The Intoxicating Birds of New Guinea

By John Tidwell

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It all began with an accident. In the summer of 1989 Jack Dumbacher was an ecology graduate student doing fieldwork on Raggiana Birds of Paradise (*Paradisaea raggiana*) in Papua-New Guinea's lush Variarata National Park. Part of his research involved catching and examining these exotic orange-yellow birds in fine 'mist nets' set throughout the forest. Sometimes other birds would also get caught and Dumbacher spent a lot of time freeing unwanted species like the Hooded Pitohui (*Pitohui dichrous*), a jay-sized New Guinean songbird with striking black and orange coloration. For most of the American research team Pitohui (pronounced *PIT-oh-whee*) were a all too familiar: they were very common, fought and scratched when being disentangled from the nets and had a pungent odor that stayed on researcher's hands for days. Even the local people had no use for them, calling them *rubbish birds*.

One day Dumbacher was freeing yet another Pitohui from his nets when it's sharp beak and claws scratched his hand. Dumbacher put his hand in his mouth and got a strange numbing sensation that he recognized as a kind of toxin. At first he thought nothing of it, since he occasionally brushed against poisonous plants in the forest. It never occurred to him to suspect the bird. But then a few weeks later another member of the team mentioned the same odd sensation when he put his injured finger in his mouth. Again the culprit was a Pitohui. Dumbacher's interest was piqued and the next year he returned to New Guinea determined to examine some of these 'rubbish birds'. "The next time we caught a Pitohui," he remembers, "I just plucked one of the feathers and tasted it: *Whammo*! Whatever it was it was definitely in the feathers."

There were only a few weeks before the Smithsonian research team's leader, Bruce Beehler, arrived and Dumbacher wanted to be as sure as he could that these birds really were producing some kind of chemical in their feathers. So he and his three other assistants sampled the feathers of several other Pitohuis, all with the same tingling

results. It was intriguing, and as he was driving Beehler up to Varirata from the airport, Dumbacher mentioned the find might make an interesting field note in New Guinea's local bird journal. But Bruce Beehler, the man who literally wrote the book on New Guinea birds, was thunderstruck. "Bruce looked at me and said 'Are you telling me you've found a *poisonous* bird?'" recalls Dumbacher, his dark eyes gleaming behind small wire-rimmed glasses. "Then he said, 'This should be on the cover of *Science*! Turn the car around! We're going back to town and get permission to study this bird!"

In the eight years since he first published his controversial discovery in Science magazine, Jack Dumbacher's life and work have been largely overtaken by this small, spunky bird. His research has not only proved that some birds use toxins for defense, but also changed the way people think about the biology of New Guinea. It also launched a scientific quest over several continents to find answers to the Pitohui's noxious mysteries. What is staggering to Beehler and many other scientists is that this discovery was made in a bird that had been known for over a hundred years, living only a few kilometers from New Guinea's bustling capitol, Port Moresby. "It was right there under our noses," Beehler admits, as he relaxes in his office at Counterpart International, a conservation organization where he heads its Environment and Natural Resources division. "The Pitohui is New Guinea's most common, widespread bird. Its been collected by scores of expeditions, museums around the world are filled with Pitohuis. And yet nobody knew it was one of the world's only toxic birds. That really says how much we don't know about what's going on out there."

But unraveling the Pitohui's strange biology has been as difficult and frustrating for Dumbacher as freeing them from his nets. When he first returned to the U.S. in 1990 with the bird's spicy feathers in hand, Dumbacher searched for a skilled chemist who could help him identify what kind of toxins were there. But few took the young grad student seriously: no one really believed that poisonous birds might exist. Months passed and Dumbacher was losing hope of ever finding the answer to the Pitohui's riddle. Then one day his luck changed. He was teaching a small seminar on Pitohuis at the University of Chicago and passed feathers around the audience for people to taste. Their odd sensation

kindled the interest of one of his colleagues, who referred him to the eminent herpetologist Charles Myers at the American Museum of Natural History. Myers had been involved in groundbreaking research on South American 'poison dart' frogs with John Daly at the National Institutes of Health, and when he reviewed some of Dumbacher's research he sent him to Daly. It proved to be a fateful introduction.

John Daly is a pioneer in pharmacology. During the 1960s and '70s Daly spent years in both the lab and the tropical forests of South America studying tiny, brilliantly colored frogs that the Choco Indians of western Colombia used to poison the darts of their blowguns. After years of research Daly and his colleagues showed that these frogs secreted a powerful collection of neurotoxins from glands on their backs. These deadly species, including a bright yellow frog Myers and Daly aptly named Phyllobates *terribilis,* were armed with three unique steroidal alkaloids called *batrachotoxins* (BTX) in concentrations so powerful that an amount equivalent to a few grains of salt would be lethal to a human. This poison, widely considered one of the most deadly, stops all electrical impulses in muscles and nerves, causing cardiac arrest almost immediately.

BTX had never been found before in any living animal, and for decades Daly toiled over this natural phenomenon, trying to figure out how the frogs were producing it and why. But since the mid-1980s Colombia's political climate had shifted and foreign scientists found it nearly impossible to get permission to work in its forests. As a result, all further research into origin of the Colombian frog's poison became impossible. Then Jack Dumbacher's Pitohui feathers floated across Daly's lab desk. Initially the craggy, grizzled scientist was skeptical, but did some routine tests, making a crude extract of the feather's chemical and injecting it into a mouse. Within minutes the animal was dead. "I got this call from him and he was really excited," Dumbacher remembers, "He said, 'Jack! You've got to send me more of those feathers! There is something extremely toxic in there!'"

At the N.I.H. Daly analyzed the Pitohui's feathers, skin and internal organs, using chromatography to identify extracts of the chemical. The results were startling:

batrachotoxins – the exact same compounds that Daly had found in the frogs! "It was totally unexpected." says Daly, "Its just very fortunate Jack sent the samples to us, because anybody else might have struggled over it for years." But what was a bird in New Guinea doing with lethal poisons only found in frogs from the other side of the world? And why wasn't Jack Dumbacher dead from tasting them?

New Guinea rises out of the sea about 100 miles north of Australia, with jagged, tree-covered mountains that disappear thousands of feet up into a nearly perpetual mist. Millions of years ago it separated from the mainland, and native species, like the Bird of Paradise and the Pitohui, followed their own, unique evolutionary paths. To foreigners it can seem ancient and magical, like a world lost in time. But to Jack Dumbacher and his team, it's a wonderland of biological mysteries. Soon after Jack's discovery was published he trekked back into New Guinea's interior forests to find why Pitohuis were poisonous.

From the start it was obvious something complex was going on. Pitohuis from some regions of the island were found to be much less poisonous than those from other regions. Tests on three other Pitohui species, the Rusty (*P. ferrugineus*) the Black (*P. nigrescens*) and the Variable (*P. kirhocephalus*) showed that they too were toxic, but not at the levels of their cousin the Hooded Pitohui. In Varirata National Park alone Dumbacher found Pitohuis so full of BTX that simply holding them made him sneeze and his eyes water. But a few miles to the north Pitohuis were almost non-toxic. To the biologists this indicated that the bird's poisons were not inherited, but rather acquired, or *sequestered*, probably from something they were eating. But proving that has been a daunting task. "It's like looking for a needle in a haystack," Beehler explains. "New Guinea has about 700,000 species of insects and maybe 15,000 plant species. The toxin source may only be from one organism, at one particular time of year."

Years before, John Daly had brought some poison dart frogs back to his NIH lab in Bethesda, Maryland for more detailed study of BTX. There he and Myers fed them a non-toxic diet of termites, and to their amazement, the next generation of frogs born in

captivity were completely non-toxic! When they grew up Daly fed them small amounts of BTX. In no time the toxin began accumulating in their skin, strongly indicating that the source of the frog's poison came from an as yet undiscovered insect deep in the Colombian rainforest. Now Dumbacher wants to do the same kind of experiment with the Pitohuis, and has a tentative agreement with the government of New Guinea to bring several birds to the National Zoo this year. If the Pitohuis lose their poison it will be hard evidence that they have a very spicy diet back home. But what?

Dumbacher and his team suspect some kind of insect, and have been examining every bug Pitohuis have been found to eat. But so far none have come up positive for BTX. In fact, the idea that any insect either produces or sequesters BTX at all is controversial. Many scientists think that insects aren't the only suspects in this biological detective story. Some have even suggested Pitohuis may get their poisons from bacteria or that BTX is somehow assembled in their bodies from plants or insects they are eating, each providing a vital chemical component. Ethnobiologist Todd Capson is heading for New Guinea this year to mount his own search for Pitohui poison. For him the evidence points to a complex food chain in which BTX is transferred from prey to predator up the evolutionary ladder to Pitohuis. "If I was a betting man, I'd bet that a plant makes it in the beginning, " he says "and that plant is then eaten by an insect, which is then eaten by the Pitohuis. My personal guess is that insect is a weevil, because weevils are everywhere and they are known to eat every part of plants."

Even so, Beehler says looking for the source of Pitohui BTX by traditional scientific methods, like examining the droppings and stomach contents of these birds and watching what they eat, is not the only - or most efficient - way to find the answer. Native Papuan tribes have been observing nature on the island for possibly 50,000 years or more, and their oral traditions of medicine and magic have collected vast amounts of biological knowledge. When he returns to the New Guinea wilds Capson plans to seek out local village elders and "wily old men" who may be able to provide clues to which local plants or animals may be poisonous.

"The answer to all these questions about the Pitohui and the Ifrita lies with the local people." Explains Beehler, who has mentored both Capson and Dumbacher, "You can do the biochemical analysis, but in terms of isolating the answers, where is *this* plant, where is *that* little bug, its the local people who are going to tell you. Those old men and old women who have talked around the fire and learned the old knowledge."

Local Papuans provided vital insights for Jack Dumbacher practically from the beginning of his adventure with the Pitohuis. In 1990 when he first realized Pitohui feathers might be toxic, a co-worker mentioned that she had read in an old book about these birds being 'bitter' to the taste. Dumbacher looked up the book, *Birds of My Kalam Country,* which was a compilation of local Kalam tribal wisdom on highland birds, written in 1977 by the New Zealand anthropologist Ralph Bulmer and his Kalam colleague Ian Saem Majnep. In the book, Dumbacher discovered a description of the *Wobob* bird (Hooded Pitohui), stating:*"…some men say the skin is bitter and puckers the mouth…"* The book also gave a similarly tantalizing account of the Blue-Capped Ifrita (*Ifrita kowaldi*), an apparently unrelated bird half the size of a Pitohui that lived in the high mountains. Its Kalam name, *Slek-yakt* , the authors wrote, literally means '*bitter bird'…And is so called because if it is not skinned before eating some men find that it burns their mouths, making their lips sore and puckered*."

In 1993 Dumbacher traveled by light plane up into the highlands to the Kaironk valley, a remote region in the southwestern corner of Mandang Province where Saem Majnep and his Kalam people still lived. Majnep had little formal Western education, but among his people he was regarded as a man deeply learned in traditional wisdom. His knowledge of the plants and animals of the highlands had impressed Bulmer so much that he asked Majnep to collaborate on his book on Kalam bird-lore. In their paragraph on the Pitohui, Majnep also included Papuan folklore about how the *Wobob* bird was often evoked in Kalam war-magic spells because it dodges around like a man avoiding arrows, and how the word *wobob* itself refers to a kind of skin disease that is uncomfortable and itchy. While such descriptions may at first seem more like mythology than science, Dumbacher points out that if one listens carefully, the valuable information in these stories can be

brought out. “The Bonua people of Central Province told me they knew the Pitohuis were poisonous, but that if you kill one and want to eat it, what you have to do is mourn for it.” He recalls, “ If you mourn for it long enough and sincerely enough, then you can eat it and it won’t make you sick. But they said they usually don’t eat the birds because you never know if you’ve mourned enough.”

What stories like this reveal, says Dumbacher, is that the Bonua knew that some Pitohuis are more toxic than others, but that in general they should be avoided. Todd Capson also found important biochemical information about Pitohuis from listening to local hunters. They told him that the only way to eat a Pitohui is to strip off its feathers and skin and then smear charcoal all over its meat before roasting it. “To most people this sounds weird,” says Capson, “But to an organic chemist what they are doing is removing the toxin, because charcoal is well known for its ability to *adsorb*, or adhere to, organic compounds like homobatrachotoxin.”

Majnep gave Dumbacher vital clues about the Blue-Capped Ifrita as well, and had his hunters collect some specimens. Small and brown with a bright blue crest, the Ifrita behaves like a nuthatch, foraging for insects among the trees of the highland cloud forests over 12,000 feet above sealevel. Everything about it was different from a Pitohui, except for one thing. “We were with the local guys,” Dumbacher remembers, “I was examining an Ifrita and was about to taste one of its feathers, when the locals started shouting ‘No!!! Don’t do that!!’ They were absolutely convinced I would die if I tried to taste it.” When the results came back from the NIH on the Ifrita’s skin and feathers, they showed nearly identical profiles of BTX alkaloids for both birds. Dumbacher also found Ifrita further to the east, in the Finisterre mountain range of Huon peninsula. In the Kaironk valley, Ifrita were loaded with BTX, but here they appeared uniformly non-toxic. Clearly this bird was also getting its poisons from a food source.

Now Dumbacher had an even bigger mystery. Two apparently unrelated birds, living in two very different regions of New Guinea, and yet both used the same spectrum of toxins. This indicated that the use of BTX among the island’s birds was more than a

single freak event of evolution: something much more complex was at work in these forests. But the larger question remained, why would a bird use poison?

In 1941 British ornithologist Hugh Cott was on military leave in the Egyptian city of Beni Suef, doing what he enjoyed most: studying birds. He was preparing some specimens for mounting and had left the skinned carcasses of a Palm Dove *(Streptopelia senegalensis aegyptica)* and a Pied Kingfisher (*Ceryle rudis rudis*) lying nearby on the grass. Then Cott noticed something odd: hornets, which love fresh meat, wer e feasting energetically on the dove, but had left the Kingfisher conspicuously untouched. Intrigued, Cott decided to test the palatability of Kingfishers and other bird's flesh, first on hornets and then on cats and humans. Cott's research eventually led him to conduct extensive international studies which not only showed some bird species were bad-tasting, but also a possible reason why. "What he found was that the more vulnerable a bird was, the nastier it tasted," says Harvard anthropologist Richard Wrangham, "He defined 'vulnerability' as being brightly colored or slow moving or the like. He also found that across Europe, Africa and North America black birds generally taste bad as well. So the old refrain about 'eating crow' holds true."

Recent studies have suggested that many birds may be using some kind of chemical weaponry as defense, much like insects and amphibians. Ocean-going Fulmars spit noxious stomach oils to drive away predators, some species of grackle give off a terrible odor when threatened, and many *passerine* birds, of which Pitohuis and Ifrita are members, have been known to smear their feathers with ants, apparently to repel parasites. Some birds, like the Eurasian Quail (*Coturnix coturnix cortunix*), the spur-winged goose (*Plectropterus gambensis*) and the African Olive-Pigeon (*Columba arquatrix*) are suspected of being toxic as a result of eating poisonous insects and plants. Two species of Australian Bronzewing (*Phaps spp.*)may even be sequestering the lethal toxin fluroacetate, more commonly known as '1080 poison' which occurs naturally in their diet of Heartleaf (*Gastrolobium bilobum*). But no one knew exactly what chemicals were being used. "The Pitohui and the Ifrita are the first examples of birds who use an

identified toxin as part of their defense strategy." Says Cornell chemical ecologist Thomas Eisner, "That discovery changed everything about how we think about birds."

Where Papuan birds and Colombian frogs diverge, Eisner says, is in the way their poisons are used. The tiny frogs store highly concentrated BTX alkaloids in glands on their backs, so that when threatened, they secrete almost pure toxin. The Pitohui and the Ifrita on the other hand, seem to have BTX in their dander, which diffuses all over their bodies, making the birds poisonous, but not necessarily lethal. In fact, Dumbacher noticed that the greatest levels of BTX were found on the bird's breasts and underside, suggesting that their eggs and nests may also be infused with BTX. This would be a particularly effective defense against snakes, which Dumbacher sees as a likely Pitohui predator. Snakes like to hunt birds in their nests at night, and tend to taste with their tongues before striking. One quick flick of a serpent's tongue might instantly tell it that Pitohuis and Ifrita were too spicy to bite. Dumbacher thinks BTX might even act as a natural bug repellant, driving off hungry lice and mosquitoes. Critics of Dumbacher's ideas say that his team is placing too much emphasis on the fact that these birds are toxic and are not noticing the possible cocktail of other repellant chemicals at play in both species. Todd Capson disagrees. "There is a real advantage to being able to use and sequester homobatrachotoxin." He explains from his homebase in Panama, "Not only is it very effective at protecting these birds against predators, but it also guarantees them an exclusive food source because they can eat bugs with this toxin that nothing else can."

In many cases predators wouldn't have to get close enough to taste these birds, or get a whiff of their distinctive smell. Like monarch butterflies and gila monsters, Pitohuis are bright orange and black, a color-coded warning that tells predators they are poisonous. Pitohuis of both sexes are equally toxic and colorful, a signal that may play a larger role in the New Guinea ecosystem.

According to UCLA writer, physiologist and naturalist Jared Diamond, large flocks of several brown and black bird species are known to forage together in the island's swampy lowlands. Usually these flocks are led by at least three of the toxic Pitohui species,

suggesting a highly complex social defense system among New Guinea's birds. Writing in the British Journal Nature shortly after Dumbacher's initial discovery, Diamond even proposed that birds of paradise might also be distasteful. "At least 15 species of bird of paradise join the Pitohui flocks," he says, "and the taste of birds of paradise has been reported as: 'the most shocking flesh I have ever eaten…bitter as gall…truly abominable.' So interactions with poisonous brown and black birds may have a long-standing selective force on birds of paradise." Right now, however, the only thing that has been shown about Pitohui and Ifrita is that they use BTX and it appears to repel some of their parasites. Whether the birds use BTX for defense, where it comes from and how they are able to withstand its effects are questions that remain tantalizingly unanswered.

Jack Dumbacher and his team plan to return to New Guinea's Varirata National Park to continue the search, looking for Pitohui nests, fitting birds with radio collars to track their feeding habits and sending new batches of suspicious bugs back to Daly at the NIH for analysis. Coupled with information from Capson and Majnep, Dumbacher hopes that his project will uncover many new things. But the process could take years. For scientists like Jack Dumbacher that's all part of the allure of New Guinea's biological *terra incognita*. "Almost nothing has been studied there," says Dumbacher, "So you can stumble across tree kangaroos and poisonous birds. All kinds of weird things. I've always tried to let the animals tell me where to look and what to study. In a place like New Guinea nature is way ahead of our imagination." Z

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