy virtually no legal protection (see "Outside the law", overleaf). "Early on in my career I realised that when the law speaks of animals, it does not mean invertebrates," says Antoine Goetschel, an international animal law and ethics consultant based in Zurich, Switzerland. "As long as the common opinion is that invertebrates do not suffer, they are out of the game."

But the game is changing. Relatively complex yet free of red tape, invertebrates have become the lab animal of choice for many researchers. Meanwhile, plans are afoot in the European Union and elsewhere to farm insects on an industrial scale. And Elwood and others are finding evidence that could have implications for all of these developments. The more we find out, the more we need to rethink a distinction based on backbone alone.

Pain is an awkward thing to test, though. It can't be measured directly or pointed at – it's not even easy to define. We know it when we feel it, of course. But when we are in pain, others just have to take our word for it. How can we tell when an animal is suffering? We have come a long way since Descartes, who argued that all non-human animals were merely automata, without self-awareness and incapable of feeling. But much of what we think we know still involves a lot of guesswork.

We have an empathy for animals that are familiar to us, especially other mammals. Many respond in the same ways we do when we are in pain, by nursing a wound, for example. Anatomical similarities give further clues. Since we feel pain, it seems logical to think that animals with a similarly organised central nervous system feel pain too. That covers vertebrates, from mammals to birds and, at a stretch, fish. But when it comes to a crab, a squid or a wasp, analogies break down. These are strange, alien creatures.

So how do we answer Stein's question? Elwood has been looking for ways to do so since running into Stein eight years ago. For a start, arguments by analogy are silly, he says. "Denying that crabs feel pain because they don't have the same biology is like ›

Spineless majority: invertebrates make up 98 per cent of species

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OUTSIDE THE LAW

Animal-welfare legislation generally prohibits the inflicting of unnecessary suffering on any animal. But in practice there is an obvious bias. "Only the killing or mistreating of vertebrates is really punishable," says Antoine Goetschel, an international animal law and ethics consultant based in Zurich, Switzerland. For invertebrates, anything goes.

Last September, for example, the group People for the Ethical Treatment of Animals (PETA) filed a criminal complaint against a lobster-processing plant in Rockland, Maine. PETA had filmed a worker ripping the claws off a live animal and impaling its squirming body on a spike. Confronted with evidence of apparent cruelty, the plant's lawyers pointed out that they had violated no regulations - since there are none - and argued that lobsters were incapable of suffering. "You can't humanise a lobster," a spokesperson said. "They are food."

For lab animals, discrimination is explicit. Regulations covering animals used for research typically exclude invertebrates. Since the start of 2013, however, squid and other cephalopods have been granted nominal protection in labs in the European Union. But what this means in practice remains to be seen.

Since we still know so little about invertebrates, some are concerned that we can't ensure their well-being even with specific guidelines. The effects of anaesthetics on cephalopods are largely unknown, for example. But Justin Goodman, director of PETA's Laboratory Investigations Department, welcomes the move. The protection should also be extended to animals outside the lab, he says, "especially since most cephalopods are harmed for food production and not experimentation."

denying they can see because they don't have a visual cortex."

Elwood and colleagues at Queen's University Belfast in the UK are instead tackling the question by looking at how these animals behave. Most organisms can respond to a stimulus that signals a potentially harmful event. Special receptors called nociceptors – which sense excessive temperatures, noxious chemicals, or mechanical injuries like crushing or tearing – are found throughout the animal world, from humans to fruit flies. When a parasitic wasp jabs its egg-laying ovipositor into a fruit fly larva, for example, the larva senses the needle and curls up, which can make the wasp pull out.

Beyond reflex

But when an animal responds to something we would consider painful, it does not necessarily mean the animal is in pain. The response might be a simple reflex, where signals do not travel all the way to the brain, bypassing the parts of the nervous system connected with the conscious perception of pain. When we scald our hand, for example, we immediately – and involuntarily – pull it away. Pain is the conscious experience that follows, once the signals have reached the brain. The key for Elwood was thus to look for responses that went beyond reflex – the crustacean equivalents of limping or nursing a wound.

He started with prawns. After so many years of working with them he thought he knew what to expect, which was to see nothing more than reflex reactions. But to his surprise, when he brushed acetic acid on their antennae, they began grooming the treated antennae with complex, prolonged movements of both front legs. What's more, the grooming diminished when local anaesthetic was applied beforehand.

He then turned to crabs. If he applied a brief electric shock to one part of a hermit crab, they rubbed at that spot for extended periods with their claws. Brown crabs rubbed and picked at their wound when a claw was removed, as it is in fisheries. At times the prawns and crabs would contort their limbs into awkward positions to reach the injury. "These are not just reflexes," says Elwood. "This is prolonged and complicated behaviour, which clearly involves the central nervous system."


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He investigated further by placing shore crabs in a brightly lit tank with two shelters. Shore crabs prefer to hide under rocks during the day, so in this situation they should pick a shelter and stay there. But giving some of the crabs a shock inside one of the shelters forced them to venture outside. After only two trials, the crabs that had received shocks were far more likely to switch their choice of shelter. "So there is rapid learning," says Elwood. "Just what you would expect to see from an animal that experienced pain."

Finally, Elwood looked at how the need to escape pain competed with other desires. For us, pain is a powerful motivational driver and we go to great lengths to avoid it. But we can also override our instincts and choose to endure it if the rewards are great enough. We suffer the dentist's drill for the long-term benefit, for example. What would a crustacean want badly enough to make it endure pain?

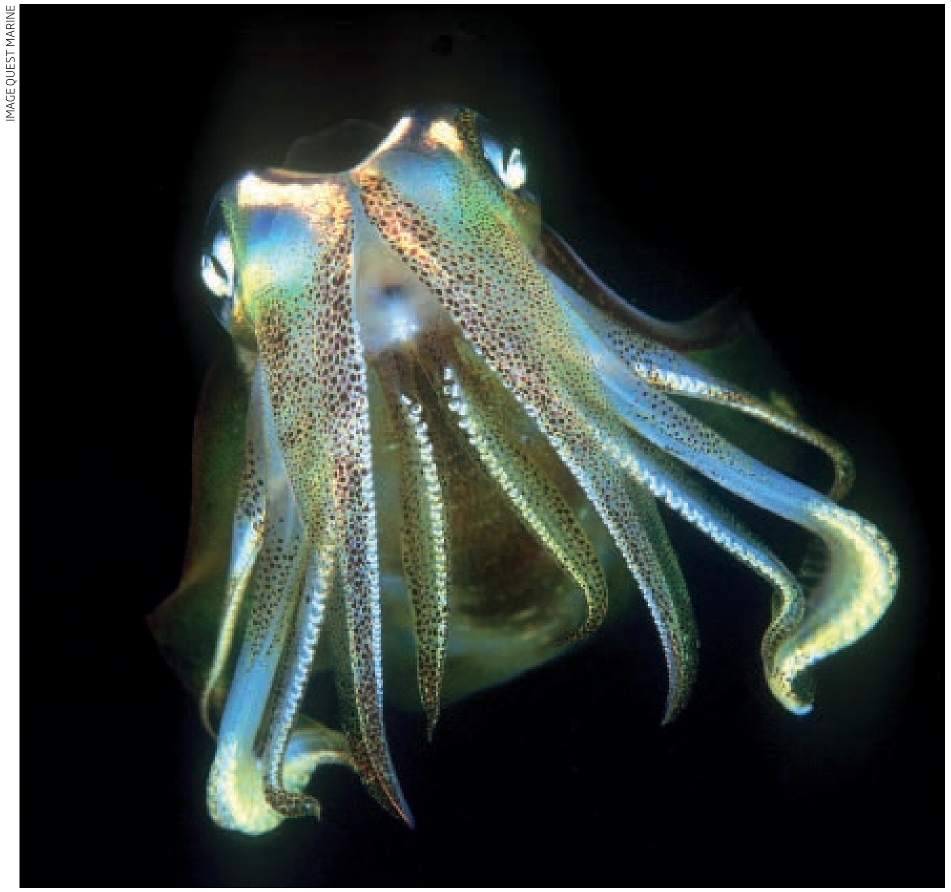
For hermit crabs, it turns out to be a good home. These animals take up residence in abandoned seashells, but can be made to give up their home if given a shock inside the shell. Elwood found that the likelihood of a hermit crab dumping its shell when given a shock depends not only on the intensity of the shock but also on the desirability of the shell. Crabs in better shells took bigger shocks before they were willing to move out. This suggests that the crabs are able to weigh different needs when responding to the noxious stimulus. Once again, this behaviour goes far beyond reflex, says Elwood.

And it is not just crustaceans. Robyn Crook, an evolutionary neurobiologist at the University of Texas Health Science Center in Houston is asking many of the same questions of cephalopods, such as squid and octopuses. "We are learning things we never expected to find," she says.

Remarkably, Crook and colleagues have only recently shown that cephalopods have nociceptors at all. She has also found that octopuses show much of the pain-related behaviour we see in vertebrates, such as grooming and protecting an injured body part. They are more likely to swim away and squirt ink when touched near a wound than elsewhere on their body.

Squid, though, may feel pain very differently. Shortly after a squid's fin is crushed, nociceptors become active not only in the region of the wound but across a large part of its body – extending as far as the opposite fin. This suggests that if it feels pain, rather than being able to pinpoint the location of a wound, an injured squid may hurt all over.

There are no regulations focusing specificially on how we treat crustaceans

IMAGE QUEST MARINE


Only recently have squid been shown to have receptors that sense injury or nasty stimuli

Crook is not certain why this would be. But it makes sense from a squid's point of view, she says. Unlike an octopus, a squid's tentacles can't reach many parts of its body, so they couldn't tend a wound even if they knew where it was. They also have a fast metabolism that forces them to stay on the move and keep hunting. An all-over heightened sensitivity may keep a squid generally more alert and wary. For example, she has found that an injured squid will be more sensitive to touch and visual stimuli. "Its long-term behaviour changes," she says. "This fulfils one important criterion for pain."

Despite this work, the topic remains controversial. "I've had senior scientists absolutely lay into me over my interest in pain and ethics," says Crook. One concern is where to redraw the line if the backbone no longer marks a boundary. After all, roughly 98 per cent of all animal species are invertebrates; Elwood and Crook may only be scratching the surface. The differences between octopus and squid show how diverse the experiences of the rest of the invertebrates could be, says Crook. A crustacean's neurons number in the low hundred-thousands. If they feel pain, she says, then what about fruit flies? They have a similar-sized nervous system.

Fruit flies are known to have nociceptors, and it is likely that other insects do too. Bees also respond differently to electric shocks given with and without anaesthetic. And insects, generally, seem capable of learning to avoid noxious stimuli. But can they suffer?

Hans Smid, who studies the brains and learning behaviour of parasitic wasps at Wageningen University in the Netherlands, dismisses the possibility outright. "I am absolutely convinced that insects do not feel pain," he says.

"Rather than being able to pinpoint a wound, an injured squid may hurt all over"

Like Elwood, Smid's interest in pain began with a simple question. A few years ago a visiting journalist was surprised at how casually Smid squashed a wasp that had escaped from its cage. Why hurt an animal you are so enthusiastic about, the journalist wanted to know. That set Smid thinking. But he is confident that insect behaviour is best understood in terms of a relatively simple series of reflexes and innate responses.

Unlike crustaceans, insects seem to have no pain-related behaviours. If an insect's leg is damaged, for example, it does not groom or try to protect the limb afterwards. Even in extreme cases, insects show no evidence of pain. Imagine a praying mantis eating a locust, says Smid. With its abdomen opened up, the locust will still feed even while being fed on itself.

No gain, no pain

In terms of relative brain size, fruit flies and the parasitic wasps that Smid studies are the masterminds of the insect world. But neurons consume a lot of energy and there is evolutionary pressure to keep brains as compact as possible. In short, there need to be good reasons to have enough brain for pain. Smid thinks that insects simply do not have the need. "I don't see the evolutionary advantage for insects to sustain such a complex system as emotion, of which pain would be just one component," he says.

Elwood agrees this is a useful way to frame the question. "From an evolutionary perspective, the only reason for pain that makes sense to me is that it enables long-term protection," he says. Pain may provide an animal with an additional, and memorable, means of focusing on a source of harm that helps it avoid it in future. If an animal's lifespan is not long enough to benefit from that – as is the case with most insects – then pain has no use. Similarly, some animals may simply be unable to avoid noxious stimuli in the first place. "Is a barnacle going to benefit from a bad experience?" says Elwood. "I doubt it."

Ultimately, we are up against the problem of consciousness. Like all subjective experience, pain remains private to each individual, leaving us only with educated guesses. But both Elwood and Crook have changed how they treat the invertebrates in their labs. They now use as few animals as possible and keep the potential for suffering to a minimum. And they are pushing others to do the same. There are signs of change, too: cephalopods at least now get some protection, in some parts of the world. "We are broadening our understanding of both pain and nociception," says Crook. "How can this not be interesting, even to the sceptics?" ■

Tamar Stelling is a freelance journalist based in The Hague, the Netherlands, and writes about art and science