Parasitophilia

A select band of scientists have dedicated their lives to the study of the various tapeworms that ride through the seas in the guts of sharks. **Robert Dunn** shows how anything in the world can be fascinating if you look at it closely enough. Photos: **Janine N Caira and Kirsten Jensen**

Hundreds of basking sharks spend the summer around the Isle of Man, and tourists travel from around the world to watch these giant fish comb the cool water for plankton. Basking sharks are rare, but rarer still are the creatures that depend on them. Unseen by most shark-watchers are the basking shark's smaller fellow travellers, including tapeworms – creatures every bit as improbable as a 12-metre shark. These harmless scroungers ride where their sharks ride, eat where their sharks eat, and dive where their sharks dive.

Shark-tapeworm-watching is, of course, not widely popular, but it does have its loyal few. One floor up from my former office at the University of Connecticut, a half dozen parasitologists hunch over microscopes, under which transparent serpents reveal their minutiae. Led by Dr Janine Caira, the queen wormer, the research group studies the tapeworms of elasmobranchs (sharks, skates and rays). It is enough to keep them all busy for the rest of their lives. The lab is set at the end of a hall where a series of four doors leads into labs thick with tapeworms – drawings of tapeworms, dissections of tapeworm parts, tapeworm papers and thousands of tapeworm slides and miscellaneous jars.

The jars glow when the light hits them right, revealing luminous bodies from every dark piece of sea. The lab is a cluttered museum of the miniature. In the hall outside, two large posters, each with dozens of drawings and pictures, call to passersby. On each looms a gallery of magnified beings. Images of hooks, scolices, proglottids and unidentifiable parts beg closer examination.

Magnified images often allow us to see the miniature on our scale and in doing so allow us a sort of empathy. Even when highly magnified, tapeworms are hard to see for what they are, much less feel compassion for. An insect looks like an insect, a goat a goat, a bear a bear, but tapeworms are more like clouds, stones or tortillas. One can see anything in their faces. In each tapeworm image you can see hooks, giant suckers, rows of hairs, claws, horns, dreadlocks, snails' antennae and anything else your tapeworm Rorschach might reveal. They are too foreign to our senses to be recognised on their own terms. Higher magnification reveals more detail and different patterns, but nothing more recognisable.

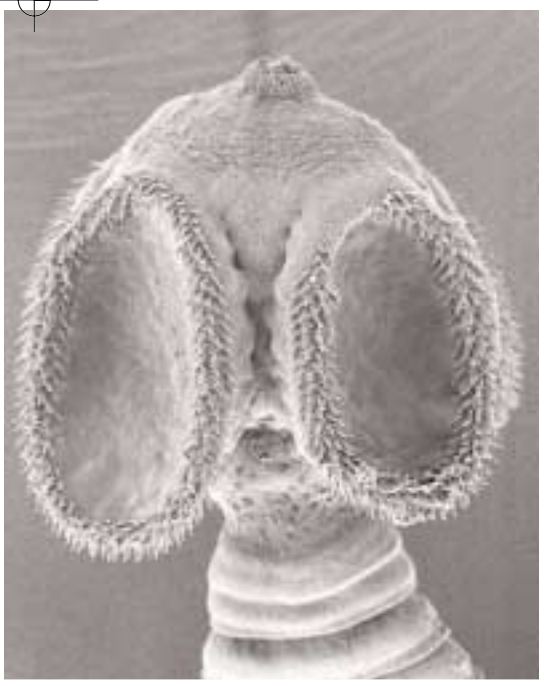
Scattered among the worms are the photos of the parasitologists – fixing trucks, on the beach, holding up sharks, peering into buckets and sundry other 'in the field' poses. In the fading light that pervades the images, parasitologists are busy documenting a wilderness.

Since I have been at the University of Connecticut, Janine and her crew have been to Borneo, Senegal, Mexico and Australia, collecting shark tapeworms. They beg or buy shark guts from shark fishermen and then spend hours on tables or planks in the sand or dirt, searching with microscopes through rolls and folds of intestines, looking for the discoloured shine or glint where the shark ends and its parasites begin. A sort of combined euphoria and exhaustion sweeps over them as they look for and find new or just poorly studied species. "I think I see a new *Echinobothrium*," someone shouts, and everyone goes on, well into night, emptying beers and parsing villi. The sun sets to the beat of the tips of forceps chiming against each other.

In the pictures, the tapeworms seem to have eyes and mouths, but tapeworms neither see nor bite. They do not even have a digestive tract. The 'eyes' and 'mouths' are the structures with which they attach to their hosts' spiral intestines and hold on against the ebb and flow of digestive tides. Tapeworms absorb the world through their body walls, particle by particle. They hold on or die, and so evolution has favoured hooks and suckers that stay fast.

Suckers mirror the intestinal villi (finger-like projections that help absorb nutrients) onto which they adhere, and suckers vary because the surfaces of shark and ray guts vary. A given tapeworm can hold on and survive in no more than one or a few hosts. Despite having collected hundreds of thousands, if not millions, of tapeworms, the Caira lab rarely finds a worm species in more than one species of shark or ray.

Over millennia, sharks have diverged into hundreds of species, and shark tapeworms have diverged with them. Forget Darwin's drab finches. Go to the tapeworm. ▶



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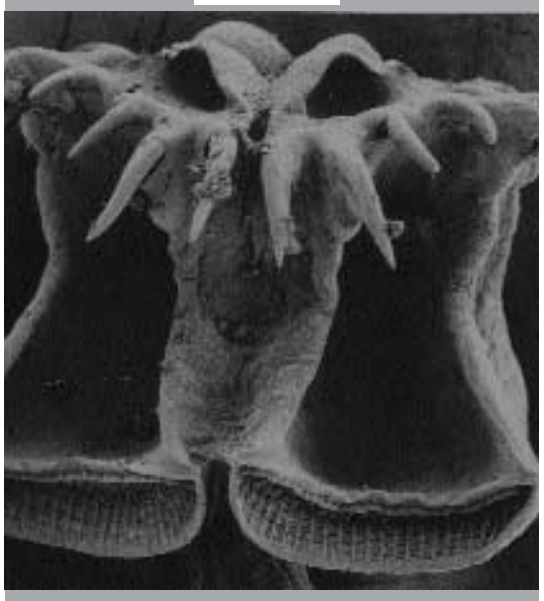

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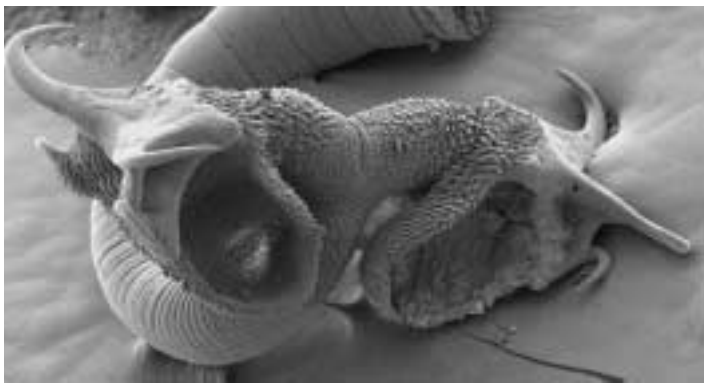
Elasmobranch intestinal wildlife – an assortment. Sharks' and rays' intestines, incidentally, are different from those of almost all other vertebrates in that they don't come in two sizes, large and small. There's just one intestine per fish, shaped in a spiral. And inside each is a large population of creatures like these, different types for each different types of shark or ray. Each picture shows a tapeworm scolex, the terminal where it connects to fish flesh. *Clockwise from top left*, they come from (1) a spotted eagleray, (2) also a spotted eagleray, demonstrating that one species can host different kinds of tapeworms, all more or less exclusive to it, (3) a guitarfish, (4) a brown shark, (5) a spotted eagleray again, and (6) a stingray.

Tapeworms are wild, serpentine and understudied. There are more than 700 known species and as many unknown ones. Janine and her lab are busy naming worms (a recently described species bore the name of our university's chancellor). Their shelves overflow with worms, some as thick as a human ankle but most as small as jewels.

Each jar or slide in Janine's lab is labelled with a collection site, a short description of how the worm was collected, who collected it and the worm's name. Read in the right order, the jars of beasts tell the biography of the lab. One of the most recent entries in the worm-jar biography is Kirsten Jensen. Jensen, now a professor at the University of Kansas, studies the tapeworms of rays.

Read the jars and tapeworm manuscripts from a few years before Kirsten, and you will find Gaines Tyler, now studying the tapeworms of Australian sharks. Read further back and you will find Peter Olson, now at the Natural History Museum in London studying the evolutionary relationships of all tapeworms, be they from sharks, humans or dogs. There are dozens of other students from Janine's lab who have filled jars, manuscripts, master's theses and dissertations with worms. Many of those students, such as Peter and Kirsten, now have their own labs, where they bend headlong into their own work. Students now fill empty jars and dissertation pages with their work, not only in Janine's labs but in her students' labs. Tapeworm biologists replicate like, well, tapeworms, and still there is no shortage of unknown. Still there are too few minds, eyes and hands.



Double grabber. Insofar as a scolex can be called a head, this is a two-headed tapeworm, with one head embedded in the gut of a brownbanded bamboo shark.

Janine's lab and others like it are usually able to study tapeworms only in dead sharks and rays. What goes on inside living sharks or what happens when a tapeworm's eggs leave the shark remain enigmatic. In general, tapeworm natural history and life-cycles must be inferred from tapeworm form and from comparison with tapeworm species we know more about. Even how tapeworms find the right ray or shark in a sea of possible hosts is not well understood. What we do know is that every stage of the tapeworm life-cycle seems to have poorer odds of occurring than the one before it.

As a tapeworm absorbs food and grows, it adds segments below its scolex. The older segments dangle from the newest segment. Going from the head down, each segment is older than the one above it. More food, more segments, more food, more segments, ad infinitum. Each mature segment has both male and female genitalia. Eventually, the sex segments detach, mate and transform themselves into egg-sacs and spill out of their sharks into miles of open sea. We are careful with our children. Tapeworms are careful to make many.

Eggs of shark and ray tapeworms are dashed against shores by hurricanes, scattered across the bottom of the ocean and disassembled back to elements in a hundred other ways. Even if an egg survives, it must pass through multiple hosts to reach adulthood. Parasitologists speculate that, to survive, tapeworm eggs must be eaten by a copepod (tiny crustacean), within which the eggs develop into larvae. The copepod must then be eaten by a crab or mollusc, which in turn must be eaten by a shark. Each tapeworm depends on finding no fewer than two different hosts.

The tapeworm's is an improbable lifestyle, but such lottery odds played over millennia have been enough to fill each shark with worms. In many sharks, tapeworms are as thick as forests of seaweed. They sway as the shark swims and eats, flourishing in their favourite darkness, riding a thousand miles without moving an inch. It is the tapeworm, not the shark, at the top of the ocean's food web – which means that, when we extinguish sharks, we are losing much more evolutionary history than just that of the shark. And, conversely, when we can conserve sharks such as the basking shark, we also have the potential to conserve much more (which is good, since a 'save the tapeworms' campaign would not be likely to fall on sympathetic ears).

When I left the University of Connecticut for a job in Australia, I looked up one last time at the tapeworm lab. I saw Janine's outline in the window as she moved hurriedly about. There are samples to sort, species to name and trips to plan. A bucket sits by the lab door with new worms from Senegal. There are miles to go before Janine sleeps. In the morning, there will be students about, studying worms, sorting worms, drawing and describing worms. For now, it is just Janine and her specimens, a scientist surrounded by the wilderness she has worked half her life to understand.

Meanwhile, a billion shark tapeworms ride their hosts through every ocean. They are neither proper nor improper. They are, as they have been since before dinosaurs, tenacious and fertile, gripping to their necessity and spilling their seed. The blue-black sea shimmers with eggs. ■

Robert Dunn works as a Postdoctoral Fellow at Curtin University of Technology in Perth, Western Australia. Rob explores the relationship between ants and the seeds they disperse, focusing on whether ants have affected the biogeography and evolution of the plant species they disperse.