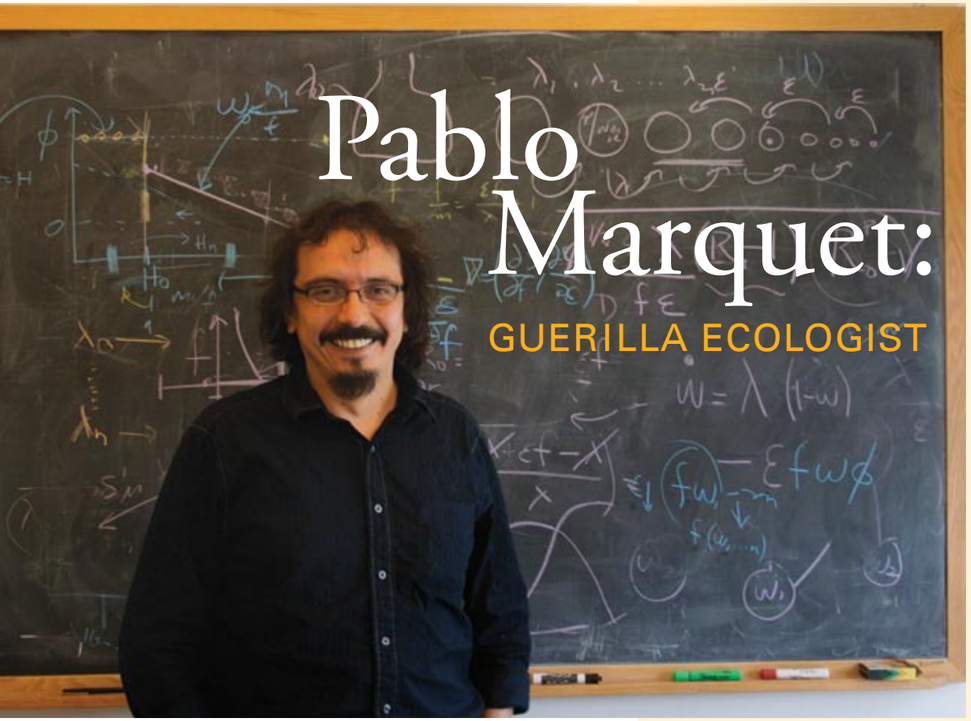

# Pablo Marquet: GUERILLA ECOLOGIST

By Julie J. Rehmeyer

SFI International Fellow Pablo Marquet

**Nature had called Pablo Marquet** years ago by inspiring him to become an ecologist, but now it was calling him in a different way. He rushed through the halls of his crowded university building in downtown Santiago, driven less by his current need than by his excitement. A scientist had just given a lecture that satisfied the frustration Marquet had been struggling with through college.

To Marquet's eye, ecology was filled with all these little studies in little areas giving little results, with no grand theories tying any of them together. But Jim Brown, Distinguished Professor at the University of New Mexico, had just shown how he was turning ecology into a quantitative, predictive science, like physics or chemistry.

Marquet stepped into the restroom and looked out through the smoggy haze at the Andes towering above. He had been even more amazed by what had happened after Brown finished speaking. The great scientists assembled in that room had attacked Brown's theory as a meaningless dead end. But Brown had fought back! He'd defended himself against the combined opposition of the greatest ecologists in North and South America combined.

Marquet had listened to the raging debate quietly. He was just 21 years old—a college kid, after all—and his English wasn't very good. But now, who should step into the restroom but Jim Brown himself. A thought flashed through Marquet's mind: "Look! I'm here, with this great scientist!" Their eyes met, but Marquet couldn't seem to untie his tongue.

Ideas were already forming in Marquet's mind, however. He was formulating an experiment that would make Brown's theory even stronger.

## SNAILS VERSUS MUSSELS: PREDICTING POPULATIONS

What Brown had done was to explore the ecological consequences of a set of beautifully simple mathematical formulas that relate body mass to a remarkable number of biological attributes: metabolic energy, life span, population density, and more. He had also begun to explain why these formulas, called scaling laws, were popping up over and over again throughout biology.

The scientists at the conference had laid into Brown's theories with a number of criticisms, and Marquet thought one of them had some legitimacy. Brown and others had found the scaling laws by pulling together data from all kinds of different animals in far-flung regions of the world. Would the laws hold in a real ecosystem, comparing animals that live in direct competition with one another? Would they hold in different ecosystems?

TOP: LAURA WARE

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Marquet figured he knew just how to find out. A professor of his was working in two stretches of coastline in Chile that were very similar, except that in one, humans weren't allowed to fish or hunt, and in the other, they were. Marquet realized that these areas were the perfect testing ground for Brown's ideas.

As a community ecologist, Marquet focused particularly on Brown's claim about population density. The theory was almost like a magic trick: give Brown any ecosystem, anywhere in the world, and tell him a particular weight, say 10 grams. Then, Brown said, he could tell you the number of creatures you'd find per acre that weigh 10 grams.

So Marquet wanted to test Brown's claim in his two Chilean ecosystems. As similar as the two regions were, they were a hard challenge for Brown's theory. In the area with hunting, people did all kinds of things that changed which animals prospered and which suffered. For example, people collected giant sea snails to eat, so the area with hunting had fewer snails than the undisturbed area. And that didn't just affect the snails. The mussels prospered when the snails declined, because snails loved to eat mussels. The differences rippled throughout the entire community of animals.

If Brown's laws were really a universal property of living things, then when the snails became rarer, some other creature with the same body size had to prosper. It might be something completely unrelated, like a little bird or a rodent, but the total number of creatures with that body size had to be the same. Similarly, when the mussels prospered, some other small creature—perhaps a barnacle or even an insect—had to suffer. Marquet wanted to find out if that was true.

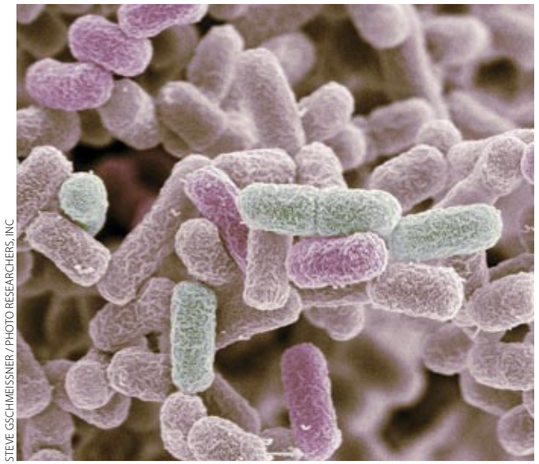
When Marquet crunched the numbers, the scaling laws held up just as Brown claimed. "It came out beautifully," Marquet says, "just like the prediction."

Brash kid that he was, he submitted the paper to *Science.* After that, he applied for a Fulbright Fellowship to be a doctoral student with Jim Brown.

Marquet's prediction about his own success was as accurate as his prediction about the abundance of populations. A week after he arrived at the University of New Mexico, the paper appeared on the cover of *Science.* "It was the best presentation any new graduate student could ever have," he says with a smile.

## THE BIOTIC BANG

It wasn't long before Marquet was driving through the piñon and juniper highlands between Albuquerque and Santa Fe to attend talks at the Santa Fe Institute. That was the beginning of a life-long association with the place. Marquet has visited periodically ever since, recently as an International Fellow.



STEVE GSCHMEISSNER / PHOTO RESEARCHERS, INC

In his quest to uncover some of the secrets of how biodiversity develops, Marquet uses bacteria, such as these rod-shaped E. coli bacilli.

The International Program at the Institute was begun in 2000 to encourage multidisciplinary collaboration in countries in which little funding is available for such work. The program funds several researchers as International Fellows each year, providing two years of financial support including up to two months in residence at the Institute, developing collaborations with SFI researchers. The Institute also supports fellows in their home countries by providing funds for them to organize workshops or host visitors.

Marquet's presence at the Institute has provided just the kind of cross-fertilization of ideas and approaches that the program intends. "Pablo asks questions and approaches things in a way that I don't think any young scientist who grew up and was trained only in the U.S. or in Britain would have," Brown says. "He is by far the most philosophical of all my former students. His work on ecology is integrated into a worldview that includes the broader science of complexity and a sense of what you might call human ecology, our place in nature."

Marquet has used that philosophical outlook to tackle perhaps the grandest question in ecology: why life first began to diversify. "The physicists try to understand the Big Bang," Marquet says. "Ecologists need a theory to understand the Biotic Bang."

With SFI support, Marquet has organized workshops in Chile, Santa Fe, and Santa Barbara that have gathered ecologists together to puzzle out an approach to the problem. He also worked with another SFI International Fellow, David Storch of the Center for Theoretical Study in the Czech Republic, to organize a workshop in Prague. Marquet, Storch, and Brown edited a book from the conference, entitled *Scaling Biodiversity,* which has just come out this year.

## ONE BACTERIUM'S WASTE IS ANOTHER'S FOOD

In his own research, Marquet is working with his former student Juan Keymer and SFI postdoc Miguel Fuentes to understand a simple experiment. In the process, they hope to uncover some of the secrets of how biodiversity developed. Put a single species of bacterium into a flask in some medium that provides food and the bacteria will reproduce madly. If you keep supplying medium for the bacteria to eat, they will continue to prosper, but should you forget, the bacteria will eat up all the food and then the population will crash.

If you are really neglectful and never pour in more medium, a surprising thing happens: a few bacteria continue to live. Despite the lack of food, the population continues at a very low level. After a while, the population will even begin to grow again. But soon thereafter, it experiences another crash. This boom and crash cycle continues for a while, until it somehow stabilizes into a continuing population of bacteria.

Marquet explains that what happens is that after the bacteria consume the initial medium and mostly die off, a mutant evolves with a remarkable innovation: it is able to consume the waste products of the original bacteria as food. "They're eating the dead bodies of their fellows," Marquet says.

The new mutant thrives until it is outcompeted by a new mutant better able to eat the waste from the previous mutant, and it repeats the cycle. The population stabilizes when mutants coexist and a whole community of bacteria evolves. Marquet, Keymer, and Fuentes are developing a mathematical model to understand this process more thoroughly, with hopes that the process may illustrate secrets behind the initial development of biodiversity.

Marquet has undertaken this line of research while at the Santa Fe Institute, and he sees an analogy in the work for the fruitfulness of the Institute. "At SFI, there are a lot of mutants, so you can create innovation just like the bacteria," he says. "Eventually, we can create a sort of food web where my throw-away insights can be your resources so we can produce something together. At the end of the day, we are like a bacterial biofilm."

Part of Marquet's unique contribution to the SFI community, Brown says, comes from his breadth of interests and ability to make surprising connections. "He reads a lot of literature, really philosophical literature. He'll sometimes say something that will change the whole tenor of conversation and send it in a new, more creative direction. Often it is by analogy, similar to the way that Isabel Allende uses alliteration in her novels."

## SCIENCE WITHIN A DICTATORSHIP

Marquet's scientific projects reflect that breadth of interest. At the same time as he works on his speculative theory-building, he also tackles an enormous variety of practical ecological problems. He is developing models to understand how climate change is likely to affect Chilean ecosystems. He is collaborating with archaeologists to understand why a hunter-gatherer society in Chile that lived 8,000 years ago had enough energy and resources to make elaborate mummies of their dead. He is also studying the patterns plants form in the Chilean Atacama Desert, which is the driest desert on earth.

Marquet has now returned to Chile, and he is committed to continuing both his practical and theoretical work there. He has been tempted to move to the United States, where he has more colleagues interested in the speculative work that he loves. But he notes: "I have a huge impact in Chile in terms of students, connecting people to my network of colleagues, changing how the system works, bringing new perspectives, and making it easier for people thinking in more theoretical ways. I would probably be just one more scientist in the States or in Europe."

He also recognizes the stamp of Chile in his own ways of working. Chile, he says, is like an island, removed from the rest of the world on one side by the Andes and on the other by the Pacific. Just as creatures on an island tend to evolve into unique forms that are different from creatures on the continent, Chilean scientists themselves develop unusual patterns of thought.

Marquet grew up during the years of Augusto Pinochet's reign, and he says that in many ways, Pinochet's dictatorship had a very bad effect on science. It limited funding for science and created an atmosphere of fear in which people were afraid to speak their minds. That was part of why he was so astonished by Brown's bold defense at the conference in 1986.

"The process of maturation in science is to find your own voice, finding yourself saying something that you believe in," he says. "That process is a combination of art and science. It's an act of creation, and I think that a dictatorship is not the best environment for creativity."

But he notes that the dictatorship also bred an attitude in the best Chilean scientists that he respects and embraces. "It's guerilla science, with 100 percent passion. I really love that spirit, feeling that what moved you to do this is such a strong force that you will overcome any obstacle." ◀

*Julie J. Rehmeyer was SFI's very first undergraduate intern. She went on to do graduate work in mathematics at MIT and to teach at St. John's College. She is now a freelance writer and the mathematics columnist for* Science News.



La Portada, Antofagasta, Chile: When Marquet applied Jim Brown's theory to a coastal region in Chile, the laws held up just as Brown claimed. "It came out beautifully," Marquet says, "just like the prediction."