Review of *What a Fish Knows: The Inner Lives of Our Underwater Cousins* by Jonathan Balcombe

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Abstract: This review summarises and comments on a book which presents research-based and anecdotal information on the worlds of fishes. The book attempts to enhance humans' understanding of and empathy for the inhabitants of those worlds. *What a Fish Knows* provides a useful foundation for ecolinguists and others who wish to apply their knowledge and skills on behalf of fishes and all the other animals impacted by what happens in aquatic ecosystems of the planet.

Keywords: fishes, sentience, cognition, fish farming

Reference

Balcombe, J. (2016). *What a fish knows: The inner lives of our underwater cousins.* New York, NY: Scientific American / Farrar, Straus and Giroux.

Review

Jonathan Balcombe, the author of this *New York Times* best-selling book, has worked for many years as an ethologist (a scientist who studies animal behaviour). He is director of animal sentience at the Humane Society Institute for Science and Policy. His website is www.jonathanbalcombe.com. His other books are *The Exultant Art: A Pictorial Tour of Animal Pleasure*, *Second Nature: The Inner Lives of Animals*, *Pleasurable Kingdom: Animals and the Nature of Feeling Good*, and *The Use of Animals in Higher Education: Problems, Alternatives, and Recommendations*.

This review attempts to give readers an understanding of the structure of the book and a sample of some the book's main points. The review ends with some comments by the reviewer. The book consists of seven parts, some of which are divided into chapters. Balcombe dedicates the book to the "anonymous trillions" of fishes, and he hopes that after reading this book (or a summary thereof) that humans will appreciate that fishes are not objects or grains of sand, but that each of the trillions of fishes is an individual who thinks and feels. Referring to his hopes for each of the approximately 7.4 billion humans' attitudes towards fishes, Balcombe quotes an anonymous poet, "Nothing has changed except my attitude—so everything has changed" (p. 8). The reviewer believes this book provides valuable resources which ecolinguists can use to change people's attitudes towards finishes.

Prologue

That quote was from the book's prologue, which includes basic information on fishes and their plight. Balcombe contends that although many, many books have been written about fishes, his is the first book written on behalf of fishes. Other works that seem to be concerned about fishes, talking about endangered species and overexploitation of fish "stocks", actually focus on fishes as commodities for human use. The lives of fishes, Balcombe believes, have value not primarily for what they offer humans. Instead, all fishes' lives have value to each of those fishes and those in their communities.

One estimate puts the number of land animals killed annually for food for humans at about 70 billion. How many fishes are killed each year to feed humans? Balcombe uses an estimate, based on FAO data, that 1 trillion to 2.7 trillion fishes are killed by humans each year. (For other stats, please visit http://www.fishcount.org.uk.) These fishes die mostly from a combination of asphyxiation (when they are taken out of the water), decompression (due to pressure change as they are brought out of the water, being crushed under the weight of the fishes and other marine animals caught with them in the same net and being slaughtered.

Part 1 – The Misunderstood Fish

Fishes are an extremely diverse collection of animals, accounting for 33,249 species, 60% of all the known vertebrates, with many more fish species likely yet to be discovered. The two main types of fishes are bony fishes (the largest group), including eels, salmons, basses, goldfishes and carps, and cartilaginous fishes, including sharks and rays. Fishes have been on the Earth much longer than humans: "[Fishes] had graced planet Earth fifty times longer than we have before they even left the water" (p. 13). As to the criticism that fishes' small brains mean that they must not be able to think or feel, Balcombe counters with the point that miniaturisation allows small objects to function as well as larger ones.

Ever heard of flying fishes? Balcombe (p. 18) clarifies that fishes do not fly. Instead, they glide:

Flying fishes have greatly enlarged pectoral fins that function as wings. In preparation for launch, they can reach speeds of forty miles per hour. Once airborne, the lower lobe of the tail may be dipped into the water and used as a supercharger to extend flights to 1,200 feet or more.

Another misconception about fishes is that because fishes have been on Earth for so many geologic ages, fishes must be primitive creatures who stopped evolving, while other vertebrates, especially mammals, continued evolving. Balcombe (p. 21) explains:

All of the fish species that were living at the dawn of legs and lungs are long gone. … The descents of early fishes have been evolving eons longer than their terrestrial counterparts, and on these terms fishes are the most highly evolved of all vertebrates. You might be surprised to know that fishes have the genetic machinery to make fingers—something that shows how similar fishes are to modern mammals. They just don't develop fingers, but fins instead, since fins are better for swimming than fingers are.

Part II – What a Fish Perceives

Part II consists of three chapters – What a Fish Sees, What a Fish Hears, Smells and Tastes, and Navigation, Touch and Beyond - focusing on the senses fishes use to perceive the world around them. All of these abilities are keenly affected by the fact that fishes live in water. For instance, sound travels much faster in water than in air. Given this and other differences in perception, humans may have difficulty understanding how fishes perceive their worlds.

What a Fish Sees

Fishes' eyes are much like human eyes, with three pairs of muscles which enable the eyes to swivel. However, fishes' vision does differ from that of humans, the main difference being that humans have eyelids, while fishes do not. However, other differences also exist. For instance, some fishes, such as adult flounders, have both their eyes on the same side of their bodies. Also, in regard to sight, just as humans use camouflage to fool hostiles, fishes also use visual cues to fool predators. For example, comet fishes lure predators to attack

their rear ends, instead of their more sensitive heads. Comet fishes are able to do this because their rear side looks like the face of a parrot fish.

What a Fish Hears, Smells and Tastes

Before looking at how fishes hear, Balcombe clears up the misconception that fishes are silent creatures. Some of the mechanisms fishes use to make sounds include vibrating their swim bladders, grating and grinding their teeth, rubbing together their bones and pushing bubbles out of their anuses. Indeed, some fishes are named for the sounds they make, for example, grunters, croakers, drums and trumpeters.

Believing fishes to be silent led to the belief that they were also deaf. This was an easy mistake for human-centric scientists, because fishes have no external hearing devices. Balcombe describes the study by Nobel Prize winning scientist, Karl van Frisch, which demonstrated fishes' ability to hear, in much the same way that Pavlov demonstrated classical conditioning with dogs. The study's sole participant was a blind catfish. van Frisch put food on a stick into the fish's home. Upon smelling the food, the fish would swim towards it. Next, the researcher started whistling before lowering the food for the fish. After a while, all the fish needed was to hear whistling and he would swim towards the usual location of the food.

Fishes can hear, and they can hear an amazing range of sounds. The fishes in one study demonstrated the ability to categorise human music (Chase, 2011). Chase's study involved three carps. A speaker was placed in their home, an apparatus for operant conditioning was set up and the fishes learned to discriminate between blues music and classical music, and to categorise newly introduced music as either blues or classical. Another study found that listening to classical music enhanced the health of a group of fishes (Papoutsoglou, Karakatsouli, Papoutsoglou, & Vasilikos, 2010).

Fishes use their sense of smell for such purposes as identifying their location, locating food and mates and recognising danger. Unlike human nostrils, which function for both smelling and breathing, fish nostrils have only an olfactory function. In some cases, fishes' olfactory capabilities far exceed those of humans. Balcombe provides examples (p. 50):

Salmon can detect the smell of a seal or sea lion diluted to one eighty billionth of water volume … . the American eel … can detect the equivalent of less than one ten millionth of a drop of their home water in [an] Olympic pool. Like salmons, eels make long migrations back to specific spawn sites, and they follow a subtle gradient of scent to get there.

As to taste, one outstanding aspect of fish anatomy is the presence of taste buds in widely different parts of the body, not just in their mouths. These other locations can include the lips, snout and fins. Also, just as groups of humans tend to have similar tastes in food, e.g., spicy foods are favoured by some cultures, so too are particular foods favoured by given fish species. However, just as is the case with humans, individual fishes may have their idiosyncratic food preferences.

Navigation, Touch, and Beyond

Fishes, not surprisingly, have superb navigational skills. They navigate by such means as feeling water turbulence caused by the presence of objects, sun compassing, dead reckoning, a natural GPS system, smell, vision and electroreception. How do schools of fishes swim together in unison? Balcombe explains (p. 59):

[Fishes have] a row of specialized scales running horizontally along their flanks, forming what is called the lateral line. ... [Each scale] is populated by neuromasts, clusters of sensory cells each with a hair-like project encased in a tiny cup of gel. … The lateral line acts as a sonarlike system and is especially useful at night and in murky waters.

Some fishes seem to enjoy touching and being touched. Touching appears to play a part in courting, in relationships between cleanerfishes and their clients, and even as a form of interaction between fishes and human divers. For example, while the evidence here is anecdotal, Balcombe reports stories of sunbathing fishes and fishes who enjoy the stimulation of the bubbles from divers' regulators.

Part III – What a Fish Feels

Part III consists of two chapters - Pain, Consciousness, and Awareness, and From Stress to Joy. Advocates on behalf of animals are fond of the following quote from the 18th century philosopher, Jeremy Bentham: "The question is not, 'Can they reason?' nor, 'Can they talk?' but 'Can they suffer?'". The two chapters of Part III start with this question and then proceed to happier topics.

Pain, Consciousness, and Awareness

Not surprisingly, Balcombe believes that fishes do feel pain. In the book's previous pages, he made the case for fishes having the same senses and other basic structures as other vertebrates. In this chapter, he notes that fishes have A-delta and C fibres in their nerves; mammals use these fibres to experience pain (Braithwaite, 2010; Sneddon, 2003). However, fishes and other nonmammal vertebrates do not have a neocortex, the body part posited to be the centre of consciousness. Balcombe counters that birds do not have a neocortex either, yet scientists agree that birds have consciousness and can feel pain. Furthermore, fishes' brains have the pallium which carries out some of the same functions as the neocortex. In additional rebuttal, Balcombe makes the analogy that just as humans can swim despite lacking the fins that fishes employ for that purpose, so too are fishes conscious despite lacking a neocortex.

While Balcombe cautions that opinion may never be unanimous on the issue of fishes and pain, he quotes a document of the American Veterinary Medical Association to argue that a general consensus has developed among scientists who study fishes (AVMA, 2013):

Suggestions that finfish [fish that are not shellfish] responses to pain merely represent simple reflexes have been refuted by studies demonstrating forebrain and midbrain electrical

activity in response to stimulation and different with type of nociceptor stimulation. Learning and memory consolidation in trials where finfish are taught to avoid noxious stimuli have moved the issue of finfish cognition and sentience forward to the point where the preponderance of accumulated evidence supports the position that finfish should be accorded the same considerations as terrestrial vertebrates in regard to relief from pain.

Balcombe summarises the chapter by stating (pp. 84-85):

Fishes show the hallmarks of pain both physiologically and behaviourally. They possess the specialized nerve fibers that mammals and birds use to detect noxious stimuli. They can learn to avoid electric shocks and anglers' hooks. They are cognitively impaired when subjected to nasty insults to their bodies, and this impairment can be reversed if they are provided with pain relief.

From Stress to Joy

While the first chapter in Part III focused on fishes feeling pain, the second chapter focuses on emotions, beginning with fear and stress but then traveling to happier emotions. Balcombe notes that, "Emotions involve relatively old brain circuits conserved through evolution and shared by all vertebrates" (p. 88). Something similar seems to be the case for hormones that link to emotions. For instance, humans produce the hormone oxytocin, which promotes bonding, and fishes appear to have a similar hormone (Reddon et al., 2012).

As to pleasurable emotions, scientists have been witnessing fishes play since 1898 (Groos, 1898). Much more recently, Burghardt, Dinets and Murphy (2014) studied three bfishes apparently playing with a thermometer which had been designed to float vertically. Each of the three fishes had their own way of playing with the thermometer. The first fish pushed down on the top of the thermometer, while the second swam round and round the thermometer occasionally touching and thereby moving it, and the third fish was the most aggressive, hitting the object at various points, thereby making it move around the tank.

Part IV – What a Fish Thinks

Part IV consists of two chapters – Fins, Scales and Intelligence, and Tools, Plans and Monkey Minds. Balcombe frames these topics by recognising that the intelligences which different creatures develop are guided by those creatures' life circumstances. Furthermore, he quotes Dinets to warn against underestimating the cognitive capabilities of nonhuman animals (p. 105), "Every other animal currently considered stupid and boring has its own amazing secrets. It's just that nobody has been able to discover them yet". At the same time, Balcombe cautions that just because one fish species or one individual fish demonstrates a particular ability does not mean that all species or all members of a particular species possess or can develop that ability.

Fins, Scales and Intelligence

In what may be the most amazing story in the book, Balcombe describes the cognitive mapping abilities of gobies (White & Brown, 2015). Gobies find their food in small tide pools. However, being in these pools exposes gobies to such predators as octopuses and herons. To escape predation, gobies jump to other pools. But how do they know where these other pools are? Their cognitive mapping abilities guide them. While swimming at high tide, gobies create a mental map of depressions in the typography, because these depressions will be the pools into which the gobies can later leap to safety at low tide.

Memory represents a crucial cognitive survival skill for many fishes. Balcombe recounts an experiment by Brown (2001), coeditor of the scientific journal, *Fish Cognition and Behavior*. In the experiment, rainbowfishes needed five trials to learn to escape through a hole in a net. Then, after 11 months, almost 1/3 of rainbowfishes' lives, after not being exposed to the experimental context in all that time, when tested again, the fishes escaped on the very first trial.

As to fishes' learning abilities, Balcombe (pp. 110-111) quotes Reebs (2001, p. 74): "for almost every feat of learning displayed by a mammal or a bird, one can find a similar example in fishes". The types of learning attributed to fishes include classical conditioning, operant conditioning, non-associative learning, sensitization and transfer of control. For instance, the internet has many resources, including Youtube videos, on how to teach companion fishes, e.g., (wikihow, n.d.).

Tools, Plans and Monkey Minds

Tool use was once thought to be a uniquely human ability, but now we know that some primates and birds also use tools. What about fishes? Balcombe notes that fishes face certain handicaps, including the lack of hands and the fact that living in water makes tool use more difficult and its results less controllable, e.g., after smashing something to obtain food, the food fragments could float away in many directions.

Nonetheless, Balcombe recounts examples of what could at least be considered tool-like use by certain fishes. For instance, archerfishes produce jets of water as part of their plan for attacking prey. Another example was reported by Bernardi, (2012) who witnessed green wrasses using a rock to smash pellets. These incidents seem to reflect both tool use and planning.

Planning was further demonstrated in a study in which fishes outperformed various primates. Two plates of food were presented to the research participants, the primates and the fishes, the only difference being that one plate was red and the other blue. When the participants took the food on the blue plate, the red plate was taken away, but when participants selected the red plate, the blue plate remained. The fishes required an average of 45 trials to figure this out, but some of the primates never solved the puzzle, even after 100 trials.

Part V – Who a Fish Knows

Part V, consisting of three chapters – Suspended Together, Social Contracts and Cooperation, Democracy and Peacekeeping - focuses on the social aspect of fishes. While some fishes are normally solitary, most swim in groups. Balcombe (p. 134) defines a shoal as a "group of fishes who have gathered together in an interactive, social way", whereas a school of fishes "is a more disciplined form of shoaling in which fishes swim in a more orderly fashion, each going the same speed and in the same direction and each spaced a fairly constant distance from the next" (p. 134). Swimming together benefits fishes in terms of more efficient movement, protection from predators and sharing of information.

Suspended Together

To most humans, fishes of the same species probably look alike, but Balcombe assures us that each fish is unique in appearance and personality, and that fishes use a variety of senses to differentiate among the members of their species. This differentiation is used for such purposes as formation of hierarchies and deciding with whom to swim with and mate. Not only can fishes differentiate among members of their own species, they have also been observed to differentiate among humans (Newport, Wallis, Reshitnyk, & Siebeck, 2016).

Social Contracts

In *Through a Window*, Goodall (1990) recounts her experiences from her research with chimpanzees. While she obviously cares deeply about these vertebrates and is very concerned about the threats chimpanzees face from humans, she does not attempt to convince readers that chimpanzees are all angels. Similarly, in describing fishes' interactions with each other in the current chapter, Balcombe reports activities that perhaps cast fishes in a negative light, pointing out that a fish can be "selfish". In fact, one of the chapter's subsections is titled, Dubious Dealing.

Perhaps the best known dealings between fishes involves cleanerfishes who remove parasites, etc. from other fishes and other marine animals. Sometimes, these fishes are very busy, e.g., one study reported a cleaner wrasse servicing more than 2000 clients a day. Furthermore, some clients make multiple visits to the same cleaner, in some instances more than 100 visits a day by a single client. The cleaners have been observed to choose their clients based on which clients will give them the most food. Balcombe summarises one such study with the comment that it shows a nonhuman animal "adjusting levels of cooperation with individual partners to account for future payoffs" (p. 155).

Balcombe recounts more examples of interactions between sneaky cleaners and their wary clients. For instance, clients watch the behaviour of cleaners and evaluate which cleaner to use. Cleaners with bad reputations lose clients, and the law of supply and demand impacts how honestly cleaners treat their clients. Similarly, clients who are predators are on their best, non-predaceous, behaviour in areas where their cleanerfishes usually can be found.

Pleasurable Kingdom: Animals and the Nature of Feeling Good is another of Balcombe's book. Not surprisingly, he maintains that pleasure surfaces prominently in relationships between cleaners and clients. He cites the following evidence:

a. Clients may ask to be cleaned even in the absence of parasites or other reasons for cleaning
b. Cleaners use their fins to "caress" clients
c. Clients sometimes change colour while being cleaned, which may indicate happiness.

Cooperation, Democracy and Peacekeeping

This chapter describes some of the perhaps surprising ways in which fishes cooperate with one another, how they even seem to do collective decision making and how they avoid dangerous conflicts with other fishes. Cooperative search for food occurs among many animals, even insects. Examples of such cooperation among fishes include the way that shoals of barracudas herd prey towards shallow water where the prey can be more easily captured (de Waal, 2006). Fishes even use their bodies to signal to others the location of prey (Vail, Manica, & Bshary, 2013).

When fishes work together, it appears not to be one fish making decisions for the group. As with other animal groupings, such as flocks of birds and primate groups, a group's members pool their knowledge to make collective decisions. On this point, Balcombe (p. 169) quotes Couzin, "When one fish heads toward a potential source of food, the other fish vote with their fins on whether to follow". Research supports the view that fishes benefit from the wisdom of numbers, e.g., larger groups of fishes are less likely than individuals or smaller group to be misled by fish robots introduced into their environment by researchers.

Part VI – How a Fish Breeds

Part VI, consists of two chapters – Sex Lives and Parenting Styles. Consistent with fishes being the diversity champions among the vertebrates, fishes exhibit a wide ranges of reproductive and parenting behaviours. For instance, Balcombe states that fishes employ 32 known breeding systems.

Sex Lives

The sex of fishes offers one area in which fishes manifest diversity. While most fishes are gonochoristic, i.e., female or male for their entire lives, other species, especially those who live near reefs, may switch sex. Conversely, the far depths of the seas are where simultaneous hermaphrodite fishes are most likely to be found. There is even an all-female species of fishes, the Amazon mollies. An example of fishes changing sex are the clownfishes, popularised in *Finding Nemo*. If the female member of a breeding pair of clownfishes dies, the male member of the pair becomes a female and a subordinate male takes the male's place in the breeding pair. In this regard, Balcombe notes that if *Finding Nemo* had been completely accurate, when Marlin lost his mother, his father would have become female.

Seduction tactics employed by fishes include dances and songs, and even art. For example, Nuwer (2013) reported that male pufferfishes attract females by using their pectoral fins to make geometric patterns on the floor of the ocean and decorating the patterns with shells and pieces of coral. Receptive females lay their eggs in a nest placed in the centre of the patterns. Other fish species exhibit similar nest building behaviours and appear to favour decorative arrangements. For example, Balcombe reports research in which tinfoil and bangles were placed at the disposal of male sticklebacks, they quickly made use of these decorative items, and with positive mating results.

Another form of reproductive diversity among fishes is whether fertilization takes place internally or externally. Balcombe recounts an example of external fertilisation among sea lampreys, which has a not-so-happy ending for the nest-building parents.

In mating, the female grasps a rock with her mouth, the male grasps the female behind her head, then twines his body around hers, and then they both vibrate vigorously. This motion stirs up fine sand that sticks to the releasing eggs, helping them sink into the nest. Next, the parents separate and begin removing stones from above the nest and placing them on the downstream side, which performs two functions: loosening sang that further covers the eggs, and shoring up the nest cavity to secure the eggs in place. … This odyssey has a Romeo and Juliet ending: the pair are so exhausted by the end that they soon die.

Parenting Styles

Most fish parents live on after reproduction, and Balcombe estimates that about 25% of fish species engage in some form of parenting behaviour. For example, while fishes, unlike mammals, do not nurse their offspring, some species provide offspring with food from their own bodies. Cichlids are one such group of fishes. Their babies feed on the mucus that surrounds their parents' bodies. This mucus is thought to provide not only nutrition but also to boost the young's immune systems.

Another way that fishes assist the survival of their offspring goes by the name of mouthbrooding. This practice involves adults protecting their young by taking them into their mouths. Mouthbrooding comes at cost to the adults, because they cannot digest food while the young are in their mouths; any food they do take in is eaten by the young. To make matters worse, some adults have been observed to mouthbrood for more than 30 days at a time.

Unlike in some terrestrial species, in which protecting the children is left to females, the males among some fish species play the major role. The best know examples are the seahorses and the pipefishes. Females deposit their eggs into the males' pouches. The males then fertilise the eggs and carry them until hatching, at which time the newly hatched young are expelled from the pouch. Balcombe reports that males may simultaneously carry the eggs or more than one female, and females may deposit their eggs into the pouches of multiple males.

Looking after the young provides examples of both cooperation by non-parents as well as "cheating" in which fish parents leave childcare to others. Examples of how non-

parents cooperate include cleaning of eggs, maintenance of breeding spots and defence of territory. The cheating behaviours have been labelled “brood parasitism”. For instance, catfishes may place their eggs in the nests of other fishes. After the eggs hatch, the parents who built the nests seem to look after both their own offspring as well as those of the parasitic parents.

Part VII - Fish Out of Water

In his conclusion to Part VI, Balcombe ends with a question which introduces Part VII:

If there is any overarching conclusion we can draw from the current science on fishes, it is this: fishes are not merely alive—they have lives. They are not just things, but beings. A fish is an individual with a personality and relationships. He or she can plan and learn, perceive and innovate, soothe and scheme, experience moments of pleasure, fear, playfulness, pain, and—I suspect—joy. A fish feels and knows. How does that knowledge mesh with our relationship to fishes?

Readers of this book will not be surprised to learn that most interactions between fishes and humans show little regard for the evidence Balcombe has compiled on the sentience of fishes. We humans pollute fishes’ habitats, and we use our technology to pull them out of the water in mind numbing numbers. Of course, the death of any one fish is a tragedy to that fish and those in their circle. Thus, it seems almost cruel to mention the collapse of fish populations worldwide, as if we only care about whether our supply of fishes for food is sustainable or whether we will still have a particular fish species to display in zoos, and yet, pay no heed to the individuals who make up those species.

But, aren’t humans replenishing fish populations via fish farming, just as we multiply the population of chickens in the factory farms, where tens of billions of chickens live lives lasting about six weeks before they are sent for slaughter. In 1970, fish farming accounted for only 5% of fish production; now, it accounts for 40%. What do these farmed fishes eat? Mostly other fishes. One estimate put the ratio of fishes fed to farmed fish for every one pound of fish for human consumption at 2.5-1.0 (Naylor, 2000). Furthermore, as is the case with pigs, whose bodies, according to one researcher, are used in 184 products beyond pork (CNN, 2010), humans use fishes for a wide variety of purposes, including cosmetics, linoleum, lubricants and insecticides.

Just as on the factory farms for farmed terrestrial animals, on fish farms, the animals are crowded together, because that saves money, and the fishes are deprived of opportunities to perform their natural behaviours, because that saves money. This crowding makes fishes susceptible to a wide variety of diseases and parasites, among them sea lice. In one of the most horrific passages in the book, Balcombe (p. 216) describes the suffering to which the lice subject farmed fishes, “As they chew through the mucus, flesh, and eyes of fishes helpless to escape them, sea louse heaven becomes farmed fish hell”.

In the book’s epilogue, Balcombe strikes a positive note, recounting that humans have, in some ways, made progress in our attitudes and behaviour towards other humans and towards our fellow animals. Nonetheless, Balcombe (p. 232) cautions that despite the

progress made in regard to humans' views of other species, changing how we view and interact with fishes may be particularly difficult:

In those flat, glassy eyes we struggle to see anything more than a vacant stare. We hear no screams and see no tears when their mouths are impaled and their bodies pulled from the water. Their unblinking eyes—constantly bathed in water and this in no need of lids—amplify the illusion that they feel nothing. With a deficit of stimuli that normally trigger our sympathy, we are thus numbed to the fish's plight.

Fortunately, Balcombe senses that change is in the air and in the water. Research about fishes is booming, in part due to an overall trend of work in Human-Animal Studies, a growing field that promotes empathy towards all nonhuman animals. For instance, Ulrike Siebeck, one of the researchers cited above, has done many studies on fish cognition (see http://researchers.uq.edu.au/researcher/581). While identifying how fishes are similar to humans and other vertebrates, the research also sees the difference between humans and our underwater cousins as "a source of fascination and admiration, and cause for sympathy. We can connect across the great divide that separates us … (Balcombe, p. 232).

Legal changes are among the positive signs that Balcombe notes. Many countries have enacted new laws protecting terrestrial animals, and Europe seems to be leading the way in legal protections, albeit meagre ones, for fishes, e.g., making it illegal to keep goldfishes in barren bowls, requiring recreational fishers to learn about more humane methods and banning some of the more egregious slaughter methods employed by industry.

Comments

This final section of the review addresses four topics: (a) what I liked about the book; (b) suggestions for readers; (c) suggestions for the author and his colleagues; and (d) use of the book with people who eat fishes.

What I Liked about the Book

Beginning with the first topic, I found much to like in this book. Here are some of the points I found commendable:

1. The book is written in a style that even a layperson, such as myself, can understand. Most ecolinguistics may lack a strong foundation in the physical science. Through reading this book, ecolinguists can acquire more knowledge of fishes' worlds, which will enable us to apply our ecolinguistic tools to helping fishes.

2. Not only does Balcombe write clearly, he also injects humour and humanity into the topic.

3. Speaking of language, Balcombe uses the plural "fishes" to highlight that our underwater cousins are individuals, just as activists promote the use of "chickens" rather than

"chicken", as in "Nowadays, people eat more chickens and fishes, rather than cows" (Dunayer, 2001).

4. The book's ample supply of references allows readers to learn more on topics of interest. Additionally, Balcombe makes clear which of his evidence is research based and which is anecdotal, while still recognising the value of anecdotal evidence. Also, while much of the research in the book was done with captive fishes, Balcombe recognises the dangers of such research, both for the fishes involved and for the validity of the research.

5. Balcombe's connection with Humane Society Institute for Science and Policy, which he mentions in the book, gives me confidence that the information in the book will be spread internationally and put to use by activists on behalf of fishes and other animals.

What Readers of the Book Can Do

I urge readers to share information on the book and the information in the book. For example, people can write short reviews or notices on the websites of book sellers and on social media. Additionally, we can ask public libraries and university libraries to order the book, and Balcombe's other books, and add the books to reading lists found online, such as on the websites of animal advocacy organisations. Furthermore, the information in the book can be very useful when commenting on articles and posts in traditional and electronic media.

What the Author of the Book Can Do

This book unlocks a buried treasure of important information about our underwater cousins. I'm sure that Balcombe and his colleagues at Humane Society Institute for Science and Policy have developed many ideas for disseminating the treasure. Also, comic book formats would be useful for illustrating the amazing but unknown-to-most-humans behaviours of our underwater cousins. Another idea would be to put together an annotated highlights list of online videos that portray fishes' abilities.

Of course, the book itself could easily have been a multi-volume encyclopaedia of the world of fishes. That said, one area about which I am particularly curious is the keeping of fishes as companions. Does Balcombe approve of this and, if so, what is his research based advice on responsible care of companion fishes? Many concerns have been raised about keeping fishes captive. For instance, the Animal Concerns, Research and Education Society (ACRES) posted on Facebook advising against buying blue tangs, the species to which Dory, the title character in the film *Finding Dory* belongs. Reasons given include (ACRES, 2016):

1. Blue tangs are saltwater fish, commonly found in coral reefs. They depend on corals to protect themselves from prey. Blue tangs live at depths of up to 40 metres and are always found in water deeper than 2 metres. Creating a habitat that is similar within our homes is very difficult.

2. There is no successful method of breeding blue tangs in captivity. Therefore, the blue tangs in shops are caught from the wild. Very often, cyanide is used to stun the fish so that it

is easier to catch them. Cyanide can kill corals and has toxic effects for other non-targeted fishes and invertebrates.

3. Blue tangs have an average lifespan of 12-14 years. Adults grow to an average length of 25 - 31cm. They are territorial, so you cannot keep more than one blue tang in a tank.

Making a Difference

I am a long time member of Vegetarian Society (Singapore). Sometimes, I hear people say, "I'm almost vegetarian; I only eat fish". This declaration comes with the implicit thought that eating fishes is not as bad as eating terrestrial animals. *What a Fish Knows* teaches us just how wrong this thought is. How can readers use the book to help people consider a diet without fish? Should the book's horrifying stories of how fishes suffer be used, e.g., Balcombe's recounting of how fishes caught in the fishing industry's huge nets are crushed by the weight of the thousands of fishes and other marine animals caught together in the same nets? Or, should a more positive approach be taken by regaling people with tales of fishes' amazing abilities, such as the cognitive mapping of gobies, or stories of the devotion of fish parents to their young, such as mouthbrooding?

From an ecolinguistics perspective, the book could be used as a basis for the analyst's ecosophy, providing criteria for judging discourses against. For example, if linguistic devices in a discourse represent fishes as being incapable of suffering or of not being intelligent, then the book provides a solid basis for criticising and resisting the discourse.

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